Kindergarten Skills and Fifth Grade Achievement: Evidence from the ECLS-K

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Abstract

Children enter kindergarten with disparate rudimentary reading and mathematics skills; capabilities for paying attention, sitting still and making friends; mental health; and inclinations for aggressive behavior. The role of these characteristics in producing fifth-grade school achievement is the subject of this paper. We find considerable impacts for school-entry academic skills but, with the exception of a kindergartener's capacity to pay attention, virtually no impacts for the collection of socioemotional skills. This finding holds both for the overall sample and for subgroups defined by race/ethnicity and socioeconomic status. The most powerful pre-school avenue for boosting fifth grade achievement appears to be improving the basic academic skills of low-achieving children prior to kindergarten entry.

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I. Introduction

There is little agreement about what constitutes school readiness. The "Neurons to Neighborhoods" report of 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: 398-99). At the same time, a report from the National Research Council's Committee on the Prevention of Reading Difficulties in Young Children argued for the primacy of pre-literacy skills before kindergarten and urged that all children be provided access to early childhood environments that promote language and literacy growth (National Research Council, 1998). The National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM) argue for the importance of high-quality mathematics education for children ages 3-6.[1]

Understanding what child abilities and behaviors at school entry lead to later school success is important for both conceptual and policy reasons. Economists have long emphasized the acquisition of concrete, achievement-related skills, measured by such indicators as completed schooling and test scores (Becker, 1964), but recently have begun to focus on the potentially important role of "noncognitive" skills, (e.g., behavior problems, attention patterns, and delinquent activities) in the production of school and adult success (Bowles, Gintis & Osborne, 2001; Farkas, 2005; Heckman & Rubinstein, 2001; Heckman, Stixrud & Urzua, 2006).

On the policy side, we know that intensive early childhood programs such as the Abecedarian (Campbell et al., 2002) and Perry Preschool programs (Schweinhart et al., 2005) improved adult outcomes, but their curricula sought to promote both academic and socioemotional development in children and improve parenting as well. Their program evaluation designs provide no way of isolating which program elements mattered the most.

More recently, random-assignment evaluation of interventions directed at improving literacy (e.g., Whitehurst & Lonigan, 1998), mathematical understanding (e.g., Ginsberg et al., 2008), anti-social behavior (e.g., Kellam et al. 1998) and attention skills (Diamond et al., 2007) have demonstrated the efficacy of their programs for improving the outcomes on which the programs focused. But few of these program evaluations assessed longer-run impacts on children's school achievement. Understanding links between school entry behavior problems and later school achievement is particularly important in light of recent evidence that center-based child care (Belsky, 2006) and even pre-kindergarten programs (Magnuson et al., 2004) may increase anti-social behavior.

We use data from a large and nationally representative sample of kindergarteners—the Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K)—to estimate the predictive power of school-entry academic, attention-related and socioemotional skills for reading and math achievement in first, third and fifth grade. We begin with a review of the theory and empirical literature, followed in Sections IV and V by a description of our models and data. Section VI presents our results, followed in Section VII by a discussion and conclusion.

II. Theory

Cunha and Heckman (2006) develop a model of the production of human capabilities that includes the cumulative role of cognitive (S^C) and noncognitive (S^N) skills, as well as skill

investments made by families, preschool programs and schools in producing adult human capital *h*. Suppose we distinguish the periods birth to age 5 (period 1), and age 6 to the end of adolescence (period 2). At birth (period 0), children have endowments of cognitive potential and temperament (S_0^C, S_0^N) that reflect some combination of genetic and prenatal influences.

It is assumed that adult human capital (*h*) is a product of an individual's period 2 cognitive and noncognitive skills:

$$h = g\,(S_2^C, S_2^N).$$

Our empirical work investigates the question of how S_2^C comes to be. Cunha and Heckman (2006) presume that achievement-related skills in period t are a product of both cognitive/achievement and noncognitive skills in the prior period, plus current-period investments:

$$S_t^C = f_t^k\,(S_{t-1}^C, S_{t-1}^N, I_t^k).$$

When t=1, preschool cognitive and socioemotional skills are a function of t=0 endowments of cognitive ability and temperament plus preschool investments from the home and child care environments. Our concern is with how skills in t=2 are formed from period t=1 inputs—in other words, how school-age skills are related to both the achievement and noncognitive skills that children bring to kindergarten. We control for school-related investments using classroom fixed effects but, to preclude bias from endogenous variables, do not include any measures of the child, his or her family, or of the school taken after kindergarten entry.

Behind this production framework are simple but appealing ideas shared by both economists and developmental psychologists about what might matter for both school and adult success. How much children learn in school is a function of both the achievement-related and noncognitive skills they bring to kindergarten, but the relative contribution of different skills is open to debate. Resolving this debate would help address whether preschool interventions should be concentrated on teaching specific literacy and numeracy skills, or should emphasize socioemotional and attention skills as well. A child who enters kindergarten knowing letters, numbers, and other rudimentary academic skills is presumably at an advantage for profiting from the human capital investments schools provide. But perhaps a child who can pay attention, inhibit impulsive behavior, and relate nonaggressively to adults and peers is even better able to take advantage of learning opportunities in the classroom.

III. Prior evidence

A wealth of data show that children's achievement test scores are strongly related to their prior cognitive functioning and basic skills in mathematics and literacy such as number and letter recognition (Stevenson & Newman, 1986; Todd & Wolpin, 2006). In their meta-analysis of early-grade longitudinal studies, La Paro and Pianta (2000) report mean correlations of .43 in academic measures from preschool to either kindergarten or first grade and .48 for academic measures between kindergarten and first or second grade.

Todd and Wolpin (2006) develop a taxonomy of causal models of the production of achievement and show that many of the models estimated in the empirical literature impose unrealistic restrictions on the production process. Their own CNLSY-based empirical work relates current-period test scores to past school and home inputs and, in some cases, lagged test scores, but does not consider the role of noncognitive factors.

Cunha and Heckman (2006) also use the CNLSY to model the production of both cognitive and noncognitive skills. Their empirical work accounts for measurement error in both inputs and prior noncognitive skills and scales test-score outcomes in units based on completed schooling and early-adult earnings. For cognitive skills in year t+2, they find that cognitive skills in year t receive much higher regression weights (.89-.91) than year t noncognitive skills (.00-.06). If anything, it appears that the importance of noncognitive skills for the production of subsequent cognitive skills declines modestly across childhood. A substantial limitation of the CNLSY for estimating the role of noncognitive skills is that they are reported by mothers rather than teachers or through direct observation.[2]

The empirical work in this paper most resembles the approach taken in Duncan et al. (2007). They use six longitudinal data sets, including the ECLS-K and CNLSY, to estimate links between cognitive and noncognitive elements of school readiness and later school reading and math achievement. Across all six studies, the strongest predictors of later achievement are children's school-entry math, reading, and attention skills. Individual differences in measures of socioemotional skills, including internalizing and externalizing problems and social skills, were generally nonsignificant predictors of later academic performance, even among children with relatively high levels of these problems. Our paper draws on longer-run ECLS-K outcome data and estimates the importance of summary indexes of cognitive and noncognitive skills. We also report results from models relating changes in skills and summary indexes across kindergarten to our outcomes.

In concentrating on school-entry skills, we ignore a large literature linking adolescent skills and behaviors to adult achievements. Research on labor market outcomes suggests that both cognitive and socioemotional skills developed by adolescence are important predictors of earnings and occupational attainment (Bowles et al., 2001; Caneiro & Heckman, 2003; Farkas, 2003; Jencks et al., 1979), although there is little agreement on which noncognitive skills matter the most. But while cognitive and socioemotional skills may relate to achievement outcomes between adolescence and adulthood, the greater malleability of younger children (Shonkoff & Phillips, 2000) may lead to a different skills production process at school entry.

IV. Models

We model school achievement as a product of the academic skills and behaviors children bring to kindergarten, children's own genetic endowments of ability and temperament, and child and family characteristics:

$$(1) \qquad ACH_{i5th} = a_1 + ß_1\, ACAD_{iFK} + ß_2\, ATTN_{iFK} + ß_3\, SE_{iFK} + \gamma_1\, FAM_i + \gamma_2\, CHILD_i + e_{it}$$

where ACH_{i5th} is the math or reading achievement of the i^{th} child at the end of fifth grade; $ACAD_{iFK}$ is the collection of math and reading skills that child i has acquired at kindergarten entry, as assessed by achievement tests in the fall of the kindergarten (FK) year; $ATTN_{iFK}$ are the attention-related behaviors, as assessed by teachers, that the child has acquired by the fall of the kindergarten year; SE_{iFK} is the collection of socioemotional skills that child i exhibits as of the fall of the kindergarten year as assessed by teachers; and FAM_i and $CHILD_i$ are family and child characteristics all measured prior to or at the time of school entry.

In the Todd-Wolpin taxonomy, ours is a "value-added plus" model, akin to the models estimated in Cunha and Heckman (2006). In contrast to Cunha and Heckman, we are able to

draw upon a richer set of noncognitive measures, all of which are reported by teachers rather than mothers. The clustered nature of the ECLS-K sample enables us to control for school inputs with classroom fixed effects. We estimate versions of model (1) with both a parsimonious set of background controls recommended by Todd and Wolpin (2006) as well as the more extensive set used in the ECLS-K-based work of Fryer and Levitt (2004) but find that neither coefficients nor standard errors are much affected by the difference.

Our data do not contain measures of children's cognitive or socioemotional functioning prior to school entry. However, we do have measures taken in the spring of kindergarten, enabling us to relate fifth-grade achievement to children's academic skills, attention-related skills and socioemotional skills at the end of kindergarten, controlling for these same measures at the beginning of kindergarten. The form of this model is:

(2) $ACH_{i5th} = a_1 + ß_1\ ACAD_{iSK} + ß_2\ ATTN_{iSK} + ß_3\ SE_{iSK} + ß_4\ ACAD_{iFK} + ß_5\ ATTN_{iFK} + ß_6\ SE_{iFK} + \gamma_1\ FAM_i + \gamma_2\ CHILD_i + e_{it}$

with ACH_{i5th}, $ACAD_{iFK}$, $ATTN_{iFK}$, SE_{iFK}, FAM_i and $CHILD_i$ defined as before. $ACAD_{iSK}$ is the collection of math and reading and general knowledge skills that child i has acquired as of the spring of kindergarten, $ATTN_{iSK}$ and SE_{iSK} are, respectively, the attention-related skills and socioemotional skills that child i has acquired as of the spring of the kindergarten year.

In this formulation, $ß_1$, $ß_2$, and $ß_3$ are the key coefficients, and the measures of ACAD, ATTN, and SE at the beginning of kindergarten serve as key control variables. An equivalent way of thinking about this equation is that the coefficients on the end-of-kindergarten assessments ($ß_1$, $ß_2$, and $ß_3$) amount to estimates of the impact of *changes* in these skills over the course of kindergarten on end-of-fifth grade reading and math scores, holding kindergarten-entry levels of these skills constant.[3]

The more general logic of this change model is that if a skill or behavior affects long-run achievement, then short-run changes in that skill or behavior, controlling for starting position, ought to be predictive of eventual achievement. Indeed, much of the Head Start debate has been framed in those terms—e.g., Head Start should augment a given skill because that will be beneficial for eventual success in school. Our data do not measure skill augmentation in the preschool period, but they do provide a measure of augmentation over the course of kindergarten. If the latter matters, then perhaps the former does as well.

V. Data

The Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K) is following a nationally representative sample of 21,260 children who were in kindergarten in the 1998-99 school year. The ECLS-K uses a multistage probability design and sampled children of kindergarten age within schools. On average at baseline, there were six children per classroom, which enables us to control for kindergarten classroom fixed effects. The study thus far has released five waves of data: fall of kindergarten and spring of kindergarten, first, third and fifth grades. Data were collected from multiple sources, including direct cognitive assessments of children, interviews with parents and surveys of teachers and school administrators.

Although baseline data were collected from over 21,000 children, missing data reduced our analysis samples to between 8,000 and 9,400 cases. Some of the missing data are deliberate, since the ECLS-K study randomly sampled half of children who changed schools between fall of

kindergarten and spring of first grade and compensated for the losses with adjustments to the sampling weights.[4] By fifth grade 5,214 children are excluded because they were either subsampled out, became ineligible, parental refusal or had not participated since baseline data collection. The total number of respondents at fifth grade was 11,820. Students were excluded from our analyses if their data were missing test scores from the fall of kindergarten or the spring of fifth grade or if they were missing data on gender. We also excluded cases that were missing two or more of the teacher rated attention and behavior scales. The vast majority of our missing data, however, is due to missing test scores—there are a total of 17,622 reading scores in the fall of kindergarten, and 11,265 reading scores in the spring of fifth grade.

Dependent Variables. Our key dependent variables consist of fifth grade achievement IRT test scores in reading and mathematics. Descriptive statistics for the reading and mathematics IRT scores between kindergarten and fifth grade are presented in Appendix Table 1 and show that growth in these achievement scores is particularly rapid in the early grades. To examine shorter-run links between school entry skills and achievement, we also estimate models using test scores and teacher reports measured at the end of first and third grades as dependent variables.

Independent Variables. Our independent variables of interest include achievement test scores and teacher reports of socioemotional skills, all measured in the fall of kindergarten. The socioemotional skill measures were all constructed by ECLS-K staff from teacher responses to a self-administered questionnaire from the fall of kindergarten and include attention-related behaviors (a measure called "Approaches to Learning" in the ECLS-K) and socioemotional skills.[5] The latter includes social skills (a combination of self-control and interpersonal behaviors) and externalizing and internalizing problem behaviors.[6]

As with tests such as the CNLSY's Peabody Picture Vocabulary Test (PPVT), scores on the ECLS-K's General Knowledge test can be taken as an indicator of cognitive ability. We use General Knowledge scores to control for cognitive ability in assessing the importance of early reading and math achievement and noncognitive skills but also note the predictive power of the General Knowledge score, and use it in an index of achievement skills.

In addition to the independent variables described above, we include an extensive list of child and family control variables in most of our models. A list of these variables and descriptive statistics for them can be found in Appendix Table 2.

VI. Results

Correlations among the various skill and behavior measures taken at the beginning of kindergarten and the end of fifth grade are shown in columns 1 and 6 of Table 1.[7] Previewing some of our regression results, these two columns show stronger fall of kindergarten to fifth grade correlations for math (.63) than reading (.50) test scores, and a stronger correlation between initial math and fifth grade reading test scores (.60) than between initial reading and fifth grade math (.47).

At .35, the teacher-reported school-entry attention measure has a respectable correlation with fifth-grade achievement. In contrast, the absolute value of the correlations between fifth grade test scores and teacher-rated school-entry socioemotional skills average .16, with none higher than .22.[8]

Basic model. Table 1 also presents estimates of various regression models of the relationship between school-entry academic, attention and socioemotional skills and fifth grade reading and math test scores. All variables have been standardized by full-sample standard deviations so that coefficients are comparable with one another and with the bivariate correlations presented in the first and sixth columns. Higher scores on internalizing and externalizing problems indicate more problems and are expected to produce negative coefficients in these regressions.

Turning first to the full control models in columns 5 and 10, it can be seen that fall of kindergarten math, reading and attention skills are predictive of subsequent reading achievement, while early reading skills are not predictive of subsequent math achievement. With the exception of the attention measure, kindergarten socioemotional skills are not predictive of fifth grade math or reading skills.

To investigate why the school-entry achievement and attention measures are so much better able than the socioemotional measures to retain their predictive power in the full-control regression models, we estimated 12 different regression models, one for each of the kindergarten-entry skills. In each case, the full set of background controls but none of the other school-entry achievement or socioemotional skills is included (Table 1, columns 2 and 7). The absolute values of virtually all of the resulting standardized regression coefficients are smaller than their corresponding bivariate correlations, but the drops are generally as modest for the socioemotional measures as for the attention and achievement measures. In these models, reading, math and attention skills are the strongest predictors of fifth grade math and reading scores. Although smaller in magnitude, the coefficients for the socioemotional skills are significantly predictive of fifth-grade math and reading achievement. The addition of school-entry achievement, attention and socioemotional skills to the regressions reduces the coefficients on the three socioemotional skills to statistical and substantive insignificance (columns 3 and 8).

One concern is that early socioemotional skills may influence early achievement skills, so controlling for the latter may rob the former of some of their explanatory power. Coefficients in columns 4 and 8 show that this is not the case. They are taken from regressions that include all four of the attention and socioemotional skill measures as well as the full controls and classroom fixed effects, but exclude school-entry math and reading skills. Only attention skills have a coefficient that exceeds .03 in absolute value.

The coefficients from our full-control models, shown in columns 5 and 10, are similar to those in columns 3 and 8, which suggest that the addition of the full set of family background variables used by Fryer and Levitt (2005) changes the coefficient estimates very little. Including the more parsimonious set of control variables suggested by Todd and Wolpin (2006) (results not shown) produces virtually identical estimates to those shown for the full-control models. Interestingly, the full-control model does not introduce multicollinearity problems, as can be seen by comparing standard errors in columns (3) and (5) and in columns (7) and (10).

Change model. Lingering concern for omitted-variable bias in these estimates led us to estimate the change model in equation (2) (results not shown). Recall that in the presence of beginning-of-kindergarten controls, the coefficients on the end-of-kindergarten measures can be interpreted as the effect of skill *changes* over the course of kindergarten. Coefficients on the end-of- kindergarten measures are quite consistent with those presented in columns 5 and 10. Gains in reading and math achievement and attention skills over the kindergarten year are highly

predictive of eventual reading (respective standardized coefficients of .19, .13 and .13) and math (coefficients of .08, .33 and .15) achievement. In contrast, none of the cross-kindergarten changes in socioemotional skills is a significant predictor of later reading and math achievement and none has a coefficient larger than .04 in absolute value.

Subgroup results. While socioemotional skills appear relatively unimportant for later achievement for the full sample of children, perhaps there are subgroups of children defined by ethnicity, SES or sex for whom the results are different. We estimated the full-control models shown in columns 5 and 10 of Table 1 separately for white, black and Latino children, as well as for boys, girls and children in low- and high-SES[9] families (results not shown). The within-group results were similar to those of the full-sample models, producing no consistently significant differences across the subgroups.

Nonlinear effects. Perhaps school-entry socioemotional skills matter for later achievement, but only for the children with the lowest levels of these skills. To test for this possibility, we estimated our full-control models using two-segment splines, which allowed for different coefficients for children in the bottom one-third and top two-thirds of the socioemotional scales (results not shown). We found no consistent evidence of significant differences in slopes. Nor was there any consistent evidence of nonlinear relationships between fifth grade test scores and the early attention, reading and math measures.

Teacher-reported outcomes. In the case of school-entry math and reading skills, there is a concern for upward bias from "shared method variance," in which school-entry test scores predict fifth grade test scores in part because some students are persistently better than others at taking tests. The ECLS-K also asked fifth grade teachers to complete academic rating scales on student reading and mathematics (see Data Appendix for details). Using a fifth-grade teacher report of achievement removes this kind of bias. Regression coefficients from models with teacher reports of achievement as outcomes and the full set of control variables and classroom fixed effects show that early math and attention skills are nearly as predictive of teacher reports of fifth-grade reading and math skills as they are of fifth-grade test scores. Also consistent with the earlier results, school-entry reading skills are somewhat predictive of teacher reports of reading (.07 standardized coefficient) in fifth grade, but not significantly predictive of teacher reports of math achievement. None of the socioemotional skills is predictive of teacher reports of either math or reading achievement.

Lack of predictive power of noncognitive skills. Perhaps the kindergarten entry measures of socioemotional skills are simply too noisy to be predictive of anything. The reported reliabilities of these measures are moderately high (ranging from .79 to .90), but reliability statistics reflect the internal rather than external validity of these measures. Unlike the models predicting achievement outcomes, school-entry externalizing problems are indeed predictive of later attention skills (standardized coefficient -.13) and fifth-grade externalizing behavior (+.31) (not shown). Early social skills and internalizing behavior problems have small but statistically significant effects in some cases. Interestingly, early reading skills are not predictive of either of these outcomes. This suggests that school-entry socioemotional skills are indeed predictive of some fifth-grade outcomes, but not school achievement.

Another possibility is that the socioemotional measures are highly predictive of shorter-run achievement but not if achievement is measured five to six years after school entry. The first four columns of Table 2 show estimates from our full-control models using reading and math

outcomes measured at the end of first and third grade. The only socioemotional skill that predicts math achievement in first or third grade is social skills, although the magnitude of its standardized coefficient is small (.04) and, contrary to expectations, negative.

Turning to the other coefficients in these models, it can be seen that kindergarten-entry reading skills are highly predictive of first grade reading (the standardized coefficient is .39), but less so of third-grade reading (coefficient is .12). This might be expected since reading achievement in both kindergarten and first grade involves letter sounds, word recognition and vocabulary; but by third grade reading involves identifying words in context, sentence comprehension, and making inferences from printed materials. Early math skills are highly predictive of both first and third grade math skills, while early attention skills predict both subsequent math and reading skills.

In an attempt to discover when socioemotional skills begin to matter, we regressed third grade achievement on first grade skills and fifth grade achievement on third grade skills. The results, presented in columns 5 through 8 of Table 2, follow a familiar pattern: achievement and attention skills in first and third grade predict achievement two years later but there is no consistent evidence that our collection of first or third-grade socioemotional skills predict later achievement.[10]

Skill composites. Stepping back from our many kindergarten measures, we sought a more global estimate of the role of school-entry academic, attention and socioemotional skills. It is possible that socioemotional skills might be predictive of later achievement if taken together but lack predictive power when considered individually. We combined externalizing and internalizing problems and social skills into a single index of socioemotional skills by standardizing each of the measures, reversing the scale of the two problem measures, and summing and scaling the resulting index to have a standard deviation of one. We also formed an achievement index by combining reading and math skills in a similar way. We present the results from estimates of our full-control models with these independent variables in columns 1 and 3 of Table 3. Estimates are consistent with our previous results: early attention and, especially, achievement skills predict subsequent reading and math achievement while socioemotional skills do not.

Given the ambiguous nature of our general knowledge measure, we also ran regressions in which the fall of kindergarten test of general knowledge is considered an element of achievement and added to the combined measure of math and reading skills. Changing the role of the general knowledge measure from cognitive control to a component of achievement skills doubles the coefficient on achievement skills from .24 to .48 in the case of reading outcomes, and increases it from .30 to .46 for math outcomes. We also estimated a change equation using these combined skill measures (not shown). The coefficients for the kindergarten change models were very similar to those shown in Table 3. Early attention skills remain predictive of reading and, especially, math achievement. In no case is the index of socioemotional skills predictive of fifth-grade achievement.

VII. Discussion

ECLS-K data enable us to relate a rich set of academic (reading and math) measures from the fall of the kindergarten year, as well as teacher-rated socioemotional and attention skills measured at the same time, to math and reading achievement measured at the end of fifth grade. Given the intensity of the debate over the importance of socioemotional skills for children's

school success, we had expected to find considerable evidence that being able to control one's temper or make friends in kindergarten would matter for fifth grade achievement. We found virtually no evidence that this was the case, either for kindergarteners as a whole, among disadvantaged population subgroups, or among children scoring the lowest on these socioemotional indicators. The only socioemotional skill with consistently predictive explanatory power were teacher ratings of the student's attention skills, which measured attentiveness, task persistence, eagerness to learn, learning independence, flexibility and organization. (We hesitate to call attentiveness a "noncognitive" skill.)

In contrast, school-entry math skills were consistently predictive of fifth-grade achievement. Early math skills such as knowing numbers and ordinality were not only highly predictive of later math achievement but of later reading achievement as well. Rudimentary math skills were the single most important set of kindergarten-entry skills emerging from our analyses, followed by reading skills, and finally attention skills, which were consistently predictive of both math and reading outcomes.

The usual caveats apply to our results. Our data are longitudinal rather than experimental and thus subject to omitted-variable bias. In particular, our links between academic ability upon school entry and five years later could reflect the influence of other positive unobservables correlated with both early and later academic skills. Here we find it reassuring that our basic results replicate in models that relate *changes* in academic skills between the fall and spring of kindergarten to the same fifth grade outcomes. Although unobservables may be driving these correlations as well, the nature of their influence (on growth rather than the initial level of academic skills) is different enough to narrow the possible list of unobservables considerably.

To draw policy conclusions regarding the likely efficacy of preschool interventions, information is needed on the relative costs of improving academic and attention skills and socioemotional skills. While our knowledge base on early reading and math skill interventions is growing, much less is known about the nature and costs of interventions targeting behavior and social and mental health problems. It is conceivable that interventions targeting attention are warranted by our analyses if their expense were substantially less than interventions targeting early mathematics and reading skills.

Data Appendix

Our measures of school-entry noncognitive skills were reported by kindergarten teachers in the fall and include attention-related behaviors (a measure called "Approaches to Learning" in the ECLS-K) and socioemotional skills.[11] The latter includes social skills (a combination of self-control and interpersonal behaviors) and externalizing and internalizing problem behaviors.

Cognitive tests were administered in all study waves. The battery of cognitive 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. The children pointed to answers or gave verbal responses and were not asked to write or to explain their reasoning. The tests were administered using a computer-assisted interviewing methodology. The cognitive assessment scores used in our analyses are item response theory (IRT) scores that are included in the ECLS-K data. Reliabilities reported for the overall IRT scores in reading and mathematics are over .9. We use the reading and math tests as measures of achievement skills at school entry. We control for children's fall of kindergarten general knowledge test scores in our models.

In fifth grade, the cognitive tests included mathematics, reading, and science. We use the IRT scores for the first two of these as dependent variables. These fifth grade assessments required students to complete workbooks and open-ended mathematics problems. Reading passages and questions were provided to children so that they could reference the passages when answering questions. However, all questions were read to the students in both reading and math.

Dependent Variables. Our key dependent variables are fifth grade achievement IRT test scores in reading and mathematics. The fifth grade reading assessment included the following skill areas: making literal inferences, extrapolation, understanding homonyms, and evaluation. Skills measured exclusively in fifth grade tested students' ability to evaluate nonfiction. The fifth grade mathematics assessment included items tapping the following areas: simple multiplication and division and recognizing complex number patterns; demonstrating an understanding of place value in integers to hundreds place; using knowledge of measurement and rate to solve word problems; solving problems using fractions; and solving word problems involving area and volume.

The ECLS-K also asked fifth grade teachers to complete academic rating scales (ARS) on student reading, mathematics, and science achievement. In the case of the reading score, teacher ratings of proficiency in expressing ideas, use of strategies to gain information, reading on grade level, and writing were combined. This scale has a reported reliability of .95 and has a .62 correlation with students' fifth grade IRT reading test scores. In mathematics, teachers were asked to rate a student's understanding of number concepts (place value, fractions, and estimation), measurement, operations, geometry, application of mathematical strategies, and beginning algebraic thinking.[12] The mathematics scale has a reported reliability of .92 and has a .63 correlation with the student's fifth grade mathematics IRT test score.

To examine shorter-run links between school entry skills and achievement, we also estimate models using as dependent variables test scores and teacher reports measured at the end of first and third grades. The first grade achievement test included five reading and five mathematics proficiency levels that reflect a progression of skills and knowledge such that if a child has mastered a higher level, she is likely to have mastered the items in the earlier levels as well. For example, an early skill area would be identifying upper- and lower- case letters of the alphabet, and a later skill area would be reading words in context. Similarly, in mathematics, an

early skill area on the first grade test is identifying one-digit numerals and recognizing geometric shapes. An example of a later skill area is multiplication and division.

Independent Variables. Our independent variables of interest include achievement test scores and teacher reports of socioemotional skills, all measured in the fall of kindergarten. The socioemotional skill measures were all constructed by ECLS-K staff from teacher responses to a self-administered questionnaire from the fall of kindergarten.[13] The items in all five measures are measured on a scale of 1 "never" to 4 "very often". We combine the self-control and interpersonal skills measures into a social skills measure.

The measure of self-control is constructed from four items that indicate a child's ability to control behavior by respecting the property rights of others, controlling temper, accepting peer ideas for group activities and responding appropriately to pressure from peers. The scale has a reported reliability of .79 in the fall of kindergarten.

The five items that comprise the measure of interpersonal skills rate a child's skill in forming and maintaining friendships, getting along with people who are different, comforting or helping other children, expressing feelings, ideas and opinions in positive ways, and showing sensitivity to the feelings of others. The reliability of interpersonal skills in the fall of kindergarten is .89. Table 1 shows little change in average scores on social skills or any of the other socioemotional behavior measures between kindergarten and fifth grade.

The teacher-reported measure of externalizing problem behaviors consists of five items that rate the frequency with which a child argues, fights, gets angry, acts impulsively, and disturbs ongoing activities. The four items that make up the measure of internalizing behaviors ask about the apparent presence of anxiety, loneliness, low self-esteem, and sadness. The reliabilities for externalizing and internalizing problem behaviors are .90 and .80, respectively.

The ELCS-K's "Approaches to Learning" scale, which we use as the measure of attention skills, includes six items that measure the child's attentiveness, task persistence, eagerness to learn, learning independence, flexibility and organization. This measure has a reliability of .89 in the fall of kindergarten.

An important fall-kindergarten control measure is the child's score on the "General Knowledge" test. Since the test covers subject matter too diverse to be divided into proficiency levels, only a single overall IRT score is available for it. The test assessed knowledge of science and social studies and evaluated children's conception and understanding of the social, physical, and natural world and their ability to draw inferences and comprehend implications. It also measured children's skills in establishing relationships between and among objects, events, or people and to make inferences and comprehend the implications of verbal and pictorial concepts. The reliability of the general knowledge test for this sample in the fall of kindergarten was .88.

As with tests such the CNLSY's Peabody Picture Vocabulary Test (PPVT), scores on the ECLS-K's General Knowledge test can be taken as an indicator of cognitive ability. At the same time, scores on this test also reflect some degree of concrete achievement skills. For the most part, we use General Knowledge scores to control for cognitive ability in assessing the importance of early reading and math achievement and noncognitive skills. But we also note the predictive power of the General Knowledge scores, and of its possible role in an index of achievement skills.

In addition to the independent variables described above, we include an extensive list of child and family control variables in most of our models. A list of these variables and descriptive statistics for them can be found in Appendix 1.

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Table 1. Coefficients and Standard Errors from Models Predicting Spring of Fifth Grade Reading and Math Achievement Using Fall of Kindergarten Reading, Math, Attention and Socioemotional Skills.

Dependent Variable 5th Grade:	Reading Achievement Test					Math Achievement Test				
	Bivariate Regressions	Separate Regressions Omitting Other Skill Measures	Single Regression Without Background Controls	Single Regression Without Achievement Skills	Single Regression With Background Controls	Bivariate Regressions	Separate Regressions Omitting Other Skill Measures	Single Regression Without Background Controls	Single Regression Without Achievement Skills	Single Regression With Background Controls
Independent Variables	(1)	(2)[a]	(3)	(4)	(5)	(6)	(7)[a]	(8)	(9)	(10)
Fall of Kindergarten Achievement Skills										
Reading IRT	.503**	.310**	.096**		.073**	.467**	.297**	-.015		-.006
	(.008)	(.011)	(.012)		(.012)	(.009)	(.011)	(.012)		(.012)
Math IRT	.596**	.401**	.173**		.191**	.626**	.476**	.362**		.346**
	(.008)	(.010)	(.012)		(.013)	(.008)	(.010)	(.012)		(.012)
Attention Skills	.353**	.312**	.127**	.323**	.109**	.351**	.363**	.145**	.396**	.171**
	(.009)	(.011)	(.014)	(.015)	(.015)	(.009)	(.011)	(.014)	(.015)	(.014)
Socioemotional Skills										
Externalizing Problems	-.157**	-.122**	-.028*	.028	-.011	-.142**	-.127**	-.002	.032*	-.002
	(.009)	(.012)	(.014)	(.015)	(.014)	(.009)	(.012)	(.014)	(.015)	(.014)
Internalizing Problems	-.147**	-.110**	-.016	-.015	-.009	-.161**	-.133**	-.034**	-.025*	-.015
	(.009)	(.011)	(.010)	(.011)	(.010)	(.009)	(.011)	(.010)	(.011)	(.010)
Social Skills	.220**	.178**	-.009	-.003	-.001	.201**	.186**	-.031*	-.039*	-.031*
	(.009)	(.011)	(.015)	(.017)	(.016)	(.009)	(.011)	(.015)	(.017)	(.015)
Background Controls		X		X	X		X		X	X
Classroom Fixed Effects		X	X	X	X		X	X	X	X
Observations			9301	9223	8527			9308	9232	8535
Number of Classrooms			2499	2614	2414			2500	2615	2415
R-squared			0.35	0.22	0.41			0.36	0.26	0.43

Note. All variables are standardized using full sample standard deviations.
Control variables include fall of kindergarten General Knowledge test scores as well as other variables listed in Appendix 1.
Standard Errors in parentheses.
* significant at 5%; ** significant at 1%

[a]Each coefficient is the result of a separate regression estimate.

Table 2. Coefficients and Standard Errors from Various Specifications Predicting Reading and Math Achievement Scores Using Achievement, Attention and Socioemotional Skills

Dependent Variable:	Achievement Test							
	Reading		Math		Reading		Math	
Dependent Variable Measured:	1st Grade	3rd Grade	1st Grade	3rd Grade	3rd Grade	5th Grade	3rd Grade	5th Grade
Independent Variables Measured:	Fall Kindergarten				Spring 1st Grade	Spring 3rd Grade	Spring 1st Grade	Spring 3rd Grade
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Achievement Skills								
Reading IRT	.389**	.119**	.048**	.007	.405**	.584**	.136**	.059**
	(.012)	(.012)	(.012)	(.012)	(.011)	(.012)	(.011)	(.011)
Math IRT	.243**	.202**	.495**	.421**	.096**	.107**	.474**	.684**
	(.012)	(.013)	(.013)	(.012)	(.011)	(.011)	(.011)	(.010)
Attention Skills	.101**	.107**	.142**	.150**	.096**	.051**	.126**	.052**
	(.014)	(.014)	(.015)	(.014)	(.012)	(.011)	(.012)	(.010)
Socioemotional Skills								
Externalizing Problems	-.022	-.009	-.018	-.010	-.014	-.002	.010	-.008
	(.014)	(.014)	(.014)	(.014)	(.011)	(.010)	(.011)	(.009)
Internalizing Problems	-.017	-.009	-.018	-.009	-.002	.003	-.014	.009
	(.010)	(.010)	(.010)	(.010)	(.009)	(.008)	(.009)	(.007)
Social Skills	-.023	.009	-.038*	-.035*	-.026*	-.011	-.027*	-.009
	(.015)	(.015)	(.016)	(.015)	(.013)	(.011)	(.013)	(.011)
Background Controls	X	X	X	X	X	X	X	X
Classroom Fixed Effects	X	X	X	X	X	X	X	X
Observations	8656	8529	8657	8566	8023	7424	8053	7424
Number of Classrooms	2436	2413	2436	2425	2379	2247	2388	2247
R-squared	.50	.44	.51	.48	.59	.70	.62	.74

Note. All variables are standardized using full sample standard deviations.

Control variables include fall of kindergarten General Knowledge test scores as well as other variables listed in Appendix 1.

Columns (4) and (8) include 3rd grade Science IRT rather than General Knowledge because General Knowledge was not administered after 1st grade.

Standard Errors in parentheses

* significant at 5%; ** significant at 1%

Table 3. Fifth Grade Achievement Regression Models Using Composite Measures of Kindergarten Skills

Dependent Variable 5th Grade:	Achievement Test			
	Reading		Math	
Independent Variables	(1)	(2)	(3)	(4)
Fall of Kindergarten Composite				
Reading and Math Skills	.243**		.303**	
	(.011)		(.011)	
Reading, Math, and General Knowledge		.481**		.455**
		(.012)		(.012)
Socioemotional Skills	.012	.018	-.016	-.015
	(.012)	(.013)	(.013)	(.013)
Attention Skills	.114**	.113**	.184**	.184**
	(.014)	(.014)	(.014)	(.014)
Background Controls	X	X	X	X
Classroom Fixed Effects	X	X	X	X
Observations	8527	8527	8535	8535
Number of Classrooms	2414	2414	2415	2415
R-squared	.41	.39	.41	.41

Note. All variables are standardized using full sample standard deviations.
Control variables include fall of kindergarten General Knowledge test scores for columns (1) and (3) as well as other variables
Standard Errors in parentheses.
* significant at 5%; ** significant at 1%

Appendix Table 1. Descriptive Statistics for Variables of Interest

	Fall Kindergarten	Spring Kindergarten	Spring 1st Grade	Spring 3rd Grade	Spring 5th Grade
Independent Variables	(1)	(2)	(3)	(4)	(5)
Achievement Skills					
Reading IRT	29.832	41.429	71.493	117.068	137.718
	(9.837)	(13.367)	(21.960)	(25.396)	(23.693)
Math IRT	23.262	33.795	57.682	91.391	112.500
	(8.885)	(11.434)	(16.671)	(21.628)	(21.817)
Attention Skills	3.032	3.159	3.056	3.025	3.027
	(.658)	(.669)	(.695)	(.688)	(.684)
Socioemotional Skills					
Externalizing Problems	1.575	1.617	1.626	1.710	1.675
	(.606)	(.610)	(.630)	(.614)	(.599)
Internalizing Problems	1.520	1.538	1.581	1.633	1.652
	(.514)	(.494)	(.516)	(.537)	(.551)
Social Skills[a]	6.161	6.391	6.331	6.268	6.263
	(1.143)	(1.159)	(1.180)	(1.210)	(1.195)

Note. Standard Deviations in parentheses

Weighted using ECLS-K sampling weights.

[a]Social Skills is a combination of the interpersonal skills and self control scales

Appendix Table 2. Descriptive Statistics for Control Variables

Variable	M	SD
Baseline child characteristics		
Race		
White	.58	.49
Black	.11	.32
Hispanic	.19	.39
Asian	.07	.25
Other	.05	.22
Female	.50	.50
Age (in months at Fall K assessment)	68.42	4.26
Age (squared)	4699.15	586.06
Age (cubed x 1000)	3.24e+08	6.08e+07
Birth weight (in pounds)	6.82	2.37
Missing birth weight	.08	.27
Premature (child over 2 weeks early)	.16	.36
Parent report of overall child health (1=excellent, 5=poor)	1.44	.94
Geographic controls		
West	.23	.42
Midwest	.26	.44
Northeast	.19	.39
South	.32	.47
Urban	.46	.50
Rural	.24	.43
Suburban	.30	.46
Home Environment		
Number of siblings	1.48	1.18
Number of siblings (squared)	3.58	6.60
Number of siblings (cubed)	12.15	46.74
Child part of multiple birth	.02	.16
Two biological parents (continuously married)	.60	.49
Adopted	.01	.11
Live with guardian	.02	.14
Single biological parent	.19	.39
Biological parent and other parent	.06	.24
Two biological parents (not continuously married)	.12	.33
English not primary home language	.15	.35
Missing primary home language	.05	.21
Four or more moves pre-school	.08	.28
Parent reads to child (days/week)	4.39	2.59
Missing read to child	.13	.34
Parent tells stories to child (days/ week)	3.22	2.56
Missing tell stories to child	.13	.34
Number of children's books in the home	65.27	61.87

Appendix Table 2 (continued).

Variable	M	SD
Missing number of books	.14	.35
Watched Sesame Street pre-school	.52	.50
Parental Characteristics		
Mother's age at child's birth	23.72	11.93194 -5
Missing mother's age at child's birth	.16	.37
Mother's age at first birth	19.91	10.67
Missing mother's age at first birth	.18	.39
Mother's education (in years)	12.82	3.89
Missing mother's education	.05	.22
Father's education (in years)	11.01	6.04
Missing father's education	.20	.40
Mother worked between birth and kindergarten	.68	.47
Missing whether mother worked between birth and kindergarten	.08	.27
Income	44268.71	37700.92
Missing income	.14	.35
Mother's occupation (prestige score)	28.01	22.86
Mother's occupation (squared)	1306.63	1325.44
Mother's occupation (cubed x 1000)	65200000	84600000
Missing mother's occupation	.36	.48
Father's occupation (prestige score)	32.37	21.10
Father's occupation (squared)	1493.10	1295.90
Father's occupation (cubed x 1000)	73800000	87900000
Missing father's occupation	.25	.43
WIC	.40	.49
Missing WIC	.05	.22
Food Stamp	.22	.41
Missing Food Stamp	.14	.34
AFDC	.14	.35
Missing AFDC	.14	.34
Child care arrangements (pre-K)		
Relative pre-school care	.13	.34
Center-Based pre-school care	.40	.49
Non-Relative pre-school care	.09	.29
Head Start	.08	.27
Varied pre-school care	.08	.27
Missing pre-school care	.05	.23
Child ever in center-based pre-school care	.66	.47

Appendix Table 2 (continued).

Variable	M	SD
Neighborhood characteristics		
(1="Big Problem", 3="No Problem")		
Neighborhood safety	2.69	.53
Neighborhood litter	2.87	.38
Neighborhood drug use	2.88	.38
Neighborhood burglary	2.87	.38
Neighborhood violence	2.96	.24
Neighborhood vacancies	2.94	.26
Parental expectations at baseline		
Years of education parent expects child to complete	13.98	5.97
Missing education expectation	.14	.35
How important is it that your child does the following by kindergarten?		
(1="Essential", 5="Not Important")		
Count	2.03	1.15
Missing count	.13	.34
Share	1.51	.80
Missing share	.13	.34
Draw	1.80	1.00
Missing draw	.13	.34
Be calm	1.69	.92
Missing calm	.13	.34
Knows letters	1.92	1.08
Missing knows letters	.13	.34
Communicates well	1.50	.81
Missing communicates well	.13	.34

[1] http://www.naeyc.org/about/positions/pdf/psmath.pdf

[2] Correlations between mothers' and teachers' responses to identical sets of questions regarding their kindergarteners' socioemotional behaviors (i.e., behavior problems, social skills) in the ECLS-K range between .10 and .25 (Duncan et al., 2006).

[3] Equation (2) is equivalent to a formulation in which ACH is a function of changes in and beginning levels of ACAD, ATTN, and SE:

(3) $ACH_{i5th} = d_1 + \delta_1 \Delta ACAD_i + \delta_2 \Delta ATTN_i + \delta_3 \Delta SE_i + \delta_4 ACAD_{iFK} + \delta_5 ATTN_{iFK} + \delta_6 SE_{iFK} + \gamma_1 FAM_i + \gamma_2 CHILD_i + \eta_{it}$

with Δ indicating a difference between the beginning and end of kindergarten. Algebraic manipulation shows that the δ_1, δ_2, and δ_3 parameters in (3) are identical to the $ß_1$, $ß_2$, and $ß_3$ parameters of equation (2) (Jencks and Phillips 1999).

[4] We found that weighted and unweighted regression coefficients were virtually identical to one another; unweighted standard errors were marginally smaller for the unweighted models. We present unweighted results in our tables, weighted results are available on request.

[5] Teacher questionnaires were administered between October and December 1998 for the fall and between March and June 1999 for the spring.

[6] Identical items were administered in the spring of kindergarten and are used in the change models discussed in the results section.

[7] These are actually coefficients from bivariate regressions.

[8] That the bivariate coefficients are larger than zero and in the expected direction demonstrates that the socioemotional measures are, in fact, correlated with the outcomes of interest.

[9] SES was defined using the ECLS-K's composite measure. "High" and "low" groups were formed from the highest and lowest quartiles of the weighted SES distribution.

[10] Cunha and Heckman (2006) find significant predictive power of time t noncognitive skills on time t+2 cognitive skills, but the size of their standardized coefficients (.00 to .08) differ little from ours. Their estimates of the importance of time t cognitive skills are 10 to 20 times larger than the importance of noncognitve skills.

[11] Teacher questionnaires were administered between October and December 1998 for the fall and between March and June 1999 for the spring. We control for the timing of the assessments in our empirical work.

[12] Reading ARS scores are available for the full sample, but only half of the teachers were asked to rate students in mathematics.

[13] Identical items were administered in the spring of kindergarten and are used in the change models discussed in the results section.