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Literacy Growth in the Academic Year versus Summer from Preschool through Second Grade: Differential Effects of Schooling across Four Skills

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Abstract

Differences in literacy growth over the summer versus the school year were examined in order to isolate how schooling affects children's literacy development from preschool through second grade across four literacy skills. Children (n = 383) were tested individually twice each year for up to four years on measures of phonological awareness, decoding, reading comprehension, and vocabulary. Growth curve analyses indicated that schooling effects were greatest for decoding skills and reading comprehension, were medium in size for phonological awareness, and were less evident for vocabulary. Except for vocabulary, relatively small amounts of growth were observed for preschoolers, followed by a period of rapid growth for kindergarteners and first graders, which slowed again for second graders. Findings demonstrate the differential effect of schooling on four separate literacy skills during the crucial school transition period.

Keywords

literacy; vocabulary; schooling; development

Developmental research over the last 20 years has increasingly investigated how well specific contexts or environments support children's learning of literacy skills (Pianta, 2003; Pianta et al., 2005), including home (e.g., Roberts, Jurgens, & Burchinal, 2005; Skibbe, Justice, Zucker, & McGinty, 2008), neighborhood (Aikens & Barbarin, 2008), and school. Time spent in school has been shown to have strong positive effects on children's literacy development (Christian, Morrison, Frazier, & Masseti, 2000; Karoly, Kilburn, Bigelow, Caulkins, & Cannon, 2001; Wong, Cook, Barnett, & Jung, 2008), which in turn is critical for subsequent educational and occupational success (e.g., Alexander, Entwisle, & Olson, 2007; Arnbak, 2004). Researchers have utilized a number of methodologies to determine the extent that observed change occurring during a school year is attributable to schooling effects, compared to age-related developmental processes that occur independently of school. These include the school cutoff design (Bisanz et al., 1995; Morrison et al., 1995) and regression-discontinuity designs (Cahan & Davis, 1987; Gormley, Gayer, Phillips, &

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Dawson, 2005), both of which utilize a between-children design by comparing children slightly older and slightly younger than an arbitrary school cut-off age to examine the effect of a single year of school. Findings have consistently shown strong effects of schooling on some, but not all, cognitive, language, and academic skills.

However, although spending time in school is associated with academic growth generally, less is known about how schooling relates to gains in particular skill sets. Existing research suggests that schooling affects academic skill sets differentially (Bisanz, Morrison, & Dunn, 1995; Connor, Morrison, & Slominski, 2006; Cooper, Nye, Charlton, Lindsay, & Greathouse, 1996; Huttenlocher, Levine, & Vevea, 1998; Morrison, Smith, & Dow-Ehrensberger, 1995). Children's developing decoding skills (Skibbe, Connor, Morrison & Jewkes, in press) show improvement consistent with schooling effects (i.e., additional growth that is observed after accounting for normal non-school development) whereas schooling effects associated with phonological awareness have been found less consistently (Morrison et al., 1995). For reading comprehension, results have also been mixed, with schooling effects observed for kindergarten, but not for pre-kindergarten (Skibbe, Hindman, Housey, & Morrison, 2010). In addition, no clear conclusions can be made when examining vocabulary development; studies using the school cutoff methodology have reported mixed findings about the effect of schooling on children's vocabularies (Christian et al., 2000; Morrison et al., 1995). However, no study to date has examined these four skills simultaneously to investigate the relative strengths of schooling effects for these different literacy skills simultaneously.

Further, schooling influences may vary across different grades, particularly during the crucial period when children transition into school. In one study, growth in phonemic awareness was found to be more pronounced in first grade than kindergarten whereas reading recognition skills were related to both kindergarten and first grade schooling experiences (Christian et al., 2000). Evidence from studies of orthographies other than English also indicates that there may be differences in schooling effects across grades. When assessing Dutch children attending first through sixth grade, researchers have found that, for skills such as decoding, schooling effects were more apparent during early grades, whereas for vocabulary, spelling, and reading comprehension, schooling effects were more consistent across grades (Aarnoutse, Van Leeuwe, Voeten, & Oud, 2001).

Increasing attention has been given to schooling effects on children's literacy development during the preschool years (e.g., Gormley et al., 2005; Magnuson, Ruhm, & Waldfogel, 2007; Skibbe et al., in press). Preschool programs positively influence children's cognitive and social skills, even if the programs vary in quality (Karoly et al., 2001; Wong et al., 2008). Understanding how children's early development and experiences relate to the success of their transition into formal schooling is an important line of inquiry (e.g., Justice, Bowles, Pence Turnbull, & Skibbe, 2009), however, the vast majority of studies (Bisanz et al., 1995; Cooper et al. 1996; Huttenlocher et al., 1998; Morrison et al., 1995) begin to study children only after they have matriculated into kindergarten, and, to our knowledge, no research has examined schooling effects for preschool as well as the early grade school years within the same study.

The present study examined schooling effects during the preschool years through second grade on four different literacy skills in order to gain a more detailed understanding of the extent, nature and timing of schooling effects during the crucial school transition period. Children's skills were measured longitudinally across multiple school years at equidistant intervals. This allows us to compare rates of literacy growth during the school year, when children are attending school, to the summer, when children are not typically attending school. If rates of growth are steeper during the school year than over the summer, we can conclude that there is a 'schooling effect.' That is, there is something about the context of school (e.g., instruction, peer interactions, exposure to educational materials) that facilitates the development of certain skill sets. Using data from multiple studies, it appears that literacy growth during the academic year exceeds that observed during the summer months from kindergarten through fifth grade (Alexander et al., 2007; Cooper et al., 1996; McCoach, O'Connell, Reis, & Levitt, 2006). The current study investigates multiple literacy skills over the course of numerous school years, starting with preschool, to gain a more detailed understanding of preschool schooling effects, differences across grades, and differences across skills.

Challenges in studying schooling effects

Examining schooling effects is complicated by the nature of children's literacy development, as development in this area often follows a nonlinear trajectory (e.g., Leppänen, Niemi, Aunola, & Nurmi, 2004; Skibbe, Grimm, Stanton-Chapman, Justice, Pence, & Bowles, 2008). Skibbe, Grimm et al. (2008; see also Hill, Bloom, Black, & Lipsey, 2007) examined reading development for a representative sample of children from preschool through fifth grade within the United States, using a reading factor comprised of decoding, phonological awareness, and comprehension measures. These researchers found that the period of greatest reading growth occurred between preschool and first grade, after which reading growth decreased in magnitude. They further found substantial individual differences in the rate of growth between children, part of which was predictable from language impairment status. Ignoring the nonlinearity and individual differences inherent in literacy development may lead to inaccurate conclusions about the nature of schooling effects. To address these shortcomings, the present study considers schooling as a within-child effect in the context of a longitudinal study allowing for nonlinear growth across a wide age range.

Another complication is that existing analytical techniques for studying schooling effects (i.e., school cutoff and regression continuity designs) were designed to address schooling effects across a single grade and are not readily adapted to multiyear research. To address this issue, we utilize a nonlinear growth model across a five-year age span. This allows us to account for the effects of age on children's literacy growth, statistically isolating the influence of schooling on children's literacy growth over a period of years. The nonlinear growth curve model can be considered a generalization of the school cutoff and regression discontinuity designs, accounting for individual-specific nonlinear age-related change to allow for the identification of schooling effects. Nonlinear growth curve analyses also allow us to examine the contribution of schooling across multiple grades, for multiple literacy skills.

Finally, a third complication is the challenge of measurement within a developmental context. Conclusions about the nature of change in developmental studies (e.g., magnitude and shape) require that the meaning of the measurement scale be maintained throughout the full breadth of development: as a necessary condition, interval measurement. Few studies of schooling effects provide justification that interval measurement is achieved. To address this issue, we utilize scales from the *Woodcock-Johnson (WJ) III Tests of Achievement* (*WJ-III*; Woodcock, McGrew, & Mather, 2001). The WJ-III tests are scaled with the Rasch measurement model (Rasch, 1960/1980), which has established psychometric characteristics that provide strong evidence of interval measurement (Perline, Wright, & Wainer, 1979). Furthermore, comparison of schooling effects across multiple skills requires that, in addition to interval measurement, the skills are all measured on identical scales with a common unit. To address this issue, we compare skills using the W score, the score reported from the WJ-III. W scores are criterion-scaled so that, for an item on which a child has a .50 probability of correct response, if the child had a W score 10 units higher, the probability would increase to .75 (Jaffe, 2009). Hence, the unit has an equivalent interpretation across subtests addressing multiple skills. We also considered two alternative scales: subtest-specific standardization based on the age 5 norms reported in the WJ-III technical manual (McGrew, Schrank, & Woodcock, 2007) and a rescaling expressing schooling effects as a proportion of total change across the course of the study. Results were consistent across the three scaling, so we report only results from the W score.

Current study

In this study, we examine schooling effects on four aspects of literacy development (i.e., decoding skills, reading comprehension, phonological awareness, and vocabulary) from preschool to second grade for the same group of children. Our study examines the following three research aims:

1. The growth pattern for each of four literacy skills will be described over the five year period encompassing the period of time when children transition to school. It is hypothesized that, consistent with other research (Hill et al., 2007; Skibbe, Grimm et al., 2008), children's literacy skill development across all four skills will exhibit a nonlinear trend, with the majority of literacy growth occurring between preschool and first grade, after which growth is expected to taper off in magnitude.
2. Second, the study examines schooling effects across four important early academic skills: decoding, phonological awareness, reading comprehension and expressive vocabulary. In particular, there has been little effort to study diverse literacy skills simultaneously to compare schooling effects across skills. It is hypothesized that schooling will be associated with differential amounts of growth in each skill with greater effects seen for decoding and lesser effects seen for reading comprehension, phonological awareness and vocabulary.
3. Third, comparing across different skills, we examine whether schooling effects differ depending on the grade examined, starting with preschool. It is hypothesized that schooling will be associated with more growth during children's first years in school than in later years.

Method

Participants

Over the course of this five year study which began in 2002, 383 participants (197 = girls; 186 = boys) were recruited from a large suburban town in the Midwest. Children attended classes in 314 classrooms within 16 schools located within one school district which served 6,400 children from preschool through high school. Data were collected in three waves. During the first wave of the study, 213 three-year olds were recruited, which represented 38% of children attending state-licensed preschools at that time in the district. In order to minimize effects due to attrition, 151 additional four-year olds were recruited during the second year of the study, and 18 additional five-year olds were recruited during the third year of the study. All schools within the district were represented allowing us to sample children from the entire population of eligible participants. Preschool classrooms ($n = 49$) recruited for this study followed the same academic calendar as the elementary schools in the area and did not offer summer programming to students. Both Head Start classrooms and those that operated on a fee- for-service basis were included.

Of the children whose parents reported their children's ethnicity (n = 278), the majority were White/Caucasian ($n = 222$), although African-American ($n = 11$), Asian/Indian ($n = 15$),

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Hispanic (*n* = 2), Multi-racial (*n* = 14), and children whose race was noted as 'other' (*n* = 14) were also represented. Two hundred and sixty-three of the parents reported English to be the native language of the child, 34 reported that a language other than English was the child's native language, and 86 parents did not respond to this question. Overall median household income was $115,000 (*Range* = $11,000 to $650,000). Mothers had, on average, 16 years of education (*SD* = 1.90), equivalent of a bachelor's degree. See Table 1 for demographic information about participants at the time of recruitment.

Procedure

Children were tested individually twice each year, once in the fall and once in the spring, for up to four years (i.e., 8 times) from the time that they entered the study. Thus, as part of this five year study, children who entered during the first wave had the potential to be tested from the first year of preschool through first grade and children who entered during the second wave were potentially tested from the second year of preschool through second grade. Children in the third wave were only tested in kindergarten and first grade. See Table 2 for average testing dates and ages for each grade. Missing data were primarily caused by absenteeism; there were no discernable patterns of missing data, as students who missed one period of data collection often returned for the next. See Table 3 for the number of children tested at each time point for each measure. Trained research assistants tested children in a quiet place in their schools using a battery of tasks measuring children's cognitive and social skills. Testing lasted approximately 20-30 minutes per child.

Measures

Woodcock-Johnson III Tests of Achievement. Children's literacy skills were measured using the *Woodcock-Johnson III Tests of Achievement* (*WJ-III*; Woodcock et al., 2001). For the present study, four subtests assessing children's literacy development were used: Letter-word Identification, Passage Comprehension, Sound Awareness, and Picture Vocabulary. *W* scores, the Rasch-based scores in which performance on the WJ-III is described, were used as the dependent measures in the current study. For all subtests, testing was discontinued when the child answered six consecutive items incorrectly in accordance with testing directions. It should be noted that Sound Awareness was not administered in second grade.

Letter-Word Identification (LW) is a 76-item test that examines children's decoding skills. Initial items focus on identifying letters and later items require children to pronounce increasingly more difficult words. For children three to eight years of age, reliability on this measure ranges from .96 to .99.

Passage Comprehension (PC) assesses children's symbolic understanding, in addition to their text comprehension and verbal language comprehension. Initial items ask children to match a graphical depiction of a word with its photograph. Then, children are asked to find the picture that goes along with a phrase. Finally, children are asked to identify which word best completes a given written passage. The reliability for this measure ranges from .92 to .96 for children between the ages of three and eight.

Picture Vocabulary (PV) is a measure of children's expressive language skills and word knowledge. For this task, children are asked to name objects represented by pictures within the book. Difficulty of items increases as the test progresses with later pictures appearing less frequently in the child's environment. Reliabilities range from .70 to .84 for children between the ages of three and eight.

Sound Awareness (SA) measures children's phonological awareness, using four different types of tasks: rhyming, deletion, substitution, and reversal. The rhyming subscale assesses both rhyme awareness and production. In the deletion subtest, children are asked to omit a phoneme or syllable from a word in order to make a new word. Substitution requires children to add new phonemes and/or syllables in order to create new words. Finally, reversal calls for children to switch syllables or phonemes within a word to create a new word. For children four to eight years of age, reliabilities on this measure ranges from .71 to .93.

See Table 3 for descriptive information about children's performance on the Woodcock-Johnson over the course of the study. Individual observed trajectories for each measure are presented in Figure 1. There is substantial heterogeneity in the trajectories, both across children and across variables. Growth trajectories are generally monotonically increasing, but there appears to be periods of substantial acceleration or deceleration.

Analytic Techniques

The analyses are conducted in three parts to (A) describe the general growth pattern of each reading skill (i.e., decoding, comprehension, phonological awareness, and vocabulary) and the nature of between-child differences in the growth pattern, (B) identify the overall schooling effect for each skill, and (C) examine whether the size of the schooling effect differs by grade. For these goals, we employ nonlinear latent growth curves (Browne, 1993; Browne & du Toit, 1991; Cudeck, 1996; McArdle, 1986, 1988; Meredith & Tisak, 1990; Rogosa & Willet, 1985; Singer & Willet, 2001) with time-varying covariates reflecting the effects of schooling (Bryk & Raudenbush, 1992). These models are fit to the repeated assessments of the Woodcock-Johnson. It should be noted that this model may underestimate the schooling effects present in the current study by oversimplifying the time periods representing the academic year and summer. That is, children received some schooling during the months that we have labeled summer, thus creating a lower bound on the size of the effect likely observed within the data. Details of the models are described below.

Nonlinear Latent Growth Curves

Nonlinear latent growth curves are a contemporary way to model systematic within-person change across time and between-person differences in change. In particular, the technique allows us to consider continuous individual-specific nonlinear age-related development punctuated by formal schooling. The general equation for the nonlinear latent growth curves we employ is

$$WJ[t]_n = \mathrm{Levl}_n + \mathrm{Slope}_n \cdot A[t] + u[t]_n, \quad (1)$$

where $WJ[t]_n$ is the score on the Woodcock-Johnson subtest (i.e., Letter-Word Identification, Passage Comprehension, Sound Awareness, or Picture Vocabulary) for child n at age t, $Level_n$ reflects child n's predicted level on the subtest, $Slope_n$ reflects child n's predicted rate of growth on the subtest, A is a vector of coefficients defining the shape of growth across age that also determines the precise interpretation for both the *Level* and *Slope*, and $u[t]_n$ is a normally distributed time-dependent residual that is uncorrelated with *Level* and *Slope*. The *Level* is defined as a child's predicted level on the subtest when $A[t]$ is equal to 0, and *Slope* is defined as the predicted magnitude of growth for a one unit change in $A[t]$. For example, we may define a linear latent growth curve by setting $A[t] = age - 5$, which implies that $Level_n$ is the predicted score at age 5 for child n, and $Slope_n$ is the predicted score change per year of age for child n. The elements of A can be defined to follow nonlinear trajectories such as exponential growth to model periods of acceleration and deceleration growth, and may depend on unknown parameters to be estimated as part of the nonlinear latent growth curve model.

In addition to the general model defined in equation 1, we add a model for individual differences among the children in the *Level* and *Slope*. The between-child model is

$$\begin{aligned} \mathrm{Levl}_n &= \mu_0 + \varepsilon_{0n} \\ \mathrm{Slope}_n &= \mu_1 + \varepsilon_{1n}, \end{aligned} \quad (2)$$

where μ_0 and μ_1 are the means across children of *Level* and *Slope* and ε_{0n} and ε_{1n} are individual deviations from the overall means that are assumed to follow a bivariate normal distribution with zero mean. That is, we assume that children's levels and slopes are normally distributed, and estimate both means, both standard deviations, and the correlation between the *Level* and *Slope*.

Step A. The first step in this analysis is to determine an appropriate age-related growth curve for the various aspects of reading skills to determine the best description of the pattern of growth from preschool through second grade separately for each subtest. We considered four alternative models: *linear, quadratic, exponential*, and *modified logistic*. In the linear model, we define

$$A[t] = \mathrm{age} - 5 \quad (3)$$

as described above. In the quadratic model, we define the shape as

$$A[t] = (\mathrm{age} - 5) + b(\mathrm{age} - 5)^2 \quad (4)$$

where b is an acceleration parameter.[1] In the exponential model, the shape is

$$A[t] = \exp\left((-r^* (\mathrm{age} - 5)\right) \quad (5)$$

where r is a parameter that reflects a general rate of growth. In the modified logistic model, we use a standard sigmoidal (i.e., S-shaped) logistic curve rescaled to maximize interpretability of the level and slope. The modified logistic model is defined as

$$A[t] = 4\lambda \left[\frac{1}{1+\exp\left(\frac{-1(\mathrm{age}-\alpha)}{\lambda}\right)} - .5 \right] \quad (6)$$

where α is the age at the point of inflection at which growth changes from accelerating to decelerating, and λ is a curvature parameter. α is also the age at which growth is at its maximum rate. The logistic curve is scaled such that *Level* is a child's predicted score at the point of maximal growth; that is, when age = α. Similarly, *Slope* is a child's predicted rate of growth at the point of maximal growth; that is, the first derivative when age = α. For all models, the child's age at assessment was utilized as the time metric as opposed to grade and term (fall/spring) to account for the unique timing of assessments, differences in the amount of time between assessments, and maturational development.

To determine the optimal model to describe the growth trajectories, we considered two standard parsimony-adjusted fit statistics: the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). Both statistics use the −2 log likelihood, the typical maximum likelihood measure of misfit, and apply a penalty, the magnitude of which depends on the complexity of the model. The AIC and BIC differ in the calculation of the

[1]A quadratic model with b allowed to vary across children did not provide better fit.

penalty, but for both, lower numbers indicate a better model that optimizes the balance of lower misfit and greater complexity.

Step B. To determine the overall size of the schooling-effect in the development of reading skills, a time-varying covariate (TVC) was added to equation 1, the general growth curve equation:

$$WJ[t]_n = \text{Levl}_n + \text{Slope}_n \cdot A[t] + \beta \cdot \text{School}[t] + u[t]_n \quad (7)$$

where *School*[*t*] is the cumulative years of schooling. The variable *School* was set equal to 0 at the first occasion in the fall of the first year of preschool, 1 at the spring after the first year of preschool, 1 at the fall of the second year of preschool, reflecting no schooling over the summer, 2 at the spring of the second year of preschool, etc. Thus, the regression-like coefficient β is the effect of each additional year of schooling on the subtest score. We initially assumed the coefficient to be equal in all years, but allowed it to vary across subtests.

Step C. In the final set of analyses, we considered whether the effect of schooling depends on grade. We replaced the growth curve model in equation 7 from Step B with

$$WJ[t]_n = \text{Levl}_n + \text{Slope}_n \cdot A[t] + \sum \beta_g [t] + u[t]_n \quad (8)$$

where the cumulative years of schooling is replaced by a set of dummy variables, d_g, for each grade, equal to 0 up to the fall of grade g and equal to 1 in spring of grade g and after. Thus, d_g represents the persisting effect of schooling in grade g. The set of β_g coefficients are the grade-specific effects of schooling.

To summarize, we considered four basic forms of growth, linear, quadratic, exponential and logistic. We conceptualized the effect of schooling as a persisting additive benefit to a child’s subtest scores, such that a child maintains a consistent growth shape from age-related development, but is bumped up to a higher quasi-parallel growth trajectory as a result of schooling. A graphical illustration of this conceptualization is presented with the results. All of the models were fit using PROC NLMIXED in SAS.

Results

The results are contained in three sections: (A) latent growth curve analysis to examine the best fitting shape of development, (B) growth curve analysis with fixed schooling effects, and (C) growth curve with grade-varying schooling effects

Latent Growth Curve Analysis

Fit statistics for the four growth models are reported in Table 4. Based on both the AIC and BIC, the changes and between-person differences in the reading-related skills were best represented by the modified logistic growth curve. Therefore, the within-person changes in each reading skill are best described as S-shaped, with accelerating growth followed by decelerating growth after a point of inflection.

Growth Curve Model with Schooling Effect

The modified logistic latent growth curve was fit with the addition of a parameter reflecting a persisting effect of schooling, assumed to be constant at all grades. Based on the AIC and BIC, the model including schooling effects was a better description of the data for all skills except Picture Vocabulary, which had slightly better AIC but slightly worse BIC. Therefore, we conclude that schooling effects occur for literacy skills, perhaps with the exception of vocabulary. Table 5 contains the parameter estimates for these models. The schooling effect per school year was found to be largest for Letter-Word Identification (9.71), followed by Passage Comprehension (5.71), Sound Awareness (3.58), and finally Picture Vocabulary (1.10); we note that, because of the complexity of our model, direct statistical comparisons of estimated schooling effects across subtests are not available. The schooling effect represents the amount of additional change in the reading skill that can be attributed to children's schooling experiences beyond normal maturational growth as reflected by the modified logistic model. For example, a year of school increases the child's Letter-Word Identification score by 9.71 units above and beyond age-based changes.

Growth Curve Model with Grade-Varying Schooling Effect

Finally, a set of models was estimated to determine whether the magnitude of the schooling-effect varied based on grade. Based on the fit statistics, this model was more optimal than the constant schooling effect model for Letter-Word Identification and Passage Comprehension, marginally better for Picture Vocabulary, and somewhat worse for Sound Awareness. Parameter estimates are presented in Table 6, and the curves based on empirical data are illustrated in Figure 2 together with a hypothetical growth curve as if there had been no schooling (i.e., all schooling dummy variables from equation 8 [d_g] set to 0) in order to aid visual isolation of the schooling effects. The skills varied substantially in both the maturational growth and the effect of schooling. Letter-Word Identification and Passage Comprehension had similar patterns of age-related growth, with an age of maximal growth (age of inflection) around 6 years of age, and a strong average rate of growth (Slope mean) at the point of inflection. Sound Awareness also had a strong rate of growth, but an earlier point of inflection at approximately 4 years. Picture Vocabulary grew less rapidly, and had an early point of maximal growth estimated at around 2 years of age, indicating that the growth of vocabulary is decelerating throughout the study. All four skills displayed substantial variation across children in both the level of skill and rate of growth at the point of inflection.

The magnitude of the schooling effect varied across grade for all reading skills, except Sound Awareness where the magnitude of the schooling effect was approximately consistent from grade to grade (between 2.77 and 4.33). Letter-Word Identification, Passage Comprehension, and Picture Vocabulary showed dramatic variations in schooling effects, with similar patterns: large schooling effects in kindergarten and first grade and much smaller, usually nonsignificant effects in other school years (see Table 6). Letter-Word Identification and Passage Comprehension had very large schooling effects in kindergarten (17.05 and 12.43, respectively) and first grade (12.43 and 15.19) relative to Picture Vocabulary (2.83 and 2.38). By comparison, schooling effects in other years were at least 58% smaller for these reading skills.

Discussion

The influence of schooling on four aspects of children's literacy growth was examined from preschool through second grade. Nonlinear patterns of development were observed for all aspects of literacy measured (decoding, reading comprehension, phonological awareness, and vocabulary). Consistent with our hypothesis, after accounting for age-related growth, schooling effects were evident across all literacy skills, although effects varied dramatically in magnitude. Specifically, schooling effects were greatest for decoding skills and reading comprehension, were medium in size for phonological awareness, and were not as strong for vocabulary. The magnitude of schooling effects also differed by grade for each skill measured; however, schooling effects were associated with children's literacy growth for all four skills during kindergarten and first grade.

Growth Patterns

Similar to other research examining literacy growth during children's early years in school (Hill et al., 2007; Skibbe, Grimm et al., 2008), growth for each literacy skill was best described by an S-shaped pattern of development. For literacy skills other than vocabulary, relatively small amounts of literacy growth were observed when children were in preschool (3-4 years of age), which was immediately followed by a period of rapid growth during the kindergarten and first grade ages that slowed again by second grade. For vocabulary, the maximal rate of growth was predicted to have occurred earlier than for the other skills. The growth patterns observed in the present study support current research emphasizing children's transition to kindergarten as a particularly fruitful and important time for examining children's reading skills (Justice et al., 2009; La Paro et al., 2003; Rimm-Kaufman & Pianta, 2000), while suggesting that first grade is an equally important time to investigate patterns of children's early literacy development, due to the rapid growth observed during this time.

When considered as a whole, children demonstrated more literacy growth during the school year than over the summer months, coinciding with previous work in this area (Alexander et al., 2007; Cooper et al., 1996; Downey et al., 2004; McCoach et al., 2006). However, the current research was able to extend previous research by examining four early literacy skills simultaneously; this is notable as there were substantial differences in schooling effects across skills. The largest average effects per school year were observed for the measures of decoding (9.71), followed by reading comprehension (5.71) and phonological awareness (3.58), with much smaller values for vocabulary (1.10). In addition, the effects of schooling on some aspects of literacy development varied widely across grade. For decoding, significant schooling effects were observed during the first year of kindergarten and first grade. Significant schooling effects for reading comprehension occurred during the first year of preschool, kindergarten, first grade, and second grade, with the greatest effects observed during kindergarten and first grade. Phonological awareness was associated with consistent schooling effects across the five-year study. For vocabulary, the greatest schooling effects were observed following kindergarten and first grade and minimal schooling effects were observed during the preschool years and second grade. These findings underscore the importance of children's age when considering the effects of school on children's early literacy development.

Methodological assumptions

It should be noted that we made two simplifying assumptions that may have affected our results. First, we assumed that no schooling occurred between the spring and fall testing occasions (i.e., summer). However, for some children, testing did not occur immediately at the beginning of the school year, nor immediately before the end, meaning that children were exposed to some school during the time that we have labeled summer. As such, the current study may have underestimated the magnitude of schooling effects associated with children's literacy development for each of the four skills examined. Note that children were only recruited from preschools that followed the same academic calendar as that found in elementary school. Nevertheless, it is still the case that children in all grades may have participated in a summer program that was academic in nature; this would also result in an underestimation of the effect of schooling found during the school year. Thus, our results can be considered a lower bound on the effect of schooling.

Second, we implicitly assumed that the home environment remained constant throughout the study, both during the school year and over summer. One study using a nationally representative data set found that, while the majority of parents provided stable home learning environments for their children, nearly one third of parents exhibited different patterns of instructional behaviors at 36 and 54 months of age (Son & Morrison, 2010). Thus, it is possible that some of the differential schooling effects observed can be explained by seasonal or developmental changes in the children's home environments.

Theoretical explanations

Schooling effects were observed for every literacy skill examined in the current study. Many factors may potentially explain the differential schooling effects observed in the present study, including access to materials provided in school (e.g., McMahon, Richmond, & Reeves-Kazelskis, 1998), interactions with and learning from peers (e.g., Stone & Christie, 1996), and the emotional support provided within the classroom (e.g., Hamre & Pianta, 2005). In addition, one likely reason that differential schooling effects were observed in the present work is that teachers emphasize certain literacy skills more than others.

The schooling effects for decoding noted in the present study align with previous observational research of teachers within their classrooms. As one example, kindergarten teachers were observed to spend about 90% of their instructional time on reading-related instruction, with more than half of that time spent on activities designed to enhance children's code-focused knowledge (Al Otaiba et al., 2008). The strong general instructional emphasis on decoding noted in kindergarten may at least partially explain the large schooling effects for that skill observed in the current study during kindergarten and first grade.

In contrast to previous work (e.g., Skibbe et al., in press), no schooling effects were observed for decoding during the preschool years. Evidence from research using the same sample of children (i.e., Connor et al., 2006), found that teachers who spent more time teaching decoding skills in preschool (e.g., letter-sound correspondence) had students who exhibited greater word-recognition growth during the school year. However, although all teachers focused on literacy content to some extent, these researchers also documented considerable variability regarding the instructional practices that target decoding within classrooms, possibly limiting our ability to uncover schooling effects during this time. It should be noted that, although most preschoolers cannot decode words per se, our measure of decoding was able to detect early indicators of decoding, such as letter recognition, as well as more advanced decoding skills.

For reading comprehension, schooling effects were observed during the first year of preschool, kindergarten, first grade, and second grade. This pattern of results was fairly similar to decoding, which is consistent with research indicating that WJ-III Passage Comprehension shares a common factor with decoding (Keenan, Betjemann, & Olson, 2008), perhaps because many of the early items appear to focus primarily on decoding rather than comprehension per se. Alternatively, instruction targeting decoding may provide children with necessary skills needed to engage in comprehension-related activities (Kaplan & Walpole, 2005). That is, schooling effects on decoding may extend to provide a foundational role in reading comprehension, possibly explaining the similar patterns of schooling effects for decoding and reading comprehension observed in the present study. Such shared schooling effects may partly explain the strong association between children's decoding ability and reading comprehension observed in other studies (Gough et al., 1996; Francis et al., 2006).

Schooling effects associated with phonological awareness were found at every time point measured in the current study, that is, from the first year of preschool through first grade. Phonological awareness is closely linked to children's ability to excel at conventional reading and writing, and it consistently predicts word recognition skills during children's first years in school (Cunningham & Stanovich, 1993; Scarborough, 1998; Storch & Whitehurst, 2002; Torgeson et al., 1999). Although the effect of schooling on phonological awareness was smaller than that for decoding or reading comprehension, classroom-based intervention programs have been related to gains in phonological awareness for children with and without special needs (Bryne & Fielding-Barnsley, 1995; Gillon, 2000; O'Connor, Notari-Syverson, & Vadasy, 1996) and teachers who focus on phonological awareness within the classroom are more likely to have children who exhibit growth in this area (At Otaiba et al., 2008). Whether the findings from the current study reflect the instructional emphases within the classroom or another aspect of school, such as the availability of educational materials that support phonological awareness, is a matter for future research.

The current study demonstrated a significant effect of schooling experiences on vocabulary development, but this effect was relatively small in magnitude when compared to the other components of literacy examined. Previous studies have provided contradictory findings regarding the effect of schooling on children's vocabulary development (Aarnoutse et al., 2001; Christian et al., 2000; Morrison et al., 1995). Again, one potential explanation involves the instructional emphases observed within preschool, kindergarten, and first grade classrooms, as teachers have been observed to focus more of their instructional time on concepts related to decoding and phonological awareness than on concepts related to vocabulary (Al Otaiba et al., 2008; Baumann et al., 2003; Juel et al., 2003). Alternatively, previous research indicates that children acquire much of their vocabulary without direct instructional guidance. During preschool, children's vocabulary growth is significantly affected by their play experiences (Connor et al., 2006). As children's play experiences during the preschool year may not differ dramatically from those that they experience during the summer, schooling effects may be less evident during this time. As children grow older, children learn many new words without direct instruction, either through independent reading (Swanborn & de Glopper, 1999) or access to books at home (Sénéchal, LeFevre, Hudson, & Lawson 1996). Since independent reading and the home environment are likely to remain relatively stable throughout the year, it may be that much of children's vocabulary growth in later years can be attributed to factors outside of the context of school. Finally, the lack of schooling effects in vocabulary during second grade may simply reflect the overall slowing of vocabulary growth noted during that time.

Overall, the current study suggests that future research should address the role of instructional practices as a determinant of schooling effects. Previous research suggests that there may be individual differences regarding the degree to which schooling relates to overall literacy development. For example, Connor, Morrison, and Katch (2004) found that children with low initial decoding scores demonstrated greater growth when teachers spent more time explicitly focusing on decoding skills, whereas children with high initial decoding skills did not benefit from greater amounts of this type of instruction. The child by instruction interactions noted in this and other studies (Connor et al., 2006; Scanlon & Vellutino, 1996) suggest that future research should examine whether schooling experiences affect literacy growth in accordance with each child's unique individual needs and skill sets.

Participants in the present study were predominantly Caucasian/White, resided in households with high median incomes, and had mothers who were well educated. It is well established that ethnicity is related to differences in literacy achievement during children's first years in school (e.g., Matthews, Kizzie, Rowley, & Cortina, 2010). In addition, children residing in low-income households have less access to literacy materials (e.g., Adams, 1990) and are more likely to struggle in school relative to peers living in higher-income homes (Duncan, Yeung, Brooks-Gunn, & Smith, 1998). Thus, it is possible that results from the present study may not generalize to all populations of children. Future research should investigate this possibility by replicating this work with a more diverse sample of children.

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Conclusion

Using a complex nonlinear latent growth curve approach, we were able to separate the effect of formal schooling from natural age-related development across five years on four literacy skills. Findings suggest that schooling plays a multifaceted role in children's literacy growth, as demonstrated by its differential impact on each literacy skill examined from preschool through second grade. Understanding how schooling relates to literacy growth over time can inform our collective knowledge about best educational practice and guide the development of future interventions designed to prevent reading difficulties.

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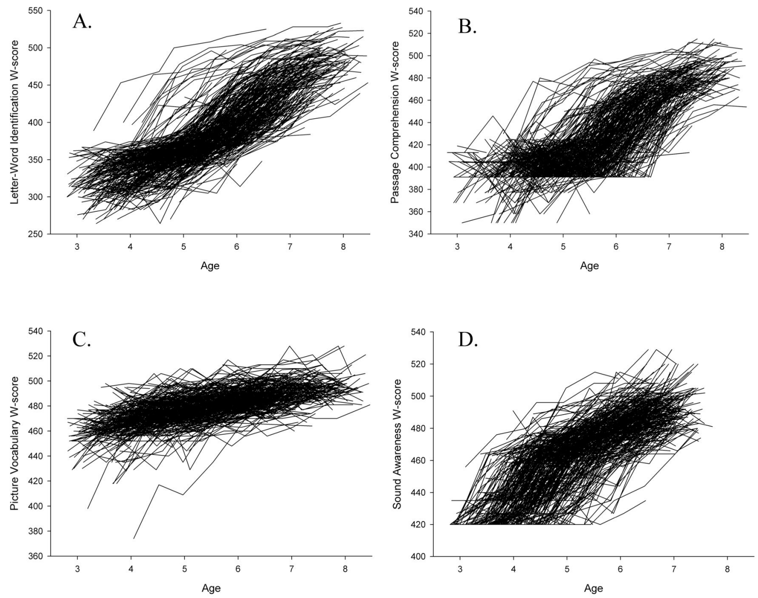

Figure 1.

Individual growth trajectories for (A) Letter-Word Identification, (B) Passage Comprehension, (C) Picture Vocabulary and (D) Sound Awareness.

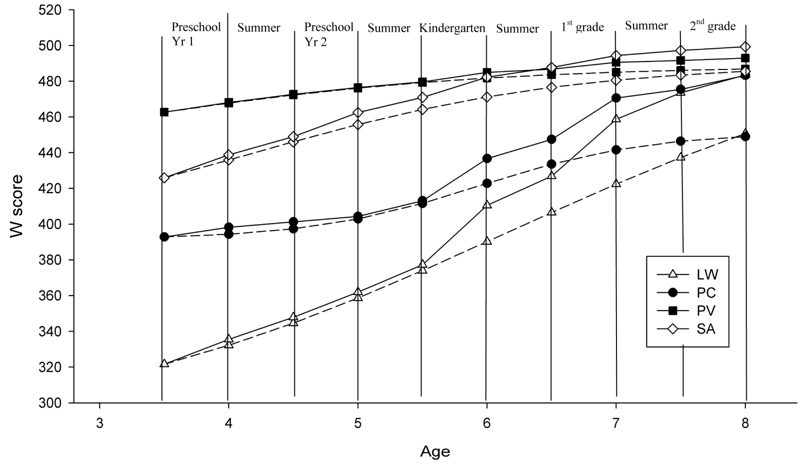

Figure 2.

Mean predicted trajectories with and without schooling effect for Letter-Word Identification, Passage Comprehension, Picture Vocabulary and Sound Awareness.

Note. The empirical growth curve for each skill is represented by a solid line and the hypothetical growth curve (i.e., with no schooling) is represented by a dotted line.

Table 1

Descriptive Information

Children (n = 383)	
Gender	
Males	186 (49%)
Females	197 (51%)
Ethnicity	
African American	11
White/Caucasian	222
Asian/Indian	15
Hispanic	2
Multi-racial	14
Other	14
No response	105
Native language	
English	263
Other	34
No response	86
Mean years of mother’s education (SD)	16.10 (1.89)

Table 2

Mean age (SD) and average date of testing for each time point

Measure	Fall		Spring	
	Mean date of testing	M age in months (SD)	Mean date of testing	M age in months(SD)
Preschool, Yr 1	October 13	42.31 (4.99)	April 26	48.51 (4.76)
Preschool, Yr 2	October 16	52.93 (3.92)	April 23	59.11 (3.89)
Kindergarten	October 25	65.43 (3.97)	April 24	71.12 (3.97)
First grade	November 3	77.70 (3.92)	April 19	83.06 (3.82)
Second grade	November 6	89.04 (3.51)	April 10	94.10 (3.47)

Table 3

Children's Fall and Spring W Scores on the Woodcock-Johnson Tests of Achievement

Measure	Grade	Fall		Spring	
		n	M (SD)	n	M (SD)
Letter-word identification	Preschool, Yr 1	199	322.82 (25.14)	193	339.38 (23.91)
	Preschool, Yr 2	315	345.48 (24.58)	310	360.78 (27.36)
	Kindergarten	288	374.96 (28.97)	284	405.41 (29.63)
	First grade	257	428.49 (30.23)	206	456.13 (26.68)
	Second grade	90	471.87 (26.09)	88	482.39 (22.61)
Passage Comprehension	Preschool, Yr 1	120	392.45 (17.95)	165	399.58 (15.72)
	Preschool, Yr 2	300	400.85 (15.27)	310	405.52 (18.08)
	Kindergarten	288	410.55 (21.76)	284	431.49 (25.89)
	First grade	257	449.83 (22.63)	206	468.51 (15.47)
	Second grade	90	478.99 (13.69)	88	485.50 (13.52)
Picture Vocabulary	Preschool, Yr 1	198	463.14 (15.05)	194	468.65 (12.08)
	Preschool, Yr 2	315	471.82 (12.73)	310	476.35 (11.52)
	Kindergarten	288	478.61 (11.42)	284	484.69 (10.26)
	First grade	257	486.37 (9.87)	206	489.66 (10.55)
	Second grade	90	494.71 (8.91)	88	494.23 (9.00)
Sound Awareness	Preschool, Yr 1	198	428.56 (13.81)	194	441.01 (17.56)
	Preschool, Yr 2	315	447.10 (18.06)	310	460.75 (16.85)
	Kindergarten	288	469.27 (14.49)	284	480.50 (12.42)
	First grade	256	487.05 (11.22)	206	493.16 (12.63)
	Second grade		--		--

Table 4

Fit Statistics for Growth Models with and without Schooling Effect

	Parms	Letter-Word Identification			Passage Comprehension			Picture Vocabulary			Sound Awareness		
		−2LL	AIC	BIC	−2LL	AIC	BIC	−2LL	AIC	BIC	−2LL	AIC	BIC
Growth Models													
Linear	6	19568	19576	19592	18367	18375	18391	15990	15997	16014	15936	15944	15960
Quadratic	7	19408	19422	19449	18209	18223	18251	15925	15939	15966	15808	15822	15849
Exponential	7	19477	19491	19519	18220	18234	18261		DNC		15998	16012	16039
Modified Logistic	8	19244	19260	19292	18001	18017	18048	15923	15939	15971	15790	15806	15838
Schooling Effect													
	9	19151	19169	19205	17962	17980	18016	15918	15936	15972	15762	15780	15816
Grade Specific Schooling Effect													
	13	19004	19030	19082	17882	17908	17959	15904	15930	15982	15760	15784	15831

Note. Parms is the number of free parameters in the model. DNC = did not converge..

Table 5

Parameter Estimates for Modified Logistic Growth Models with Constant Schooling Effect

	Letter-Word Identification	Passage Comprehension	Picture Vocabulary	Sound Awareness
Fixed-Effects				
Intercept Mean	383.35**	423.74**	352.51**	441.51**
Slope Mean	40.99**	35.37**	23.14	20.58**
Curvature (λ)	0.82**	0.46**	3.16**	1.15**
Age of Inflection (α)	6.08**	6.20**	−2.66	4.31**
Schooling Effect (β)	9.71**	5.71**	1.10*	3.58**
Random Effects				
Intercept Deviation	25.67**	14.04**	48.80	13.55**
Slope Deviation	8.63**	7.27**	8.21	3.94**
Intercept/Slope Correlation	.41**	.58**	−.99**	−.54**
Residual Deviation	12.88**	14.43**	6.82**	8.68**

* *Note*. indicates a significant parameter at $p<.05$;

** indicates a significant parameter at $p<.01$

Table 6

Parameter Estimates for Modified Logistic Growth Models with Grade-Varying Schooling Effect

	Letter-Word Identification	Passage Comprehension	Picture Vocabulary	Sound Awareness
Fixed-Effects				
Intercept Mean	395.06 **	421.41 **	456.26 **	439.35 **
Slope Mean	32.78 **	23.04 **	11.13 **	20.49 **
Curvature (λ)	1.76 **	.65 **	1.46 **	1.23 **
Age of Inflection (α)	6.15 **	5.94 **	2.92 **	4.17 **
Schooling Effect 1 (β_1 - 1st Year of Pre-K)	3.32	3.95 *	.39	2.88 *
Schooling Effect 2 (β_2 - 2nd Year of Pre-K)	.01	−2.51	−.05	3.85 **
Schooling Effect 3 (β_3 - Kindergarten)	17.05 **	12.43 **	2.83 **	4.33 **
Schooling Effect 4 (β_4 - 1st Grade)	15.94 **	15.19 **	2.38 **	2.77 **
Schooling Effect 5 (β_5 - 2nd Grade)	−3.46	5.18 *	.54	--
Random Effects				
Intercept Deviation	25.72 **	14.04 **	14.30 **	13.79 **
Slope Deviation	6.61 **	6.14 **	4.33 **	3.90 **
Intercept/Slope Correlation	.39 **	.61 **	−.84 **	−.56 **
Residual Deviance	12.35 **	14.09 **	6.77 **	8.69 **

Note. * indicates a significant parameter at p<.05;

** indicates a significant parameter at p<.01; Sound Awareness was not administered in 2nd grade.