School Readiness and Later Achievement

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Using 6 longitudinal data sets, the authors estimate links between three key elements of school readiness—school-entry academic, attention, and socioemotional skills—and later school reading and math achievement. In an effort to isolate the effects of these school-entry skills, the authors ensured that most of their regression models control for cognitive, attention, and socioemotional skills measured prior to school entry, as well as a host of family background measures. Across all 6 studies, the strongest predictors of later achievement are school-entry math, reading, and attention skills. A meta-analysis of the results shows that early math skills have the greatest predictive power, followed by reading and then attention skills. By contrast, measures of socioemotional behaviors, including internalizing and externalizing problems and social skills, were generally insignificant predictors of later academic performance, even among children with relatively high levels of problem behavior. Patterns of association were similar for boys and girls and for children from high and low socioeconomic backgrounds.

Keywords: school readiness, socioemotional behaviors, attention, early academic skills

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Early childhood programs and policies that promote academic skills have been gaining popularity among politicians and researchers. For example, President George W. Bush (2002) endorsed Head Start reforms in 2002 that focus on building early academic skills, observing that "on the first day of school, children need to know letters and numbers. They need a strong vocabulary. These are the building blocks of learning, and this nation must provide them" (p. 12). The National Research Council's Committee on the Prevention of Reading Difficulties in Young Children recommends providing environments that promote preliteracy skills for all preschool children (Snow, Burns, & Griffin, 1998). Similarly, the National Association for the Education of Young Children and the National Council of Teachers of Mathematics (2002) issued a joint statement that advocated for high-quality mathematics education for children ages 3–6.

Others, however, maintain that a broad constellation of behaviors and skills enables children to learn in school. Asked to identify factors associated with a difficult transition to school, kindergarten teachers frequently mentioned weaknesses in academic skills, problems with social skills, trouble following directions, and difficulty with independent and group work (Rimm-Kaufman, Pianta, & Cox, 2000). Researchers too have made this point. The National Research Council and Institute on Medicine argued that "the elements of early intervention programs that enhance social and emotional development are just as important as the components that enhance linguistic and cognitive competence" (Shonkoff & Phillips, 2000, pp. 398–399).

These two views have emerged in the current debate about what constitutes school readiness and in particular about what skills predict school achievement. Many early education programs, including Head Start, are designed to enhance children's physical, intellectual, and social competencies on the grounds that each domain contributes to a child's overall developmental competence and readiness for school. However, if early acquisition of specific academic skills or learning-enhancing behaviors forecasts later achievement, it may be beneficial to add domain-specific early skills to the definition of school readiness and to encourage interventions aimed at promoting these skills prior to elementary school. Thus, understanding which skills are linked to children's academic achievement has important implications for early education programs.

We adopted a child-centered model of school transition, which is nested within a broader ecological framework but focuses on the set of individual skills and behaviors that children have acquired prior to school entry (Rimm-Kaufman & Pianta, 2000). A child's individual characteristics contribute to the environments in which the child interacts and the rate at which the child may learn new skills; in turn, the child receives feedback from others in the environment (Meisels, 1998). Thus, because they affect both the child and the social environment, early academic skills and socioemotional behaviors are linked to subsequent academic achievement because they provide the foundation for positive classroom adaptation (Cunha, Heckman, Lochner, & Masterov, 2006; Entwisle, Alexander, & Olson, 2005).

For example, a child who enters kindergarten with rudimentary academic skills may be poised to learn from formal reading and mathematics instruction, receive positive reinforcement from the teacher, or be placed in a higher ability group that facilitates the acquisition of additional skills. Similarly, a child who can pay attention, inhibit impulsive behavior, and relate appropriately to adults and peers may be able to take advantage of the learning opportunities in the classroom, thus more easily mastering reading and math concepts taught in elementary school. For these reasons, the skills children possess when entering school might result in different achievement patterns in later life. If achievement at older ages is the product of a sequential process of skill acquisition, then strengthening skills prior to school entry might lead children to master more advanced skills at an earlier age and perhaps even increase their ultimate level of achievement.

Although there are strong theoretical reasons to expect that individual differences in children's early academic skills and behavior are linked to subsequent behavior and achievement, surprisingly little rigorous research has been conducted to test this hypothesis. Consequently, the purpose of this article is to assess as precisely as possible, using six longitudinal, nonexperimental data sets, the association between skills and behaviors that emerge during the preschool years and later academic achievement. As with Robins's (1978) classic study of adult antisocial behavior, our approach consists of comparable analyses of a number of different longitudinal developmental studies.[1] We are especially interested in identifying academic, attention, and socioemotional skills and behaviors that may be learned or improved through experiences prior to school entry. In the following sections, we draw from developmental literature to identify key dimensions of school readiness and to derive theoretical predictions about how children's school-entry skills and behaviors contribute to short- and long-term academic success.

Associations Between Early Skills and Later Achievement

Academic achievement is a cumulative process involving both mastering new skills and improving already existing skills (Entwisle & Alexander, 1990; Pungello, Kuperschmidt, Burchinal, & Patterson, 1996). Information about how children acquire reading and math skills points to the importance of specific academic skills but also indicates that more general cognitive skills, particularly oral language and conceptual ability, may be increasingly important for later mastery of more complex reading and mathematical tasks. Basic oral language skills become critical for understanding texts as the level of difficulty of reading passages increases (NICHD Early Child Care Research Network, 2005b; Scarborough, 2001; Snow et al, 1998; Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998). Likewise, mastery of foundational concepts of numbers allows for a deeper understanding of more complex mathematical problems and flexible problem-solving techniques (Baroody, 2003; Ferrari & Sternberg, 1998; Hiebert & Wearne, 1996).

Although children's academic achievement is largely stable throughout childhood, children do demonstrate both transitory fluctuations and fundamental shifts in their achievement trajectories (Kowaleski-Jones & Duncan, 1998; Pungello et al., 1996). Nonexperimental data show that children's achievement test

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[1] Robins (1978) justified her approach as follows: "In the long run, the best evidence for the truth of any observation lies in its replicability across studies. The more the populations studied differ, the wider the historical eras they span; the more the details of the methods vary, the more convincing becomes that replication" (p. 611).

scores are related to prior cognitive functioning and the attainment of basic skills in math and literacy such as number and letter recognition (Stevenson & Newman, 1986). In their meta-analysis, La Paro and Pianta (2000) found middle-range correlations in cognitive/academic skills both from preschool to kindergarten (.43) and from kindergarten to first or second grade (.48).

Attention-related skills such as task persistence and self-regulation are expected to increase the time during which children are engaged and participating in academic endeavors. Research has shown that signs of attention and impulsivity can be detected as early as age 2.5 but continue to develop until reaching relative stability between ages 6 and 8 (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Posner & Rothbart, 2000). Studies linking attention with later achievement are less common, but consistent evidence suggests that the ability to control and sustain attention as well as participate in classroom activities predicts achievement test scores and grades during preschool and the early elementary grades (Alexander, Entwisle, & Dauber, 1993; Raver, Smith-Donald, Hayes, & Jones, 2005). These attention skills, which are conceptually distinct from other types of interpersonal behaviors, are associated with later academic achievement, independent of initial cognitive ability (McClelland, Morrison, & Holmes, 2000; Yen, Konold, & McDermott, 2004) and of prior reading ability and current vocabulary (Howse, Lange, Farran, & Boyles, 2003). Examining attention separately from externalizing problems has clarified the role of each in achievement, suggesting that attention is more predictive of later achievement than more general problem behaviors (Barriga et al., 2002; Hinshaw, 1992; Konold & Pianta, 2005; Ladd, Birch, & Buhs, 1999; Normandeau & Guay, 1998; Trzesniewski, Moffitt, Caspi, Taylor, & Maughan, 2006).

Children's socioemotional skills and behaviors are also expected to affect both individual learning and classroom dynamics. Inadequate interpersonal skills promote child–teacher conflict and social exclusion (Newcomb, Bukowski, & Pattee, 1993; Parker & Asher, 1987), and these stressors may reduce children's participation in collaborative learning activities and adversely affect achievement (Ladd et al., 1999; Pianta & Stuhlman, 2004). Correlational evidence linking problem behaviors to academic achievement is found in the Beginning School Study. First-grade ratings on items describing a cheerful, outgoing temperament (roughly the opposite of internalizing problems) predicted adult educational attainment better than preschool or first-grade achievement scores (Entwisle et al., 2005). Other studies yield similar results. For example, children with consistently high levels of aggression from ages 2–9 were more likely than other children to have achievement problems in third grade (NICHD Early Child Care Research Network, 2004).

Experimental Evidence and Crossover Effects

Many nonexperimental studies find associations between early achievement, attention, and behavior and later achievement, yet few of these studies are designed to determine which of these skills can be modified prior to school entry or whether these changes predict later achievement. In theory, intervention research should shed light on this gap by demonstrating ways to improve children's skills and by testing whether improvements in early skills are associated with better adjustment in the long term. Indeed, a small number of experimental interventions provide encouraging evidence that high-quality programs for preschool children "at risk" for school failure produce gains in cognitive and academic skills and reduce behavior problems (Conduct Problems Prevention Research Group, 2002; Karoly, Kilburn, & Cannon, 2005; Love et al., 2003). Early educational interventions have also been found to result in long-term reductions in special education services, grade retention, and increases in educational attainment (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002; Lazar et al., 1982; Reynolds & Temple, 1998).

As is the case with nonexperimental studies, few intervention studies are designed to isolate the relative contributions of changes in achievement, attention, and behavior to later school achievement. A first problem is that behavioral interventions tend to measure behavioral but not achievement outcomes, whereas reading and math interventions tend to measure achievement but not behavioral outcomes. Interesting exceptions are a small number of experimental behavior-based interventions that tested for achievement impacts (Coie & Krehbiel, 1984; Dolan et al., 1993). For example, a random-assignment evaluation of a behavioral intervention targeting both aggressive and shy behaviors among first graders found short-run improvements in both teacher and peer reports of aggressive and shy behavior but no crossover impacts on reading achievement (Dolan et al., 1993; Kellam, Mayer, Rebok, & Hawkins, 1998). Given evidence, albeit limited, that behavioral interventions succeed at improving behavior but not achievement, behavior would appear to play a limited role in academic success.

A second problem is that many intervention programs target both children's academic skills and their socioemotional behaviors, rendering it impossible to assess their separate impacts through simple experimental contrasts. For example, the Fast Track prevention program provided a number of services to children who were identified as disruptive in kindergarten, including direct tutoring in reading skills in first grade (Conduct Problems Prevention Research Group, 1992; 2002). It is possible to estimate nonexperimental mediated models to determine whether program effects are more likely to be due to children's improved achievement, attention, or behavior skills (e.g., Reynolds, Ou, & Topitzes, 2004). This is rarely done, however.

The Present Study

This study builds on previous school readiness research in several ways. First, the scope of the study is unprecedented. We estimated a carefully specified set of models with data from six large-scale longitudinal studies, two of which were nationally representative of U.S. children, whereas two were drawn from multisite studies of U.S. children, with one each focusing on children from Great Britain and Canada. Second, we included as predictors a wide representation of school readiness indicators used in previous research and carefully distinguished between related but conceptually distinct skills (e.g., oral language vs. preliteracy skills, attention vs. externalizing problems) wherever possible. Third, we examined multiple dimensions of academic achievement outcomes, including grade completion and math and reading achievement as assessed by both teacher ratings and test scores. Fourth, we implemented rigorous analytic methods that attempted to isolate the effects of school-entry academic, attention, and socioemotional skills by controlling for an extensive set of prior child, family, and contextual influences that may have been

related to children's achievement. Finally, we assessed whether the predictive power of school readiness components differs by gender or socioeconomic status, which would indicate that some children are at heightened risk of low achievement.

We tested a number of hypotheses related to how school-entry academic, attention, and socioemotional skills are associated with later school achievement. Developmental theory suggests that children's informal, intuitive knowledge of early language and math concepts plays an important role in the acquisition of more complex skills formally taught in elementary school (Adams, Treiman, & Pressley, 1998; Baroody, 2003; Griffin, Case, & Capodilupo, 1995; Tunmer & Nesdale, 1998). Theoretically, children's attention and socioemotional skills should also affect achievement because they influence children's engagement in learning activities and facilitate (or disrupt) classroom processes (Ladd, Birch, & Buhs, 1999; Pianta & Stuhlman, 2004). However, some scholars point out that it is important to distinguish between behaviors that are directly relevant for learning, such as attention, and those that may be correlated with attention but are less likely to be directly linked with achievement, such as interpersonal skills and problem behavior (Alexander et al., 1993; Cooper & Farran, 1991; McClelland et al., 2000; McWayne, Fantuzzo, & McDermott, 2004). Therefore, we expected early academic and attention-related skills to predict subsequent test scores and teacher achievement ratings, and we expected attention skills to predict achievement more consistently than do socioemotional behaviors.

In seeking a better understanding of the extent to which our broad set of early skills is associated with later achievement, it is important to consider how outcomes are being measured. Although test performance provides a key independent assessment of academic achievement, teacher ratings also lend insight into children's everyday performance in the classroom. Teachers' evaluations are probably based on a broad picture of children's accomplishments, which include their academic skills as well as whether they complete assignments on time, work independently, get along with others, and show involvement in the learning agenda of the classroom. Moreover, previous research has found that children's behavior can play a role that is equal to, if not greater than, prior cognitive ability in predicting teacher-rated attainment or achievement (Lin, Lawrence, & Gorrell, 2003; Schaefer & McDermott, 1999) and academic skills (National Center for Education Statistics, 1993). Consequently, we expected a stronger relationship between school-entry socioemotional behaviors and subsequent teacher-rated achievement than with subsequent test scores.

Although many previous studies have examined the association between early academic, attention, and socioemotional skills and subsequent achievement, few have systematically considered the extent to which these associations differ by gender (Trzesniewski et al., 2006). On average, boys receive poorer grades and have more difficulties related to school progress (e.g., grade retention, special education, and drop out) than do girls (Dauber, Alexander, & Entwisle, 1993; McCoy & Reynolds, 1999), and these differences are especially pronounced among low-income children (Hinshaw, 1992). Children from low-income families enter school with lower mean academic skills, and the gap tends to increase during the school years (Lee & Burkam, 2002). These groups also have higher rates of problems with attention and externalizing behavior

(Entwisle et al., 2005; Miech, Essex, & Goldsmith, 2001; Raver, 2004).

Despite differences in children's behavior linked to gender and family socioeconomic status, few studies have considered whether gender and socioeconomic status moderate the association between these early skills and behaviors and subsequent achievement. We expected early academic skills, attention, and socioemotional behaviors to matter more for these subgroups, particularly when children enter school with very low levels of these skills.

To estimate the associations between early academic skills and socioemotional behaviors and later school achievement, we summarize results from a coordinated series of analyses across six longitudinal data sets in two ways. First, we relate early academic, attention, and socioemotional skills to later achievement in each of the six data sets and provide a basic summary of these results. Second, we formally summarize the findings from these studies in a meta-analysis, again focusing on the extent to which this collection of early skills predicts later achievement.

Method

In this section, we describe the data sets used in this study and the common analytic procedures that were implemented across studies. Detailed information about the measures, descriptive statistics, and regression results from each study is presented in Appendices A–F, which can be found online. As the goal of our study was to relate early academic, attention, and socioemotional skills and behaviors to later achievement, each data set has measures of these constructs, although there is variation across the studies with respect to when and how each skill or behavior is assessed.

Table 1 provides an overview of data sources and measures available in each study. All six data sets provide measures of children's academic skills as well as assessments of attention and socioemotional behaviors at about age 5 or 6. Because most children enter elementary school at this age, we refer to the timing of these measures as *school entry* but alert the reader that the precise timing varies considerably across studies. To facilitate comparison of findings across studies, we standardized all measures to have a mean of 0 and standard deviation of 1.

We measured achievement outcomes using teachers' reports, test scores, and grade retention in early elementary school and, in some studies, middle childhood. In terms of the timing of the measurement of achievement outcomes, the children of the National Longitudinal Survey of Youth (NLSY) measures are assessed as late as early adolescence, the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD) as late as fifth grade, and the 1970 British Birth Cohort Study (BCS) at age 10, whereas none of the other studies measures achievement beyond third grade. As for measurement methods, two studies have both test-score-based and teacher reports of reading and mathematics achievement (the Early Childhood Longitudinal Study–Kindergarten Cohort [ECLS-K] and NICHD SECCYD).

We measured attention and socioemotional behaviors on the basis of mothers' reports, teachers' reports, and observation. Table 1 provides an overview of the similarities and differences in measurement across the six studies. One of our data sets, the Infant Health and Development Program (IHDP), has observer reports of

Table 1
Study Measures of Outcomes, School Entry and Preschool Achievement, Attention and Socioemotional Behaviors

Measure	ECLS-K Grade 3	NLSY age 13–14	NICHD SECCYD Grade 5	IHDP age 8	MLEPS Grade 3	BCS age 10
Outcomes						
Reading	Achievement Test Reading item response theory (IRT) "advanced" subscales: Extrapolation, Evaluation Academic Rating Scale (α = .95): Teacher Report	Peabody Individual Achievement Tests (PIAT) Reading Recognition: Matching letters, naming names, and reading single words out loud (test–retest = .89)	Woodcock–Johnson Psycho-Educational Battery—Revised (WJ-R) Reading: Letter-Word, Word Attack Academic Skills Ratings Scale: Teacher Report	Woodcock–Johnson Tests of Achievement—Revised: Broad Reading (α = .90s)	Verbal Skills: Use/ understanding of French, characteristics of oral communication (α = .94): Teacher Report	Edinburgh Reading Test: Self-completion, word recognition, use and understanding of syntax, sequencing, comprehension, and retention (α = .96)
Math	Achievement Test Math IRT "advanced" subscales: Multiplication/division, Place-value, Word problems Academic Rating Scale (α = .94): Teacher Report	PIAT Math: Application of mathematical concepts, number recognition, counting, multiplication, division, fractions, and advanced algebra and geometry (test/retest = .74)	WJ-R Math: Applied problems Academic Skills Ratings Scale: Teacher Report	Woodcock–Johnson Tests of Achievement—Revised: Broad Math (α = .90s)	Number Knowledge Test: Number sequence, addition, subtraction, multiplication, division, fractions, decimals	University of Bristol Math Test: Rules of arithmetic, place value, fractions, measurement, algebra, geometry, and statistics (α = .93)
School entry skills	Fall of kindergarten	Age 5–6	Age 4.5	Age 5	Junior and senior kindergarten	Age 5
Achievement						
Reading	Achievement Test Reading IRT "early" subscales: Letter recognition, beginning and ending word sounds	PIAT Reading Recognition	WJ-R Reading: Letter-Word Identification (α = .84)			
Language/verbal ability			Preschool Language Scale–3: Expressive communication	Wechsler Preschool and Primary Scale of Intelligence (WPPSI): Verbal IQ (α = .94)	Peabody Picture Vocabulary Test (PPVT), Forms A and B, French adaptation: Split-half reliability .66 and .85 for A and B, respectively; test–retest at 1 week = .72	English Picture Vocabulary Test: Verbal intelligence
Math	Achievement Test Math IRT "early" subscales: Counting, ordinality and relative size	PIAT Math	WJ-R Math: Applied problems (α = .84)		Number Knowledge Test: Informal number knowledge, counting, addition, number sequence	
Attention skills						
Attention skills	Approaches to Learning (α = .89): Teacher Report		Continuous Performance Task: Attention		Attention: Child concentrates, listens attentively, etc. (α = .82): Teacher Report	
Attention problems		Hyperactivity (difficulty concentrating, restless, etc.): Maternal Report	(I) Child Behavior Checklist (CBCL), Attention problems (α = .93): Fall of Kindergarten Teacher Report (II) Continuous Performance Task: Impulsivity	Achenbach Child Behavior Profile, Attention problems (α = .61): Maternal Report	Hyperactive: Child seems agitated, impulsive, etc. (α = .90): Teacher Report	Rutter Scale: Inattention (α = .67): Maternal Report

Table 1 (*continued*)

School entry skills	Fall of kindergarten	Age 5–6	Age 4.5	Age 5	Junior and senior kindergarten	Age 5
Socioemotional behaviors						
Externalizing problems	Externalizing Problems (α = .90): Teacher Report	(I) Head Strong (stubborn, strong temper, etc.): Maternal Report (II) Antisocial (cheats, bullies, etc.): Maternal Report	CBCL, Aggressive behavior (α = .93): Fall of Kindergarten Teacher Report		Aggression: Child fights, bullies others, etc. (α = .72): Teacher Report	Rutter Scale, Externalizing: Child bullies others, is disobedient, etc. (α = .72): Maternal Report
Internalizing problems	Internalizing Problems (α = .80): Teacher Report	Anxious/depressed (feels unloved, sad): Maternal Report	CBCL: Internalizing (α = .93): Fall of Kindergarten Teacher Report		Anxious/Depressed: Child worries, cries often, etc. (α = .80): Teacher Report	Rutter Scale, Internalizing: Child worries, seems miserable, etc. (α = .54): Maternal Report
Social skills	(I) Self Control (α = .79): Teacher Report (II) Interpersonal Skills (α = .89): Teacher Report		Social Skills Rating System (SSRS): Cooperation, assertion, self-control (α = .93): Fall of Kindergarten Teacher		Prosocial: Child is helpful, sympathetic to others, etc. (α = .92): Teacher Report	
Prior child controls	Age 3–4		Age 3	Age 3	Junior and senior kindergarten	Age 42 months
Prior cognitive/ achievement	Peabody Picture Vocabulary Test— Revised (PPVT-R; split-half reliability of .80)		Bracken Basic Skills (colors, letters, numbers, etc., α = .93) Reynell Developmental Language Scale (vocabulary comprehension, α = .93; expressive language, α = .86)	Stanford-Binet IQ Test	Peabody Picture Vocabulary Test (PPVT), Forms A and B, French adaptation: Split-half reliability .66 and .85 for A and B, respectively; test–retest at 1 week = .72 Number Knowledge Test: Informal number knowledge, shapes, colors, counting, number sequence, addition	Counting (α = .95) Speaking & Vocabulary (α = .79) Copying designs (α = .83) Age 22 months: Cube stacking, Language (α = .93), Copying designs test (α = .46)
Prior attention skills/socioemotional behavior	Compliance (α = .59): Maternal Report Sociability (α = .93): Interviewer ratings of child's cooperation during the assessment		CBCL, Externalizing, internalizing: Maternal Report Forbidden toy laboratory task: Impulsivity	CBCL, Overall behavior problems (α = .94): Maternal Report Attention (α = .94): Test observer's report		Cooperation: Interviewer ratings of child's cooperation during the assessment Age 22 months: Personal development (α = .82)

Note. Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K) includes a school entry test of general knowledge. National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD) includes age 4.5 WJ-R Cognitive Ability measure. Infant Health and Development Program (IHDP) includes age 5 Wechsler Preschool and Primary Scale of Intelligence (WPPSI) Performance IQ (α = .93) and age 5 Achenbach Child Behavior Profile Maternal Report: Overall behavior problems (α = .93). British Birth Cohort Study (BCS) includes age 5 Human Figure Drawing, Copying Designs Test, and Profile Drawing. Roman numerals index measures consistently in Tables 1 and 2. NLSY = National Longitudinal Survey of Youth; MLEPS = Montreal Longitudinal-Experimental Preschool Study.

attention, another (NICHD SECCYD) has both test-based and teacher-rated measures of attention, and three (NLSY, IHDP, and BCS) have parent rather than teacher reports of socioemotional behaviors. In addition, two of the studies (NICHD SECCYD and the Montreal Longitudinal-Experimental Preschool Study [MLEPS]) measure both attention skills and problems, whereas three (NLSY, IHDP, and BCS) have measures of attention problems but not skills, and one study (ECLS-K) has a measure of attention skills but not attention problems. In addition, with one exception, all of the studies provide measures of academic, attention, and socioemotional skills prior to the point of school entry, which we used as key control variables in our analyses.

The Studies and Samples

The Early Childhood Longitudinal Study–Kindergarten Cohort (ECLS-K). The ECLS-K follows a nationally representative sample of 21,260 children who were in kindergarten in 1998–1999. We used data from kindergarten, first grade, and third grade. Data were collected from multiple sources, including direct achievement tests of children and surveys of parents, teachers, and school administrators (see Table 1; National Center for Education Statistics, 2001).

Achievement tests were administered in the fall of kindergarten and in the spring of kindergarten, first grade, and third grade. We used teacher reports of children's "approaches to learning" (which measure both attention skills and achievement motivation) and socioemotional behaviors, including internalizing and externalizing problems, self-control with peers, and interpersonal skills, collected in the fall and spring of kindergarten.

The battery of achievement tests given as part of the ECLS-K kindergarten and first-grade assessments covered three subject areas: language and literacy, mathematical thinking, and general knowledge. For third grade, the achievement tests included mathematics, reading, and science. We used item response theory scores for the first two of these as key dependent variables. These third-grade assessments required students to complete workbooks and open-ended mathematics problems. As detailed in Appendix A, a host of family- and some child-level controls are available in the data.

The children of the National Longitudinal Survey of Youth (NLSY). The NLSY is a multistage stratified random sample of 12,686 individuals age 14 to 21 in 1979 (Center for Human Resource Research, 2004). Black, Hispanic, and low-income youth were overrepresented in the sample. Annual (through 1994) and biennial (between 1994 and 2000) interviews with sample members and very low cumulative attrition in the study contribute to the quality of the study's data.

Beginning in 1986, the children born to NLSY female participants were tracked through biennial mother interview supplements and direct child assessments. Given the nature of the sample, it is important to note that early cohorts of the child sample were born disproportionately to young mothers. With each additional cohort, the children become more representative of all children, and NLSY children younger than age 14 in 2000 share many demographic characteristics of their broader set of age mates.

The sample used in the present analysis consists of 1,756 children whose academic achievement was tracked from age 7–8 to age 13–14 and whose achievement and behavior was assessed at age 5–6. Consequently, our sample comprises children who were age 5 or 6 in 1986, 1988, 1990, or 1992. The age 13–14 achievement and behavior of these children were assessed in the respective 1994, 1996, 1998, and 2000 interviews.

School readiness measures, including math and reading test scores (Peabody Individual Achievement Test; Dunn & Markwardt, 1970) and maternal reports of children's behavior problems (adapted from the Achenbach Behavior Problems Checklist; Baker, Keck, Mott, & Quinlan, 1993) were collected at age 5 or age 6. Academic achievement outcome measures were collected biennially for children between the ages of 5 and 14. In addition, key control variables include children's receptive vocabulary (Peabody Picture Vocabulary Test—Revised; Dunn & Dunn, 1981) and children's temperament (compliance and sociability) at age 3 or 4. Additional family- and child-level control variables are described in Appendix B.

The NICHD Study of Early Child Care and Youth Development (SECCYD). Longitudinal data from the NICHD SECCYD are drawn from a multisite study of births in 1991 (NICHD Early Child Care Research Network, 2005a). Participants were recruited from hospitals located at 10 sites across the United States. During 24-hr sampling periods, 5,265 new mothers met the selection criteria and agreed to be contacted after returning home from the hospital. At 1 month of age, 1,364 healthy newborns were enrolled in the study. Although it is not nationally representative, the study sample closely matches national and census tract records with respect to demographic variables such as ethnicity and household income. The majority of children in the sample are White, 12% are African American, and 11% are Hispanic or of another ethnicity. About 30% of mothers had a high school education or less, and 14% were single parents (NICHD Early Child Care Research Network, 1997). The analysis sample had valid data on the achievement outcome measures and at least three sources of information on the key independent variables (approximately 981 at first grade, 928 at third grade, and 907 at fifth grade).

School readiness measures, including achievement tests and attention/impulsivity tasks, were administered in a controlled laboratory setting at age 4.5, and attention problems, aggression, internalizing behavior, and social skills were measured by teacher report in the fall of the kindergarten year. Outcomes at first, third, and fifth grades include achievement in math and reading according to teacher ratings and Woodcock–Johnson Tests of Achievement—Revised test scores (Woodcock & Johnson, 1990; see Table 1). Key control variables at age 3 include children's cognitive ability, language skills, impulsivity, externalizing problems, and internalizing problems. The NICHD SECCYD also collects information from infancy about children's early environments, including child-care type and quality, home environment, and parenting; these and other child- and family-level covariates are described in Appendix C.

The Infant Health and Development Program (IHDP). The IHDP is an eight-site randomized clinical trial designed to evaluate the efficacy of a comprehensive early-intervention program for low birth weight (LBW) premature infants. Infants weighing 2,500 g (5.51 lb) or less at birth were screened for eligibility if their postconceptional age between January and October 1985 was 37 weeks or less and if they were born in one of eight participating medical institutions. A total of 985 infants was randomly assigned either to a medical follow-up only or to a comprehensive early

childhood intervention group immediately following hospital discharge.

Infants in both the comprehensive early childhood intervention and medical follow-up only groups participated in a pediatric follow-up program of periodic medical, developmental, and familial assessments from 40 weeks of conceptional age (when they would have been born if they had been full term) to 36 months of age corrected for prematurity. The intervention program, lasting from hospital discharge until 36 months, consisted of home visits, child-care services, and parent group meetings. A coordinated educational curriculum of learning games and activities was used both during home visits and at the center.

The primary analysis group consisted of 985 infants. Of these 985 infants, cognitive assessments are available for 843 children at age 3, 745 children at age 5, and 787 children at age 8. In addition, 76 children who were born at an extremely low birth weight (ELBW; 1,000 g [3.27 lb] or less) were excluded from the sample because ELBW children differ markedly from other LBW children in cognitive and behavioral functioning (Klebanov, Brooks-Gunn, & McCormick, 1994a, 1994b). Thus, this study focuses on a subsample of 690 children who were not born ELBW and for whom cognitive assessment and family background data were available.

Data come from a variety of sources: questionnaires, home visits, and laboratory tests (see Table 1). School readiness measures include preschool performance and verbal test scores, parental reports of children's mental health and aggressive behavior, and observer reports of children's attention and task persistence. We assessed reading and math achievement using the Woodcock–Johnson Tests of Achievement—Revised broad reading and math tests and the Wechsler Intelligence Scale for Children—Third Edition (Wechsler, 1991) performance and verbal tests at 8 years of age. Key control variables include cognitive ability, sustained attention, and behavior problems at age 3. Additional family- and child-level control variables are described in Appendix D.

The Montreal Longitudinal-Experimental Preschool Study (MLEPS). The MLEPS comprises several consecutive cohorts launched from 1997 to 2000. The original sample of 4- and 5-year-old children ($N = 1,928$), representing one third of its population base, was obtained after a multilevel consent process involving school board administrators, local school committees, parents, and teachers. Given that its final cohort (2000) does not meet all the data requirements for the research objective examined here, we limited ourselves to the sample of children beginning kindergarten in the fall of 1998 and the fall of 1999.

Incomplete data reduced the sample from 1,369 to 767 children. Students in the final sample had a valid value on any of the four outcome measures of interest (first- and third-grade achievement measures) and on at least four of the six socioemotional measures. Of the 767 participants in the final sample, 439 began kindergarten in 1998 and 328 began kindergarten in the fall of 1999. Additionally, for 350 of the 767 students, initial data were collected during the fall of junior kindergarten (332 who began junior kindergarten in 1997 and 18 who began junior kindergarten in 1998).

Initial and follow-up data were collected from multiple sources, including direct cognitive assessments of children and surveys of parents and teachers. Early academic assessments include individually administered number knowledge and receptive vocabulary tests at the end of senior kindergarten. Teachers rated children's behavioral development, including physically aggressive, anxious, depressive, hyperactive, inattentive, and prosocial behavior. Third-grade assessments include a group-administered math test and teacher ratings of children's French language skills (see Table 1). Key control variables include number knowledge and vocabulary measured on entry into junior kindergarten (age 4) for Cohort 1 and on entry into senior kindergarten (age 5) for Cohort 2. Additional family- and child-level control variables are detailed in Appendix E.

The 1970 British Birth Cohort Study (BCS). The U.K. 1970 BCS, a nationally representative longitudinal study, has followed into adulthood a cohort of children born in Great Britain during 1 week in 1970 (Bynner, Ferri, & Shepherd, 1997). The birth sample of 17,196 infants was approximately 97% of the target birth population. Attrition has reduced the original sample to 11,200 participants. Nevertheless, the representativeness of the original birth cohort has largely been maintained, although the current sample is disproportionately female and highly educated (Ferri & Smith, 2003). Missing data on key variables reduce the sample size for most analyses to between 9,000 and 10,000 cases.

At each wave, cohort members were given a battery of tests of intellectual and behavioral development (see Table 1). School readiness measures include vocabulary and copying skills tests, and maternal reports of attention, externalizing behavior, and internalizing behavior were collected when the children were 5 years of age. Reading and mathematics achievement tests were administered at age 10. Key control variables include measures of basic skills and behavior at ages 22 and 42 months for a 10% subsample of the data. Additional family- and child-level controls are described in Appendix F.

Analysis Plan

We begin our analysis by estimating a similar set of regression models across all six studies, in which school-entry academic, attention, and socioemotional skills are related to later academic achievement. For example, in ECLS-K data, the school-entry skills and behaviors are measured in the fall of kindergarten (referred to hereafter as *FK*), whereas math and reading achievement are measured in the spring of third grade (referred to hereafter as *3rd*). The resulting equation is as follows:

$$ACH_{i3rd} = a_1 + \beta_1 ACAD_{iFK} + \beta_2 ATTN_{iFK} + \beta_3 SE_{iFK}$$
$$+ \gamma_1 FAM_i + \gamma_2 CHILD_i + e_{it}, \quad (1)$$

where ACH_{i3rd} is the math or reading[2] achievement of child i in the spring of third grade; $ACAD_{iFK}$ is the collection of math, reading, and general knowledge skills that child i has acquired at school entry, assessed by achievement tests in the fall of the kindergarten year; $ATTN_{iFK}$ is a teacher-reported measure of attention; SE_{iFK} is the collection of socioemotional skills that child i's teacher reports; FAM_i and $CHILD_i$ are sets of family background and child characteristics, respectively, included in analyses to control for individual differences that might influence child achievement before and after school entry; a_1 is a constant; and e_{it} is a stochastic error term.

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[2] We use *reading* as shorthand for the set of reading, language, and verbal ability skills measured in our data sets.

Our interest is in estimating β_1, β_2, and β_3, which, if correctly modeled, can be interpreted as the impact of school-entry academic, attention, and socioemotional skills on subsequent achievement. A key challenge in this approach is ensuring that we have accounted for the possibility of omitted variable bias, which is likely to arise if unobserved family or child characteristics are correlated with both children's school entry skills and their later achievement. Our principal strategy for securing unbiased estimation of β_1, β_2, and β_3 is to estimate a model of the form of Equation 1 that includes as many prior measures of relevant child and family characteristics as possible.

All of the studies contain important measures of child and family characteristics that may be confounded with children's achievement, attention, and behavior. Although the specific set of covariates varies across studies, most studies include measures of the child's race and ethnicity, maternal education, family structure, and family income or economic well-being. In some studies, measures of child health, maternal depressive symptoms, parenting, and quality of the home environment, as well as children's participation in early child care and education during early childhood were also included as controls.[3] Details about the specific controls used in each study are provided in the appendices, and a complete list of covariates for each study can be found in Tables A6, B6, C6, D5, E6, and F5.

Our analysis was designed to examine the relations between early skills and later achievement, irrespective of the characteristics of the classroom/school the child attends. The ECLS-K is an exception, owing to a sample design that selects an average of 4 students per kindergarten classroom to be enrolled in the study. We took advantage of this classroom clustering by adjusting our ECLS-K estimates for classroom fixed effects. Thus, all of the variation used in the regression stems from within-classroom differences, which holds constant school and classroom characteristics.

Of course, we cannot be certain that even a comprehensive set of control variables captures all of the important confounds, which leaves open the possibility that this approach will still produce biased estimates of β_1, β_2, and β_3. For example, an obvious bias of this sort would arise if scores on a kindergarten mathematics test reflected both math skills and underlying cognitive ability.

To further reduce the possibility of biases, we include measures of a child's attention and socioemotional behaviors and either cognitive ability or preacademic skills assessed prior to school-entry, which are available in all but two studies (ECLS-K and MLEPS).[4] With these prior measures, our model becomes

$$\text{ACH}_{i3\text{rd}} = a_1 + \beta_1\text{ACAD}_{i\text{FK}} + \beta_2\text{ATTN}_{i\text{FK}} + \beta_3\text{SE}_{i\text{FK}}$$
$$+ \beta_4\text{ACAD}_{i\text{Pre-FK}} + \beta_5\text{ATTN}_{i\text{Pre-FK}} + \beta_6\text{SE}_{i\text{Pre-FK}}$$
$$+ \gamma_1\text{FAM}_i + \gamma_2\text{CHILD}_i + e_{it}. \quad (2)$$

$\text{ACAD}_{i\text{Pre-FK}}$, $\text{ATTN}_{i\text{Pre-FK}}$, and $\text{SE}_{i\text{Pre-K}}$ refer to child i's respective achievement, attention, and socioemotional behavior prior to school entry, respectively. This constitutes a particularly powerful version of Equation 1, because controlling for the child's cognitive and behavioral skills before school entry should reduce, if not eliminate, omitted-variable bias in β_1, β_2, and β_3.

One concern about Equation 2 is that by controlling for school entry achievement, we might reduce the deserved explanatory power of attention and socioemotional skills. This would occur if one of the ways in which attention and socioemotional skills affected later achievement were to raise children's school entry academic skills. We investigate this possibility by estimating versions of Equation 2 that omit $\text{ACAD}_{i\text{FK}}$.

In the second step of our analysis, we use meta-analytic techniques to summarize coefficients obtained from our six studies' estimates of Equation 2 and seek to determine whether particular study characteristics are associated with larger (or smaller) coefficients. More specifically, the meta-analysis treats the standardized regression coefficients from Equation 2 as observations in a regression predicting academic achievement measured as late in childhood as possible. Independent variables in the meta-analytic regression include (a) the type of school-entry measure,[5] (b) elapsed time (scaled in years) between measurement of school-entry characteristics and the outcome, (c) whether the outcome is math or reading achievement, and (d) whether the outcome is based on a test or a teacher report. In keeping with standard meta-analytic practices, we weighted each regression coefficient observation by the inverse of its variance (Hedges & Olkin, 1985).

Results

Regression Results

To consider whether school entry[6] achievement, attention, and socioemotional skills are predictive of subsequent achievement, we first estimated a comparable set of regressions (Equation 2) across all of the studies. For each study, reading and math outcomes measured as late in the data set as possible were regressed on school-entry achievement, attention, and socioemotional behaviors, with controls for important family and child characteristics also included in the regression. In all but two cases, our regressions include measures of both cognitive ability and either attention or socioemotional behaviors.

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[3] Our list of child and family control variables is more extensive than in most developmental studies. In selecting these variables, we were careful to include only variables measured prior to or concurrently with our school-entry measures of achievement and behavior. We were also mindful that added controls might introduce multicolinearity into our regression estimation, but there was no indication that this might be the case. And finally, our appendix tables compare models run with and without our child and family controls and show that the results of our analyses depend little on adjustments for these factors; concurrent controls for the other achievement and behavioral measures matter much more.

[4] The MLEPS provides preschool cognitive measures but not attention or socioemotional behaviors (see Table 1).

[5] The decision of which type of measure should serve as the omitted dummy variable category is noteworthy, because the coefficients on the included measure categories represent differences from the omitted category. We selected internalizing behavior problem coefficients as the omitted category because the simple average of their regression coefficients was very close to zero (–. 01 for reading outcomes and –. 01 for math outcomes).

[6] We remind the reader we use the term *school entry* somewhat loosely. It refers to age 5 in four cases, age 5–6 in one case, and the fall of the kindergarten year in only one case.

Standardized regression coefficients and standard errors from models predicting achievement from the school-entry academic, attention, and socioemotional behaviors are presented in Table 2. Complete regression results using all available reading and math outcomes are presented in appendix tables and are summarized below in our meta-analysis.

As expected, the regression results indicate that school-entry reading and math skills are almost always statistically significant predictors of later reading and math achievement, with standardized coefficients ranging from .05 to .53. Not surprisingly, school-entry reading skills predict subsequent reading achievement better than subsequent math achievement, just as early math skills are more predictive of later math than reading achievement.

In the case of attention skills and attention problems, coefficients are usually smaller than those for math skills, but they are statistically significant for more than half of the coefficients. In contrast, coefficients for socioemotional behaviors—externalizing and internalizing behavior problems and social skills—rarely pass the threshold of statistical significance.

This general pattern—relatively strong prediction from school-entry reading and math skills, moderate predictive power for attention skills, and few to no statistically significant coefficients on socioemotional behaviors—is also found for reading and math achievement measured at earlier points in the studies and in logistic regressions in which grade retention is the dependent variable (results shown in Tables A3, B3, C3, D3, E3, and F3 but not in Table 2).

To consider whether the effects of school-entry skills differ by children's gender or socioeconomic status (SES), we ran regressions (Equation 2) but also included gender interactions with school-entry achievement, attention, and socioemotional skills for all six data sets and SES interactions for all but the NICHD SECCYD and MLEPS (results shown in Appendices A–F).[7] In the case of gender interactions, 10 of 76 relevant interaction coefficients were .05 or larger and statistically significant, but there was no consistent pattern in the direction of effects. In the case of SES interactions, only 2 of the 30 interaction coefficients were .05 or greater and statistically significant. It appears that the influences of school-entry achievement, attention, and socioemotional skills are broadly similar for both boys and girls and for children from both low- and high-SES families.[8]

Meta-Analytic Results

To summarize findings across the six studies more systematically, we first averaged the 102 bivariate correlations between school-entry achievement, attention, and socioemotional skills and the latest available reading and math achievement available in each of the data sets. (Detailed correlation tables are shown in Tables A2, B2, C2, D2, E2, and F2.) As shown in the first column of Table 3, the absolute value of these correlations average between .40 and .50 for school-entry reading and math achievement, average .25 for the collection of attention measures, and average between .10 and .21 in absolute value for the three sets of socioemotional measures.

Next, we conducted a formal meta-analysis of the standardized regression coefficients emerging from the individual study regressions. We used two sets, with the first comprising the 102 coefficients shown in Table 2, and drew from regressions based on Equation 2 and achievement

outcomes measured as late in childhood as possible. These results are shown in the second column of Table 3. The second meta-analytic regression is based on the 228 coefficients taken from regressions with outcomes measured at all possible points in a given study. These coefficients are shown in the appendix tables and produce the results shown in the third, fourth, and fifth columns of Table 3.

A clear conclusion from the first meta-analytic regression is that only three of the school-entry skill categories predict subsequent reading and math achievement: reading/language, math, and attention. Moreover, rudimentary mathematics skills appear to matter the most, with an average standardized coefficient of .33.[9] The association of reading skill with later achievement was less than half as large (.13), and, at .07, the average standardized coefficients on the attention-related measures was less than one quarter the size of the mean math-skills coefficient. As expected from Table 2, the meta-analysis results confirm that behavior problems and social skills are not associated with later achievement, holding constant achievement as well as child and family characteristics. Indeed, none had a standardized coefficient that averaged more than .01 in absolute value.

Turning to the other coefficients listed in the second column of Table 3, one can see that the school-entry skills coefficients decreased a little (.010 per year) with each additional year between school entry and the point of assessment of the math or reading outcome. As for whether teacher-report outcomes or direct skill assessments are more likely to be predicted by early skills, our meta-analytic results suggest that both types of measures performed about the same.

Our appendices (Tables A3, B3, C3, D3, E3, and F3) provide standardized coefficients from regressions of achievement outcomes measured at different ages, which constitute the 228 observations used for the meta-analytic regression results shown in the remaining columns of Table 3. The advantage of using outcomes at several ages is that it enables us to control for the study from which a given standardized coefficient was estimated, which we do by including a set of study indicator variables.[10] The third column of Table 3 summarizes the results across domains, and the fourth and fifth columns show

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[7] Coefficients were excluded from our summary calculations if the standard errors for the gender or SES interactions were too large to detect differences of .15.

[8] The ECLS-K, NLSY, and IHDP studies provided enough observations on Black and White children to enable us to test for race interactions as well. We found no consistent evidence of race-based interactions.

[9] Technically speaking, the .33 coefficient reflects the regression-adjusted difference between the average school-entry math and the omitted-group internalizing problem behavior standardized coefficient. Recall that the simple average of regression coefficients on internalizing behavior problems was −.01 for both math and reading outcomes. The large sample sizes available in the ECLS-K push weighted meta-analytic results closer to the ECLS-K study coefficients than when the coefficient-variance weights are not used. Unweighted, the coefficients on school-entry reading and math are .12 and .20, respectively; the coefficient on attention is .05, the coefficient on externalizing is .00, and the coefficient on social skills is −.01.

[10] With study dummies in the regression, we have what amounts to a fixed-effects regression in which coefficients are averaged within rather than across studies. Dropping the study dummies produced few changes in the remaining coefficients.

Table 2

Coefficients From Regressions of Individual Study Achievement Outcomes on School Entry Achievement, Attention, and Socioemotional Behaviors From Models With Full Controls

Independent variable	ECLSK Grade 3 Achievement test score Reading	ECLSK Ach Math	ECLSK Teacher-rated Reading	ECLSK Teacher-rated Math	NLSY age 13–14 Reading	NLSY age 13–14 Math	NICHD SECCYD Gr 5 Ach Reading	NICHD Ach Math	NICHD Teacher-rated Reading	NICHD Teacher-rated Math	IHDP age 8 Reading	IHDP age 8 Math	MLEPS Gr 3 Verbal	MLEPS Gr 3 Math	BCS age 10 Reading	BCS age 10 Math
School entry																
Achievement																
Reading	.18*** (.01)	.05*** (.01)	.15*** (.02)	.09*** (.02)	.16** (.02)	.12** (.02)	.19*** (.04)	.11** (.04)	.09* (.04)	.11** (.04)	.30*** (.05)	.34*** (.05)	.19* (.09)	.05 (.08)	.13*** (.03)	.09** (.03)
Language/Verbal Ability							.11** (.04)	.12** (.04)	.20*** (.04)	.12** (.05)			.07 (.06)			
Math	.27*** (.01)	.53*** (.01)	.31*** (.02)	.34*** (.02)	.11** (.02)	.22** (.02)	.07 (.04)	.19*** (.04)	.12** (.04)	.12* (.05)				.29*** (.05)		
Attention skills	.04** (.01)	.10*** (.01)	.14*** (.02)	.12*** (.02)			−.02 (.03)	.00 (.03)	.05 (.03)	.08* (.03)			.20*** (.06)	.14** (.05)		
Attention problems (I)					−.05* (.02)	−.09** (.03)	−.11** (.04)	−.17*** (.04)	−.11** (.04)	−.17*** (.05)	−.05 (.03)	−.09* (.04)	.12 (.07)	−.11* (.06)	−.08** (.03)	−.09** (.03)
Attention problems (II)							.05 (.03)	.06* (.03)	.03 (.04)	.01 (.04)						
Socioemotional behaviors																
Externalizing problems (I)	.00 (.01)	−.01 (.01)	.00 (.02)	.01 (.02)	.03 (.02)	.00 (.03)	.09* (.04)	.05 (.04)	.11*** (.04)	.11*** (.04)			−.03 (.06)	−.06 (.05)	−.03 (.03)	.00 (.03)
Externalizing problems (II)					−.05* (.02)	−.02 (.03)										
Internalizing problems	.00 (.01)	.00 (.01)	−.01 (.01)	−.02 (.01)	.01 (.02)	.02 (.03)	.03 (.03)	.05 (.03)	.12*** (.03)	.04 (.04)			.00 (.05)	.03 (.04)	.01 (.03)	.02 (.03)
Social skills (I)	.01 (.02)	.00 (.02)	.01 (.02)	.01 (.02)			.06 (.04)	.03 (.04)	.12*** (.04)	.06 (.04)			.04 (.05)	.00 (.04)		
Social skills (II)	.02 (.02)	−.02 (.01)	.01 (.02)	−.01 (.02)												
Prior controls																
Controls for prior cognitive/ achievement					Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
Controls for prior attention/ socioemotional behaviors					Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
Other background measures	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
Observations	10,779	10,833	8,776	8,647	1,756	1,756	907	907	859	851	690	690	477	565	1,778	1,753
Number of classrooms (fixed effects)	2,579	2,586	2,292	2,280												
R^2	.44	.50	.39	.32	.64	.36	.42	.43	.36	.29	.57	.54	.23	.28	.45	.44

Note. Standard errors are in parentheses. Early Childhood Longitudinal Study–Kindergarten Cohort (ECLS-K) regressions include a school entry test of general knowledge. National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD) regressions include age 4.5 Woodcock–Johnson Psycho-Educational Battery—Revised Cognitive Ability measure. Infant Health and Development Program (IHDP) regressions include age 5 Wechsler Preschool and Primary Scale of Intelligence Performance IQ and age 5 Achenbach Child Behavior Profile Maternal Report: Overall behavior problems. British Birth Cohort Study (BCS) regressions include age 5 Human Figure Drawing, Coping Designs Test, and Profile Drawing. Incl. = set of measures included in the regression; NLSY = National Longitudinal Survey of Youth; MLEPS = Montreal Longitudinal-Experimental Preschool Study.

$* p < .05.$ $** p < .01.$ $*** p < .001.$

Table 3
Average Correlations and Meta-Analytic Regression Results for the Standardized Coefficients From the Six Data Sets

Independent variable	Zero-order correlation coefficients	Most recent reading and math outcomes	Reading and math	All observed outcomes	
				Reading	Math
School-entry measure					
Reading	.44	.13*** (.01)	.17*** (.03)	.24*** (.03)	.10*** (.02)
Math	.47	.33*** (.06)	.34*** (.04)	.26*** (.02)	.42*** (.04)
Attention skills	.25	.07* (.02)	.10*** (.01)	.08*** (.02)	.11*** (.02)
Externalizing problems	−.14	.01 (.00)	.01 (.01)	.01 (.02)	.01 (.01)
Internalizing problems[a]	−.10	—	—	—	—
Social skills	.21	−.01 (.01)	−.01 (.01)	−.00 (.02)	−.01 (.01)
Time (years between school entry measure and outcomes)		−.010*** (.001)	−.009 (.005)	−.012** (.005)	−.005 (.005)
Outcome source					
Test score		.00 (.01)	−.00 (.02)	−.01 (.02)	.01 (.02)
Teacher report[a]		—	—	—	—
Outcome subject					
Math		.01** (.00)	−.00 (.02)		
Reading[a]		—	—	—	—
Data set					
ECLS-K[a]			—	—	—
NLSY			−.01 (.03)	.00 (.03)	−.02 (.03)
NICHD SECCYD			−.01 (.02)	−.01 (.02)	−.01 (.02)
IHDP			.03 (.05)	−.01 (.03)	.08 (.09)
MLEPS			−.03 (.02)	−.05 (.03)	−.03 (.02)
BCS			−.00 (.02)	−.01 (.03)	.01 (.02)
Observations	102	102	228	114	114
R^2		.75	.74	.80	.86

Note. All coefficients used in these analyses come from the individual study regressions that include full controls. Column 1 shows the simple average correlation between the given measure and the most recent math and reading outcomes. Model 2 standard errors are corrected for within-study clustering using Huber–White methods. Regression coefficient observations are weighted by the inverse of their variances. Robust standard errors are in parentheses. Dashes indicate that this category was omitted. ECLS-K = Early Childhood Longitudinal Study–Kindergarten Cohort; NLSY = National Longitudinal Survey of Youth; NICHD SECCYD = National Institute of Child Health and Human Development Study of Early Child Care and Youth Development; IHDP = Infant Health and Development Program; MLEPS = Montreal Longitudinal-Experimental Preschool Study; BCS = British Birth Cohort Study.
[a] Omitted in regression models.
* $p < .05$.   ** $p < .01$.   *** $p < .001$.

results separately for reading and math outcomes. To provide a visual representation of the data underlying the meta-analysis, we plot the 114 coefficients for reading outcomes in Figure 1 and the 114 coefficients for math outcomes in Figure 2.

The general pattern of results found for outcomes measured later in childhood also holds when we also consider the broader set of regression coefficients, which includes outcomes measured earlier in childhood (column 3 of Table 3). With an average standardized coefficient of .34, school-entry math skills are most predictive of subsequent achievement outcomes, followed by reading skills (.17) and attention-related measures (.10). None of the socioemotional behavior categories show predictive power.

Results in columns 4 and 5 of Table 3 confirm that early reading skills are stronger predictors of later reading achievement than of later math achievement. Less expected are the fourth column's results showing that early math skills are as predictive of later reading achievement as are early reading skills. Children's attention skills appear to be equally important (and socioemotional behaviors equally unimportant) for reading and math achievement. The separate regressions for reading and math skills also show that the association between school-entry skills and later achievement declines more quickly over time for reading than for math outcomes.

As before, we find no overall difference in the size of the standardized coefficients depending on whether the outcome being predicted is based on teacher reports or direct skill assessments. To answer the more specific question of whether shared method variance might lead to more pronounced associations between school-entry achievement test scores and later achievement (as opposed to school-entry teacher-reported achievement) outcomes, we added to the meta-analytic regressions interactions between the categories of school entry skills and dummy variables for type of achievement measure (results not shown). Surprisingly, we found no evidence that the impact of early reading and math skills mattered more for test-based than for teacher-reported outcomes.[11] Thus, shared method variance does not appear to be biasing our results.

Because some of our skills groupings are quite broad, we explored whether they might be concealing systematic differences among more specific skills. For example, our reading category

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[11] None of the interactions between type of achievement assessment and school-entry reading and math skills was statistically significant. We did find one statistically significant interaction—between the school-entry assessments of attention and the mode of outcome assessment. The average coefficient on attention skills was nearly twice as large for teacher reports of reading and math achievement (.13) as for reading and math test scores (.07). However, this result does not bear on the issue of whether the explanatory power of school-entry achievement test scores is artificially high owing to shared method variance.
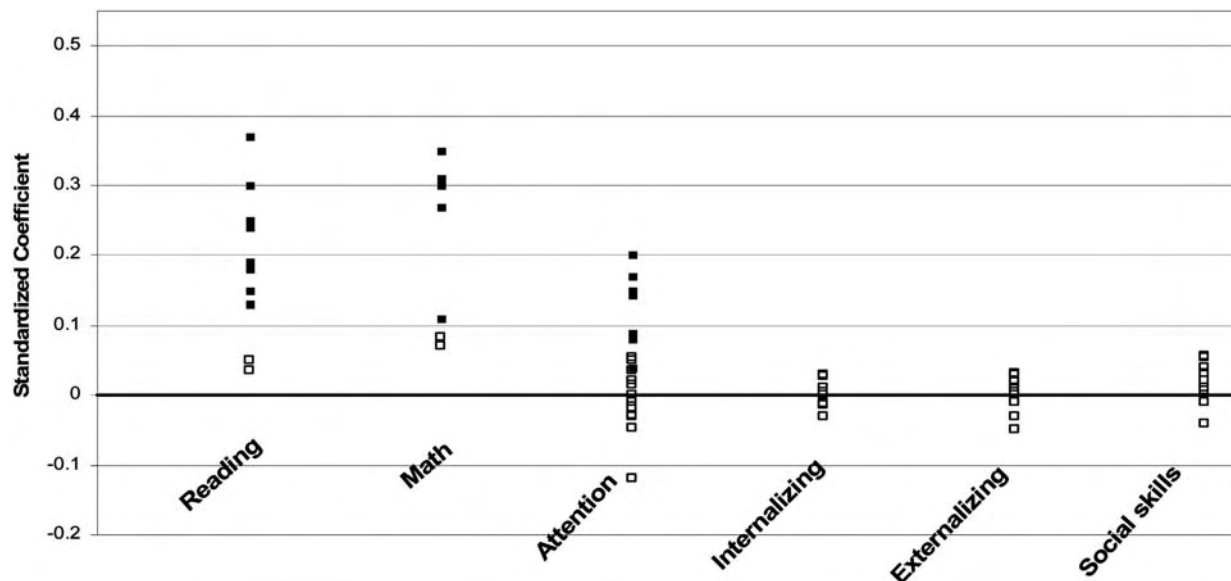
Figure 1. Standardized coefficients from models of reading achievement estimated from six data sets. Filled squares indicate statistically significant coefficients.

includes measures of school-entry reading achievement as well as language and verbal ability. When we reran the meta-analytic regression in the third column of Table 3 with separate groups for reading achievement and the collection of other language-related measures, we found that we could not reject the hypothesis of equal effects ($p = .11$).

Extensions

Beyond shared method variance, there are a number of other reasons to worry that we may have stacked the deck in favor of our school-entry achievement measures: (a) Attention and socioemotional skills may be more difficult to measure than achievement-related skills; (b) maternal reports available in three of our data sets may be less predictive than teacher reports of later academic achievement, in part because parents do not observe their children in school settings; (c) our models may overcontrol for achievement-related impacts of attention and socioemotional skills; (d) socioemotional skills may matter more for important school-related outcomes such as drop out than do test scores, because drop out reflects some combination of achievement and behavior; (e) most of our outcomes are measured in middle childhood, and the relative importance of school-entry factors may change as schools encourage older children to become independent learners; (f) a number of our socioemotional measures are counts of students' problems, which restricts their range and perhaps explanatory power relative to the full-scale achievement measures; and (g) substantial attrition in some of our studies may bias results.

A first potential threat to our general conclusion is that children's behavior is more difficult to measure than their early achievement. Perhaps the lower reliability or validity of the behavioral measures accounts for their weaker explanatory power. It is certainly true that school-entry tests have high internal consistency (e.g., the alphas were at least .74). But the internal consistency of most of the attention and socioemotional skills was also

fairly high, particularly in the case of teacher reports, which were all .79 or higher.

To investigate the potential impact of unreliable measurement on our results, we used the reported internal consistencies in the ECLS-K and NLSY data to estimate regression models, using the errors-in-variables reliability adjustment in the EIVREG procedure in Stata (Stata Corporation, 2004). To accord the behavioral measures maximum explanatory power, we included in our regressions school-entry academic test scores as well as family and child control variables but only the given measure of attention or socioemotional behaviors.

For third-grade reading outcomes and with no reliability adjustments in the ECLS-K, the respective standardized coefficients on approaches to learning, self-control, interpersonal skills, externalizing problems, and internalizing problems were .05, .02, .02, −.03, and .00, respectively. Reliability adjustments produced very similar coefficients: .06, .02, .03, −.04, and .00, respectively. Reliability-related changes to the coefficients on these measures predicting math achievement were similarly modest.

For the NLSY early-adolescence reading test score outcome, respective coefficients associated with hyperactivity, headstrong, antisocial behavior, and anxiety/depression were −.06, −.02, −.05, and −.01, respectively. Adjusting for reliability generally increased (the absolute value of) these coefficients somewhat to −.09, −.03, −.08, and −.01, respectively. Reliability-related changes in coefficients predicting early adolescents' math scores were similar. Although the proportionate increases in these coefficients are substantial in some cases, none of the reliability-adjusted coefficients begins to rival the size of the coefficients on early reading and math skills. In sum, it is unlikely that lower internal reliability explains the low explanatory power of our attention and socioemotional behavior measures. Although test–retest correlations may provide a richer understanding of the reliability of these measures, these data were not readily available. Nevertheless, with
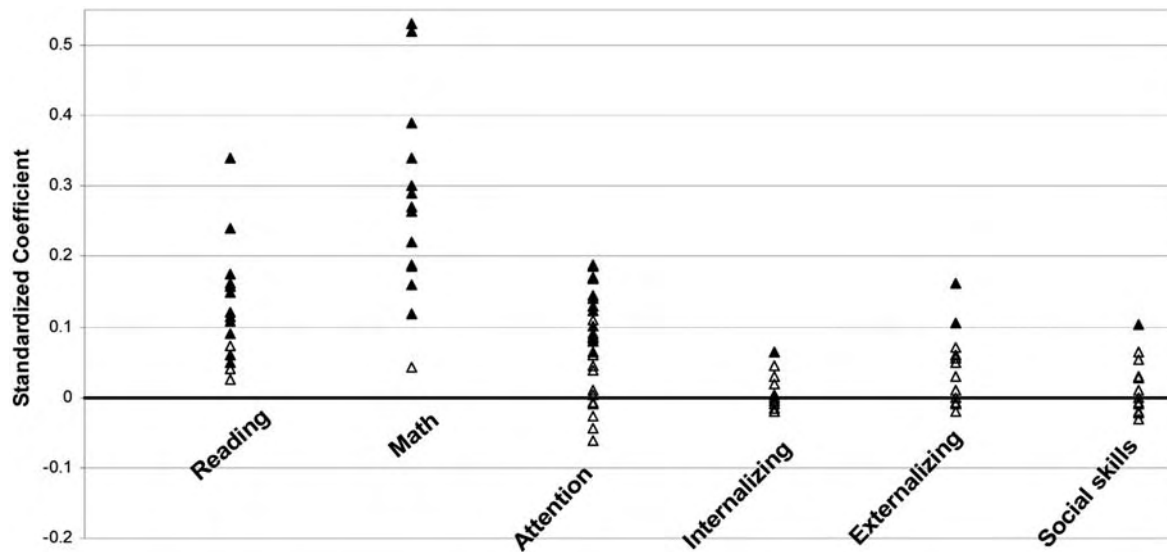
Figure 2. Standardized coefficients from models of math achievement estimated from six data sets. Filled triangles indicate statistically significant coefficients.

average effect sizes ranging from –.01 to .01 (see Table 3), it is unlikely that even substantial reliability adjustments to our behavior and social skills measures would change our conclusions.

The overall validity of the attention and socioemotional behavior measures is much more difficult to assess. Correlations shown in the first column of Table 3 between later achievement and the attention and socioemotional behavioral measures have the expected signs and range from .10 to .25 in absolute value, suggesting at least some degree of validity. However, there remains the possibility that low validity might lead us to underestimate their predictive power. Of course, the validity of kindergarten-level achievement tests has also been questioned (Hirsh-Pasek, Kochanoff, Newcombe, & de Villiers, 2005; Meisels & Atkins-Burnett, 2004), so validity-based downward bias is also a concern with respect to the coefficients on the early achievement measures.

A second concern is that we relied on maternal reports of socioemotional behaviors in three studies (NLSY, IHDP, and BCS). Because maternal ratings are comparatively (siblings vs. classmates) and contextually (family vs. school) different from teacher ratings, it is possible that our reliance on maternal reports in these data sets leads to a downward bias in the estimated effects of the attention and socioemotional behavior measures (Gagnon, Vitaro, & Tremblay, 1992).

To investigate whether this might be the case, we took data from the ECLS-K and NICHD SECCYD, both of which gathered comparable ratings from parents and teachers of several components of socioemotional behaviors, and substituted parent reports for the teacher-report-based measures of these skills. Using our full set of controls and averaging across latest reading and math outcomes, we found that standardized coefficients on externalizing and internalizing problems and social skills averaged, respectively, .05, .03, and .03 for teacher reports and –.00, .01, and .01 for parent reports. Noting the unexpected direction of effects for the teacher reports of problem behaviors and the very modest coefficients in general, reporter bias does not appear to be driving our results.

The third issue, overcontrol, is complicated. Our regression models control for school-entry achievement, but if early attention and socioemotional skills affect later achievement primarily by affecting school-entry achievement skills, are we not robbing the school-entry nonachievement measures of some of their explanatory power?[12] The pattern of average correlations presented in the first column of Table 3 bears on this issue. Bivariate associations between school-entry attention and socioemotional skills are considerably larger than their regression-adjusted partial associations, suggesting that this might possibly be the case.

To investigate this possibility more systematically, we reestimated our full-control models, using the latest outcomes in each study and omitting our school-entry measures of reading and math skills (but retaining all other control variables). Standardized coefficients on attention, externalizing problems, internalizing problems, and social skills averaged .13, .03, .02, and .03, respectively, without school-entry reading and math skills. Corresponding averages for coefficients from models that included school-entry academic skills were .07, .03, .02, and .02, respectively. Thus, even without including school-entry reading and math skills, only attention skills appear to relate to later reading and math achievement, and this may be due in part to their correlation with the omitted school-entry achievement measures rather than to a true mediation through achievement. That said, it remains the case that our analysis is focused on behavior during the years just before and at the point of school entry. If some types of socioemotional skills are well established before the preschool years, and unchanging during these years, then we will not be able to detect their effects.

Fourth, attention and socioemotional skills may matter more for outcomes such as special education classification or dropping out

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[12] Note that an overcontrol argument applies equally to the achievement as to the nonachievement measures, because early success in learning reading and math skills may alter preschool behavior.

of school than for the test scores and teacher-reported achievement outcomes used in our studies. The outcomes of our analyses are indeed limited, and it may well be that these types of measures of school completion and success are more strongly linked to children's socioemotional behavior and attention skills than to academic skills. Our test for this possibility was to estimate models of the effects of early academic and self-regulatory skills on grade retention, an outcome that includes elements of both academic and behavioral competence. Results in Tables A3, B3, C3, D3, E3, and F3 were quite similar to those from models with purer achievement-related outcomes.[13] Nevertheless, the possibility remains that the predictive power of school-entry skills may differ for other, even more behavior-based educational outcomes.

A fifth concern is that most of the outcomes were measured during children's elementary-school years. This is important for two reasons. First, teachers and classrooms differ across the extent to which they support learning academic, attention, and behavior skills. Our analysis does not consider how the associations among these skills may differ as a function of classroom and teacher contexts. Moreover, the associations among these skills may change over time as the contexts of classrooms change. Achievement in the middle- and high-school years involves increasingly complex reading and mathematical tasks, and it may be that general cognitive skills, particularly oral language and conceptual abilities, are crucial for comprehension and advanced problem solving (Baroody, 2003; Ferrari & Sternberg, 1998; Hiebert & Wearne, 1996; NICHD Early Child Care Research Network, 2005b; Scarborough, 2001; Snow et al., 1998; Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998). It is also possible that once children are past learning the basics in the early grades, the relative importance of early attention and socioemotional skills grows as children are increasingly called on to be independent learners, allocate their own time, and complete group work and assignments.

For a general look at the evidence about whether any of the impacts of academic, attention, and socioemotional skill measures are growing over time, we reran our meta-analytic regressions including interactions between each of the school-entry measures and the time between school entry and the outcome assessment. Coefficients on the interactions with early reading, early math, attention, and socioemotional behavior were all negative and ranged from −.023 to −.039 annual decrements in effect sizes, providing no support for hypotheses of increasing importance.

Because most of our outcomes are assessed in elementary school, the interactions shed relatively little light on what would happen if more outcomes were measured during middle or high school. The NLSY data are most telling on this point, because the same skill assessment was given at both age 7–8 and age 13–14. In regressions of outcomes based on these two time points, we find that although school-entry hyperactivity retained its modest explanatory power (effect sizes around −.07) between these two points, the explanatory power of reading and math fell. In the case of NICHD SECCYD outcomes measured in third and fifth grade, there was inconclusive evidence on the direction of coefficient change.

A sixth worrisome methodological concern is that a number of our socioemotional measures are counts of students' problems, which restricts the range of behaviors they capture and might therefore reduce their predictive power. We explored this possibility by estimating spline regressions, which allow for nonlinear effects (results not shown). In these analyses, two linear segments per measure were fit to the data. The first segment was estimated for the most problematic third of the sample distribution, and the second segment was estimated for the other two thirds. If, say, externalizing behavior problems matter a great deal for the children with very high levels of problem behavior but owing to the restricted range, much less for the others, then the slope of the line fit to the most problematic group should be significantly larger (in absolute value) than the slope for the rest of the sample.

We found little systematic evidence that this was the case. In the ECLS-K data, there was some evidence that improving early math skills mattered more for low math achievers, whereas the NLSY showed that hyperactivity mattered more for the most hyperactive children. No significant nonlinearities emerged in the analysis of NICHD SECCYD data. These spline analyses confirm that there are few nonlinear associations between the socioemotional measures included in this study and the outcomes they predict. It does not rule out, however, the possibility that other measures that capture a broader range of behaviors may be more strongly associated with later achievement.

A seventh and final concern is that sample attrition in some of our studies may bias our results. The extent of attrition is documented in our appendices. All of the coefficients used in our meta-analyses come from models in which missing data are accounted for with missing data dummy variables. In the appendices, we present results for three of our data sets (ECLS-K, NICHD SECCYD, and MLEPS) in which missing data are handled with multiple imputation and listwise deletion.

In two data sets (ECLS-K and MLEPS), we also used nonresponse weighting adjustments. In the ECLS-K, both multiple imputation and listwise deletion estimates are slightly smaller in magnitude than the results using missing data dummy variables, although the pattern of results is consistent across all the techniques. In the MLEPS, the pattern of results does not change across the different methods; however, listwise deletion produces few statistically significant estimates given the reduction in sample size from 500 to approximately 150. In the NICHD SECCYD, the overall pattern of results is similar across the two missing data techniques; however, the coefficient estimates are most consistent between missing data dummy estimates and multiple imputation. Across the three data sets, the respective coefficients on school entry reading, math, attention, externalizing, internalizing, and social skills averaged .13, .23, .06, .04, .02, and .02, respectively, when we used missing data dummies. Corresponding coefficient averages for multiply-imputed models were .12, .17, .06, .01, .01, and .02, respectively. Corresponding coefficient averages for listwise deletion models were .09, .27, .07, .00, .02, and .00, respectively. Corresponding coefficient averages for nonresponse weighted models were .12, .31, .10, −.00, .01, and −.00, respectively.

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[13] Only the BCS has followed study participants long enough to measure their completed schooling and early-career labor market earning and, in results not reported in the appendices, we found that school-entry attention problems were a significant predictor of school completion but not labor market success.

Discussion and Conclusions

We have presented results from a coordinated analysis of six longitudinal data sets relating school-entry skills to later teacher ratings and test scores of reading and math achievement, holding constant children's preschool cognitive ability, behavior, and other important background characteristics. Our meta-analytic results indicate that such early math concepts as knowledge of numbers and ordinality were the most powerful predictors of later learning (the average effect size of school-entry math skills was .34 and every bit as large as early reading skills in predicting later reading achievement). Less powerful, but also consistent, predictors across studies were early language and reading skills such as vocabulary; knowing letters, words, and beginning and ending word sounds (the average effect size across our studies was .17); and attention skills (average effect size .10). The average effect sizes of externalizing and internalizing problem behaviors and social skills were close to zero.

Despite our extensive investigation of the robustness of our key results, any nonexperimental analysis using imperfectly measured cognitive, achievement, and behavioral constructs such as ours cannot rule out all threats to its conclusions. First, although shared method variance, reporter bias, overcontrol, restricted range, and measurement reliability cannot account for the differential predictive power of school-entry achievement and socioemotional measures, we are unable to rule out bias from the lower *validity* of socioemotional measures. Second, despite our ability to control for cognitive ability prior to school entry in five of our six studies, and despite our controls for concurrent reading skills in all six studies, it remains possible that our surprisingly large school-entry math coefficients overstate causal impacts.

One of our noteworthy results is that early math is a more powerful predictor of later reading achievement than early reading is of later math achievement. Despite our controls for cognitive ability, it remains possible that some of the apparent effects of early math skills is spurious. To the extent that the effects are real, it is important to discover why. Math is a combination of both conceptual and procedural competencies. Although our data do not allow us to examine these competencies separately, future research could focus on this direction. Another productive avenue of research would be to examine efforts to improve math skills prior to school entry. Random-assignment evaluations of early math programs that focus on the development of particular mathematical skills and track children's reading and math performance across elementary school could help to illuminate missing causal links between early skills and later achievement.

Another finding from our analysis is that attention skills are modestly but consistently associated with achievement outcomes. One explanation for this predictive power is that attention skills increase the time children are engaged and participating in academic endeavors and learning activities. Other studies have shown that attention skills have important associations with school success, independent of cognitive and/or language ability (Alexander et al., 1993; Howse et al., 2003; McClelland et al., 2000; Yen et al., 2004), but few of these studies have controlled for prior levels of academic skills as well as prior levels of behavior. Our results suggest that attention skills, but not problem behavior or social skills, predict achievement outcomes, even after the effects of early achievement knowledge and cognitive ability have been netted out.

Although all of the studies we analyzed were drawn from normative populations, all contain at least some children falling in the clinical ranges of behavior problems. We were surprised that our spline-regression models produced no consistent evidence of nonlinear effects of problem behaviors on later achievement. We caution, however, that it remains possible a more focused analysis, perhaps with clinical samples, might reach different conclusions.

Given that teachers emphasize the importance of attention skills and socioemotional behavior for school readiness and the possibility that these skills shape classroom learning processes, it might be expected that these early skills would have crossover effects on subsequent reading and math achievement. With the important exception of attention skills, we did not find evidence that changes in these skills during the preschool years predict later achievement. However, as noted earlier, academic skills are only one facet of educational success, and improvements in problem behavior or social skills may better predict other important school outcomes, such as a child's engagement in school and motivation for learning, relationships with peers and teachers, and overall self-concept and school adjustment (Greenberg et al., 2003). It might also be the case that early-grade teachers are somehow able to prevent problem behaviors from interfering with student learning but that problem behaviors would be linked with lower achievement if teachers were less capable. Despite the uniformly small and often insignificant coefficients on these measures in our regressions, we caution against completely dismissing the potential academic benefits of environments or programs that promote positive socioemotional development.

An additional caveat is that any one child's socioemotional behavior, in particular externalizing problem behaviors, may affect other students' achievement more than the child's own individual achievement. For example, problem behaviors may disrupt classroom activities such that even well-behaved children spend less time engaged in instructional and learning activities. Our analyses do not consider this possibility because it requires more complete data about classmates' behavior than the studies provide. We raise this point, however, because we believe that the topic of peer effects deserves further attention in future research on socioemotional behavior.

Our analyses focus on skills and behaviors that emerge at the time of school entry and not on the effects of socioemotional behaviors that emerge after children enter school. This is important, because it may be that reading achievement and problem behavior develop in tandem during the early elementary years (Trzesniewski et al., 2006). Additional research is necessary to further elucidate the potentially complex and reciprocal relationships between children's socioemotional behaviors and their academic achievement.

Our conclusions about the importance of early academic and attentions skills are consistent with the recommendations endorsed by the National Association for the Education of Young Children and the National Council of Teachers of Mathematics (2002) and the National Research Council's Committee on the Prevention of Reading Difficulties in Young Children (Snow et al., 1998). However, our results say nothing about the types of curricula that would be most effective in promoting these skills. Play-based, as opposed to "drill-and-practice," curricula designed with the developmental

needs of children in mind can foster the development of academic and attention skills in ways that are engaging and fun. Taking early math skills as an example, the Big Math for Little Kids program has been designed to capitalize on children's interest in exploring and manipulating numbers (Greenes, Ginsburg, & Balfanz, 2004). In addition, play-based curricula may also have the added benefit of fostering attention-related skills (Berk, 1994).

Our findings support three key conclusions for developmental research. First, math and reading skills at the point of school entry are consistently associated with higher levels of academic performance in later grades. Particularly impressive is the predictive power of early math skills, which supports the wisdom of experimental evaluations of promising early math interventions. Second, among attention-related and socioemotional behaviors, only the attention-related skills predicted later academic achievement with any consistency. We find no noteworthy regression-adjusted associations between either interpersonal skills (or problems) or aggression and later achievement. Finally, all of our data sets suggest that reading and math tests that were individually administered to children by trained personnel around the point of school entry can be a highly reliable way of assessing early skills. That said, it was also the case that we could not attribute most of the variation in later school achievement to our collection of school-entry factors, so the potential for productive interventions during the early school grades remains.

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