Longitudinal Predictors of Reading and Math Trajectories Through Middle School for African American Versus Caucasian Students Across Two Samples

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This study's primary purpose was to examine the relative contribution of social-behavioral predictors to reading and math skills. The study expands on Duncan et al.'s (2007) work by using longitudinal methodology from the National Institute of Child Health and Human Development's Study of Child Care and Youth Development (SECCYD) and the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 (ECLS-K) databases, and by focusing on potential differences in patterns of early predictors of later reading and math trajectories for African American versus Caucasian students. Predictor measures were selected at kindergarten, and the outcomes included standardized reading and math scores obtained from Grades 1, 3, 5, and 9 for the SECCYD sample, and Grades 3, 5, and 8 for the ECLS-K sample. Consistent with Duncan et al.'s findings, results reflect the relative contributions of early reading and math skills to later functioning in these respective academic domains for both samples, and there are indications for the importance of early expressive language skills to both reading and math in the SECCYD sample. Findings related to the power of social-behavioral predictors, however, are not consistent across samples. Although the SECCYD sample evidenced no such predictors, several interactions in the ECLS-K sample suggested the moderating effects of early ratings of aggressive behaviors and internalizing behaviors on later reading and math for African American students. The moderating effects of early teacher ratings of attention and internalizing behaviors for African American students as compared with Caucasian students in later math growth also were noted. The importance of early social-behavioral functions as related to later academic skills remains an important area of inquiry.

Keywords: academic skills in African American youths, early predictors of learning, kindergarten predictors of reading and math trajectories

The search for evidence-based early predictors of later learning has become an important quest over the past several decades. Findings from studies of emergent literacy have evidenced the importance of specific, early skills (e.g., alphabetic code skills) to the development of later reading in English and non-English speaking children (Adams, 1990; Denton & West, 2002; Dickin-

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son, McCabe, Anastasopoulos, Peisner-Feinberg, & Poe, 2003; Lyytinen et al., 2004; Muter & Diethelm, 2001; National Institute of Child Health and Human Development [NICHD] Early Child Care Research Network, 2005; Scarborough, 2001; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Storch & Whitehurst, 2002; West, Denton, & Germino-Hausken, 2000; Whitehurst & Lonigan, 1998), and parallel relationships have emerged for early predictors of later math skills (Baroody, 2003). Similarly, a number of studies have evidenced the relationship of socialbehavioral problems in young children to later lower school performance. These studies have shown aggressive behaviors (Doctoroff, Greer, & Arnold, 2006; Entwisle, Alexander, & Olson, 2005; NICHD Early Child Care Research Network, 2005; Pianta & Stuhlman, 2004; Raver, 2004) and attention (Barriga et al., 2002; Dobbs, Doctoroff, Fisher, & Arnold, 2006; Konold & Pianta, 2005; Trzesniewski, Moffitt, Caspi, Taylor, & Maughan, 2006) to be significantly related to later school performance.

In one of the most comprehensive examinations of this topic to date, Duncan et al. (2007) utilized six longitudinal data sets to examine the predictive value of academic skills, attention, and social-behavioral functioning at school entry for later reading and math performance during the early grades through adolescence. Findings reflected the importance of early math, reading, and attention skills in the prediction of later reading and math skills;

however, measures of social-behavioral functioning did not predict later reading and math skills after controlling for socioeconomic status, degree of social-behavioral problems, and other key variables. In general, these findings call into question the relative importance of such functions as critical predictors of later academic achievement.

Early Predictors of Reading and Math Skills in African American Children

Although the relationship between early language and later social-behavioral functioning (Hooper, Roberts, Zeisel, & Poe, 2003), social-behavioral characteristics and academic outcomes (Brody et al., 2006; Gaylord-Harden, 2008; Taylor & Lopez, 2005), and first-grade social-behavioral features and later substance abuse (Ensminger, Juon, & Fothergill, 2002) has been documented for older African American children and adolescents, these relationships remain relatively unexamined for preschool children, particularly with respect to early predictors of later reading and math performance. Major national concern has focused on examination of the "achievement gap" and the educational success of children in high-risk settings (e.g., McCoy & Reynolds, 1999). Further, the observation that African American children account for approximately 40% of school enrollees suggests that early predictors of any type may contribute to lessening this gap via early identification and intervention for a large number of children. With respect to the presence of social-behavior problems in the African American population, Carlson et al. (2009) documented higher rates of such difficulties in their minority sample in the Pre-Elementary Education Longitudinal Study, and this finding raised questions about the importance of these variables to later reading and math skills in an African American sample of preschool children. Although data do exist with respect the academic performance of African American students, few studies have addressed the critical issue of what variables might serve as reliable early predictors of later challenges in learning (Davis, 2003).

Rabiner, Murray, Schmid, and Malone (2004) provided evidence for the relationship between ethnicity, attention problems, and academic achievement in a large sample of first-grade African American students. Using teacher ratings of first-grade students, Rabiner et al. found attention ratings to be a significant predictor of teacher ratings of academic achievement skills. This association was especially strong for the African American sample; however, teacher ratings of other behavior problems were not related to concurrent achievement ratings by teachers. These findings were extended by the work of Herman and colleagues, who showed that academic performance in first-grade African American students mediated the relationship between inattention in first grade and later depression in third grade (Herman, Lambert, Ialongo, & Ostrander, 2007) and middle school (Herman, Lambert, Reinke, & Ialongo, 2008).

Bowman, Barnett, Johnson, and Reeve (2006) examined the interrelationships between language impairment, behavior problems, and academic achievement in a sample of African American kindergarten children. They found that children with language problems were likely to manifest learning problems and that learning problems mediated the relationship between language and behavior problems. Finally, McGroder, Zaslow, Papillo, Ahluwalia, and Brooks (2005), using the sample from the National Eval-

uation of Welfare-to-Work Strategies Study, estimated the effect of maternal employment on preschool African American children and their school readiness and behavior. These investigators did not find any significant relationships with later learning; however, maternal employment did predict more positive behavior status, suggesting the importance of socioeconomic factors as key covariates for such investigations.

The Current Investigation

The above studies are intriguing in that they all address the utility of social and behavioral factors in the prediction of later learning; however, although compelling, we believe that this is not a simple question of presence or absence of findings but, rather, what is being predicted for a specific population and when the predictors are obtained. For this study, we plan to examine the question of early school predictors on subsequent reading and math trajectories in a selected target group-African American children-using two data sets: the NICHD Study of Child Care and Youth Development (SECCYD) and the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K). For this article, we examine the extent to which measures of early academic skills, expressive language, attention, and socialbehavioral skills at kindergarten predict reading and math trajectories through Grade 9 for the SECCYD study and from third to eighth grade for the ECLS-K sample.

In addition to comparing our findings with those obtained by Duncan et al. (2007) on early predictors, we expand on Duncan et al.'s findings in several ways. First, we look at academic outcomes longitudinally in the SECCYD and the ECLS-K samples to see whether measures of social-behavioral skills obtained at kindergarten predict rates of change over time in academic skills or whether they fail to predict level of academic skills as reported by Duncan et al. Relatedly, we move away from controlling academic skills at school entry, but we do control for a variety of other key variables (e.g., environmental factors) in an attempt to have exogenous covariates. Second, we include interactions of change and other key variables with race. These interactions allow us to assess differences between children of different ethnic backgrounds with a particular focus on differences between African American students and Caucasian students.

Method

Participants

In this study, we utilized two longitudinal data sets: the SECCYD and the ECLS-K. The SECCYD data set included 1,364 healthy newborns enrolled in the study at 1 month of age. The sample is largely Caucasian, and about 30% of the mothers have a high school education or less (NICHD Early Child Care Research Network, 1997). For this study, we were most interested in the 12% of the sample that was African American, which permitted an examination of a sample of 107 children, with about equal numbers of boys and girls being represented. Maternal education showed that most of the mothers achieved at least a high school degree, although family income reflected poverty levels. Data were available for this sample through the ninth grade.

The ECLS-K followed 21,409 children from kindergarten through eighth grade (Tourangeau, Nord, Lê, Pollack, & Atkins-Burnett, 2006). Data were collected on only a subsample during first grade, so these analyses focused on achievement scores in third, fifth, and eighth grades, with covariates collected in the fall of kindergarten. Longitudinal weights are provided for the sample for respondents with complete data over the range selected for analysis (i.e., from third grade to eighth grade). The subset of those with data over this range included 12,206 observations. The total sample was about 49% female, with maternal education reflecting at least a high school degree for a majority of the sample. Minority students composed approximately 42% of the overall sample, with about 11.3% of the total sample representing African American students.

Measures

SECCYD measures. For this sample, we selected a number of key predictor variables, the academic outcomes of reading and math, and specific covariates. The predictor variables were collected at 54 months of age or the fall of kindergarten, and they included measures of preacademic skills (Woodcock–Johnson–Revised [WJ-R] Letter-Word Identification and Applied Problems subtests; Woodcock & Johnson, 1990), language skills (Preschool Language Scale–3 Expressive Communication scale; Zimmerman, Steiner, & Pond, 1979), attention (Continuous Performance Test correct responses; NICHD, 1991), and social behavior (Child Behavior Checklist–Teacher Report Form Aggression and Internalizing scales; Achenbach & Edelbrock, 1986; Social Skills Rating System total score; Gresham & Elliot, 1990).

Outcome variables were generated from the WJ-R Reading and Math subtests. At first grade, specific outcomes include the WJ-R Letter-Word Identification subtest and the WJ-R Applied Problems subtest. For Grades 3, 5, and 9, the outcomes included the WJ-R Broad Reading and Broad Math clusters. For our analyses, we used the W score, which is a derivative of Raush–Wright scaling and provides a strong metric for longitudinal studies. Covariates included gender, birth order, general health of the child, martial status, parenting skills, maternal age, maternal education, family income, maternal depression, time in center versus home care, and the Observational Record of the Caregiving Environment (NICHD Early Child Care Research Network, 1996) quality total.

ECLS-K measures. Measures used in the ECLS-K study provided a nice parallel to those used in the SECCYD study, but we used different time points of outcome from this longitudinal study; namely, we utilized predictors from kindergarten and extended our findings longitudinally from Grade 3 through Grade 8. Reading and math achievement measures were develop for and tested on the research sample. Both are item response theory scored, resulting in scores that are reliable and that can be compared over time. These were used as outcome variables in Grades 3, 5, and 8. Measures taken in the fall of kindergarten were considered baseline measures and were included as predictors.

There was not an expressive language measure in the ECLS-K data set, so expressive language was not included in the analysis. Similarly, there was no attention measure comparable with the Continuous Performance Test; however, we included a measure labeled "Approaches to Learning." This variable was obtained via teacher ratings and formed a composite of six items measuring

organization, eagerness to learn, ability to work independently, adaptation to change, persistence, and attention. In third and fifth grades, a seventh item was added about following rules. Composite variables for internalizing behavior, externalizing behavior, and social skills were created from teacher reports of child behavior. Covariates for this sample included gender, maternal education, maternal marital status, and maternal age. Measures of income and child care prior to kindergarten had large amounts of missing data and so were excluded from analysis.

Data Analyses

Data analyses mirrored the methods of Duncan et al. (2007) as closely as possible for the samples from both studies; however, derived models in the present study were longitudinal in nature, modeling change over time in both reading and math achievement outcomes. Predictors and covariates were chosen to match Duncan et al.'s study as closely as possible. Further, we included interactions with ethnicity for all key variables, allowing for assessment of potential variability both in mean achievement scores and in change over time. Given differences in measurement between the two studies, precise replication was impossible for the ECLS-K data set, but we were able to select similar enough variables to make it a theoretical replication.

For the SECCYD subsample, longitudinal analyses (via SAS PROC MIXED) were run for each outcome, with grade representing "time" and the primary predictor variables described above. Interactions of each of these predictors with grade and with ethnicity were included to assess the degree to which developmental trajectory varied with changes in these other variables. Grade was centered at fifth grade. Dummy variables were used to indicate African American, Hispanic, and other ethnicities, with Caucasian students as the comparison group. A set of covariates also was included in the model: child gender, whether the child was first born, health at 54 months, parent marital status, a measure of parenting (composite of maternal sensitivity and Home Observation for Measurement of the Environment total score; Caldwell & Bradley, 1979), mother's education, income, mother's depression, public assistance, in center care, in home care, and quality of care. The first analysis modeled reading score, with reading defined as Letter-Word at first grade and Broad Reading in third, fifth, and ninth grades. Math was measured as Applied Problems in first grade and Broad Math in third, fifth, and ninth grades.

We replaced missing data in the SECCYD sample using multiple-imputation through SAS PROC MI. Multiple-imputation draws replacement values for missing observations on the basis of the multivariate distribution of the variables included in the imputation model (Rubin, 1976; Schafer & Graham, 2002). This is done repeatedly, resulting in multiple complete data sets. In these analyses, we imputed 10 data sets. The resulting data sets were then analyzed as described below, and the results were combined via the SAS procedure MIANALYZE to obtain final estimates of parameters and standard errors for the analysis model.

Comparable reading and math models were estimated for the ECLS-K sample. In this sample, outcome measured were gathered in third, fifth, and eighth grades, with grade centered at fifth grade. Just as in the SECCYD analysis, ethnicity was scored as a series of dummy variables indicating African American, Hispanic, and other. A set of covariates, measured in the fall of kindergarten, was

included in the model: child gender, child health, parent marital status, and mother's education. We measured both outcome variables using the ECLS-K achievement measures derived from item response theory. Longitudinal survey weights are provided via the ECLS-K database and were included in the analysis model, making missing data replacement unnecessary for this sample.

To allow for comparisons between samples, we computed d-type effect sizes for all of the parameters estimated. These effects sizes were computed as $(\beta \times SDx)/SDy$. The effect sizes for the interaction terms still represent the effect size of the slope but at different levels of predictor of interest. "Low" refers to the effect at one standard deviation below the mean on that variable, and "High" is one standard deviation above the mean. Thus, for each interaction, specific slope estimates (change over time measured by year in school) were made at one standard deviation above the mean on the predictor variable and at one standard deviation below the mean for each group. Once calculated, these effect sizes can be compared with the overall effect for Grade/Year in School to make judgments about the degree to which the slope changes as a function of the predictor. Interaction effect sizes were computed only for significant interactions. This type of effect size has a lower bound at zero but, unlike R^2 , has no upper bound. Effect sizes < 0.30 are generally considered small, up to 0.79 are considered medium, and ≥ 0.80 considered large.

Results

Findings From the SECCYD Sample

Means and standard deviations for the targeted outcome variables in reading and math across the different ethnicities can be seen in Table 1. The reading and math outcomes variables for the WJ-R growth scores are presented for Grades 1, 3, 5, and 9. Table 2 provides means and standard deviations for selected predictor variables for each of the ethnicities examined in this study. The data presented in these tables were compiled before missing data were replaced.

Reading outcome. The first analysis predicted reading scores across Grades 1, 3, 5, and 9 using our full model that matched Duncan et al.'s (2007) model and our model that included each of the individual predictors: expressive language, academic skills, attention, and behavior. Individual intercepts were estimated for

each participant. Covariates in both models included child gender, whether the child was first born, health at 54 months, parent marital status, a measure of parenting (composite of maternal sensitivity and Home Observation for Measurement of the Environment total score), maternal education, income, maternal depression, public assistance, in center care, in home care, quality of care, and missing data indicators for each of these variables. Time was centered at Grade 5, and all other predictors were centered at the sample mean.

Table 3 presents the results for Duncan et al.'s (2007) model, the SECCYD data set, and the ECLS-K data set for the reading outcomes. For the fixed effects, African American students tended to score lower on average than did Caucasian students (mean difference = 3.28, p < .05), with no other race effects being noted. Early reading (B = 0.21, p < .001), math (B = 0.14, p < .001), and expressive language (B = 0.10, p < .001) skills were all positively related to later reading skills. Further, as can be seen in Table 3, children with faster reading trajectories tended to be rated by their teacher as displaying more internalizing behavior (B = 0.10, p < .05) but better social skills (B = 0.09, D > .05). Aggressive behaviors and attention were not related to later reading growth.

Although all children showed substantial gains in reading over time (B=7.77, p<.001), there were no significant two-way or three-way interactions with race. There was a significant interaction between early reading and change over time (B=-0.04, p<.001), but the negative parameter indicates that higher early reading scores are associated with slower rates of change over time.

Math outcome. Table 4 presents the results for Duncan et al.'s (2007) model, the SECCYD data set, and the ECLS-K data set for the math outcomes. For the fixed effects, African American students tended to have lower math scores than did Caucasian students (mean difference = -4.27, p < .001). Similar to the reading model, early reading (B = 0.13, p < .001), early math (B = 0.24, p < .001), and early expressive language (B = 0.10, p < .001) skills were positively related to later math scores. There was nonsignificant evidence that early social skills were positively related to later math ability (B = 0.06, p < .10). None of the other early predictors were significantly related to rates of growth in later math skills.

Table 1
Means and Standard Deviations at Grades 1, 3, 5, and 9 in the SECCYD Sample for the Outcome Variables

			Grade 1		Grade 3		Grade 5	Grade 9		
Ethnicity	Subject	n	M(SD)	n	M(SD)	n	M(SD)	n	M(SD)	
Caucasian	Reading	734	455.02 (22.74)	785	496.92 (13.88)	723	509.86 (12.61)	653	522.66 (11.18)	
	Math	734	472.34 (14.74)	785	495.11 (11.78)	723	512.55 (11.72)	654	527.02 (16.12)	
African American	Reading	107	457.19 (13.85)	118	483.45 (15.41)	112	495.16 (17.82)	96	508.11 (13.48)	
	Math	107	438.54 (21.58)	117	481.35 (20.4)	112	499.26 (14.97)	96	510.00 (12.32)	
Hispanic	Reading	55	447.09 (28.03)	62	491.39 (14.35)	56	505.54 (12.61)	50	516.44 (9.07)	
•	Math	54	465.63 (12.71)	62	492.18 (11.01)	56	509.46 (10.55)	50	523.76 (14.79)	
Other	Reading	41	453.98 (27.42)	48	493.27 (16.85)	42	507.12 (15.07)	40	519.53 (11.96)	
	Math	40	470.2 (19.1)	48	493.69 (11.99)	42	510.93 (13.74)	42	510.93 (13.74)	

Note. Means and standard deviations are reported from the Woodcock–Johnson–Revised Academic Achievement Test and use W scores. Higher scores reflect a higher level of reading and math skills. SECCYD = Study of Child Care and Youth Development.

Table 2
Means and Standard Deviations for the Kindergarten (K) Predictor Variables in the SECCYD Sample by Race

	Caucasian		Afr	ican American		Hispanic	Other		
Variable	n	M(SD)	n	M(SD)	n	M (SD)	n	M (SD)	
WJ-R LW W score, 54 months	736	371.91 (20.3)	109	357.33 (21.47)	54	360.28 (19.55)	40	372.9 (24.1)	
PLS standard score, 54 months	733	104.9 (17.65)	108	84.56 (19.89)	54	93.96 (19.74)	37	96.24 (21.26)	
WJ-R AP W score, 54 months	736	428.52 (16.06)	107	406.93 (21.89)	54	416.91 (24.15)	39	423.41 (18.84)	
CPT: 54 months	708	0.75 (0.19)	100	0.68 (0.21)	50	0.71 (0.20)	38	0.75 (0.20)	
TRF Aggression T score, K	716	53.33 (5.82)	94	55.9 (7.58)	53	52.94 (5.20)	39	53.51 (6.58)	
TRF Internalizing T score, K	716	46.86 (8.87)	94	48.53 (9.99)	53	45.02 (8.69)	39	47.9 (10.03)	
SSRS T score, K	708	104.57 (13.62)	93	96.54 (13.71)	53	104.91 (14.63)	38	102.42 (12.15)	

Note. The data in the table above were compiled before missing data were replaced. Scores for the Woodcock–Johnson–Revised (WJ-R) reflect W scores; scores for the Preschool Language Scale (PLS) and Social Skills Rating System (SSRS) reflect standard scores with a M = 110 (SD = 15); scores for the Teacher Rating Form (TRF) reflect T scores with a M = 50 (SD = 10); and scores for the Continuous Performance Test (CPT) reflect raw scores for errors of omission. SECCYD = Study of Child Care and Youth Development; LW = Woodcock–Johnson–Revised Letter-Word Identification subtest; AP = Woodcock–Johnson–Revised Applied Problems subtest.

For the slope effects, the model indicated a significant negative interaction between race and change over time (African American B = -0.74, p < .01). Here, African American students tended to improve at a slower rate than did Caucasian students. No other two- or three-way interactions were significant.

Findings From the ECLS-K Sample

Means and standard deviations for the reading and math outcomes at Grades 3, 5, and 8 for the different races/ethnicities for the ECLS-K sample can be seen in Table 5, whereas means and standard deviations for the kindergarten predictor variables for the race/ethnicity groups are provided in Table 6.

Reading outcome. The hierarchical linear modeling analysis estimated individual intercepts for the children and predicted reading scores over time in a model that included predictors of interest and covariates (i.e., child gender, maternal education, maternal age). As can be seen in Table 3, for the fixed effects, African American students tended to have lower reading scores than did Caucasian students (mean difference = -4.94, p < .001). Those classified ethnically as "other" also showed lower reading scores than did Caucasian students (mean difference = -1.85, p < .05). Early reading (B = 0.68, p < .001) and early math (B = 0.80, p < .001) skills were both positively related to later reading outcomes. The attention proxy variable, Approaches to Learning, also was positively related to later reading achievement (B = 4.11, p < .001), such that better attention ratings from teachers reflected more rapid gains in later reading skills.

For the slope effects noted in Table 3, several two-way and three-way interactions were noted. There was a significant two-way interaction between early reading skills and change in later reading over time ($B=-0.12,\ p<.001$), but the negative parameter indicates that higher reading scores were associated with slower rates of change over time. Early math skills also significantly predicted later reading skills ($B=0.03,\ p<.001$), with the positive parameter indicating that higher early math skills were associated with more rapid rates of change over time in later reading skills. Similarly, better teacher ratings of attention at kindergarten reflected more rapid gains in later reading skills ($B=0.39,\ p<.05$). Two-way interactions also were noted for race/

ethnicity, with African Americans (B = -1.64, p < .001), Hispanics (B = -0.62, p < .001), and the other racial grouping (B = -0.73, p < .001) showing slower rates of reading growth over time than Caucasian students. For the three-way interactions, higher early reading skills (B = 0.09, p < .05), higher ratings of internalizing behaviors (B = 1.11, p > .01), and lower ratings of aggression (B = -0.79, p < .05) produced more rapid growth in later reading for African American children than for Caucasian children.

Follow-up examination of these interactions revealed several complex moderating effects of change over time. These interactions were probed by slope estimates for the relevant ethnic categories (primarily African American and Caucasian students) at low (i.e., <1~SD below the mean) and high (>1~SD about the mean) levels of the specific moderating variable. As can be seen in Table 7, Caucasian students in the ECLS-K sample with low early reading scores showed faster increases in reading ability (B=15.63) than did those with high early reading scores (B=14.11). The pattern was reversed in African American students, such that poor early readers (B=13.52) actually improved more slowly than those with high early reading scores (B=15.35). Effect sizes for these rates of change were large.

Ratings of aggression (see Table 8) did not appear to moderate change over time in Caucasian students (high externalizing B=14.35, low externalizing B=14.51); however, in African American students, increases in aggressive behavior were associated with slower change over time (high externalizing B=13.96, low externalizing B=14.90). Internalizing behavior (see Table 9), however, had the opposite association. For Caucasian students, the difference between high internalizing (B=14.25) and low internalizing (B=14.60) was negligible. In African American students, high internalizing behavior was associated with a faster rate of change (low internalizing B=13.87, high internalizing B=14.99). Effects sizes were large across these social-behavioral variables for each race/ethnicity.

Math outcome. As can be seen in Table 4 for the ECLS-K sample, the fixed effects revealed that the African American students scored lower on math than did Caucasian students (mean difference = -6.83, p < .001). Early reading (B = 0.08, p < .01) and early math (B = 1.17, p < .001) skills were both positively related to later math outcome. The attention proxy variable, Approaches to Learning, also was positively related to later

Table 3
Reading Outcome Parameter Estimates and Effect Sizes Across Duncan et al.'s (2007) Study, the SECCYD Sample, and the ECLS-K Sample

	Duncan et al.'s (study	(2007)	SECCYD sar	nple	ECLS-K sample		
Effect type	B (SE)	d	B (SE)	d	B (SE)	d	
Fixed effects							
African American			$-3.28(1.55)^*$	-0.11	$-4.94(0.87)^{***}$	-0.20	
Hispanic			-0.28(1.71)	-0.01	0.51 (0.70)	0.02	
Other race			0.19 (1.84)	0.01	$-1.85(0.79)^*$	-0.08	
Early reading	$0.19(0.04)^{***}$	0.29	0.21 (0.02)***	0.15	0.68 (0.04)***	0.28	
Expressive language	0.11 (0.04)**	0.16	0.10 (0.03)***	0.06			
Early math	0.07 (0.04)	0.10	0.14 (0.03)***	0.09	$0.80 (0.04)^{***}$	0.30	
Attention ^a	-0.02(0.03)	0.00	0.00 (0.05)	0.00	4.11 (0.62)***	0.11	
Aggressive behavior	0.09 (0.04)*	0.04	0.06 (0.08)	0.01	-0.33(0.54)	-0.01	
Internalizing behavior	0.03 (.03)	0.02	0.10 (0.05)*	0.03	-0.15(0.57)	0.00	
Social skills, teacher ratings at kindergarten	0.06 (.04)	0.06	0.09 (0.04)*	0.04	-0.24(0.62)	-0.02	
Slope effects	` /		` ,		, ,		
Grade			7.77 (0.11)***		14.43 (0.08)***		
Grade × African American			-0.27(0.40)		$-1.64(0.24)^{***}$		
Grade × Hispanic			-0.46(0.46)		$-0.62(0.22)^{**}$		
Grade × Other Race			-0.01(0.50)		$-0.73(0.26)^{**}$		
Reading \times Grade			-0.04 (0.01)***		-0.12 (0.01)***		
Expressive Language × Grade			0.01 (0.01)		***= (****)		
Math × Grade			-0.01(0.01)		0.03 (0.01)***		
Attention × Grade			-0.01(0.01)		0.39 (0.20)*		
Aggressive Behavior × Grade			0.00 (0.02)		0.14 (0.17)		
Internalizing Behavior × Grade			0.01 (0.01)		-0.30(0.18)		
Social Skills × Grade			0.00 (0.01)		0.02 (0.20)		
Grade × Reading × African American			0.02 (0.02)		0.09 (0.04)*		
Grade × Reading × Hispanic			-0.02(0.02)		0.01 (0.04)		
Grade × Reading × Other			-0.02(0.02)		0.01 (0.03)		
Grade × Expressive Language × African American			0.00 (0.02)		0.01 (0.03)		
Grade × Expressive Language × Hispanic			-0.01 (0.03)				
Grade × Expressive Language × Other			-0.01 (0.03)				
Grade × Math × African American			0.00 (0.02)		0.00 (0.04)		
Grade × Math × Hispanic			0.02 (0.03)		0.06 (0.04)		
Grade × Math × Other			0.00 (0.03)		0.01 (0.03)		
Grade × Attention × African American			-0.03 (0.03)		0.12 (0.46)		
Grade × Attention × Hispanic			0.03 (0.05)		-0.63 (0.49)		
Grade × Attention × Other			0.04 (0.06)		0.02 (0.04)		
Grade × Aggressive Behavior × African American			-0.02(0.06)		$-0.79 (0.36)^*$		
Grade × Aggressive Behavior × Hispanic			-0.18(0.09)		-0.38(0.42)		
Grade × Aggressive Behavior × Other			0.18 (0.09)		-0.61 (0.6)		
Grade × Internalizing Behavior × African American			0.01 (0.08)		1.11 (0.43)**		
Grade × Internalizing Behavior × Hispanic			0.02 (0.03)		-0.4(0.47)		
Grade × Internalizing Behavior × Other			-0.04 (0.05)		0.13 (0.53)		
Grade × Social Skills × African American			, ,				
			0.01 (0.03)		0.38 (0.47)		
Grade × Social Skills × Hispanic Grade × Social Skills × Other			-0.02(0.04)		0.13 (0.51)		
Orace A Social Skills & Other			-0.03 (0.04)		-0.08 (0.59)		

Note. SECCYD = Study of Child Care and Youth Development; ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999. a Duncan et al.'s (2007) model also included two measures of attention problems.

math achievement (B = 5.00, p < .001), whereas kindergarten teacher ratings of social skills were negatively related (B = -1.83, p < .001).

For the slope effects noted in Table 4, several two-way and three-way interactions were present. For the two-way interactions, there was a significant interaction between ratings of early internalizing behaviors and later math skills over time (B = -0.31, p < .001), with the negative parameter indicating that higher internalizing scores (i.e., more symptoms) were associated with slower rates of change over time. A two-way interaction also was noted

for race/ethnicity, with African American students (B=-1.02, p<.001) showing slower rates of math growth over time than Caucasian students. For the three-way interactions, higher early math skills (B=0.11, p<.01) for both African American and Hispanic students (B=0.06, p<.05) contributed to a more rapid rate of gain in later math skills than seen in Caucasian students. Higher kindergarten teacher ratings of internalizing behaviors also produce a more rapid gain in later math skills for African American students than for Caucasian students (B=0.70, p>.05). For the three-way interaction, a positive rate of gain in later math skills

^{*} p < .05. ** p < .01. *** p < .001.

Table 4

Math Outcome Parameter Estimates and Effect Sizes Across Duncan et al.'s (2007) Study, the SECCYD Sample, and the ECLS-K Sample

	Duncan et al.'s study	(2007)	SECCYD sar	nple	ECLS-K san	nple
Effect type	B (SE)	d	B (SE)	d	B (SE)	d
Fixed effects						
African American			$-4.27(1.36)^{***}$	-0.17	$-6.83(0.72)^{***}$	-0.46
Hispanic			0.37 (1.50)	0.01	-0.06(0.57)	0.00
Other race			0.43 (1.59)	0.02	-0.89(0.65)	-0.06
Early reading	0.11 (0.04)**	0.32	0.13 (0.02)***	0.11	0.08 (0.03)**	0.06
Expressive language	0.12 (0.04)**	0.17	0.10 (0.03)***	0.08		
Early math	0.19 (0.04)***	0.17	0.24 (0.03)***	0.18	1.17 (0.03)***	0.73
Attention	-0.00(0.03)	0.00	0.06 (0.05)	0.02	5.00 (0.51)***	0.22
Aggressive behavior	0.05 (0.04)	0.02	0.01 (0.08)	0.00	-0.47(0.44)	-0.02
Internalizing behavior	0.05 (0.03)	0.07	0.07 (0.04)	0.02	-0.70(0.47)	-0.02
Social skills, teacher ratings at kindergarten	0.03 (0.04)	0.07	$0.06(0.03)^{\dagger}$	0.04	$-1.83(0.51)^{***}$	-0.20
Slope effects	` /		, ,		, ,	
Grade			6.65 (0.07)***		12.28 (0.07)***	
Grade × African American			$-0.74(0.26)^{**}$		$-1.02(0.19)^{***}$	
Grade × Hispanic			0.09 (0.29)		0.02 (0.17)	
Grade × Other Race			-0.04(0.33)		0.33 (0.21)	
Reading \times Grade			0.00 (0.00)		-0.01(0.01)	
Expressive Language × Grade			0.00 (0.01)		**** (****)	
Math × Grade			0.00 (0.01)		0.01 (0.01)	
Attention × Grade			-0.02(0.01)		0.26 (0.16)	
Aggressive Behavior × Grade			0.00 (0.01)		0.00 (0.13)	
Internalizing Behavior × Grade			0.01 (0.01)		$-0.31 (0.15)^*$	
Social Skills × Grade			0.01 (0.01)		-0.26(0.16)	
Grade × Reading × African American			0.00 (0.01)		0.04 (0.03)	
Grade × Reading × Hispanic			-0.01 (0.02)		-0.02(0.03)	
Grade × Reading × Other			-0.01 (0.02)		0.01 (0.02)	
Grade × Expressive Language × African American			-0.01 (0.01)		0.01 (0.02)	
Grade × Expressive Language × Hispanic			0.01 (0.02)			
Grade × Expressive Language × Other			0.00 (0.02)			
Grade × Math × African American			-0.01 (0.01)		0.11 (0.04)**	
Grade × Math × Hispanic			0.00 (0.02)		0.06 (0.03)*	
Grade × Math × Other			0.01 (0.02)		-0.01 (0.03)	
Grade × Attention × African American			-0.01 (0.02)		0.17 (0.37)	
Grade × Attention × Hispanic			0.00 (0.02)		-0.16(0.38)	
Grade × Attention × Other			-0.03(0.04)		1.19 (0.47)*	
Grade × Aggressive Behavior × African American			-0.03 (0.04) -0.01 (0.04)		-0.24(0.30)	
Grade × Aggressive Behavior × Hispanic			-0.06(0.04)		-0.48(0.34)	
Grade × Aggressive Behavior × Other			0.00 (0.00)		-0.06(0.42)	
Grade × Aggressive Behavior × Official American			-0.01 (0.03) -0.01 (0.02)		0.70 (0.35)*	
Grade × Internalizing Behavior × Hispanic			-0.01 (0.02) -0.01 (0.04)		-0.31 (0.37)	
Grade × Internalizing Behavior × Other			-0.01 (0.04) -0.04 (0.03)		0.15 (0.46)	
Grade × Social Skills × African American			, ,		, ,	
Grade × Social Skills × Hispanic			-0.01 (0.02) -0.01 (0.02)		0.33 (0.39)	
Grade × Social Skills × Other					-0.26(0.40)	
Orace A Social Skills A Other			0.01 (0.03)		-0.42 (0.47)	

Note. SECCYD = Study of Child Care and Youth Development; ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999. $^{\dagger}p < .10. \quad ^*p < .05. \quad ^{**}p < .01. \quad ^{***}p < .01.$

was positively related to the Approaches to Learning variable (i.e., attention proxy) for the other race category (B = 1.19, p < .001).

As can be seen in Tables 9 and 10, we conducted follow-up examination of these interactions to explore potential moderating effects on change over time using slope estimates for the relevant ethnic categories (primarily African American and Caucasian students) at low (i.e., <1 SD below the mean) and high (>1 SD about the mean) levels of the specific moderating variable. As can be seen in Table 9, no distinct differences were noted between the rates of progress in later math skills for either Caucasian students or African American students in the ECLS-K sample for differing

levels of internalizing behaviors; however, as noted in Table 10, kindergarten math skills were predictive of more rapid growth in later math skills over time for both African American and Hispanic students. Effect sizes for these variables were uniformly large.

SECCYD and **ECLS-K** Model Comparisons

Tables 3 provides a comparison between the effect sizes obtained from the main effects from Duncan et al.'s (2007) study, the SECCYD sample, and the ECLS-K sample for reading outcomes. Across all three studies, the effect sizes for the main effects tended

Table 5
Means and Standard Deviations of Outcome Variables in the ECLS-K Sample

		Grade 3			Grade 5	Grade 8		
Ethnicity	Subject	n	M (SD)	n	M (SD)	n	M (SD)	
Caucasian	Reading	6,646	81.79 (23.25)	6,541	134.70 (25.81)	6,442	157.10 (23.76)	
	Math	6,646	66.26 (18.01)	6,558	105.28 (22.90)	6,447	129.41 (22.27)	
African American	Reading	1,306	69.15 (20.32)	1,273	112.34 (25.09)	1,266	134.91 (26.00)	
	Math	1,306	52.52 (14.08)	1,291	83.36 (21.66)	1,267	106.17 (24.41)	
Hispanic	Reading	1,921	70.95 (21.21)	2,119	115.73 (27.15)	2,081	139.78 (25.77)	
•	Math	2,147	55.68 (15.72)	2,129	90.85 (23.23)	2,082	116.11 (24.43)	
Other	Reading	1,431	79.49 (26.01)	1,409	124.80 (27.71)	1,391	147.43 (27.66)	
	Math	1,431	60.50 (17.84)	1,426	98.87 (25.76)	1,392	124.94 (26.07)	

Note. Reading and math scores were determined by item response theory. ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999.

to be small, with some notable exceptions. Within this broad range, effect sizes for early reading skills during kindergarten were small to moderate in all three studies, suggesting the importance of early reading skills to later reading development through the ninth grade. For the SECCYD and ECLS-K samples, there were small-tomoderate effect sizes for early math skills, suggesting a more general effect of early academic skills on later reading development; however, this was not present in Duncan et al.'s study. Expressive language skills produced small effect sizes for the SECCYD study and Duncan et al.'s study; however, this variable was not replicable in the ECLS-K study. Of interest to this study, only a few of the social-behavioral variables showed a significant association with later reading development, and, for those variables, the effect sizes were small and were inconsistently present across the three studies. Whereas Duncan et al. found a small effect size for aggressive behaviors, neither of the other comparison samples produced such a finding. Conversely, the SECCYD sample showed a small, but significant, relationship between internalizing behaviors and social skills at kindergarten to later reading that was not present in the other two studies; furthermore, the ECLS-K sample showed a small, but significant, effect for their Approaches to Learning variable with respect to later reading skills.

Table 4 indicates a similar magnitude of effect sizes across the different samples for the math outcomes, with most of the effect sizes falling within the small range. Early reading had a weak effect in the ECLS-K sample, as well as in the SECCYD sample, and a small-to-moderate effect in the original analysis by Duncan et al. (2007). Early math skills had small-to-moderate effects in

both Duncan et al.'s study and the SECCYD sample but a fairly large effect in the ECLS-K sample. Similar to the comparison of effect sizes in reading outcomes across studies, both Duncan et al.'s study and the SECCYD sample produced small, but significant, effect sizes for expressive language, which was a variable not present in the ECLS-K sample. None of the social-behavioral variables was related to later math outcomes for Duncan et al.'s study, but kindergarten teacher ratings of social skills were related to later math outcomes for both the SECCYD and ECLS-K samples, and kindergarten teacher attention ratings in the ECLS-K sample showed a small effect size.

Despite these similarities and differences, the focus of these comparative findings should be on the difference in magnitude as a function of ethnicity and the key predictor variables. With regard to the effect of early reading on the change over time in later reading, the pattern was notably similar between the two samples (see Table 7). Specifically, although the effect is nonsignificant, Caucasian students with lower early reading scores improved faster than those with higher scores, and African American students with lower reading scores improved more slowly than those with higher early reading scores. No other interactions in the SECCYD or ECLS-K samples were large enough to make similar comparisons.

Discussion

In this study, we examined the importance of selected early predictors at kindergarten on subsequent reading and math trajectories through ninth grade using two data sets: the SECCYD and

Table 6
Means and Standard Deviations of Kindergarten Predictor Variables in the ECLS-K Sample

Caucasian		Africa	n American	Н	lispanic		Other	
Variable	n	M(SD)	n	M(SD)	n	M (SD)	n	M(SD)
Approaches to learning	6,151	3.09 (0.65)	1,211	2.83 (0.70)	2,044	2.93 (0.65)	1,432	3.01 (0.67)
Externalizing problem behavior Internalizing problem behavior Interpersonal skills	6,087 6,034 5,918	1.56 (0.60) 1.51 (0.51) 3.06 (0.62)	1,195 1,169 1,159	1.73 (0.66) 1.53 (0.54) 2.86 (0.63)	1,995 1,969 1,883	1.57 (0.60) 1.55 (0.53) 2.94 (0.59)	1,413 1,386 1,340	1.56 (0.59) 1.53 (0.50) 2.93 (0.62)

Note. ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999.

Table 7
Slopes and Effect Sizes for the Grade × Early Reading × African American Interactions in the ECLS-K Sample

			Reading				Math			
		SECCYD		ECLS-K ^a		SECCYD		ECLS-K		
Ethnicity	Rating	Slope	d	Slope	d	Slope	d	Slope	d	
Caucasian	Low	8.63	0.83	15.63	1.30	6.56	0.77	12.34	1.69	
	High	6.91	0.66	14.11	1.17	6.73	0.79	12.21	1.68	
African American	Low	7.93	0.71	13.52	1.13	6.57	0.77	11.89	1.63	
	High	8.16	0.78	15.35	1.28	6.53	0.77	12.65	1.74	

Note. ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999; SECCYD = Study of Child Care and Youth Development. a Significant three-way interaction.

the ECLS-K. A key focus of this investigation was to examine predictors of later reading and math growth rates for African American versus Caucasian students. Given the ongoing challenges of closing the achievement gap between African American students and their Caucasian peers, being able to identify learning problems earlier may help to lessen the academic morbidity that many African American students experience. In this study, we also wanted to challenge the notion that social-behavioral factors may not be important, or as important, as other variables (e.g., preacademic skills) in predicting later academic performance. In that regard, we attempted to replicate the findings by Duncan et al. (2007) on early predictors, but we have placed an emphasis on examining the subsample of African American children in each of these large data sets. We also have expanded on Duncan et al.'s findings by determining whether social-behavioral skills predicted rates of change over time in reading and math skills using longitudinal methodology.

Findings from these analyses across the two samples reflected the relative contribution of early reading and math skills to later functioning in both of these academic domains for African American youths, but there also were indications for the importance of early expressive language skills to both reading and math in at least one of the samples. Several interactions suggested the moderating effects of early ratings of aggressive behaviors and internalizing behaviors on later reading and math for African American students in the ECLS-K sample but not for those included in the SECCYD sample. For the ECLS-K sample, our findings suggest slower gains in reading in the presence of high ratings of aggressive behavior in

kindergarten for the ECLS-K sample but more rapid gains in the presence of more internalizing symptoms; however, this was not replicated in the SECCYD sample or present in Duncan et al.'s (2007) study. Similarly, for long-term outcomes in math, several interactions suggested the moderating effects of early teacher ratings of attention and internalizing behaviors for African American students as compared with Caucasian students in the ECLS-K sample versus the SECCYD sample, with better ratings of attention and presence of internalizing behaviors in kindergarten being associated with more rapid rates of progress in math. Again, these findings were not uncovered in either the SECCYD sample or in Duncan et al.'s study.

Although the relative contributions of social-behavioral variables to later academic performance were inconsistent and, at best, minimal across the two samples, the current findings do not resolve the question of the importance of such variable to later academic skills in African American students. In general, the differences obtained from the SECCYD and the ECLS-K samples reflect the need for ongoing investigation of the relationship between multiple predictor variables with African American children. The differences in findings between the two large data sets, as well as Duncan et al.'s study, were perplexing and did not appear to be related to issues of power or sample ascertainment. Further, the SECCYD and the ECLS-K samples both contained similar percentages of African American students. One major difference related to the models constructed to examine the research questions in that the SECCYD sample permitted examination of many more covariates than the ECLS-K sample, and this

Table 8 Slopes and Effect Sizes for the Grade \times Aggression \times Race Interactions in the ECLS-K Sample

	Rating		Reading				Math				
Ethnicity		SECCYD		ECLS-K ^a		SECCYD		ECLS-K			
		Slope	d	Slope	d	Slope	d	Slope	d		
Caucasian	Low	7.75	0.74	14.35	1.19	6.66	0.64	12.23	1.02		
	High	7.80	0.75	14.51	1.21	6.65	0.64	12.23	1.02		
African American	Low	7.91	0.76	14.9	1.24	6.72	0.65	14.41	1.20		
	High	7.64	0.73	13.96	1.16	6.58	0.63	12.13	1.01		

Note. ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999; SECCYD = Study of Child Care and Youth Development. a Significant three-way interaction.

Table 9
Slopes and Effect Sizes for the Grade × Internalizing × Race Interactions in the ECLS-K Sample

			Reading				Math				
		SECCYD		ECLS-K ^a		SECCYD		ECLS-K ^a			
Ethnicity	Rating	Slope	d	Slope	d	Slope	d	Slope	d		
Caucasian	Low	7.69	0.74	14.60	1.22	6.56	0.77	12.43	1.71		
	High	7.86	0.75	14.25	1.19	6.73	0.79	12.12	1.66		
African American	Low	7.57	0.73	13.87	1.15	6.57	0.77	11.93	0.99		
	High	7.92	0.76	14.99	1.25	6.34	0.74	12.36	1.05		

Note. ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999; SECCYD = Study of Child Care and Youth Development. a Significant three-way interaction.

may have accounted for the weak, but significant, interactions that were present in the ECLS-K sample.

Taken together, these findings show relatively strong replication of the original findings from the larger study by Duncan et al. (2007). For their more expansive study that included large heterogeneous groups of children, Duncan et al. concluded that the best predictors of later achievement were kindergarten math, reading, and attention skills, in that order, but that early social-behavioral functioning was insignificant with respect to predicting later achievement. Our study would support these findings, particularly the early reading, math, and, perhaps, expressive language skills for both Caucasian and African American populations. In contrast, we did not find consistency across studies for the importance of early attention-related variables to later learning.

It was curious that we uncovered significant evidence, albeit weak, suggesting the importance of aggressive and internalizing behaviors in kindergarten as important to later reading growth, and the importance of internalizing behaviors in kindergarten as important to later math growth in only the ECLS-K sample. These findings are intriguing in that they could be directly related to underlying cognitive processes that contribute to both behavior regulation and learning. They also could be related to the possibility that many children with various kinds of internalizing and externalizing behaviors (e.g., conduct problems, heightened anxiety) may miss out on key instructional time because of being removed from the class secondary to disruptive behavior, which, in turn, may interfere with the development of specific academic

skills. How these types of problems interact with other key predictors, such as attention problems, also may be important to understand (e.g., Phillips-Smith, Prinz, Dumas, & Laughlin, 2001). When the findings from these two samples, as well as the findings from the larger study by Duncan et al. (2007), are compared, nearly all of the effect sizes fall within the small range, indicating that other factors (e.g., type of school, student–teacher relationships, family variables) are contributing to long-term academic outcomes.

Although there is an abundant literature addressing the learning challenges of African American students, there is a relative dearth of work examining reasons for underachievement in African American youths (Davis, 2003). Our findings with African American students provide one of the first glimpses of the relative predictive power of selected factors for the development of core reading and math skills throughout the elementary school years via two large longitudinal samples. These findings replicated many of the findings by Duncan et al. (2007), but they are only the beginning of the process of delineating other early predictors that might be of importance for this population. Indeed, the relationship between early behavior problems and later lower math skills is consistent with available work studying learning in African American children (Carlson et al., 2009). Conversely, a number of investigators have reported the relative importance of poor academic achievement skills as early predictors of later affective symptoms in middle school (Herman et al., 2008). How these complex relation-

Table 10 Slopes and Effect Sizes for the Grade \times Early Math \times Race Interactions in the ECLS-K Sample

Ethnicity			Reading				Math				
	Rating	SECCYD		ECLS-K		SECCYD		ECLS-K ^a			
		Slope	d	Slope	d	Slope	d	Slope	d		
Caucasian	Low High	7.95 7.59	0.76 0.73	14.11 14.76	1.17 1.23	6.68 6.62	0.78 0.78	12.14 12.41	1.67 1.70		
African American	Low	7.79	0.75	14.39	1.20	6.77	0.79	11.21	1.54		
Hispanic	High Low High	7.76 7.34 8.20	0.75 0.71 0.79	14.47 13.84 15.02	1.20 1.15 1.25	6.53 6.67 6.62	0.77 0.78 0.78	13.33 11.69 12.86	1.83 1.60 1.77		

Note. ECLS-K = Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999; SECCYD = Study of Child Care and Youth Development. a Significant three-way interaction.

ships hinder school performance and worsen the achievement gap for African American students remains to be determined.

Finally, it is important to note that language impairments, academic deficits, and concomitant social-behavioral difficulties are not independent of one another (Bowman et al., 2006; Brinton & Fujiki, 2004; Nelson, Benner, Lane, & Smith, 2004; Tomblin, Zhang, Buckwalter, & Catts, 2000). In this regard, Davis (2003) has called for a defined research agenda to focus on the achievement issues of African American students and for early assessment and intervention to address many of the achievement gap challenges. In the meantime, the importance of social-behavioral functioning to the later learning of African American students should remain an important area of ongoing scientific inquiry; however, a clear focus should be on increasing the early core skills necessary for later learning, as these skills have modest power in facilitating later growth in reading and math.

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