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Measuring success: Within and cross-domain predictors of academic and social trajectories in elementary school

Amy Pace[a,*], Rebecca Alper[b], Margaret R. Burchinal[c], Roberta Michnick Golinkoff[d], Kathy Hirsh-Pasek[e]

[a] University of Washington, Department of Speech and Hearing Science, 1417 NE 42nd St, Seattle, WA 98103, United States
[b] Communication Sciences and Disorders, Temple University, 110 Weiss Hall, 1701 North 13th Street, Philadelphia, PA 19122, United States
[c] FPG Child Development Institute, CB#8185, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-8185, United States
[d] School of Education, University of Delaware, 206 Willard Hall, Newark, DE 19716, United States
[e] Department of Psychology, Temple University, Weiss Hall, 1701 North 13th Street, Philadelphia, PA 19122, United States

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ABSTRACT

Children's skill levels in language, mathematics, literacy, self-regulation, and social–emotional adjustment at kindergarten entry are believed to play an important role in determining school success through their long-term association with academic and social skills in primary and secondary education. Hence, children's school readiness is a national priority. To date, there is some evidence that specific individual school readiness skills relate to specific outcomes, but much of that research has not addressed concerns regarding generalization due to the high levels of correlations among the school readiness skills. The interrelationships among school readiness domains and patterns of skill acquisition – during the first three years of primary education in which basic skills are the focus and in the later years of primary or secondary education when higher-order skills are the focus – have not been explored adequately. Using the NICHD Study of Early Child Care and Youth Development dataset ($n = 1364$), this research conducted growth curve analyses to examine a comprehensive set of readiness indicators in kindergarten and identify which domains were stronger predictors of academic and social trajectories through grade 3 and from grades 3 to 5. Results highlight the importance of examining multiple school readiness domains *simultaneously* rather than separately, and moving beyond outcomes (skill levels) at a particular grade to consider which kindergarten skills predict gains over time (skill acquisition) both within- and across-domains. Empirical and methodological implications are considered for educational research, policy, and practice.

1. Introduction

Children's kindergarten performance within domains like language, mathematics, literacy, self-regulation, cognition, approaches to learning, and social–emotional adjustment is generally maintained throughout the primary and secondary years (Entwisle & Alexander, 1999; Reardon, Valentino, & Shores, 2012). Because of this continuity, children's school readiness is a national priority; educators and policymakers have focused on identifying and promoting the particular skills young children are thought to need to assure long-term success in school (Scott-Little, Lesko, Martella, & Milburn, 2007). When considered independently, development in each of these domains has been positively associated with academic achievement and social adjustment during the transition to school and throughout the school years (Snow & Van Hemel, 2008).

Along with improvements in operationally defining discrete readiness domains, recent research has deepened the field's understanding of complex interrelationships among developmental processes that facilitate success in traditional classroom environments (Hair, Hanson, Wolfe, & Pollak, 2015; Johnson, 2008; Lerner, Lerner, Bowers, & Geldhof, 2015). This work has also fostered a greater appreciation for the intricate tapestry of multi-level interactions – between children, caregivers, teachers, classroom environments, community contexts, and cultural values – that directly influence or mediate developmental outcomes (Baptista, Osório, Martins, Verissimo, & Martins, 2016; Connor et al., 2009;

* Corresponding author.
E-mail addresses: amypace@uw.edu (A. Pace), rebecca.alper@temple.edu (R. Alper), burchinal@unc.edu (M.R. Burchinal), roberta@udel.edu (R.M. Golinkoff), khirshpa@temple.edu (K. Hirsh-Pasek).

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Downer, Sabol, & Hamre, 2010; McCormick, O'Connor, Cappella, & McClowry, 2013). Furthermore, there is an emerging consensus that development in one domain often influences – or is contingent upon – development in other domains (Bierman, Torres, Domitrovich, Welsh, & Gest, 2009; Hamre, Hatfield, Pianta, & Jamil, 2014). Hence, academic and social development are interrelated and dynamic over time (McWayne, Hahs-Vaughn, Cheung, & Wright, 2012; van Geert & Steenbeek, 2005). This amounts to a substantial empirical foundation from which to consider not only the child's developmental correlates for academic achievement, but also how multiple contextual and ecological factors interact with these individual-level variables.

Despite – or by virtue of – these strides, the field of child development finds itself at a crossroads. We have amassed a basic knowledge regarding the critical skills and contexts for school success, providing a unique opportunity for reconsidering the direction of education research, policy, and practice. But these skills do not develop completely independently of one another. Although mounting evidence suggests that skill in one domain may be influenced – directly or indirectly – by skill in other domains, standards for school readiness are often based on research measuring outcomes in a single domain at a single point in time (Scott-Little et al., 2007; Stedron & Berger, 2010). There are ample data on the individual contributions of skills in specific domains, but there is much less evidence about the ways in which these domains work together to foster development. And whereas recent work has called attention to skills that may predict development across domains more broadly (Best, Miller, & Naglieri, 2011; Dickinson, Golinkoff, & Hirsh-Pasek, 2010; Dickinson & Porche, 2011; Purpura, Hume, Sims, & Lonigan, 2011; Snow & Matthews, 2016), this evidence has yet to be translated into education policy and practice. This topic may be of particular relevance given the recent push to emphasize certain types of instruction (mathematics and reading) over others (social and emotional) at earlier grades (Bassok, Latham, & Rorem, 2016) without a comprehensive understanding of how these skills may be interrelated (Dickinson, Freiberg, & Barnes, 2011).

Given this context, the purpose of this article is both empirical and practical. First, we use a longitudinal dataset to investigate how multiple dimensions of readiness including cognitive development, pre-academic skills, social skills, emotional adjustment, and overall health – when considered together – predict academic and social trajectories during the elementary school years, focusing specifically on skill acquisition within and across domains. We discuss these findings, their limitations, and directions for future research in the context of the current educational landscape, with particular emphasis on issues surrounding methodology and measurement. Second, this paper considers implications for policy and practice. We suggest that research may do well to move beyond isolated studies of discrete domains and promote a richer understanding of the multiple factors that contribute to developmental outcomes within and across dimensions. To meet this aim, we discuss future directions for scientific inquiry intended to support evidence-based methods for measuring, improving, and sustaining academic and social development from readiness to achievement and beyond.

1.1. Kindergarten predictors of academic achievement

It is widely accepted that children's competencies at kindergarten entry are important for long-term success in school (Sabol & Pianta, 2012). Recent comprehensive frameworks for school readiness emphasize a multifaceted construct comprised not only of language development, physical health, motor development, and pre-academic skills (early literacy, mathematics, science, and general knowledge; Wackerle-Hollman, Schmitt, Bradfield, Rodriguez, & McConnell, 2015), but also children's approaches to learning in the classroom (e.g., enthusiasm, curiosity, attention and persistence; Barbu, Yaden, Levine-Donnerstein, & Marx, 2015), social–emotional development, and executive functioning (including attention, working memory, and mental flexibility; Blair & Raver, 2015; Schmitt, McClelland, Tominey, & Acock, 2015). Many state and federal early childhood programs like Head Start already incorporate multiple dimensions in their learning standards (Scott-Little et al., 2007).

Positive associations with subsequent academic achievement is available from research in each respective domain. **Physical health** has generally been positively associated with academic performance (Singh, Uijtdewilligen, Twisk, Van Mechelen, & Chinapaw, 2012; Trudeau & Shephard, 2008), and children with chronic health conditions or disabilities are more likely than their healthier peers to have poor academic outcomes (Fowler, Johnson, & Atkinson, 1985; Hack et al., 2002). Some evidence suggests that **fine motor skill** may also be an important predictor of later achievement (Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010). **Language development** – including vocabulary, grammar, narrative discourse, and pragmatics – has long been recognized as a positive predictor of academic outcomes, with particular influence on reading proficiency (Catts, Corcoran Nielson, Sittner Bridges, & Liu, 2016; Dickinson et al., 2011; Murphy, LARRC, & Farquharson, 2016). **Pre-academic skills** such as letter recognition and number awareness, are also highly correlated with children's later achievement in reading (NELP, 2009) and mathematics (Claessens and Engel, 2013; Duncan et al., 2007).

Over the last decade, children's ability to regulate social, emotional, and cognitive behaviors and how these are related to academic achievement has also garnered increased attention. These skills help children navigate structured learning environments and classroom contexts. Positive **social and emotional skills** have been shown to foster children's interactions with peers and teachers (Keogh, 1992) and support learning outcomes (McCormick et al., 2013). Aspects of **executive function** such as attentional flexibility, working memory, and inhibitory control (see Carlson, Zelazo, & Faja, 2013 for a review; McClelland, Cameron Ponitz, Messersmith, & Tominey, 2010), are thought to be foundational for school success in that they help children avoid distractions and persist through difficulty (McClelland et al., 2014) and have been identified as strong, consistent predictors of long-term academic outcomes (McClelland, Acock, Piccinin, Rhea, & Stallings, 2013).

Each of these domains is highly complex, so it is no great surprise that many research programs are largely devoted to studying development within the boundaries of a single domain. However, the abundance of within-domain knowledge has given rise to questions surrounding the mechanisms that may support shared development across dimensions. Addressing questions of how readiness skills act in tandem to predict later outcomes has significant implications for parents, educators, and policymakers regarding how to best prepare children to succeed in school (Duncan & Murnane, 2011) and continue to support children's growth throughout the school years. Despite clear links between the skills in early development, the relative contribution of the selected school readiness skills to predict school-age academic and social trajectories is still largely unclear. Although a wealth of research identifies key developmental domains that have been independently related to subsequent success in school (Halle, Hair, Burchinal, Anderson, & Zaslow, 2012), empirical evidence to explain why such associations exist – and how they may interact – has been more limited.

1.2. Links across developmental domains

Within-domain research has yielded many important findings, but a growing body of evidence has drawn attention to the fact that none of these readiness skills develop in isolation. Rather, recent

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work across disciplines has identified cross-domain predictions (McClelland, Acock, & Morrison, 2006; Puranik, Lonigan, & Kim, 2011; Vallotton & Ayoub, 2011) and intervention effects (Schmitt et al., 2015) – demonstrating the interconnectedness of academic and cognitive domains during early childhood and beyond (Downer et al., 2010; Rhemtulla & Tucker-Drob, 2011). One body of research has examined whether certain abilities and behaviors at kindergarten entry are more strongly predictive of later school success than others. This work has revealed complex and occasionally inconsistent predictive associations between early skills and later achievement.

Duncan and colleagues conducted meta-analyses of large longitudinal studies, using kindergarten-entry measures of reading, mathematics, attention, and socioemotional skills to predict academic outcomes in third (Duncan et al., 2007) and fifth grade (Claessens, Duncan, & Engel, 2009). Results from this set of studies found that reading skills at entry to school predicted subsequent reading skills at both ages and mathematics skills in fifth grade, but mathematics skill at entry to school was the strongest predictor of both reading and mathematics skills in third and fifth grade. Attention, but not social skills or behavior problems, was a more modest but significant predictor of subsequent academic skills in these analyses. Using some of the same datasets, Grissmer et al. (2010) found that fine-motor skills and general knowledge of the social and physical world also predicted later mathematics, reading, and science outcomes along with attention and early academic skills (Grissmer et al., 2010), with general knowledge being a stronger predictor than early mathematics and early reading for some outcomes.

Other research has focused on identifying general abilities that may be correlated with achievement across domains while simultaneously isolating content-specific skills that may influence achievement in one domain (e.g., math) but not another (e.g., reading). For instance, children's abilities in first grade such as working memory and processing speed were related to both mathematical and reading achievement in fifth grade, but specific quantitative competencies were uniquely predictive of mathematical achievement, not reading (Geary, 2011). Another study showed that third-grade calculation and word-reading performance were both significantly related to general cognitive processes such as memory retrieval and attentive behavior measured in first grade, but other skills – such as counting and early language – were uniquely predictive of mathematics or language but not both (Fuchs, Geary, Fuchs, Compton, & Hamlett, 2016). Taken together, this promising approach has yielded evidence that domain-general and domain-specific skills are often both related to academic achievement across domains, but these effects manifest in varied ways with diverse factors acting as mediating variables that account for individual differences in outcomes across distinct domains (see also Chu, vanMarle, & Geary, 2016).

Self-regulation, executive functioning and approaches to learning during early childhood have been identified by other research as the strongest predictors of school-age academic and social outcomes (Blair & Raver, 2015; Clements, Sarama, & Germeroth, 2016; Hamre & Pianta, 2001; Sasser, Bierman, & Heinrichs, 2015). For instance, children with better approaches to learning skills at kindergarten entry – including persistence, emotion regulation, and attentiveness – showed stronger mathematics and reading performance in kindergarten, first, third, and fifth grade (Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010). New evidence from a study that measured executive function and effortful control in preschool children demonstrated these aspects of self-regulation were related to initial levels of mathematics and reading ability, but persisted only for mathematical achievement in second grade (Blair et al., 2015). Importantly, this study indicated that executive functioning contributed to the model even when entry-to-school language skills were considered as a covariate (Blair et al., 2015).

Other studies have used person-centered approaches to create subgroups of children with different school readiness profiles to investigate whether these subgroups also differed on subsequent outcomes. Hair, Halle, Terry-Humen, Lavelle, and Calkins (2006) examined patterns of readiness at school entry and how these profiles predicted first-grade outcomes in a nationally representative sample of first-time kindergartners from the Early Childhood Longitudinal Study – Kindergarten Class of 1998-99 (ECLS-K; Hair et al., 2006). Four profiles emerged in cluster analyses of physical health, social–emotional development, language/literacy, and cognition, with the profiles ranging from a group with high scores across all domains to a group with below average scores in each domain. Not surprisingly, the children in the profiles with lower preschool scores had lower academic and social outcomes in first grade.

Similarly, using the kindergarten and first grade outcomes from the NICHD Study of Early Child Care and Youth Development (SECCYD), Konold and Pianta (2005) conducted cluster analyses with social–emotional and cognitive skills, finding that children with higher levels of cognitive skills (high vs. average) had higher mathematics and language skills in first grade (Konold & Pianta, 2005) and better outcomes on mathematics through fifth grade (Sabol & Pianta, 2012), regardless of social–emotional skills. However, for children with average cognition, those with higher social competence were significantly more likely to have better academic outcomes compared with children who had low social skills in combination with average cognition. Put simply, social skills appeared to compensate for poor cognitive performance, revealing multiple pathways to academic success.

In summary, a number of studies have looked at some, but not all, of the school readiness domains as predictors of outcomes during elementary school. Most analyzed outcomes in specific grades rather than longitudinally and many have omitted at least some of the dimensions as explicit predictors, most conspicuously language. Mathematics and executive functioning have frequently been implicated as the strongest predictors of subsequent academic skills. However, analyses, even of the same data, have yielded different conclusions regarding which school readiness dimensions were the best predictors of child outcomes depending on which school readiness skills were included. These differences have been related to several methodological factors like whether measures of language or general knowledge were included and when specific outcomes were measured (e.g., before or after third grade). The timing of the school-age assessments may be especially important given the onset of high-stakes testing in third grade and the prevailing belief that children who are not making sufficient progress by third grade struggle to catch up later (Jacob, 2017). Given these differences, it is increasingly relevant to simultaneously examine unique contributions of domain specific abilities as well as how multiple domains work together to support subsequent learning. Together, these data may inform the way in which early childhood education programs can meet their mandate of preparing children to succeed in school (Barnett & Frede, 2010; Duncan & Magnuson, 2013; Neuman, 2014).

1.3. Growth vs. proficiency

Although it is important to examine skill levels at school entry, it is equally relevant – and perhaps more informative – to examine gains in skills over time. Using school-age outcomes from specific grades may be problematic if the goal is to identify school readiness skills that predict learning during school years and not the maintenance of the rank-ordering of skills from school entry up to that grade. As one of the best predictors of skills at the end of the year in elementary school is the level of skills at entry to

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school, it is critical that the acquisition of new skills be examined rather than just an overall outcome score at a particular point in development. Probing this question would allow greater investigation into the school readiness domains that have the largest impact on various academic or social skills, above and beyond the level of skill children bring with them to school. Obtaining these answers could prove useful in guiding the allocation of limited classroom resources, making specific recommendations regarding overall improvement in children's academic gains, and addressing growing concerns with patterns of academic fadeout in which the initial positive impacts of early childhood educational experiences diminish over time (Barnett, 2011; Lipsey, Farran, & Hofer, 2015; Magnuson & Duncan, 2016).

Whereas a majority of the existing research has examined predictors of academic outcomes at a single point in time, fewer studies have analyzed longitudinal growth trajectories. Growth modeling techniques represent important methods for understanding children's learning over time, estimating the direction and strength of this learning, and allow for consideration of how individual differences and family factors might influence these effects (Hindman, Cromley, Skibbe, & Miller, 2011). One such study used entry-to-school mathematics skills to investigate the acquisition of mathematics skills from kindergarten to third grade, revealing that children with the lowest level of mathematics skills at school entry also showed the least growth over this period, despite receiving the most time on instruction compared with their peers who had average or high mathematics achievement at the start of kindergarten (Bodovski & Farkas, 2007).

Another recent study examined preschool executive functions to predict gains in mathematics, language, and literacy, finding some evidence that learning related behaviors (e.g., task orientation) mediated the relation between executive function skills and academic gains in preschool (Nesbitt, Farran, & Fuhs, 2015). Sasser and colleagues used growth curve models to estimate the predictive associations between pre-kindergarten executive function skills and trajectories of academic skill development (e.g., mathematics and literacy) and social–emotional adjustment through third grade (Sasser et al., 2015). Preschool EF significantly predicted later mathematical skills, but not literacy skills; EF also predicted social trajectories and this relation was fully mediated by classroom learning behaviors (Sasser et al., 2015). A smaller set of studies has examined the directionality of the relationship between EF and mathematical achievement, hypothesizing that mathematical instruction also supports EF development (Clements et al., 2016). None of these studies, however, included a comprehensive set of school readiness domains as predictors of academic and social trajectories across the school years.

Some work has investigated the extent to which individual gains children make across multiple diverse domains of functioning can be attributed to global developmental processes (Rhemtulla & Tucker-Drob, 2011). Multivariate growth-curve models were fitted to longitudinal data on language, mathematics, reading, gross motor, and fine motor skills of children from preschool through age 7. Results indicated that a domain-general dimension of individual differences in what the authors term "cognitive and psychomotor development" accounted for up to 42% of the individual differences in change across domains, suggesting that a global factor may significantly contribute to development in the early elementary years. Some of this research has revealed that predictive associations may diminish over time, such that certain skills in preschool may be related to academic performance in kindergarten but no longer predictive by later grades (see Blair & Razza, 2007; Sasser et al., 2015). Research that directly addresses how within- and across-domain effects may shift over time is also quite limited. Understanding the factors that influence children's academic and social trajectories over time may help to explain why some skills may be more predictive than others.

1.4. The present study

Foundational research has identified important associations between dimensions of development for school readiness and academic achievement. The present study builds on the existing evidence to further our understanding of the extent to which children's skills at entry to kindergarten predict academic and social trajectories during subsequent schooling. Whereas much of the prior research has examined school readiness domains separately, the present study includes a comprehensive set of school readiness skills as predictors for subsequent learning and social adjustment. Whereas prior studies have largely focused on predicting achievement outcomes in specific grades rather than *gains* in skills during the school years, the present research evaluates overall levels of skill as well as skill gains during the first and later years of primary school. In addition, much of the existing research has measured outcomes at a single point in time. Though achievement at any one point in time may be a valid indicator of current ability, it may be a poor prognosticator of long term success (Kagan, 1990).

The present research conducted growth curve analyses by parsing longitudinal data into two within-individual contrasts to explicitly estimate rate of change in academic and social outcomes from grade 1 to 3 and from grade 3 to 5 based on specific school readiness skills. These growth models evaluated whether children's school readiness skills appeared to facilitate learning over time in a manner that differentiated learning during the early years, closest in time to entry to school, and later years of elementary school. Based on existing evidence of discontinuities in certain domains (e.g., McCoach, O'Connell, Reis, & Levitt, 2006), we hypothesized that kindergarten predictors might differentially be associated with academic and social outcomes in the early elementary years (first through third grade) compared with the later elementary years (third through fifth grade). Finally, effects of school-entry language, academic, attention, health, and socioemotional skills on social and academic trajectories were considered when child (e.g., age, gender, disability status) and family (e.g., marital status, maternal education, income) factors were included as covariates to reduce potential selection bias.

2. Methods

2.1. Participants

Secondary data analyses of NICHD Study of Early Child Care and Youth Development (NICHD SECCYD) were conducted. The participants for this observational longitudinal study ($n = 1364$) were recruited at birth from hospitals located in ten sites around the United States in 1991. During 24-h sampling periods, 5265 new mothers met the selection criteria and agreed to be contacted after returning home from the hospital. Slightly over 50% of those contacted agreed to participate. At 1 month of age, 1364 healthy newborns were enrolled in the study, and over 1200 children were still enrolled when children entered kindergarten. Although it was not a nationally representative sample as it under represented low-income families and excluded certain groups (e.g., families expecting to move), the study sample closely matched national and census tract records with respect to some demographic variables such as ethnicity at the time of data collection. The majority of children in the sample were White, while 12% were African American, and 11% were Hispanic or of another ethnicity. About 30% of mothers had a high school education or less, and 14% were single parents (NICHD Early Child Care Research Network, 1997).

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2.2. Measures

Family, child care, and child outcome variables were measured in home- and lab-based assessments when the children were 6, 15, 24, 36, and 54 months and in grades 1, 3, and 5. Assessments included repeated measures of demographic and parental characteristics, quality of parenting, type, amount and quality of child care, and children's social, language, cognitive, and academic skills. Here we focused on measures of school readiness, children's academic and social skills in grades 1, 3, and 5, and selected covariates.

2.2.1. School readiness measures

The National Academy of Science recommended that measures of preschoolers include assessments of language and cognitive skills, early academic skills (including mathematics and reading), executive function (including aspects of approaches to learning and attention), behavior problems, social skills, and health (Snow & Van Hemel, 2008). For this dataset, each of these skills was tested at the final assessment prior to entry to kindergarten. In some cases, there were multiple measures, and they were combined if they appeared to be assessing a single construct according to measures of internal validity.

Language skills at the 54-month data collection wave included the *Preschool Language Scale* (PLS-3; Zimmerman, Steiner, & Pond, 1979) and *Woodcock–Johnson-Revised Picture Vocabulary* (WJ-R PV; Woodcock & Mather, 1989). The *PLS* measures a range of language behaviors, including vocabulary, morphology, syntax, and integrative thinking, which are grouped into two subscales: Auditory Comprehension and Expressive Language. The test is standardized to have a mean of 100 and a standard deviation of 15 (Cronbach alphas = .89 and .92 respectively in the current study). The *WJ-R Picture Vocabulary* measures the ability to recognize or to name pictured objects. The first 6 items are in a multiple-choice format. The child is asked to point to the picture that shows the object mentioned by the examiner. Subsequent items require the child to name familiar and unfamiliar pictured items. The split-half reliability for children tested at age 5 was .70 for Picture Vocabulary. A factor analysis of the 2 summary scores from the *PLS* and the *WJ-R PV* indicated a single factor, and the internal consistency was high (alpha = .82). A single composite was created as the mean of the standardized scores for the 3 summary scale scores.

Early academic skills were measured with the *WJ-R*. Children's early literacy skills were assessed with the *Letter-Word Identification* scale and early mathematical skills with the *Applied Problems* scale (Woodcock & Mather, 1989). The *Letter-Word Identification* scale measures letter skills and developing word-decoding skills and has a median split-half reliability of 0.98 for children 4–7 years old (Mather & Woodcock, 2001). The *Applied Problems* scale measures children's early mathematical operations needed to solve practical problems. Published split-half reliabilities for children 4–7 are 0.92–0.94 (McGrew & Woodcock, 2001). Although correlated, we retained the two as separate measures because prior work had indicated that early mathematical skills were especially predictive of academic skills during elementary school (Duncan et al., 2007).

Attention skills – both sustained and selective attention – were measured using the *Continuous Performance Task* (CPT; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956), also considered a measure of aspects of executive function. This instrument was administered by an experimenter to each child individually towards the end of a 2 ½-h laboratory visit. The child was seated at a table in front of a 2-inch square screen and a red button. Dot-matrix pictures of 10 familiar objects (e.g., butterfly, fish, flower) were generated by a computer and presented on the screen. The child was asked to press the button "as fast as you can" each time a target stimulus (a chair) appeared on the screen. A total of 220 stimuli were presented in 22 blocks. The target stimulus was randomly presented within each block and appeared twice within each block for a total of 44 presentations, leaving 176 presentations of non-target stimuli. Each stimulus appeared on the screen for 500 ms, with 1500 ms inter-stimulus intervals. Children's task was twofold: (a) to press the red button as soon as they saw the image of the chair on the screen and (b) to refrain from pressing the button at the appearance of other non-target stimuli. The task took 7 min 20 s on average. Children's performance on the CPT has high construct validity as a measure of attention (Halperin, Sharma, Greenblatt, & Schwartz, 1991), and adequate predictive validity (e.g., Barkley, 1994; Campbell & Ramey, 1994).

Social–emotional adjustment was measured using two questionnaires completed by the kindergarten teachers when the child entered school, *Social Skills Rating System* (SSRS; Gresham & Elliott, 1990) and *Child Behavior Checklist* (CBCL; Achenbach, 1991). The 38 items on the *Social Skills Questionnaire* from the SSRS involve questions with three response options (never, sometimes, often) asking them to rate how often the child exhibited each behavior in four areas: cooperation (e.g., keeps room neat and clean without being reminded), assertion (e.g., makes friends easily), responsibility (e.g., asks permission before using a family member's property), and self-control (controls temper when arguing with other children). The total score is the sum of all items, with higher scores reflecting higher levels of perceived social competence. The SSQ was normed on a diverse, national sample of children in the 3-to-5-year age range and shows high levels of internal consistency (median = .90) and test–retest reliability (.75–.88). The 113 items on the CBCL ask teachers to rate the extent to which problem behaviors are not true (0), somewhat true (1), or very true (2) of a particular child. The items define two subscales: *Internalizing Problems* (e.g., too fearful and anxious) and *Externalizing Problems* (e.g., argues a lot). Achenbach reports test–retest reliability of .89, inter-parent agreement of .70, and stability of scale of .71 over 2 years. The CBCL scores were standardized to have a mean of 100 and standard deviations of 15, reversed so a higher score meant fewer problems, and a mean of the SSQ and CBCL Externalizing was created.

Health was measured through a rating by the mother during the home visit. She rated the child's overall health, using a scale ranging from 1 (poor health) to 4 (excellent health).

2.2.2. Child outcomes

The school-age outcomes were measured using many of the same assessment tools used to measure school readiness. Language skills were measured with the *WJ-R Picture Vocabulary* scale. Mathematical skills were measured with the *WJ-R Applied Problems* scale. Reading skills were measured with the *WJ-R Letter-Word Identification* scale in grade 1 and with the *Passage Comprehension* scale in grades 3 and 5. The *Passage Comprehension* subtest measures children's ability to read and comprehend texts of increasing difficulty. The WJ-R w-scores were developed to accurately describe change over time, and were used in all analyses for that purpose. Teachers rated children's behavior problems and social skills each spring. The child's behavior problems were measured from the teacher ratings of externalizing problems on *CBCL* and their social skills with the *SSQ.*

One methodological issue related to reading outcomes deserves mention. Reading skills were measured with a test of decoding and letter/word identification in grade 1 and a test of reading comprehension in grade 3 and 5, reflecting the change in focus of reading instruction in those years. Despite measurement-related limitations with this approach, the across time correlations among the three scores suggest that they are measuring a developmental trajectory, with correlations of .64 (G1–G3) and .78 (G3–G5) for adjacent scores (i.e, reflecting a pattern seen in all of the other longitudinal assessments such as WJ Applied Problems with

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r(G1,G3) = .68 and r(G3,G5) = .78). Thus, we maintain both in our analyses.

2.2.3. Covariates

Covariates included measures collected in the first visit with the family, including site, race and ethnicity (African American, Hispanic, White or non-Hispanic or other), gender, and maternal education. Home visits at 6, 18, 24, 36, and 54 included questions about family income, household size, and the mother's marital status. Composites were computed, reflecting the proportion of mothers who were married and the family's average income (computed each time as income divided by federal poverty threshold given household size). Using the mean family income divided by needs, we identified families as low-income if their mean income/needs ratio was less than 2. In addition, at 54 months the mother was asked whether the child had a diagnosed disability, and at fall of kindergarten we computed the child's age at entry based on birthdate and date of entry to school.

2.3. Data analysis

Descriptive analyses for all analysis variables and correlations among them preceded longitudinal analyses of each of the school-age outcomes. As shown in Tables 1 and 3, there are some missing data on some of the family characteristics, school readiness variables, and longitudinal outcomes. Multiple imputations were conducted to account for missing data (Rubin, 1996). This approach assumes that data are missing at random, that the reason they are missing is not a function of the outcome measures themselves but due to other factors. Multiple imputation provides good estimates of missing data when there are many other variables in the data that are moderately to highly correlated with the variables that have missing data. For each missing value, a set of plausible values was estimated from the imputation model using a Bayesian E-M algorithm (Schafer, 1997). The missing values are imputed across multiple data sets to provide valid imputation of missing data without reducing variability. Our multiple imputation analyses generated 40 datasets. Analyses were conducted using each of these 40 datasets, and the coefficients and standard errors were combined using PROC MIANALYZE in SAS 9.3. The random variance estimates were averaged over the analyses of the imputed datasets.

Longitudinal analyses involved probing the grade 1, 3, and 5 scores on each outcome as a function of the covariates and school readiness variables. Hierarchical linear models (HLM) were conducted that estimated separate intercepts and slopes for each child as random variables. We used an approach that examined changes from grades 1 to 3 and from grade 3 to 5 so we could address questions about the association between school readiness skills and acquisition of skills in early and later elementary school. Instead of aggregating change over time into linear and quadratic slopes, we estimated two separate slopes that explicitly estimated rate of change from grade 1 to 3 and from grade 3 to 5. This resulted in estimating an intercept that described the child's average level of skill from grade 1 to 5 instead of the child's skills at entry to school. We chose this approach over the more conventional polynomial HLM model because it directly examined issues of interest to us – overall level, rate of change through grade 3, and rate of change after grade 3. The model included the covariates and school readiness variables as predictors of both the intercept and the two slopes reflecting change over time. All variables in these models were standardized to have a mean of 0 and standard deviation of 1 so the coefficients can be interpreted as effect sizes or comparable to standardized regression coefficients.

The analyses focused on testing the degree to which the school readiness skills predicted level and change in academic and social skills from grades 1 to 5. Consistent with the analysis tradition with economics, sociology, and biostatistics, this approach focused on testing the coefficients in the model reflecting those associations rather than testing the overall model. Such an approach is more appropriate when developmental theories are tested.

The outcome measures were both age/grade equivalency scores and standard scores. Ideally, interval-level measures that reflected changes in skill levels over time would be used for all outcomes. Interval-level assessment is critical for all linear model or structural equation analyses including HLM that rely on normal distributions for analyses. Analyzing ordinal-level data with HLM requires special methods that can accommodate a relaxing of the assumption that a one-point difference on the scale reflects the same difference in skill level within a time point and across time. Our academic and language outcomes met both the distributional assumption and reflected change over time because the w-scores are calibrated to reflect acquisition of skills over time with interval level measurement.

Our social skills and psychological outcomes did not reflect change over time, but their standard scores are measured at the interval level. Neither the CBCL nor the SSQ provide scores that describe developmental changes across time between grades 1 and 5. The same items are administered in all these grades, but using the raw scores would provide ordinal, not interval, level measurement. Furthermore, there is no reason to expect developmental shifts in the raw scores since the SSQ asks teachers to rate children relative to their age peers and the incidence of behavior problems is not expected to increase or decrease markedly across these grades.

3. Results

3.1. Descriptive analyses

Table 1 reports descriptive statistics, including demographic characteristics and performance on measures of school readiness prior to kindergarten entry.

Table 2 reports the simple correlations among the covariates and school readiness skills. We see the expected pattern of correlations among school readiness variables, including large correlations among WJ-R measures of language, reading, and mathematics. The highest correlation among the school readiness skills variables involved mathematics and language, as reported in other studies (e.g., Howes et al., 2008; Peisner-Feinberg & Burchinal, 1997). Attention and social-emotional adjustment at entry to school showed moderate correlations with academic and language skills. Health tended to show very modest correlations, likely reflecting the overall good health of these children and the fact that health was not measured as a continuous variable.

Table 3 shows the descriptive statistics for the school-age outcomes, Table 4 lists their correlations within and between grades, and Table 5 displays the correlations between the school readiness variables and school-age outcomes. Analyses revealed high levels of correlations among the language and academic variables and among the social–emotional variables (Table 4). Similar, albeit somewhat weaker, patterns emerged among the correlations between the school readiness variables and school-age variables in Table 5. Except for health, there were moderate to large correlations between the selected school readiness variables and the school outcomes, with larger correlations in general between academic and language school readiness skills and subsequent language and academic school-age outcomes and between the social–emotional school readiness measure and subsequent behavior problems and social skills. This likely reflects both continuity within domain and measure-specific variance since many of the same measures were used to assess school readiness and school-age outcomes.

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Table 1
Descriptive statistics: Demographic characteristics and school readiness skills.

	N	Prop.	Mean	SD	Min	Max
Race/Ethnicity	1364					
African American		0.13			0.00	1.00
Hispanic		0.06			0.00	1.00
White/nonHispanic		0.77			0.00	1.00
Other		0.05				
Gender (female = 1)	1364	0.48			0.00	1.00
Mother's Education	1363		14.23	2.51	7.00	21.00
Low Income: 6–54m	1302	0.30			0.00	1.00
Mother married: Prop 6–54m	1363		0.75	0.40	0.00	1.00
Age at entry to K	1080		5.41	0.31	4.80	6.61
Diagnosed disability at entry to K	1084		0.05	0.23	0.00	1.00
Social-Emotional Composite (α=·71)	1006		102.3	12.07	45.52	125.0
CBCL Externalizing –fall K	1004		50.49	8.90	22.00	61.00
SSRS Social Skills total-fall K	993		103.47	14.05	49.00	130.00
CPT% Correct (attention) 54m	1002		32.61	8.42	2.93	44.00
General Health 54m	1083		3.39	0.65	1.00	4.00
WJ-R Letter Word (pre-reading) 54m	1056		98.93	13.52	63.00	166.0
WJ-R Applied Problems (math) 54m	1053		102.9	15.63	41.00	153.0
Language Composite (α=·82)	1078		99.67	15.99	48.33	130.7
WJ-R Picture Vocabulary 54m	1060		100.24	15.03	10.00	143.00
PLS Auditory Comprehension 54m	1063		98.34	19.92	50.00	139.00
PLS Expressive Communication 54m	1055		100.62	19.95	50.00	128.00

Note. CBCL = Child Behavior Checklist; CPT = Continuous Performance Task; PLS = Preschool Language Scale; SSRS = Social Skills Rating Scale; WJ-R = Woodcock Johnson-Revised.

Table 2
Correlations among demographic characteristics and school readiness skills.

	Demographic Characteristics								School Readiness Skills					
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Covariates														
1. African 0American	–.10	–.09	.00	–.20	.32	.40	.06	.07	–.18	–.12	–.09	–.20	–.32	–.36
2. Hispanic		–.06	.00	–.12	.10	–.05	–.01	–.04	.00	–.02	–.10	–.10	–.10	–.12
3. Other			.01	.00	.01	–.08	–.02	–.01	.01	.01	–.05	.05	.00	–.04
4. Female				.04	–.03	–.02	–.10	–.04	.00	.03	.02	.10	.12	.10
5. M Education					–.48	.41	.05	.08	.20	.15	.16	.38	.39	.47
6. Low Income						–.53	.00	.11	–.19	–.18	–.13	–.32	–.36	–.44
7. M Married							.00	–.07	.25	.15	0.10	.25	.30	.35
8. Age –K entry								.04	.03	–.05	0.03	–.04	–.07	–.07
9. Disability									–.10	–.06	–.13	–.09	–.11	–.19
School Readiness Skills														
10. Social-Emotional										.18	.04	.23	.32	.31
11. Attention											.02	.24	.32	.31
12. General Health												.08	.09	.15
13. Pre-reading													0.58	.56
14. Math														.71

Note. correlations of |.10| or greater have a $p < .001$, of |.085| or greater have a $p < .01$, and of |.06| or greater have a $p < .05$.

Table 3
Descriptive statistics: Child outcomes in grades 1, 3, and 5.

	Grade								
	1			3			5		
	N	Mean	Sd	N	Mean	Sd	N	Mean	Sd
CBCL Externalizing (t score)	1007	50.68	8.72	982	51.51	9.36	927	50.96	9.15
SSRS Social Skills (standard score)	1000	103.2	13.64	975	102.2	14.48	921	102.8	14.44
WJ-R Letter-Word & Passage Comprehension (w score)[a]	1025	452.6	23.99	1011	495.3	14.53	991	505.2	12.73
WJ-R Applied Problems (w score)	1023	470.0	15.54	1013	497.3	13.19	993	509.8	12.85
WJ-R Picture Vocabulary (w score)	1020	483.9	12.27	1014	496.9	11.51	992	505.8	12.08

Note: [a]Letter-Word Identification was administered in Grade 1 and Passage Comprehension in Grades 3 and 5.

3.2. HLM analyses

The HLM analyses were conducted using the multiply imputed data, with coefficients and standard errors combined across the analyses in each dataset. The models included the six school readiness variables, the selected covariates, and time. To represent individual differences in change across the three time points, we created two across-time contrasts. One contrast described each child's change from grade 1 to 3 and the other from grade 3 to 5. The HLMs tested the extent to which the school readiness variables independently added to predicting the child's overall school-age skill, change from grade 1 to 3, and change from grade 3 to 5. Results are shown in Table 6, listing the "standardized" regression coefficients and their standard errors and the random variance estimates.

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Table 4
Correlations among child outcomes in grade 1, 3 and 5.

	CBCL Ext G3	CBCL Ext G5	SSRS G1	SSRS G3	SSRS G5	WJLW G1	WJPCG3	WPCW G5	WJAP G1	WJAP G3	WJAP G5	WJPV G1	WJPV G3	WJPV G5
CBCL Ext G1	0.54***	0.47***	−0.57***	−0.36***	−0.33***	−0.16***	−0.19***	−0.16***	−0.16***	−0.17***	−0.18***	−0.18***	−0.17***	−0.17***
CBCL Ext G3		0.52***	−0.35***	−0.61***	−0.37***	−0.319***	−0.21***	−0.20***	−0.17***	−0.18***	−0.22***	−0.24***	−0.19***	−0.20***
CBCL Ext G5			−0.33***	−0.35***	−0.60***	−0.13***	−0.20***	−0.20***	−0.15***	−0.18***	−0.20***	−0.20***	−0.19***	−0.19***
SSRS G1				0.42***	0.38***	0.26***	0.26***	0.26***	0.31***	0.31***	0.28***	0.28***	0.26***	0.27***
SSRS G3					0.43****	0.28***	0.25***	0.24***	0.30***	0.26***	0.30***	0.23***	0.24***	0.20***
SSRS G5						0.22***	0.28***	0.29***	0.27***	0.27***	0.33***	0.27***	0.25***	0.24***
WJ LW G1							0.64***	0.54***	0.58***	0.53***	0.50***	0.39***	0.45***	0.44***
WJ PC G3								0.78***	0.54***	0.65***	0.63***	0.56***	0.65***	0.65***
WJ PC G5									0.54***	0.61***	0.64***	0.54***	0.60***	0.65***
WJ AP G1										0.69***	0.70***	0.49***	0.47***	0.48***
WJ AP G1											0.78***	0.50***	0.55***	0.54***
WJ AP G5												0.51***	0.53***	0.58***
WJ PV G1													0.74***	0.71***
WJ PV G1														0.79***
WJ PV G5														

Table 5
Correlations between school readiness variables and child outcomes in grade 1, 3 & 5.

Elementary School Outcomes		School Readiness Skills					
	Grade	Social Emotional	Attention	Health	Reading	Math	Language
CBCL Externalizing	1	−.43	−.22	−.08	−.17	−.20	−.20
	3	−.40	−.18	−.09	−.20	−.23	−.26
	5	−.32	−.17	−.02	−.16	−.17	−.21
SSRS Social Skills	1	.42	.23	.09	.22	.30	.33
	3	.36	.17	.06	.22	.28	.30
	5	.32	.16	.06	.20	.26	.33
WJ-R Letter-Word & Passage Comprehension	1	.21	.20	.15	.56	.44	.42
	3	.23	.21	.11	.53	.52	.58
	5	.27	.19	.11	.47	.50	.57
WJ-R Applied Problems	1	.26	.29	.09	.44	.62	.58
	3	.26	.23	.08	.45	.56	.53
	5	.29	.21	.08	.44	.56	.56
WJ-R Picture Vocabulary	1	.26	.15	.12	.42	.47	.64
	3	.22	.14	0.12	.48	.47	.62
	5	.22	.16	.10	.48	.56	.61

Regression coefficients presented are the equivalent of standardized coefficients and, as such, represent the effect size as computed as the relative gain in *SD* units of the outcome when the predictor is one *SD* higher. We present HLM results focusing first on which school readiness domains positively predict the overall levels of academic skills and social adjustment during the primary school years (first 6 rows) and second, which skills best predict gains over time across the primary school years (rows 7–12 show grade 1–3; rows 13–18 show grade 3–5). We adjusted the overall alpha to be 0.01 for these analyses to account for the fact that models include six school readiness variables as the predictors of primary interest.

3.3. Overall level of academic and social outcomes

The first six rows of Table 6 show the main effect coefficients from analyses of academic and social outcomes from grade 1 to 5, revealing the extent to which school readiness skills predicted children's overall skills averaged over time. Children tended to show stability of development as reflected by significant correlations between school readiness skills and overall level of that skill for each domain: preschool social-emotional skills predicted the level of school-age social skills ($B = .25$, $p < .001$) and externalizing behavior problems ($B = -.28$, $p < .001$); preschool math skills predicted the level of school-age math skills ($B = .19$, $p < .001$); preschool reading skills predicted the level of school-age reading skills ($B = .11$, $p < .001$); preschool language skills predicted the level of school-age language skills ($B = .36$, $p < .001$). In addition, there were some across-domain associations in predicting overall level of language, math, and reading. Preschool reading skills predicted overall school-age level of language ($B = .16$, $p < .001$) and math ($B = .08$, $p < .001$). Preschool math skills predicted overall school-age level of reading ($B = .06$, $p < .001$). Preschool language skills predicted overall level of math ($B = .19$, $p < .001$) and reading ($B = .13$, $p < .001$), and was "marginally" related to overall levels of social skills ($B = .08$, $p < .05$).

3.4. Academic and social gains from kindergarten to higher grades

The next set of rows describe change from grade 1 to 3 and the final set of rows describe change from grades 3 to 5 (Table 6). In general, children who entered kindergarten with lower levels of skills in a specific domains showed larger gains over time within that domain, whereas children with higher levels of skills showed smaller gains over time. Children with lower levels of language skills at entry to school showed larger gains in language from grades 1 to 3 ($B = -.10$, $p < .01$) and from grade 3 to 5 ($B = -.10$, $p < .01$). Similarly, children who entered kindergarten with lower mathematics skills also showed significantly larger gains in mathematics skills between grades 1 and 3 ($B = -.08$, $p < .001$) and between grade 3 and 5 ($B = -.09$, $p < .001$), and children who entered school with lower levels of reading skills showed markedly larger gains in reading between grades 1 and 3 ($B = -.26$, $p < .001$), and between grade 3 and 5 ($B = -.28$, $p < .001$). In addition, children who entered kindergarten with lower levels of social skills showed significantly smaller gains in externalizing problems between grades 3 and 5 ($B = .11$, $p < .001$).

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Table 6
HLM analyses predicting grade 1–5 academic and social skills from school readiness skills.

	Language WJ-R PV *B* (se)	Math WJ-R AP *B* (se)	Reading WJ-R LW/PC *B* (se)	Behavior Problems CBCL Ext *B* (se)	Prosocial Skills SSRS total *B* (se)
Fixed Effect Parameter Estimates					
Average Level (intercept)					
Social-emotional	.00 (.02)	.03 (.01)	.02 (.01)	−.28*** (.03)	.25*** (.03)
Attention	−.03 (.02)	.00 (.01)	.00 (.01)	−.07 (.03)	.04 (.03)
Health	.00 (.01)	−.01 (.01)	.01 (.01)	−.01 (.03)	.00 (.02)
Early reading	.16*** (.02)	.08*** (.02)	.11*** (.02)	−.03 (.03)	.01 (.03)
Early math	.00 (.03)	.19*** (.02)	.06*** (.02)	.05 (.04)	.02 (.04)
Language	.36*** (.03)	.12*** (.02)	.13*** (.02)	.03 (.04)	.08 (.04)
Change G1-G3 (slope)					
Social-emotional	−.03 (.02)	.02 (.02)	.00 (.02)	.08 (.03)	−.05 (.03)
Attention	.00 (.02)	−.05** (.02)	−.03 (.02)	.05 (.03)	−.06 (.03)
Health	−.01 (.02)	.01 (.01)	−.05** (.02)	.02 (.03)	−.03 (.03)
Early reading	.04 (.02)	−.05** (.02)	−.26** (.02)	.00 (.04)	.01 (.04)
Early math	.00 (.03)	−.08*** (.02)	−.05 (.03)	.04 (.05)	−.04 (.05)
Language	−.10** (.03)	−.02 (.02)	.11*** (.03)	−.06 (.05)	−.00 (.06)
Change G3-G5 (slope)					
Social-emotional	−.03 (.02)	.02 (.02)	.01 (.02)	.11** (.03)	−.08 (.04)
Attention	.01 (.02)	−.06*** (.02)	−.03 (.02)	.04 (.04)	−.06 (.04)
Health	−.01 (.02)	.00 (.01)	−.05 (.02)	.05 (.03)	−.03 (.04)
Early reading	.04 (.03)	−.05 (.02)	−.28** (.03)	.00 (.04)	.01 (.05)
Early math	.01 (.03)	−.09*** (.02)	−.05 (.03)	.07 (.06)	−.07 (.06)
Language	−.10** (.04)	−.02 (.02)	.10** (.03)	−.04 (.06)	.04 (.06)
Random Variances	$\sigma 2$	$\sigma 2$	$\sigma 2$	$\sigma 2$	$\sigma 2$
Intercept Variance	.194	.157	.439	.273	.158
Grade Variance	.007	.003	.083	.448	.559
Intercept grade covariance	.014	.012	−.076	.012	.012
Residual variance	.129	.097	.083	.448	.559

* $p < .05$; ** $p < .01$; *** $p < .001$ Controlling for site, ethnicity, gender, maternal education and marital status during early childhood, poverty during early childhood, age at entry to K, and disability status at entry to K. Models allowed for individual differences in intercepts and linear rates of change across grade through estimating random intercepts and slopes.

Across domains, we also see limited evidence of gains over time. Children showed slightly smaller gains in mathematics if they entered kindergarten with significantly higher levels of attentional skills (grades 1–3 $B = -0.05$, $p < .01$; grades 3–5 $B = -.06$, $p < .01$) and reading skills (grade 1–3 $B = -.05$, $p < .01$). In addition, children showed slightly smaller gains in reading between grades 1 and 3 if they entered kindergarten with significantly higher rating of health ($B = -.05$).

A different pattern of results, however, emerged in analyses of reading skills during elementary school. Children who entered school with higher levels of language skills showed significantly *larger* gains in reading between grades 1 and 3 ($B = .11$, $p < .001$) and grades 3 and 5 ($B = .10$, $p < .001$). This was the only evidence to suggest that entry level skills in one domain (language) supported the acquisition of skills in another domain (reading) over time, and suggested that children who entered school a standard deviation apart (15 points on the standardized scores for this measure of language) on average had reading scores that were 13% of a standard deviation higher and showed gains of about 21% of standard deviation more over time in their reading skills (i.e., a total of 5.1 points on standardized measures of reading).

4. Discussion

4.1. Overview

This study examined the degree to which school readiness skills at kindergarten entry predicted children's academic and social skills trajectories from 1st to 3rd and 3rd to 5th grade. By including a comprehensive set of predictor variables, we explored which domains positively predicted the overall levels of children's academic skills and social adjustment and which of those school readiness skills best predicted children's gains over time across the primary school years. Three key findings emerged from this investigation. First, although skills within a given domain were almost always the best predictor of skills in that domain during the school years, important differences in the patterns of prediction across domains emerged. Second, few skills at school entry emerged as compelling predictors of longitudinal gains in academic and social skills across the elementary school years; in fact, kindergarten language was the only predictor of longitudinal gains both within and across domains. We did not identify significant discontinuities between early (1–3) and later (3–5) elementary grades. Third, children who entered school with lower skill levels within a given domain tended to show larger gains (and, it follows, children who entered school with higher skill levels tended to show smaller gains), suggesting that schooling was reducing the achievement gap between children with more and fewer skills at entry to school. These findings are discussed in more detail below.

4.2. Predictors of overall performance across academic and social outcomes

Specific cognitive, academic, and social skills at school entry revealed strong within-domain prediction of overall performance from first to fifth grade. That is, kindergarten language skills were the strongest predictor of language outcomes, mathematics skills were the strongest predictor of mathematical outcomes, and social–emotional skills were the strongest predictor of social outcomes. This pattern of domain-specific prediction is consistent with previous research that focuses on early predictors of academic performance within a single domain (Fuhs, Nesbitt, Farran, & Dong, 2014; Li-Grining et al., 2010; McClelland et al., 2013). The use of the same instrument to measure reading, mathematics, and social skills during the pre-school and school years likely increased this association, but it is unlikely that it completely explains these findings. Strong within-domain associations suggest that developmentally appropriate, high-quality instruction in individual content areas

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continues to be integral for specific skill outcomes (Odom, Pungello, & Gardner-Neblett, 2012; Phillips et al., 2017).

In addition, there were several significant predictors of outcomes *across* school readiness domains. In our analyses, language at school entry predicted overall performance in four out of the five domains: language, mathematics, reading, and social skills (but not behavior problems). Following language, kindergarten reading skills predicted three outcomes (language, mathematics, and reading), and early mathematics skills predicted two (mathematics and reading). In this case, language skills at entry to school emerged as the most consistent predictor of subsequent skill levels across academic and social domains. In addition, language skills at kindergarten entry emerged as the strongest overall predictor of reading performance – stronger even than early reading skills themselves!

These findings extend previous research that has identified early skills including mathematics (Duncan et al., 2007), executive function, and self-regulation (Best et al., 2011; Li-Grining et al., 2010; McClelland et al., 2013) as significant predictors of later academic and social achievement in elementary school. Specifically, this research suggests language skills at school entry should be considered in conjunction with other skills more carefully. When language was included in a comprehensive set of indicators, it emerged as a strong and consistent predictor of outcomes. It is already widely accepted that oral language ability is important as an independent predictor of achievement (Asaridou, Demir-Lira, Goldin-Meadow, & Small, 2016; Bleses, Makransky, Dale, Hojen, & Ari, 2016 ; Shanahan & Lonigan, 2010; Morgan, Farkas, Hillemeier, Hammer, & Maczuga, 2015; NICHD ECCRN, 2005); much of this research has identified grammar to be more predictive than other measures such as vocabulary (Shanahan & Lonigan, 2010). Additional evidence is needed, however, to understand how language ability – consisting of lexical, morphological, and syntactic skills – interacts with other domains to predict academic and social outcomes. One view suggests that language functions as a toolkit to help encode relational concepts (such as science terms, abstract vocabulary words and math ideas) of the type that school teaches (Gentner, 2016).

Simple correlations revealed moderate associations across domains, suggesting that analyses that focus on a single or subset of school readiness skills may be misinterpreting the effects of the omitted school readiness skills as the effects of the examined school readiness skills. Consistent with a large body of prior research, language and mathematics were among the strongest correlations in this study, suggesting that these two measures may be fundamentally linked (LeFevre et al., 2010). One limitation, however, is the difficulty in determining how much of this association may be accounted for by language demands on mathematics assessments such as the tool used in this Applied Problems subtest from the WJ-R (Vukovic & Lesaux, 2013). One study showed, for instance, that vocabulary in preschool was no longer predictive of numeracy performance in kindergarten when mathematical language was also considered in the model (Purpura & Reid, 2016). In other words, the variance accounted for by general vocabulary skills in predicting numeracy was better accounted for by math-specific vocabulary. Furthermore, from an applied perspective, these correlations cannot be used as evidence for causation; additional experimental research is needed to identify cross-domain effects. To date, limited research has evaluated whether intervening on certain skills (e.g., language), would have a direct and immediate impact on children's skills in other domains (e.g., mathematical development) or whether there is an indirect relation wherein concurrent interventions (in mathematics and language, perhaps) would demonstrate additive effects when delivered simultaneously. Future work must continue to investigate and evaluate the causal relations between these domains, for both research and educational purposes.

4.3. Predictors of academic and social gains over time

This study employed growth curve models which divided elementary school trajectories into meaningful segments, exploring unique contributions of kindergarten predictors to change over time between grade 1–3 and 3–5. Findings showed that, in general, children who entered kindergarten with lower levels of skills made larger gains from 1st to 3rd and 3rd to 5th grade than those who entered with higher skill levels. This pattern can be viewed as an overall reduction in the achievement gap between children who entered kindergarten with lower versus higher skill levels and reflects a phenomenon termed the "catch-up" effect (Barnett, 2011). This finding is encouraging in light of recent evidence showing persistent disparities in academic achievement between children from high- and low-income families, even as racial gaps in performance have narrowed (Reardon, 2011; Reardon & Portilla, 2015; Reardon, Robinson-Cimpian, & Weathers, forthcoming). Importantly, it should be noted that the data analyzed in this research was collected in the late 1990s and early 2000s. In the two decades since, many nationwide policies such as No Child Left Behind and Every Student Succeeds Act have shifted the educational landscape (Bassok et al., 2016). For this reason, generalizations to educational attainment for children currently in elementary school should be made with caution.

The converse was also true: children who entered kindergarten with higher levels of skills made smaller gains, in general, than those with lower skills at school entry. A large body of literature examining the short- and long-term effects of early-childhood and pre-K programs has investigated this phenomenon. Although the impact of early educational interventions on cognitive, social, and academic outcomes show diminishing effect sizes over time – a pattern often termed "fade-out" (Barnett, 2011; Lipsey et al., 2015) – most recent rigorous program evaluations have identified meaningful, lasting impacts on the development and adult success of children (Burchinal et al., 2016; Rossin-Slater & Wüst, 2016), especially those from disadvantaged backgrounds (Barnett & Masse, 2007) and when interventions begin during the critical developmental period of birth to three (García, Heckman, Leaf, & Prados, 2016; Campbell et al., 2014). Still it is concerning that even though children who arrived at kindergarten with higher levels of skills also had better academic outcomes overall in the present study, they did not make the academic gains that might be expected given their abilities at school entry. This pattern of findings suggests that additional attention and resources should be dedicated to understanding how children's level of skills translates – or fails to translate – into academic gains over time.

One exception to this pattern emerged. Whereas higher skill levels in most school entry domains tended to predict smaller gains over time, higher language skills at school entry actually predicted *larger* gains over time in reading. Language was the only school readiness domain that predicted more rapid acquisition of school-age skills, namely reading skills from first to third, and third to fifth grade. This finding could be explained, in part, by the transition from "learning to read" to "reading to learn," at around 3rd grade (Justice & Sofka, 2010). The "learning to read" phase focuses on letter-to-sound correspondences – the mechanics of reading, or reading code. Later, "reading to learn" skills emphasize comprehension and are known to be heavily grounded in language skills such as vocabulary size and interpretation of syntactic structures (Hoff et al., 2013). These findings bolster the existing body of evidence showing that language acquisition in preschool and kindergarten is critical to later reading success (Dickinson & Tabors, 2001; Storch & Whitehurst, 2002) and lend urgency to research programs that seek to understand how language-rich instructional practices in preschool and kindergarten can improve student literacy outcomes.

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Several possibilities may help to explain why there were so few predictors of academic or social gains over time. First, it is possible that this finding reflects the recently described misalignment between children's skills at school entry and the type of instruction they receive in kindergarten, with teachers spending an inordinate amount of time teaching basic content (e.g., recognizing shapes and counting) that many children had already mastered before starting kindergarten (Engel, Claessens, & Finch, 2013). Converging evidence on how to optimize learning opportunities in preschool and elementary classrooms suggests that effective instruction must be tailored to individual student needs, such that spending class time on letters and sounds is linked to reading outcomes only for children who have not yet mastered these skills (McDonald Connor, Vandell, & Sparapani, 2017). The need for "continuity in instruction" from preschool through third grade has gained traction, but has yet to be translated into policy or practice (Stipek, Franke, Clements, Farran, & Coburn, 2017). Evidence suggests that intentionally organizing and sequencing content and instruction within and across grades – as well as within and across content areas – eliminates redundancies, helps children connect with and build upon previous learning, and contributes to higher student achievement (Neuman, 2014). Additional research and resources are needed to better understand and measure the skills children already have when they arrive at school, identify how content-rich instruction can be tailored to build upon what children know, and evaluate how learning across the curriculum can be bolstered.

It is also possible that this null finding is a reflection, in part, of limitations in the existing tools and instruments commonly used – in this and other research – to measure academic and social competencies. The current research, for example, relied on a narrow measure (Continuous Processing Task) of a single feature (i.e., attention) of executive function as a kindergarten predictor. In addition, the present research relied upon two *WJ-R* subtests included in the NICHD dataset to describe reading trajectories (Letter-Word Identification in G1 and Passage Comprehension in G3 and G5). Reliance on a more comprehensive battery of developmentally appropriate tasks for each domain of interest may provide a more nuanced examination of cross-domain effects over time. Still, identifying *which* skills to measure, as well as *when* and *how* to measure them is no easy task. Along with greater knowledge of the unique factors (e.g., attention, self-regulation, and working memory) that comprise multidimensional constructs (e.g., executive function; McClelland & Cameron, 2012; Schmitt, Pratt, & McClelland, 2014) comes a need for increased precision and accuracy of measurement (e.g., Carlson, Faja, & Beck, 2016) across domains. Improvements in assessment instruments, in turn, must be balanced with the burden placed on teachers, children, and families by this type of in-depth evaluation (Miyake et al., 2000; Wiebe, Espy, & Charak, 2008; Willoughby, Wirth, & Blair, 2011). More research is needed to design and evaluate psychometrically valid and reliable instruments for measuring multidimensional constructs such as social interaction, teacher–child relationships, and academic achievement (Auger, Farkas, Burchinal, Duncan, & Vandell, 2014; McCormick et al., 2013; Sabol, Hong, Pianta, & Burchinal, 2013; Williford, Maier, Downer, Pianta, & Howes, 2013) – with particular attention to approaches that facilitate measurement of change over time (McConnell, Priest, Davis, & McEvoy, 2002; Willett, 1989).

4.4. Implications for research, practice, and policy

Most directly, these data point to the importance of building a strong language foundation early on (Pace, Hirsh-Pasek, & Golinkoff, 2016) and continuing to focus on language skills even during the decoding years to support later reading success (Dickinson et al., 2010; Harris, Golinkoff, & Hirsh-Pasek, 2011) and success in other academic areas throughout the school years (Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Justice et al., 2015). Furthermore, once children enter school, a strong emphasis on language skills must be maintained, particularly for children who start school behind their peers. It is likely that students who start off with poor language skills have a hard time catching up in the other readiness domains, which are increasingly dependent upon their language abilities. Although recent evidence based on nationally representative samples suggest that the gap in school readiness measured at school entry has narrowed over the last two decades (Reardon, Waldfogel, & Bassok, 2016), a concerted effort will need to address how to augment children's acquisition of skills – above and beyond merely maintaining the levels that children already demonstrate upon arrival to kindergarten. This finding may be especially important given much of the prior research has not included language when it looked at school readiness skills (e.g., Duncan et al., 2007; Sabol & Pianta, 2012).

In addition, the present findings make a methodological contribution in that they point to the importance of examining a comprehensive set of school readiness skills in combination. School-readiness skills vary in breadth and depth of inter- and intra-domain influence. For instance, our analyses revealed that early language skills had the broadest influence on outcomes in other academic domains, but that there were other important, inter-domain relationships that emerged from the data. These findings were only revealed because we examined multiple domains simultaneously in the same cohort. Rather than studying school readiness skills as entirely separable quantities, it is essential to look at them comprehensively. Furthermore, the degree to which domain-specific skills affect outcomes across disciplines is likely better conceptualized as a *continuum of influence* as opposed to "constrained" vs. "unconstrained" skills. By approaching school readiness skills comprehensively and examining the nuanced interrelationships, we can make better, more informed educational policy and practice decisions.

Finally, this research suggests that measurement itself should be a topic of continued investigation. Renewed attention has been focused on the now infamous question of whether children's academic and social success should be measured in terms of *proficiency* or *growth* (Ho, 2008; Ho, Lewis, & MacGregor Farris, 2009; Ho & Reardon, 2012). Whereas the proficiency approach evaluates performance compared to relatively static benchmarks, such as a certain score on a standardized test, the growth approach (ideally) allows for evaluating individual students based on how much they improve over time. One significant contribution from this research is that we evaluated how a comprehensive set of readiness indicators in kindergarten predicted both levels *and* gains in academic and social achievement. Contrary to our hypothesis, patterns of skill acquisition over time were largely consistent between early (1st to 3rd) and later (3rd to 5th) elementary years, with no clear discontinuities (i.e., accelerations or decelerations). Furthermore, few predictors of gains emerged from our comprehensive set of readiness skills at kindergarten entry. Future research should evaluate the unique factors that predict growth for all students, including the lowest and highest achievers.

If the field is to move toward gains over time as a measure of achievement, one future methodological challenge will be setting rigorous yet realistic growth targets. It may not be obvious how much growth, on average, should be expected across diverse learning domains and the very idea of individualized growth targets may mean that goals for one child may be very different from goals for another. Therefore, additional descriptive data – collected via dynamic and not just static assessment – are needed to clarify what development should look like both within and across domains. In addition, emphasis on gains should not take away from complementary goals in which all students demon-

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strate a certain level of mastery, regardless of growth. Identifying developmentally-appropriate and domain-relevant targets may require more advanced planning, additional time to collect baseline and summative data, and additional resources to calculate and interpret student scores (Lachlan-Haché & Castro, 2015). This goes hand in hand with alignment of standards and assessments within and across grades and domains of learning.

5. Conclusion

Enhancing children's skill acquisition so that they may capitalize on educational opportunities to build knowledge more rapidly than expected given their entry levels should be a continued focus for research, with intention to inform policy and practice. Within the broader context of structural (e.g., teacher–child ratios) and interactive (e.g., teacher–child interaction) aspects known to support student outcomes (Burchinal et al., 2008), additional research is needed to investigate how to promote long-term, far-reaching, mutually-reinforcing academic and social achievement across domains.

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