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Bidirectional Relations between Phonological Awareness and Letter Knowledge in Preschool Revisited: A Growth Curve Analysis of the Relation between Two Code-Related Skills

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Abstract

Despite the importance of phonological awareness for the development of reading in alphabetic languages, little attention has been paid to its developmental origins. In this study, dual-process, latent growth models were used to examine patterns of bidirectional relations between letter knowledge and phonological awareness during preschool. The sample comprised 358 children (mean *age* = 48.60 months, *SD* = 7.26). Growth models were used to quantify the unique longitudinal relations between the initial level of each skill and growth in the other skill during the preschool year, after controlling for initial level of the same skill, vocabulary, age, and growth in the code-related skill being used as a predictor. Letter-name knowledge and phonological awareness were bi-directionally related; the initial level of each uniquely predicted growth in the other. Initial letter-sound knowledge and phonological awareness growth were not uniquely related, and vocabulary was not related to growth in phonological awareness. These findings extend the evidence of the relation between letter knowledge and phonological awareness to supra-phonemic tasks, indicating that this bidirectional relation begins at an earlier point in the development of phonological awareness than previously reported. In addition, these findings help to rule out general growth in letter knowledge and phonological awareness as an alternative explanation for the bidirectional relation between these two code-related skills.

Keywords

Phonological awareness; Alphabet knowledge; Emergent literacy; Phonemic awareness; Letter knowledge; Preschool students

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Proficient reading skill is a key determinant of quality of life. For example, compared with adults who can read proficiently, those with only basic reading skills are (a) 2 to 4 times more likely to earn less than $300 per week, (b) 7 to 15 times more likely to receive public assistance, and (c) 39% less likely to report being in “very good or excellent health” (Wood, 2010, p. 11). In light of these findings, reading skills of grade-school children are alarmingly low. For example, only 34% of fourth-grade students and 27% of eighth-grade students demonstrated proficient reading skills in 2013 (Aud et al., 2013). The developmental

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trajectory toward the level of reading skill a child will ultimately attain appears to be determined, in large part, during the first years of formal education (e.g., Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996; Torgesen & Burgess, 1998). For example, even after accounting for general cognitive ability, poor reading skills as early as the first grade uniquely predict 27% of the variance in reading comprehension 10 years later (Cunningham & Stanovich, 1997). Furthermore, the pattern of individual differences in reading skill may stabilize as early as the kindergarten year. First-grade reading achievement is strongly predicted by kindergarten letter knowledge and phonological awareness, even after controlling for parental education level and teacher-rated academic competence (Ortiz et al., 2012). In light of the relation between skilled reading and quality of life and the early emergence of stable individual differences in reading skill, it is critically important to examine the factors that influence the development of skilled reading.

Significance of phonological awareness in reading skill development

Phonological awareness is one of the strongest predictors of reading skill. Evidence from longitudinal studies suggests a unique predictive relation between phonological awareness and the development of reading skill. For example, Wagner et al. (1997) reported that phonological awareness, measured at the beginning of the kindergarten year, uniquely predicted reading skill in second grade after controlling for vocabulary, phonological memory, and initial reading skill. In the same study, phonological awareness was also a unique predictor of subsequent individual differences in reading from first to third grades and from second to fourth grades, indicating that the strong, unique predictive relation between phonological awareness and subsequent reading skill continues throughout early elementary school. Individual differences in phonological awareness are not only uniquely related to future decoding abilities; evidence from intervention studies indicates that this relation is causal in nature (e.g., Torgesen, Morgan, & Davis, 1992; Vadasy & Sanders, 2010). The results of a meta-analysis of phonological awareness training studies revealed that effect sizes on reading skills were approximately equal to effect sizes on phonological awareness tasks (ds = .70 and .73, respectively), suggesting that improvements in phonological awareness cause equivalent improvements in reading performance (Bus & van IJzendoorn, 1999). Although other factors may mediate the relation between phonological awareness and reading skill (see Castles & Coltheart, 2004, for a review), evidence from longitudinal and experimental studies is consistent with a significant relation between phonological awareness and reading skill. Similarly, many cases of reading difficulties can be traced to problems with phonological awareness (e.g., Morris et al., 1998; Stanovich, 1988), suggesting that at least some degree of phonological awareness may be a necessary precursor to becoming a skilled reader.

Developmental trajectory and nature of phonological awareness

Despite considerable evidence that phonological awareness is an important contributor to skilled decoding in alphabetic languages, relatively few studies have examined the developmental origins of phonological awareness. Phonological awareness appears to emerge in an ordered developmental progression. First, a rudimentary awareness of sounds within words is demonstrated by the ability to detect and manipulate larger units of sound (e.g., syllables, onsets, rimes). Next, a more sophisticated awareness of the sounds that compose spoken language is demonstrated by the ability to detect and manipulate smaller units of sound such as phonemes (Anthony, Lonigan, Driscoll, Phillips, & Burgess, 2003; Lonigan, Burgess, Anthony, & Barker, 1998). Despite this ordered progression, evidence from factor analytic studies (e.g., Anthony et al., 2003; Lonigan et al., 2009; Schatschneider, Francis, Foorman, Fletcher, & Mehta, 1999) indicates that, among children whose phonological awareness is sufficiently developed to detect and manipulate single phonemes, the same underlying capacity is responsible for performance on phonological awareness tasks regardless of the size of the sound unit that must be detected or manipulated. Given that the ability to detect larger units of sound is an earlier emerging indicator of the same underlying capacity responsible for sensitivity to phonemes, examining the influences on growth in sensitivity to larger units of sound will help to determine the extent to which factors that influence later emerging indicators of phonological awareness have a similar effect at an earlier point in the development of phonological awareness.

Influences on the development of phonological awareness

Two primary lines of research have examined the early development of phonological awareness. One line of research has focused on the relation between phonological awareness and letter knowledge (e.g., Johnston, Anderson, & Holligan, 1996; McBride-Chang, 1999). Another line of research, based primarily on the lexical restructuring model (LRM; Metsala & Walley, 1998; Walley, Metsala, & Garlock, 2003), has focused on the influence of vocabulary size on the development of phonological awareness.

Letter knowledge

Letter knowledge appears to be related to the development of phonological awareness, and some evidence suggests that this influence may be more important for phoneme-level tasks (Bowey, 1994; Johnston et al., 1996) than for tasks that require sensitivity to larger units of sound such as onsets, rimes, and syllables (MacLean, Bryant, & Bradley, 1987). Effects of phonological awareness on the acquisition of letter knowledge also have been reported. For example, Kim, Petscher, Foorman, and Zhou (2010) found that for letter names that included clues to the corresponding sound, knowing the name of a letter was a strong predictor of also knowing the corresponding sound but only for children with more well-developed phonological awareness skills. Intervention studies provide mixed evidence regarding the causal status of the bidirectional relation between letter knowledge and phonological awareness. For example, in a two-phase intervention design, children who received phonological awareness training in the first phase made significantly larger gains in subsequent letter-sound training compared with children who received the same letter-sound training without previous phonological awareness training (Castles, Coltheart, Wilson, Valpied, & Wedgwood, 2009). It could be that effective instruction in one code-related skill somehow facilitated the acquisition of other code-related skills. In contrast, findings from other intervention studies indicate that instruction in letter knowledge does not result in increases in phonological awareness (e.g., Lonigan, Purpura, Wilson, Walker, & Clancy-Menchetti, 2013; Piasta, Purpura, & Wagner, 2010; Piasta & Wagner, 2010), and successful instruction in phonological awareness does not result in increases in letter knowledge (e.g., Lonigan et al., 2013). Taken together, evidence from separate studies indicates some degree of interdependence between phonological awareness and letter knowledge; however, few studies have examined both directions over the same time period within the same sample.

Vocabulary

Another line of evidence indicates that vocabulary knowledge appears to influence the development of phonological awareness (e.g., Goodrich & Lonigan, 2015; Metsala & Walley, 1998; Walley et al., 2003). According to the LRM, words are first stored in a holistic or word-level manner without regard to the smaller units of sound within each word. Although holistic storage may be effective for a small number of words, it becomes inefficient when children are required to maintain distinctions among larger numbers of increasingly similar words. Thus, as vocabulary size increases, increasingly dense phonological word neighborhoods require a more systematic and segmental strategy to maintain the distinctions between words. In the LRM, this lexical representation of words in segmented form provides the basis for the emergence of phonological awareness.

Evidence from separate studies suggests that both letter knowledge and vocabulary are related to the development of phonological awareness. However, there is limited evidence regarding the relative strength of the contributions of these two factors to the early development of phonological awareness because most studies of phonological awareness development include either vocabulary or letter knowledge as a predictor, but not both. To date, at least one study has included both predictors. Burgess and Lonigan (1998) reported evidence of a bidirectional relation between letter knowledge and phonological awareness in a model that also accounted for the influence of vocabulary knowledge. In a sample of 97 children, letter knowledge at age 5 years was a significant and unique predictor of performance on phoneme-level phonological awareness tasks at age 6 years in a model that included initial level of phonological awareness and vocabulary as simultaneous predictors. In the same sample, phonological awareness at age 5 was a significant and unique predictor of both letter-name and letter-sound knowledge at age 6 in predictive models that included initial levels of vocabulary and the same letter knowledge measure as simultaneous predictors.

The current study

The current study was designed to examine (a) the possible bidirectional relation between letter knowledge and earlier emerging facets of phonological awareness and (b) the relation between vocabulary size and growth in phonological awareness. To date, studies demonstrating evidence of a relation between these two code-related skills prior to school entry have focused on phoneme-level tasks and have included only older preschool children, probably because phoneme-level tasks are too difficult for many younger preschool children. For instance, although Burgess and Lonigan (1998) demonstrated that letter knowledge and phonological awareness were bidirectionally related over time, they did not test whether this influence extended to earlier manifestations of phonological awareness, namely performance on supra-phonemic tasks (i.e., phonological awareness tasks that assess individual differences in sensitivity to units of sound larger than single phonemes such as syllables, onsets, and rimes). Given that phonological awareness tasks requiring sensitivity to supra-phonemic units of sound draw on the same underlying ability as those requiring sensitivity to single phonemes (e.g., Anthony et al., 2003), administering tasks including these larger units to younger children would make it possible to examine earlier influences on the development of the same construct (i.e., phonological awareness) previously studied in older children. Moreover, because both phonological awareness and letter knowledge are developing rapidly during the early childhood period, it is possible that apparent bidirectional relations over time may represent the joint product of correlated developmental trajectories and imperfect measurement.

Three primary hypotheses were tested in this study. First, children with higher initial levels of letter knowledge were expected to experience more growth in phonological awareness across the preschool year than that experienced by children with lower initial levels of letter knowledge. Next, children with higher initial levels of phonological awareness were expected to experience more growth in letter knowledge across the preschool year than that experienced by children with lower initial levels of phonological awareness. Finally, consistent with the LRM, children with higher levels of initial vocabulary were expected to experience more growth in phonological awareness across the preschool year than that experienced by children with lower initial levels of vocabulary. We anticipated that these relations would be independent of age and any influence of the rate of growth in the code-related skill being used as a predictor.

METHOD

Participants

Participants were recruited from preschools in north Florida. The sample comprised 358 children who were approximately 4 years of age at the start of the study (M = 48.60 months, SD = 7.26). Slightly more than half of the children were girls (52.6%). The majority of the sample was White (85.8%), whereas the remainder was African American/Black (7.3%) or another racial/ethnic group (6.9%).

Measures

Phonological awareness—Each of the experimenter-created phonological awareness tasks used in this study began with two or three practice trials, during which examiners confirmed and explained correct answers. When children responded incorrectly, the correct answer was provided and explained, along with another opportunity to complete the same item. Next, test trials including word-, syllable-, and phoneme-level items were administered without feedback. All correct responses were real words.

Word blending: Children were asked to combine a pair of one-syllable words into a compound word. On practice trials, examiners showed and named two pictures (e.g., “This is a fire and this is a man.”). Children were then asked to combine the two words into one (e.g., “What do you get when you say ‘fire’…‘man’ together?”) while the two pictures were physically moved toward each other to clarify the instructions. Eleven test trials were administered without pictures. Across the three time points, this task had excellent internal consistency (*as* = .92, .93, and .92, respectively).

Syllable and phoneme blending: Children were asked to combine sound units of varying size to form real words. Examiners presented each of the constituent units separately (e.g., "What do you get when you say /p/…'ill' together?") and asked children to produce the full word. Ten test trials were administered. Across the three time points, this task had good internal consistency (*as* = .83, .82, and .81, respectively).

Multiple-choice blending: Children were asked to combine sound units of varying size to form real words (e.g., "pen…cil"). For each item, four pictures (e.g., pencil, pumpkin, jacket, paper) were presented and named by the examiner. Children could respond correctly either by stating the blended word (e.g., "pencil") or by pointing to the corresponding picture. Ten test trials were administered. This task assessed phonological awareness at the syllable and phoneme levels. Across the three time points, this task had marginal internal consistency (*as* = .64, .61, and .69, respectively).

Word elision: Examiners presented a compound word, composed of a pair of one-syllable words, and children were asked to produce the word that would remain after removing either the first or second word. Examiners first presented the compound word as two separate parts and then as a single word (e.g., "Here's a door and here's a mat. Say doormat."). Children were asked to say one part of the word without the other (e.g., "Now say doormat without saying door."). Only the practice trials included pictures. During these trials, examiners physically separated the picture cards to clarify the instructions. Eleven test trials were administered without pictures. Across the three time points, this task had excellent internal consistency (*as* = .93, .93, and .92, respectively).

Syllable and phoneme elision: Examiners verbally presented a stimulus word and asked children to produce the target word by repeating the stimulus word without a specific syllable or phoneme (e.g., "Say meat. Now say meat without saying the /m/ sound."). Ten test trials were administered. Across the three time points, this task had good internal consistency (*as* = .84, .82, and .81, respectively).

Multiple-choice elision: Examiners presented four cards and named the picture shown on each. Children were then asked to point to the word that would be left after removing part of the stimulus word (e.g., "Point to door without /d/."). Children were allowed to respond either verbally or by pointing to one of the cards. Ten test trials were administered. This task assessed phonological awareness at the syllable and phoneme levels. Across the three time points, this task had relatively low internal consistency (*as* = .37, .50, and .39, respectively).

Rhyme oddity: This task was similar to the rhyme detection task used by MacLean et al. (1987) and used the same words. Examiners presented four picture cards, named the item shown on each (e.g., "pig, hat, bat, rat"), and then asked children to choose the one that did not rhyme (e.g., "Which one doesn't rhyme? Which one doesn't sound like the others?"). This task assessed phonological awareness at the supra-phonemic level (i.e., onset and rime units). Eleven test trials were administered. Across the three time points, this task had adequate to good internal consistency (*as* = .59, .78, and .81, respectively).

Rhyme matching: Examiners presented one card with a single picture and asked children which of three pictures on a second card rhymed with it (e.g., "Does hat sound like pig, bat, or hose?"). Children could respond either by saying the rhyming word or by pointing to the corresponding picture. Eleven test trials were administered. This task assessed phonological awareness at the supra-phonemic level (i.e., onset and rime units). Across the three time points, this task had good internal consistency (*as* = .71, .83, and .84, respectively).

Letter knowledge: For both examiner-created letter knowledge tasks, the randomly determined order of presentation was identical for all children, and uppercase letters were presented on white 3 × 5-inch index cards.

Letter-name knowledge: This task comprised 25 letters, each of which was presented separately. Due to a clerical error, the letter "W" was not included. Letters were presented one at a time until children either provided five incorrect answers or all cards had been presented. Scores on this task were highly stable, as indicated by the 3-month test–retest correlation ($r = .87$, $p < .001$).

Letter-sound knowledge: Children were asked to produce the sound represented by each of eight letters (M, B, D, A, C, O, P, and S) one at a time. For letters that can represent more than one sound, any of the correct sounds was accepted (e.g., /s/ and /k/ for "c"). If a child produced a correct letter name instead of the corresponding sound, the examiner provided a single prompt ("That's the name of the letter. What sound does it make?"). Given that letter-sound knowledge emerges later than letter-name knowledge, a subset of letters was used to minimize fatigue and frustration. Scores on this task were relatively stable, albeit less so than scores on the letter-name task, as indicated by the 3-month test–retest correlation ($r = .57$, $p < .001$).

Receptive vocabulary—Vocabulary was measured using the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981), a norm-referenced receptive vocabulary test validated for children as young as age 2.5 years. For each item, children were shown four black-and-white line drawings and asked to point to the target item. Rasch–Wright latent trait split-half reliability for children between 3 and 5 years of age is high (*rs* = .70–.79).

Procedure

Informed consent was obtained from children's parents before and during the first weeks of preschool. Children were tested individually in a quiet area of the preschool by trained graduate and undergraduate students. Measures of phonological awareness and letter knowledge were administered at approximately 4-month intervals at the beginning, middle, and end of the preschool year. The same procedures were used at each time point. Vocabulary was measured at the first time point only. Tasks were presented in one of six predetermined random orders to counterbalance any order effects. When pictures were used as multiple-choice response options on phonological awareness tasks, they were presented in a randomly determined order that was uniform across all participants. Although we did not formally observe the instruction provided in these preschools, informal observation revealed little to no evidence of explicit code-focused instruction. Data for this study came from a multi-year longitudinal study that began during the early 2000s.

RESULTS

Preliminary analysis and descriptive statistics

Descriptive statistics for all measures at each time point are shown in Table 1. At the beginning of the year, the distribution of scores on several tasks was characterized by small, mostly positive skew (mean skew = .62, *SD* = .65). At the end of the year, the scores on several tasks were characterized by small to moderate, mostly negative skew (mean skew = .44, *SD* = .91; only multiple-choice blending had skew greater than ±1.0). Despite some clustering at the high end of the distribution at the end of the year, only 1.2% of the children answered more than 90% of the phonological awareness items correctly and fewer than 25% of the children answered more than 90% of the letter knowledge items correctly. During the preschool year, some children stopped attending the preschool or were unavailable during the range of dates when one time point of data was collected. As a result, data were missing for between 0% and 4% of children on any given task, but 89% of children had no missing data on any task. Measurement models for latent growth curve models

The trajectories of phonological awareness and letter knowledge across the preschool year were examined by creating second-order latent growth models (McArdle, 2009) in Mplus 5.1 (Muthén & Muthén, 1998). These models were otherwise identical to latent growth models based on observed scores (e.g., Curran & Muthén, 1999), but instead of estimating growth on the basis of observed scores, these models estimated growth using latent variables to represent phonological awareness and observed scores to represent letter knowledge. Vocabulary was represented by PPVT-R standard scores at the first time point. Full information maximum likelihood estimation was used to account for missing data on all tasks, and the Yuan–Bentler chi-square (Y–B χ^2; Yuan & Bentler, 1996), a robust estimator, was used to adjust standard errors to account for non-normality. In addition to nonsignificant Y–B χ^2 values, comparative fit index (CFI) values greater than or equal to .95 and root mean squared error of approximation (RMSEA) values less than or equal to .08 were considered to indicate adequate model fit (Hu & Bentler, 1999). To test the hypotheses concerning the influence of initial scores on growth, the first time point was set as the intercept.

The first step in the model building process was to construct separate latent growth models for each phonological awareness factor (i.e., Blending, Elision, Rhyme, Composite Phonological Awareness) and for each letter knowledge task. The first three phonological awareness factors were represented by the variance shared across tasks that required the same operation (i.e., blending, elision, rhyme) but differed in format. The fourth factor was represented by the variance shared by all eight phonological awareness tasks. In each model, factor loadings of each phonological awareness task on the respective factors were constrained to equality across the three time points to ensure measurement invariance. In addition, the intercepts for each phonological awareness factor were constrained to equality across time points, with the exception of the model for rhyme, in which varying estimates for the intercepts were required to achieve model convergence. As shown in Table 2, these models provided adequate fit to the data, indicating that the tasks measured phonological awareness in the same way at each time point (i.e., measurement invariance). Significant intercept variance was detected in all six models, indicating significant inter-individual differences on all outcomes at the beginning of the preschool year. Significant slope variance was detected in all four phonological awareness models and the letter-name model but not the letter-sound model, indicating significant inter-individual differences in the rate of growth in all four phonological awareness factors and letter-name knowledge.

Simulation studies have demonstrated that skew values greater than ±3.00 can lead to model misspecification (Kline, 2011). Although no skew values more extreme than ±3.00 were observed, the distribution of scores on some tasks was truncated at the high or low end of the range of possible scores (e.g., rhyme matching at Times 2 and 3). A truncated distribution of scores suggests that significant differences in the skill being measured may still exist among children who achieved the same (either the highest or lowest) score on a task because the task was not adequately sensitive to individual differences at one end of the distribution. If standard maximum likelihood estimators are used to test predictions of an outcome whose distribution is truncated at one end (i.e., censored), biased estimates can result from the violation of the assumption of approximate univariate normality even in the absence of problematic levels of overall skew (Powell, 1984). Therefore, the censored variable function in Mplus was used to create the models in which growth in the Rhyme factor was predicted. The treatment of the Rhyme factor as censored did not materially change the parameter estimates generated by the model but was required to achieve model convergence.

Conditional growth curve models

Zero-order correlations—As shown in Table 3, vocabulary was correlated with initial status on all four phonological awareness outcomes but was unrelated to growth in any outcome. Older children began the year with higher scores on all four phonological awareness outcomes and letter-name knowledge. Although age was unrelated to growth in most outcomes, older children did experience slightly faster growth in rhyme and letter-name knowledge. Growth in Blending, Elision, and Composite Phonological Awareness was weakly or nonsignificantly related to initial letter knowledge, whereas growth in rhyme was significantly and positively related to initial levels of both letter-name and letter-sound knowledge. Within-construct correlations indicated that intercepts were at least weakly and negatively correlated with slope for Blending, Elision, letter-name knowledge, and letter-sound knowledge, indicating that children who started the preschool year with higher levels of these skills tended to experience less growth in the same skill during the preschool year than children who started the year with lower levels of these skills. There was a significant positive correlation between intercept and slope for Rhyme, indicating that children who started the year with more developed rhyme skills tended to experience more growth in the same skill during the preschool year than children who started the year with less developed rhyme skills. There was a small, nonsignificant positive correlation between slope and intercept for the Composite Phonological Awareness factor. This trend was probably the result of opposing slope–intercept correlations for rhyme versus blending and elision.

Predictive models—In the first set of models, initial letter-name knowledge and receptive vocabulary were tested as possible unique predictors of growth in each of the four phonological awareness factors while controlling for child age, the initial level of the same phonological awareness factor being predicted, and growth in letter knowledge. The rate of growth of the same letter knowledge factor being used as a predictor was included to account for individual differences in the overall rate of acquisition of code-related skills and to control for possible effects of code-related instruction occurring in children's preschools. The second set of models was identical to the first except that letter knowledge was represented by letter-name knowledge in the first set of models and by letter-sound knowledge in the second. In the third and fourth sets of models, initial phonological awareness and vocabulary were tested as possible unique predictors of growth in letter-name and letter-sound knowledge, respectively, while controlling for child age, initial level of the letter knowledge skill in which growth was being predicted, and growth in phonological awareness. Again, the rate of growth of the phonological awareness factor was included to help account for overall growth in code-related skills. The Composite Phonological Awareness factor was first used as a predictor and, in the case of a significant relation between initial phonological awareness and letter knowledge growth, follow-up analyses of individual phonological awareness factors were used to identify the factor or factors most associated with the predictive relation.

Phonological awareness outcomes—Results of models in which letter-name knowledge was included as a predictor are shown in the upper panel of Table 4. For all phonological awareness outcomes except rhyme, children with higher initial levels of phonological awareness experienced less growth in phonological awareness across the preschool year than did children with lower initial levels of phonological awareness. For all phonological awareness outcomes except elision, older children experienced more growth in phonological awareness than did younger children. Growth across all phonological awareness outcomes was associated with growth in letter-name knowledge, indicating a degree of similarity in the developmental trajectory of these two code-related skills. Children with higher initial levels of letter-name knowledge experienced faster growth in phonological awareness across the preschool year than did children with lower initial levels of letter-name knowledge. Vocabulary was weakly but positively related to growth in phonological awareness; however, it achieved a conventional level of statistical significance only for the blending outcome. Intraclass correlation coefficients (ICCs) were calculated for each phonological awareness task at each time point. The ICCs (range = 0.01–0.16, M = 0.06, SD = 0.05) indicated that, on average, 6% of the variance on these tasks was attributable to preschool-level factors and yielded design effects (DEs) that were generally small in magnitude (M = 1.91, SD = 0.80). The DEs for two tasks (word and syllable elision at Time 1 DE = 3.35; rhyme detection at Time 2 DE = 2.12) were greater than 2.0, which may suggest the need to account for the clustering of children within preschools (Muthén & Satorra, 1995). Because the use of multilevel models with fewer than 20 clusters can lead to biased parameter estimates (Maas & Hox, 2005), each predictive model was estimated with and without a sandwich estimator in Mplus to account for preschool-level variance. When models were estimated using a sandwich estimator, results were unchanged; therefore, the unadjusted parameter estimates are reported.

Results of models in which letter-sound knowledge was included as a predictor are shown in the lower panel of Table 4. Growth across all phonological awareness outcomes, except rhyme, was positively associated with growth in letter-sound knowledge, indicating a degree of similarity in the developmental trajectory of these two code-related skills. Unlike the results for letter-name knowledge, however, neither initial level of phonological awareness nor initial level of letter-sound knowledge was uniquely associated with growth in phonological awareness, suggesting that phonological awareness and letter-sound knowledge shared much of their predictive variance (i.e., rendering the significant relation between initial phonological awareness and growth in phonological awareness nonsignificant). Neither vocabulary nor age was significantly associated with growth in the Blending, Elision, or Composite Phonological Awareness factor; however, age was positively associated with growth in the rhyme factor. When models were estimated using a sandwich estimator, results were unchanged; therefore, the unadjusted parameter estimates are reported.

Letter knowledge outcomes—As shown in Table 5, higher initial letter-name knowledge was associated with slower growth in the same skill. Growth in letter-name knowledge was uniquely predicted by higher initial composite phonological awareness but not by age or vocabulary. Follow-up analyses indicated that growth in letter-name knowledge was most strongly predicted by initial status on the Elision factor ($\beta = .41$, $p < .001$), marginally related to initial status on the Blending factor ($\beta = .23$, $p = .058$), and not significantly related to initial status on the Rhyme factor. There were no significant predictors of growth in letter-sound knowledge. Although the ICCs for the letter knowledge tasks at each time point were low on average (range = .02–.12, $M = .08$, $SD = .04$), they yielded slightly larger DEs than the ICCs for the phonological awareness tasks (range = 1.51–3.47, $M = 2.59$, $SD = 0.74$). When models were estimated using a sandwich estimator, results were unchanged; therefore, the unadjusted parameter estimates are reported.

DISCUSSION

The results of this study demonstrated that growth in two important code-related skills, phonological awareness and letter knowledge, was partially dependent on the initial level of the other skill. That is, there were bidirectional predictive relations between the initial status of each skill and growth of the other skill across the preschool year. Children who initially had more letter-name knowledge experienced more growth in phonological awareness, and children who initially had more phonological awareness experienced more growth in letter-name knowledge. Significantly, these predictive relations were detected using measures of phonological awareness that included both phonemic- and supra-phonemic-level items, indicating that the link between letter knowledge and phonological awareness is not limited to phonemic awareness. These results indicate that the pattern of bidirectional relations between letter knowledge and phonological awareness originates at an earlier point in development than previously reported. Finally, the simultaneous inclusion in each model of age and growth in the code-related skill being used as a predictor adds specificity to the findings by indicating that the observed bidirectional relation was not better accounted for by general maturation or the correlated development of letter knowledge and phonological awareness.

Previous studies of the relation between letter knowledge and phonological awareness included older preschool children and examined developmental influences on the skills required to detect or manipulate individual phonemes (e.g., Bowey, 1994; Johnston et al., 1996). Although younger children are likely to score at or near the floor of phoneme-level tasks, they are able to perform phonological awareness tasks that require manipulation of larger sound units (e.g., words, syllables, onsets, rimes). Burgess and Lonigan (1998) examined the relation between letter knowledge and phonological awareness using tasks that required sensitivity to both larger and smaller units of sound. Although they included phonological awareness tasks requiring manipulation at the supra-phonemic level at the beginning and end of the preschool year, the phonological awareness tasks used to test the influence of letter knowledge on phonological awareness involved only manipulation of individual phonemes due to ceiling effects on the supra-phonemic tasks at the end of the preschool year. Therefore, the possibility that letter knowledge may influence the development of earlier emerging aspects of phonological awareness was not examined. In contrast, in this sample, significant inter-individual differences on tasks requiring both phonemic and supra-phonemic sensitivity were present across the entire preschool year. The detection of largely the same bidirectional relation between letter knowledge and earlier emerging aspects of phonological awareness indicates that this relation begins earlier in the development of phonological awareness than previously reported. The extension of the relation between letter knowledge and growth in phonological awareness to supra-phonemic tasks is consistent with previous evidence regarding the dimensionality of phonological awareness during preschool (e.g., Lonigan et al., 2009; Schatschneider et al., 1999). Specifically, given that phonemic and supra-phonemic phonological awareness tasks are indicators of the same underlying capacity, the same relation would be expected between initial letter knowledge and growth in both types of phonological awareness tasks. This study provides empirical evidence to support that prediction.

Cross-construct predictors

Letter-name knowledge—Initial level of letter-name knowledge predicted individual differences in growth in the Blending, Elision, Rhyme, and Composite Phonological Awareness factors, with the weakest association between initial letter-name knowledge and the Rhyme factor. This pattern almost exactly replicates the findings of Burgess and Lonigan (1998), who reported that letter-name knowledge was uniquely related to blending, elision, and alliteration detection but not rhyme. Burgess and Lonigan hypothesized that letter knowledge promoted the development of phonological awareness by facilitating the identification of single phonemes. However, the results of this study indicate that the role of letter knowledge in the development of phonological awareness is more general because it is also related to the development of supra-phonemic skills.

Although the initial level of each code-related skill was uniquely associated with the rate of growth in the other, the mechanism responsible for this association is unknown. Given that there was only a modest amount of school-level variance (i.e., 6–8%) in performance on the phonological awareness and letter knowledge tasks, it appears that school-level factors were not strongly related to either outcome. Perhaps it is the case that children who know more letters at the time of preschool entry have had more exposure to print and, therefore, have an initial understanding that letters represent sounds in words, although they have not yet matched specific letters in words to specific sounds in words. Similarly, it is possible that children who begin the year with higher levels of certain code-related skills are more likely to engage in literacy-related activities with teachers or other adults or do so more successfully. Either of these possibilities would be consistent with Ehri's (2005) model of decoding development, in which children who enter preschool knowing some letter names would be in the more advanced "partial alphabetic phase" compared with children who enter preschool knowing few or no letters, who would be in the earlier "pre-alphabetic phase."

One possible explanation of the relation between letter-name knowledge and the development of phonological awareness is that knowing the name of a letter may increase its facilitative effects on the detection and manipulation of sounds within spoken language. This explanation is consistent with the findings of a systematic review (Castles & Coltheart, 2004) that examined the relation between phonological awareness and other reading-related skills. Castles and Coltheart (2004) concluded that letter knowledge may facilitate performance on phonological awareness tasks not by influencing phonological awareness itself but rather by increasing the salience of letters as clues for identifying and manipulating the sounds within words. Although alphabet knowledge does appear to facilitate the performance of phonological tasks, evidence from experimental studies (e.g., Hulme, Caravolas, Málková, & Brigstocke, 2005) demonstrates that some degree of phonological awareness, even at the level of single phonemes, can exist in the absence of any letter knowledge. Specifically, children were able to identify single phonemes for which they could not identify the corresponding grapheme, and children who could not identify even one grapheme were able to correctly identify and manipulate at least some single phonemes. Thus, letter knowledge appears to promote, but does not necessarily underlie, the detection and manipulation of sounds within spoken language.

Given the significant univariate correlations between letter knowledge and phonological awareness, the apparent bidirectional influence between these two code-related skills could indicate that both skills are driven by the same influences (e.g., exposure to print) or it could simply represent general maturation. However, the results of this study do not support either of these alternative explanations. That is, initial letter-name knowledge was predictive of growth in phonological awareness and initial phonological awareness was predictive of growth in letter-name knowledge even after accounting for age and the common rate of growth across the two skills. Thus, the relation between initial letter knowledge and growth in phonological awareness and the relation between initial phonological awareness and growth in letter-name knowledge were both independent of the observed similarities in the rate of development in these two skills. Although the absence of an experimental manipulation precludes causal inference, ruling out maturation and correlated developmental trajectories as sufficient explanations of the observed bidirectional relation between phonological awareness and letter knowledge increases the specificity of the predictive relations being examined.

Letter-sound knowledge—In contrast to the bidirectional relation between phonological awareness and letter-name knowledge, initial letter-sound knowledge did not uniquely predict growth in phonological awareness, and initial phonological awareness did not uniquely predict growth in letter-sound knowledge. The absence of a relation between initial phonological awareness and growth in letter-sound knowledge was probably attributable to the pattern of individual differences on the letter-sound knowledge task. In this sample, reliable individual differences were detected in initial status but not growth in letter-sound knowledge. As a result, it was possible to test initial letter-sound knowledge as a predictor of growth in phonological awareness, but it was not possible to examine predictors of individual differences in letter-sound knowledge growth. Although the individual differences in initial letter-sound knowledge were statistically significant, the narrow range of scores on this measure reduced the statistical power to detect a relation between initial letter-sound knowledge and growth in phonological awareness. One purpose of this study was to determine how the relation between earlier emerging aspects of letter knowledge and phonological awareness among younger preschool children might resemble or differ from the relation between later emerging aspects of the same two skills in older preschool children. In this sample, children's initial level of letter-name knowledge significantly predicted growth in phonological awareness, but initial letter-sound knowledge did not. This finding suggests that earlier emerging aspects of phonological awareness (i.e., sensitivity to larger units of sound) may be more closely related to earlier emerging aspects of alphabet knowledge than later emerging aspects of alphabet knowledge.

Phonological awareness—The unique relation between initial phonological awareness and letter knowledge growth in this study is consistent with evidence that phonological awareness facilitates the development of letter knowledge. Specifically, when letter names provide clues to the corresponding letter sounds, children with higher levels of phonological awareness are more able to utilize those clues (e.g., Ehri, 2005; Foulin, 2005; Kim et al., 2010). The absence of reliable individual differences in letter-sound knowledge growth precluded a test of predictors of that growth in this sample; however, the unique relation between phonological awareness and growth in letter-name knowledge in this study represents a similar relation between phonological awareness and an earlier emerging indicator of alphabet knowledge. With regard to the mechanism that may be responsible for this relation, given that phonological memory and phonological awareness are part of the same construct in preschool children (Lonigan et al., 2009), children with more developed phonological awareness would be more able to maintain auditory information about letter names (e.g., "This is the letter B.") in working memory while looking at the letter. As a result, children with more developed phonological awareness could more efficiently encode letter-name pairings into long-term memory.

Vocabulary—With the exception of the blending tasks, vocabulary was not uniquely related to phonological awareness growth. Evidence regarding the relation between vocabulary size and phonological awareness is mixed. For example, according to the LRM, early vocabulary development is characterized by storage of whole words, but as children learn increasingly many similar-sounding words (i.e., dense phonological neighborhoods), a more segmental system is required to maintain distinctions between similar words.

Consistent with the LRM, results of at least some studies support a relation between vocabulary size and increases in phonological awareness (e.g., Metsala & Walley, 1998; Walley et al., 2003). At least one study has reported findings consistent with the LRM in a preschool sample. Goodrich and Lonigan (2015) reported a significant relation between expressive vocabulary and concurrent phonological awareness during the preschool year. In contrast, results from a number of experimental studies indicate that, contrary to the predictions of the LRM, increases in the specificity of phonological representations are independent of vocabulary size in general and neighborhood density in particular. For example, Swingley and Aslin (2000) reported that children ranging in age from 18 to 23 months could differentiate between correct pronunciations of familiar words and non-word mispronunciations that differed by a single phoneme (i.e., minimal pairs) and that the degree to which children could make this distinction was orthogonal to vocabulary size. Similar findings were also reported in a sample of children aged 14 months (Ballem & Plunkett, 2005). Specifically, neither expressive nor receptive vocabulary was significantly correlated with degree of sensitivity to mispronunciations of familiar words (e.g., ball, cup) or novel non-words (e.g., tuke, vope). Given that vocabulary size was uncorrelated with the degree to which children could detect mispronunciations, it seems unlikely that increasing vocabulary size was the mechanism responsible for or a necessary prerequisite to growth in phonological awareness. The absence of an observed relation between vocabulary and growth in phonological awareness in this study is consistent with the findings of these experimental studies; however, the absence of a relation between vocabulary size and growth in phonological awareness is not entirely inconsistent with the findings of Goodrich and Lonigan (2015) the difference between studies could represent differences between longitudinal and concurrent relations between vocabulary and phonological awareness. Future studies might address this distinction by examining both concurrent and longitudinal relations between vocabulary and phonological awareness across the preschool year.

Within-construct predictors

For both phonological awareness and letter-name knowledge, initial status and growth were negatively related. Children's initial level of code-related skill may indicate their level of exposure to print before preschool entry. In that case, print exposure during preschool would be more novel and, therefore, more influential for children with lower levels of previous exposure than it would be for children with higher levels of previous exposure. As a result, children with lower initial skill levels would be expected to benefit more from preschool activities than those with higher initial skill levels. Another possibility is that children who began the year knowing more letter names or with more developed phonological awareness were more likely than their peers to approach the ceiling of these measures during the year. For instance, 23% of children achieved the highest possible score on the letter-name knowledge task at the third time point. For letter-sound knowledge, in contrast, only 13% of children achieved the highest possible score at the third time point. As a result, children who began the year knowing more letter sounds than their peers were less likely to be limited in the number of letter sounds that remained to be learned. Accordingly, initial status and growth were positively related for letter-sound knowledge. Scores across the repeated administrations of the letter-sound knowledge task were also less strongly correlated than were scores on the letter-name knowledge task, indicating that whatever mechanism may account for the relation between initial status and growth in letter knowledge appears to be more important for learning letter names than for learning letter sounds, at least during the early stages of letter knowledge acquisition.

Limitations and future directions

Although this study had a number of strengths, including a relatively large sample and measurement operations that allowed growth modeling of phonological awareness and letter knowledge constructs, the results should be considered in the context of several limitations. The absence of an experimental manipulation precludes causal inference; however, the presence of significant unique relations observed while controlling statistically for the most plausible alternative explanations provides increased specificity relative to previous studies of the relation between phonological awareness and letter knowledge. Second, predictors of growth in letter-sound knowledge could not be tested because the rate of growth in this skill was uniform across all participants. The inclusion of only eight items may have limited the detection of individual differences in letter-sound knowledge growth. However, the task included the eight earliest acquired letter sounds (Phillips, Piasta, Anthony, Lonigan, & Francis, 2012), and most children in this study could identify fewer than four letter sounds, even at the end of the preschool year. Therefore, it is unlikely that individual differences in letter-sound knowledge growth would have been detected by a task including additional, later-acquired letter sounds. Children in this study attended preschools that did not explicitly teach letter names and sounds. In contrast, children who attend preschools that effectively teach letter names and sounds may have demonstrated greater individual differences in letter-sound knowledge growth, thereby providing a better opportunity to examine the relation between phonological awareness and letter-sound knowledge. Still, many children do attend preschools that do not provide effective instruction in code-related skills. For instance, according to data from the Office of Early Learning (2015), many children attend preschools that do not adequately prepare them for kindergarten. Specifically, between 2010 and 2013 (the years for which data using the current assessment procedures are available), only 75% of preschools prepared at least 90% of students adequately for kindergarten and more than one-third of preschools prepared fewer than 75% of students adequately for kindergarten. Therefore, it is important to know how these skills relate in the absence of explicit, effective code-focused instruction.

The findings of this study should also be considered in light of two potential measurement issues. Although the internal consistency of most of the phonological awareness tasks was good or excellent, the reliability of other phonological awareness tasks was more modest. As expected, the multiple-choice measures (blending and elision) had the lowest levels of internal consistency, probably as a result of random variance introduced by guessing. Ideally, each phonological awareness factor would have been represented only by tasks with high internal consistency. However, only reliable variance on each task contributed to factor scores in the latent variable growth models; therefore, lower reliability on a subset of the phonological awareness tasks cannot explain the observed interdependence between letter knowledge and phonological awareness. Both letter-name knowledge and letter-sound knowledge were modeled as manifest variables, which cannot separate variance attributable to task-specific features from variance attributable to letter knowledge itself. However, it is not clear that latent variables are necessary for the measurement of letter knowledge. Compared to phonological awareness, an abstract capacity that can be measured by various types of tasks, letter knowledge is typically represented by observed scores. Furthermore, if extraneous variance did influence scores on the letter knowledge measures, this could only decrease the reliability of these measures. Therefore, the use of observed scores to represent letter knowledge in the growth models could only attenuate the estimates of predictive relations between letter knowledge and phonological awareness but could not account for the observed pattern of cross-construct relations.

Summary and conclusions

The findings of this study replicate and extend previous evidence of a bidirectional relation between phonological awareness and letter knowledge. Specifically, the influence of letter knowledge on the development of phonological awareness was extended to larger, earlier emerging units of sound, including words, syllables, and onset–rime pairs. Moreover, this study provided evidence that the influence of phonological awareness on the development of letter knowledge, previously demonstrated only with phoneme-level tasks (e.g., Bowey, 1994; Johnston et al., 1996), is also present earlier in the development of phonological awareness. Finally, the use of more sophisticated statistical models both allowed a demonstration of bidirectional developmental influences on actual rates of growth in phonological awareness skills and letter knowledge—as opposed to prediction of an outcome at a later point in time controlling for scores on the outcome at an early point in time—and increased the specificity of the relation being tested by demonstrating that the influence of initial status in each code-related skill on growth in the other was independent of overall growth in code-related skills.

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Table 1

Descriptive statistics for each task at the beginning, middle, and end of the preschool year.

Measure and time point	*M*	*SD*	Min	Max	*n*	Skew
Age						
Time 1	48.54	7.26	33.00	67.00	341	0.18
Time 2	51.55	6.97	34.00	67.00	340	0.00
Time 3	55.48	6.92	38.00	70.00	334	−0.02
Blending words						
Time 1 raw scores	4.06	3.93	0.00	11.00	343	0.46
Time 2 raw scores	6.15	4.11	0.00	11.00	340	−0.33
Time 3 raw scores	7.54	3.75	0.00	11.00	331	−0.87
Blending syllables and phonemes						
Time 1 raw scores	3.01	2.63	0.00	10.00	344	0.83
Time 2 raw scores	4.14	2.62	0.00	10.00	337	0.35
Time 3 raw scores	4.93	2.57	0.00	10.00	331	0.20
Blending, multiple choice						
Time 1 raw scores	7.87	1.95	1.00	10.00	344	−0.83
Time 2 raw scores	8.65	1.57	2.00	10.00	339	−1.26
Time 3 raw scores	9.01	1.59	0.00	11.00	331	−2.68
Elision words						
Time 1 raw scores	3.27	3.87	0.00	11.00	342	0.76
Time 2 raw scores	5.34	4.09	0.00	11.00	337	−0.09
Time 3 raw scores	6.81	3.91	0.00	11.00	329	−0.69
Elision syllables and phonemes						
Time 1 raw scores	1.39	2.11	0.00	9.00	344	1.35
Time 2 raw scores	2.45	2.38	0.00	10.00	337	0.67
Time 3 raw scores	3.20	2.47	0.00	10.00	331	0.25
Elision, multiple choice						
Time 1 raw scores	4.75	1.78	0.00	9.00	343	0.22
Time 2 raw scores	4.82	1.96	0.00	10.00	337	0.19
Time 3 raw scores	5.51	1.77	0.00	10.00	329	−0.03
Rhyme oddity						
Time 1 raw scores	3.51	2.21	0.00	11.00	344	1.14
Time 2 raw scores	4.23	2.96	0.00	11.00	340	0.73
Time 3 raw scores	5.15	3.19	0.00	11.00	331	0.35
Rhyme matching						
Time 1 raw scores	5.26	2.78	0.00	11.00	343	0.58
Time 2 raw scores	6.51	3.26	0.00	11.00	336	−0.03
Time 3 raw scores	7.20	3.23	0.00	11.00	330	−0.38
Letter names						
Time 1 raw scores	10.50	9.53	0.00	25.00	344	0.31
Time 2 raw scores	13.68	9.66	0.00	25.00	336	−0.20

Measure and time point	***M***	***SD***	**Min**	**Max**	***n***	**Skew**
Time 3 raw scores	16.63	9.21	0.00	25.00	331	−0.74
Letter sounds						
Time 1 raw scores	1.73	2.39	0.00	8.00	344	1.40
Time 2 raw scores	2.63	2.98	0.00	8.00	336	0.67
Time 3 raw scores	3.50	3.02	0.00	8.00	331	0.20
Vocabulary, Time 1 standard score	98.99	15.52	0.00	138.00	343	−1.33

Table 2

Unconditional model parameters for the second-order latent growth models.

Model	Y-B χ^2	*df*	CFI	RMSEA [95% CI]	Slope		Intercept variance
					Mean	Variance	
Phonological awareness							
Blending	52.79^{**}	26	.96	.06 [.03-.08]	1.52^{***}	0.71^{**}	5.49^{***}
Elision	65.88^{***}	25	.96	.07 [.05-.09]	1.73^{***}	1.22^{**}	9.25^{***}
Rhyme	28.23^{***}	6	.97	.10 [.07-.14]	0.97^{***}	1.26^{***}	3.56^{***}
Composite	626.87^{***}	255	.89	.07 [.06-.07]	1.43^{***}	0.44^{**}	4.78^{***}
Letter knowledge							
Names	1.18^{ns}	2	1.00	.00 [.00-.09]	2.96^{***}	10.86^{***}	90.74^{***}
Sounds	7.79^{ns}	3	.98	0.7 [.00-.13]	0.82^{***}	0.25^{ns}	3.12^{***}

Note. In the letter-sound knowledge model, residuals were constrained to equality across all three time points so that variance of slope and intercept could be estimated.

ns $p > .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Univariate relations between print-related predictors and outcomes for each model of phonological awareness.

Model and factor	Parameter	Age	Vocabulary	LN intercept	LN slope	LS intercept	LS slope	PA intercept[a]	PA slope[a]
Phonological awareness									
Blending	Intercept	$.42^{***}$	$.25^{***}$	$.58^{***}$	$-.15^{*}$	$.73^{***}$	−.10	–	–
	Slope	−.01	.08	.05	$.29^{**}$	−.09	$.66^{***}$	$-.22^{*}$	–
Elision	Intercept	$.35^{***}$	$.28^{***}$	$.54^{***}$	−.03	$.68^{***}$	−.05	–	–
	Slope	.03	−.05	.01	$.31^{**}$	$-.20^{**}$	$.53^{***}$	−.17	–
Rhyme	Intercept	$.37^{***}$	$.22^{***}$	$.45^{***}$	−.04	$.67^{***}$	.03	–	–
	Slope	$.23^{*}$	.09	$.38^{***}$	.10	$.33^{**}$	$.27^{*}$	$.46^{**}$	–
Composite	Intercept	$.41^{***}$	$.28^{***}$	$.57^{***}$	−.08	$.77^{***}$	−.03	–	–
	Slope	.07	.04	$.13^{+}$	$.35^{***}$	−.10	$.51^{***}$	.07	–
Letter knowledge									
Letter name	Intercept	$.15^{*}$	.02	–	$-.40^{***}$	–	–	$.57^{***}$	$.13^{+}$
	Slope	−.07	−.04	$-.40^{***}$	–	–	–	$-.08^{ns}$	$.35^{***}$
Letter sound	Intercept	$.12^{*}$	−.01	–	–	–	−.10	$.77^{***}$	−.10
	Slope	$.20^{*}$	$.13^{+}$	–	–	−.10	–	−.03	$.51^{***}$

Note. LN, letter-name knowledge; LS, letter-sound knowledge; PA, phonological awareness.

[a]Parameter for intercept from blending, elision, rhyme, or composite phonological awareness model or intercept and slope from composite phonological awareness model. Within-construct relations were taken from models that included letter-name knowledge.

$^{+}$ $p < .10$.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 4

Multivariate relations between print-related predictors and outcomes for each model of phonological awareness using second-order latent growth models.

Predictor	Phonological awareness dependent variable			
	Composite	Rhyme	Blending	Elision
Models for letter-name knowledge				
Initial letter-name knowledge	.48***	.24*	.40**	.33*
Slope letter-name knowledge	.51***	.21*	.37**	.44***
Initial phonological awareness	−.48***	.17	−.59**	−.40+
Receptive vocabulary	.15+	.05	.21*	.05
Chronological age	.23**	.35**	.21+	.15
R^2 for slope parameter	.32***	.25*	.29**	.21*
Models for letter-sound knowledge				
Initial letter-sound knowledge	−.06	.08	−.19	−.06
Slope letter-sound knowledge	.48***	.18	.81*	.59***
Initial phonological awareness	−.12	.14	.31	−.13
Receptive vocabulary	.07	.09	−.05	−.03
Chronological age	.15	.30*	−.22	.05
R^2 for slope parameter	.30	.18*	.59	.40**

+ $p < .10$.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 5

Initial phonological awareness and phonological awareness slope as predictors of growth in letter knowledge during the preschool year using second-order latent growth models.

Predictor	**Letter knowledge dependent variable**	
	Letter-name knowledge	**Letter-sound knowledge**
Initial letter-name knowledge	−.63***	–
Initial letter-sound knowledge	–	−.06
Initial phonological awareness	.34***	−.11
Slope phonological awareness	.46***	.47***
Receptive vocabulary	−.05	.13
Chronological age	−.02	.21*
R^2 for slope parameter	.39***	.31**

Note. Phonological awareness is represented by the Composite factor.

* $p < .05$.

** $p < .01$.

*** $p < .001$.