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Wijaythilake, Marasinghe A. D. K., Parrila, Rauno, Inoue, Tomohiro and Nag, Sonali

Wijaythilake, M. A. D. K., Parrila, R., Inoue, T. and Nag, S. (2018). Instruction matters to the development of phoneme awareness and its relationship to akshara knowledge and word reading : Evidence from Sinhala. *Scientific Studies of Reading, 22*(5), pp. 420-433. https://doi.org/10.1080/10888438.2018.1466890

RUNNING HEAD: Phoneme-level instruction

Instruction matters to the development of phoneme awareness and its relationship to akshara knowledge and word reading: Evidence from Sinhala.

M.A.D.K. Wijaythilake

University of Alberta

R. Parrila

Macquarie University

Tomohiro Inoue

University of Alberta

&

Sonali Nag

University of Oxford

Author Note: We would like to than Dr. David Share and the reviewers for their helpful comments on earlier versions of this manuscript. Correspondence regarding this paper can be sent either to Dr. Deepani Wjijaythilake at wijayth@ualberta.ca or to Dr. Rauno Parrila at rauno.parrila@mq.edu.au.

Abstract

We examined whether global instruction of complex akshara and explicit phoneme-level instruction of akshara impact the development of phoneme awareness and its association with akshara knowledge and word reading accuracy. The participants were 100 Sinhala-speaking children from Grades 4 and 5 in Sri Lanka. Phoneme awareness showed stronger growth and a significant relationship with word reading accuracy and akshara knowledge only after children received explicit phoneme-level instruction in akshara construction. Both word reading accuracy and akshara knowledge predicted phoneme awareness, but the opposite was not true. The results suggest that phoneme awareness in Sinhala is sensitive to the method of reading instruction, and, contrary to the studies in alphabetic languages, it does not have a bidirectional relationship with reading.

Instruction matters to the development of phoneme awareness and its relationship to akshara knowledge and word reading: Evidence from Sinhala.

A number of longitudinal and intervention studies have shown that phonological skills provide a critical foundation for learning to read in alphabetic orthographies and that the relationship between phonological skills and reading is bidirectional (e.g., Caravolas, Lervåg, Defior, Seidlova Malkova, & Hulme, 2013; Hulme, Bowyer-Crane, Carroll, Duff, & Snowling, 2012; Wagner, Torgesen, & Rashotte, 1994). As children learn letters and graphemes, they learn to identify the corresponding phonemes which then leads to enhanced phonemic awareness (e.g., Wagner et al., 1994), while the early phonological awareness, including phonemic awareness, makes the task of learning letter names and sounds easier (e.g., Burgess & Lonigan, 1998; Hulme, Hatcher, Nation, Brown, Adams, & Stuart, 2002; Lerner & Lonigan, 2016). Given that graphemes in alphabetic orthographies represent phonemes and early reading instruction frequently focuses on this relationship, the link between learning letters (and graphemes) and improved phoneme awareness is expected.

The relationship between phonology and orthography, however, is different in Indic alphasyllabaries where the basic orthographic units, akshara, map to phonology both at the level of syllables and at the level of phonemes (e.g., Bright, 1996; Daniels, 1996; Daniels & Share, 2017; Nag, 2017). Framed within Ziegler and Goswami's grain size theory (2005), the 170 million children learning to read an Indic alphasyllabary gain from the ease of availability and consistency because akshara represent the phonologically salient syllable unit but must deal with mixed granularity in the orthographic representation of phonology. Reading instruction in the akshara orthographies typically addresses the question of mixed granularity with a preference for

the larger grain size. Thus, early reading instruction commonly emphasizes the syllable level mapping by teaching akshara as whole units, whereas the instruction on diacritics that mark individual phonemes only follows at later grades (Nag, 2007, 2011; Nag, Treiman, & Snowling, 2010). While the current evidence on the association between reading and phonological development in the akshara orthographies points to slower emergence of phoneme awareness, the available studies are with groups receiving syllable-level, whole akshara instruction (e.g., Nag, 2007; Nakamura, Joshi, & Ji, 2017). It is possible that when there is phoneme-level instruction, the association between reading acquisition and phonological awareness in akshara orthograhies will be similarly bidirectional as reported in alphabetic orthographies.

Examining the role of akshara instruction differing in level of granularity is also of interest for a related theoretical issue of what kind of literacy learning improves phonemic awareness. In a seminal study, Read, Zhang, Nie, and Ding (1986) showed that Chinese adult readers who had been exposed only to the morphosyllabic writing system did not show phoneme awareness whereas those who had been exposed to an alphabetic writing system (pinyin) did. Thus, the insight about orthography-phonology mapping was the impetus for phoneme awareness. However, it is equally possible that alphabetic literacy per se is not the effective force but rather the explicit instruction in phoneme level units. These associations cannot be separated in alphabetic orthographies or in Chinese (without using an auxiliary writing system) but can in akshara orthographies. In the current paper, we present a one-year longitudinal study with two cohorts of children learning to read Sinhala: one receiving instruction focused on the whole akshara (syllable-level) and the other receiving instruction focused on diacritics (phoneme-level). Examining phoneme awareness and its relationship with akshara knowledge and word reading accuracy in children learning to read Sinhala not only extends current understandings based on a

limited set of orthographies but also can clarify if the manner of instruction rather than just the gaining of literacy per se drives the relationship.

Sinhala orthography

Sinhala belongs to the Indo-Aryan branch of Indo-European languages and is written with a unique akshara script. The basic orthographic unit, akshara, can represent a single vowel or consonant (/V/, /C/), a consonant or consonant cluster with the inherent vowel /a/ (/Ca/, /CCa/, /CCCa/), and a consonant or consonant cluster with a vowel other than the inherent vowel (/CV/, /CCV/, /CCCV/). Both vowels and consonants have their primary forms while all the vowels and most consonants have also secondary forms, or diacritics. When a consonant with a vowel other than the inherent /a/ is written (/CV/, /CCV/, /CCCV/), the /a/ is dropped from the pronunciation of the syllable and the secondary sign (diacritic) of the new vowel is attached to the consonant core. If the akshara includes a consonant cluster, the first consonant can also be ligatured to the second, and it can include a schwa suppressant diacritic, called *hal lakuna*, indicating that the inherent vowel is not pronounced for the first consonant. Example 1 shows five different akshara with the same base consonant.

Example 1:

(a) /k/ with inherent vowel: ක /ka/

(b) /k/ with /i/: කි /ki/

(c) /kr/ with inherent vowel: ක්‍ර /kra/

(d) /kr/ with /i/: ක්‍රි /kri/

(e) /kr/ with /e:/: ක්‍රේ /kre:/

Line *a* shows the base consonant with an inherent vowel that is unmarked and line *b* shows that same consonant with /i/ ligatured on top. Line *c* shows a second consonant /r/

ligatured on the bottom of /k/ with an inherent vowel. Line *d* shows the same combination with the vowel changed to /i/, and line *e* shows the same combination of /kr/ but /e:/ ligatured to the left of the consonant marker and hal lakuna ( ) attached to the top right corner to clarify that the akshara is not pronounced /kare/. Thus, the surface organization of an akshara is typically a symbol block representing a syllable with the additional phonemic markers attached to a core consonant based on a systematic combinatorial principle (Nag, 2017). Once all phonemic markers are attended to, akshara are highly consistent from orthography to phonology – the same akshara is always pronounced as the same syllable.

Reading instruction in Sinhala

Sinhala reading instruction in Sri Lanka follows a fixed sequence and children are introduced to increasingly more complex akshara as wholes for the first four years. Grade 1 students are taught whole akshara with an inherent vowel (Ca), primary vowels (V), CV akshara with a vowel other than the inherent vowel and the primary consonants (C). Students are expected to master consonants with eight vowel diacritics (e.g., the /i/ and /e:/ in Example 1), two schwa suppression diacritics, and two high frequency consonant diacritics (e.g., the /r/ in Example 1) by the end of Grade 1; however, they do not receive instruction in how to identify the specific diacritics inside the akshara block. In Grades 2 and 3, the major focus of the reading and writing instruction is to continue practicing the akshara learned in Grade 1 and correctly read the śuddha akshara set[1]. Teachers use akshara charts to introduce new akshara and excessive

[1] The śuddha akshara set is a subset of the miśra akshara set that contains all the akshara necessary to write classical Literary Sinhala. The current Spoken Sinhala can be represented fully by the śuddha akshara, but Literary Sinhala retains reference to special Sanskrit and Pali sounds captured by the miśra akshara. This is mostly needed for representing the Middle Indic phonemes, such as aspirates, that have disappeared from Spoken Sinhala over time (Gair & Paolillo, 1997; Paolillo, 1997).

copywriting and recitation is the common practice in the classroom in order for students to memorize the shape and the name (which is also the sound of the syllable akshara represents) of akshara. In Grade 4, consonant clusters (the complex CCV akshara) and the miśra akshara set (see footnote 1) are introduced and the new akshara are still taught as whole units (syllable-level instruction). In Grade 5, students are for the first time taught how to decompose CV and CCV akshara into their phonemic components. Students are first taught how to deconstruct single akshara into their phonemic components and then how to deconstruct words akshara-by-akshara.

Nag (2011, 2017) has argued that a key task in akshara learning is to understand the principle that underpins the surface arrangement of the writing system. Recognising the regularities and redundancies in diacritic use across akshara may open the door to a more combinatorial understanding of the orthography. Within this formulation, decomposition is the mechanism that underpins the difference between a global and an analytic representation of the akshara. While it is reasonable to predict that insights about decomposition become available only when children are explicitly shown how akshara break up into diacritic markers, there is to date no direct evidence for this hypothesis. What is known instead is that in groups receiving syllable-level, whole akshara instruction, many children in Grades 2 and 3 are at floor on phoneme manipulation tasks and that better readers show greater phonemic awareness (e.g., Nag, 2007); and when explicit teaching of decomposition begins early, gains in phonemic awareness are recorded earlier (e.g., Sircar & Nag, 2013). Because of the nature of Sinhala reading instruction in Sri Lanka, comparing Grades 4 and 5 offer a natural experiment on the relationship between akshara knowledge, word reading and phoneme awareness when decomposition is left to be inferred and when it is taught explicitly.

Word reading in akshara orthographies

Given that in most akshara orthographies children have to memorize hundreds of akshara (over 400 in Sinhala by Grade 6), it is not surprising that akshara knowledge has emerged as the strongest predictor of reading accuracy and the most common area of deficit in poor readers (e.g., Nag & Snowling, 2012). Further, syllable awareness has consistently been associated with akshara knowledge and with reading performance across the primary school years (Nag, 2007; Nag & Snowling, 2011; Nag-Arulmani, 2003; Nakamura et al., 2017; Nakamura, Koda & Joshi, 2014; Prakash, Rekha, Nigam & Karanth, 1993), whereas phoneme awareness is slow to emerge (Nag, 2007). Once it does emerge, it is concurrently associated with akshara knowledge and reading skills, although it may not predict unique variance in akshara knowledge (Nag, 2007) or word reading accuracy (Nakamura et al., 2014, 2017) after syllable awareness is controlled. Nag and Snowling (2012) suggested that the nature of the writing system promotes syllable level representations making phoneme level processing slower to emerge. When children's knowledge of CV and CCV/CCCV types of akshara increases, their attention is drawn to diacritics and a stronger correlation (around .5 in Nag & Snowling's, 2012, study) between reading and phonemic skills is apparent. Nag (2007) provided preliminary evidence that akshara knowledge drives this relationship: knowledge of complex akshara in time 1 predicted phoneme awareness a year later, but the opposite was not true.

Current study

We examined how akshara instruction impacts the development of phoneme awareness and, further, how phoneme awareness, akshara knowledge, and word reading are interrelated in Grade 4 and 5 students learning Sinhala. More specifically, we examined whether the growth of phoneme awareness and the association between phoneme awareness and akshara knowledge and word reading is strengthened by direct instruction in diacritics rather than by exposure to

complex akshara alone. Several studies with biliterates have suggested that phoneme awareness improves as a consequence of instruction in English (e.g., Mishra & Stainthorp, 2007; Prakash et al., 1993). In Sri Lankan schools, English instruction starts at Grade 2 and our cross-sectional data (Authors, submitted) indicates a Grade 2 boost in phonemic awareness (from a mean of 7 to a mean of 19; see task description below) but the growth slows down in Grade 3 (mean = 22). In the current study, we focus on the learning of diacritic markers in the native language. We focus on Grades 4 and 5, more than two years after initiation of English instruction, and the years when the focus of instruction is first on recognizing the complex akshara with multiple phoneme markers as a whole, and only later on decomposing the complex akshara into its phoneme markers.

We test five hypotheses related to the interrelations between phoneme awareness, akshara knowledge and word reading. First, if children have the capacity to spontaneously infer the combinatorial nature of the writing system, the instruction of complex akshara as whole units in Grade 4 should be sufficient for growth of phonemic awareness. Second, since focus on phoneme level units is greater when instruction is on diacritics than on whole akshara, the growth in phonemic awareness will be greater when there is explicit instruction than when spontaneous inferences have to be made. In Grade 4 children learning Sinhala have been introduced to complex CCV akshara with multiple diacritic markers, but the explicit instruction on those markers and the phonemes they represent takes place only in Grade 5. To assess the first two hypotheses, we will examine how phoneme awareness develops in Grades 4 and 5. Third, we expect that phoneme awareness will be less correlated with akshara knowledge and word reading in Grade 4 than after the instruction on phoneme markers in Grade 5, and, fourth, we expect akshara knowledge rather than phoneme awareness to be the primary predictor of word

reading across both grades due to the nature of instruction and the large akshara set being learned. For hypotheses three and four, we examine both concurrent and cross-lagged associations between phoneme awareness, word reading and akshara knowledge first taking all akshara types together and then examining only those akshara with multiple diacritics (CCV akshara). The cross-lagged correlations will also allow us to examine whether the relationships between phoneme awareness and akshara knowledge/word reading are bidirectional, as expected on the basis of studies in alphabetic orthographies. Given the preliminary findings by Nag (2007), our fifth hypothesis is that this is not the case with Sinhala.

In summary, this study examines the effect of instruction delivered at two levels of granularity (syllable-level and phoneme-level) on the relationships between phoneme awareness, akshara knowledge, and word reading in an Indic orthography. Understanding how different types of akshara instruction affect learning has potentially significant practical importance in guiding reading instruction and interventions. At the theoretical level, the study extends current understanding of reading development to the Sinhala orthography and examines the generalizability of the assumptions that the relationship between reading and phoneme awareness is bidirectional and that literacy acquisition triggers phonemic awareness.

METHOD

Participants

One-hundred Sinhala-speaking children from two well-functioning government schools in Kandy and Kegalle districts in Sri Lanka participated in this study. Fifty students with no documented sensory or behavioural difficulties were assessed prior to entry into Grade 4 (22 females, 28 males; mean age in Time 1 was 100.98 months, *SD* = 2.92) and Grade 5 (20 females, 30 males; mean age in Time 1 was 114.08 months, *SD* = 3.33). Time 2 assessments were

conducted a year later at the end of Grade 4 and Grade 5. Two children, both from the younger cohort, withdrew from the study. Students' first language and the medium of instruction was Sinhala. Both schools were suburban schools serving families from middle to upper-middle socioeconomic backgrounds. All teachers had tertiary education and were Government certified. Students received English and Tamil instruction for several periods during the school week from Grade 2 onwards in line with the language education policy in Sri Lanka.

Materials

Phoneme awareness

Phoneme deletion task required the participant to repeat the words (30) and nonwords (30) after removing the designated sound from the beginning (10), middle (10), or end (10) of the word or nonword. Cronbach's alpha reliability ranged from .95 to .98. Total score was the number of correctly pronounced words/nonwords after removing the designated sound.

Word Reading Accuracy

The participants were asked to read aloud 110 words taken from Grade 1 to 6 language arts books. The length of words increased from two to nine syllables and the test included words with and without CCV akshara. A participant's reading accuracy score was the total number of correctly read words. Cronbach's alpha reliability for the current sample ranged from .94 to .97.

Akshara Recognition

Participants were asked to name aloud (the name and the sound of akshara are the same) 80 akshara taken from Grade 1 to 6 language arts books. Ten most and least frequently appearing akshara from four different akshara categories (Ca, CV, V and CCV) were included. The akshara were presented on paper and the score was the total number of correctly named akshara. Cronbach's alpha reliability ranged from .83 to .92.

Procedure

All participants completed the assessments during the last term of the school year between September and December. Each child was tested individually in a quiet room in their school by a native Sinhala-speaking graduate student who received extensive training on test administration. Testing was completed within a 45 minutes session. The tests were administered in fixed order (word reading accuracy, phoneme awareness, akshara knowledge).

Study Design and Statistical Analyses

The study was longitudinal sequential cohort study where two groups of children were followed for one year with two measurement points each. Grade 4 group was assessed prior to the entry into Grade 4 (at the end of Grade 3) and again at the end of Grade 4. As the changes captured in the measures reflect mostly learning in Grade 4, we will call this the Grade 4 group. Similarly, Grade 5 group was assessed prior to entry into Grade 5 (at the end of Grade 4) and at the end of Grade 5.

To examine the cross-lagged associations between phoneme awareness, akshara knowledge, and word reading accuracy, we performed path analysis using Mplus (Version 7; Muthén & Muthén, 1998–2015). Two separate models were constructed; one for the Grade 4 group and one for the Grade 5 group (see Figures 2 and 4). Because the models were saturated, no fit indices could be estimated. The parameters of the models were estimated using full-information maximum likelihood estimation (FIML; Muthén & Muthén, 1998–2015), which enables all the observations in the dataset to be used in estimating the parameters of the models. To avoid statistical biases resulting from deviations from normality in some measures (see below), we used maximum likelihood estimation with robust standard errors (MLR; Muthén & Muthén, 1998–2015).

Next, in order to examine whether the cross-lagged associations among measures differ between the groups, we performed multiple group analyses. A set of models was tested by fixing each of the cross-lagged path coefficients to be equal across the groups, one at a time, and then comparing the constrained model with the freely estimated model. If the fit of the model did not change significantly after the restrictions, the constrained associations were assumed equal between the groups (Muthén & Muthén, 1998–2015).

Power analysis was conducted using the pwr package (Champely, 2017) in R (R Core Team, 2016), and focused on the cross-lagged correlations between phoneme awareness, akshara knowledge, and word reading accuracy. Although no prior work in Sinhala is available to inform effect size expectations, Nag et al. (Nag, 2007; Nag & Snowling, 2012) have reported weak to high correlations (.25–.80) among the variables in Kannada, and this was considered as a possible scenario for the effect sizes. Our sample (N = 50 for each group) provides a power of 42% to estimate a correlation of .25 at the 5% significance level, and a sample size of 122 participants would be needed to achieve a power of 80% for this value. If a true correlation is .80, the power estimate would be 100%. Based on the current sample size, we were able to detect an effect greater than .38 (N = 50, significance level = .05, power = 80%).

RESULTS

Descriptive Analysis

Descriptive statistics for the two groups are shown in Table 1. Prior to analyses, we examined the data for normality and outliers. In the Grade 4 group, word reading accuracy in Time 2 was negatively skewed. In the Grade 5 group, phoneme awareness in Time 2 and word reading accuracy in Time 1 and Time 2 were negatively skewed. For these measures, reflection plus log transformation was used to improve the distributions (Tabachnick & Fidell, 2012).

Because the scores were reflected, we multiplied the reflected scores by -1 to correct for direction. One or two univariate outliers (more than 3 *SD* above/below the mean of each group) were moved to the tail of the distribution to avoid overemphasizing their impact on the results: one outlier in Time 1 akshara knowledge and Time 2 word reading accuracy in the Grade 5 group; two outliers in Time 1 phoneme awareness in the Grade 4 group.

The data shows a slow but steady increase in all the measures from Grade 4 to Grade 5. Phoneme awareness shows a small increase during Grade 4 (from 22.60 to 26.90), but a large increase during Grade 5 (from 29.52 to 46.56).

We also conducted a mixed model repeated-measures ANOVA with bootstrapping technique in order to estimate effect sizes for growth in phoneme awareness with confidence intervals. The results showed that the interaction between time and group was significant, $F(1, 96) = 39.07$, $p < .001$, $\eta_G^2 = .09$; there was slow (but significant) growth for the Grade 4 group, and significantly faster growth for the Grade 5 group (see Figure 1).

Correlations among the variables

The zero-order correlations among the measures for the two groups are shown in Table 2. Phoneme awareness correlated moderately with akshara knowledge ($r = .30$) and word reading accuracy ($r = .39$) prior to Grade 4 entry; however, at the end of Grade 4 phoneme awareness did not correlate significantly with akshara knowledge or word reading in either group. After the Grade 5 group received instruction in diacritics, phoneme awareness was correlated significantly with akshara knowledge ($r = .48$) and word reading accuracy ($r = .55$; Time 2 above the diagonal). Correlations between akshara knowledge and word reading were strong at all points (ranging from .57 to .72).

Cross-lagged correlations

The cross-lagged model for phoneme awareness, akshara knowledge, and word reading accuracy (Figure 2) showed that (a) Time 1 phoneme awareness did not predict Time 2 akshara knowledge or word reading accuracy in either group ($-.12 \leq \beta \leq .05$); (b) Time 1 word reading accuracy predicted Time 2 phoneme awareness in the Grade 5 group ($\beta = .41$) but not in the Grade 4 group ($\beta = -.07$); and (c) Time 1 akshara knowledge predicted Time 2 word reading accuracy but not phoneme awareness in both groups, although for the Grade 5 group the akshara knowledge to phoneme awareness path approached significance.

The results of a series of multigroup analyses showed that the path coefficient from Time 1 word reading accuracy to Time 2 phoneme awareness for the Grade 5 group was larger than that for the Grade 4 group ($\Delta\chi^2 = 10.26$, $df = 1$, $p < .001$).

Exposure to complex akshara

To further examine the effects of introduction of complex akshara on the association between akshara knowledge and phoneme awareness, we repeated the multigroup cross-lagged analyses with the akshara knowledge score for the 20 CCV akshara alone. To keep the models comparable, we kept word reading in these models. A mixed model repeated-measures ANOVA confirmed a significant interaction between time and group, $F(1, 96) = 46.56$, $p < .001$, $\eta_G^2 = .02$; CCV akshara knowledge shows a significant growth during Grade 4 when instruction on complex akshara is provided, but not on Grade 5 when instruction focuses on diacritics (see Figure 3).

The cross-lagged model for phoneme awareness, knowledge of complex akshara, and word reading accuracy (Figure 4) showed that phoneme awareness did not predict knowledge of complex akshara in either group whereas knowledge of complex akshara predicted phoneme awareness in both groups.

The results of multigroup analyses showed that the path coefficients from Time 1 knowledge of complex akshara to Time 2 phoneme awareness and word reading accuracy for the Grade 5 group were larger than those for the Grade 4 group (knowledge of complex akshara to phoneme awareness: $\Delta\chi^2 = 8.52$, $df = 1$, $p < .01$; knowledge of complex akshara to word reading accuracy: $\Delta\chi^2 = 5.20$, $df = 1$, $p < .05$). Thus, knowledge of complex akshara was an important predictor of future phoneme awareness irrespective of level of granularity of akshara instruction but it was a more important predictor of phoneme awareness and word reading following phoneme-level instruction.

DISCUSSION

The purpose of this study was to examine whether the growth of phoneme awareness and the correlation between phoneme awareness, akshara knowledge and word reading is strengthened by direct instruction in diacritics rather than by exposure to complex akshara alone, and whether the observed relationships are bidirectional or unidirectional. In Sri Lanka, akshara are taught as whole units (syllables) from Grade 1 to Grade 4 and students are expected to memorize the akshara set. With the formal introduction of consonant clusters in Grade 4, students are asked to pay close attention to the internal details of akshara and be aware of secondary vowel and consonant markers and the ways of stacking them onto the core consonant following ligaturing rules. Our results indicate that this increased exposure to more complex akshara with multiple diacritics in Grade 4 had a significant but only modest impact on the development of phoneme awareness. To further support understanding of diacritics, students in Grade 5 are taught how to decompose an akshara into its different phonemic constituents and how to build an akshara by adding separate phonemic markers (diacritics) together. Perhaps not surprisingly, we see a large increase in phoneme awareness in Grade 5. In our study, phoneme awareness showed strong growth only in Grade 5. These results indicate that while learning

about complex akshara in Grade 4 may impact phoneme awareness, explicit instruction on the diacritics marking phonemes accelerated the growth significantly in Grade 5. These findings are in line with existing studies in other akshara orthographies showing that phoneme awareness emerges slowly when instruction is at the level of whole akshara (e.g., Nag, 2007; Nag & Snowling, 2011, 2012; Nakamura et al., 2017; Prakash et al., 1993). They expand the previous research by showing rapid growth following instruction in diacritics, and confirm preliminary trends reported in Bengali (Sircar & Nag, 2013).

These results are also in line of earlier findings from Chinese (e.g., Read et al., 1986) and expand them to Indic akshara orthographies that represent both syllable and phoneme level information without an auxiliary system, such as pinyin. In an akshara orthography where children learn to map phonological syllables to orthographic syllable units, advanced phoneme awareness requires explicit instruction on phoneme markers embedded in those orthographic units and, likely, analytic akshara knowledge. We suspect that some children develop this analytic knowledge and phoneme awareness implicitly (see individual level data in Figure 1). Another driver for growth may be the limited English instruction the children receive. For most children, however, learning to read is likely not enough and direct instruction on the phoneme markers in their native language is necessary for the rapid growth and advanced phoneme awareness to materialise.

Our third hypothesis was that phoneme awareness correlates only moderately with akshara knowledge and word reading accuracy in the Grade 4 group receiving whole akshara instruction, but more strongly in Grade 5 after the instruction in diacritics. In essence, this pattern was observed (see Table 2). The correlations between phoneme awareness and akshara knowledge were significantly smaller before instruction in diacritics than after it. Similarly,

correlations between phoneme awareness and word reading were significantly smaller before diacritics were taught than afterwards. In sum, instruction in diacritics was required for the strong relationship between phoneme awareness and akshara knowledge or word reading accuracy to emerge.

Importantly, and in contrast to the evidence from alphabetic orthographies, the relationship between phoneme awareness and word reading was not bidirectional but either not present (Grade 4) or unidirectional (Grade 5) from word reading to phoneme awareness. A similar pattern of relationships was observed also for phoneme awareness and akshara knowledge, and in particular for knowledge of complex CCV akshara. In sum, phoneme awareness did not predict future word reading or akshara knowledge but was itself predicted by them. Future studies will need to establish whether the improved phoneme awareness at some later point predicts further growth in word reading, but our results suggest that for Sinhala learners, phoneme awareness is a by-product of instruction rather than a driver of reading development. We should note that these results are in line with the formulation by Nag (2017) that an insight into the combinatorial nature of the writing system drives the development of not just akshara knowledge but also phoneme awareness. Our results extend this formulation by indicating that the insight is likely a product of direct instruction in diacritics.

Finally, and in line with previous studies, our results show that akshara knowledge predicts growth in word reading even at the later stages of word reading development and after controlling for earlier word reading, as is done in all of our cross-lagged models. This is not surprising given that akshara is the basic decoding unit early in reading, but we could expect this relationship to diminish when students learn to decompose akshara into their phonemic constituents. We did not observe this pattern in the current study. More longitudinal studies are

required to establish whether these relationships continue beyond elementary school years. Further, with the exception of Grade 4 word reading in Time 1 predicting knowledge of complex akshara in Time 2, possibly showing that the children who read more learned the complex akshara taught during Grade 4 better, the relationship between akshara knowledge and word reading was unidirectional. These results clearly indicate the central role of akshara knowledge, both global and analytic, for word reading.

The results of this study should be considered in light of its limitations. First, there is a systematic confound of Grade 5 children having one more year of reading experience than the Grade 4 children. What role greater exposure to more complex words in particular plays is not possible to examine in natural experiments of this kind that take benefit of systematic differences in instructional methods from one year to the next. Only an experimental study moving instruction in diacritics earlier could control for exposure as a confound. Second, some of the current findings, especially some of the nonsignificant cross-lagged associations between the variables might be partly explained by a relatively weak statistical power due to the small sample size in this study (N = 50 for each group). However, it should be noted that all the effects of phoneme awareness on later akshara knowledge or word reading were very weak in both groups (-.15–.05), suggesting that these nonsignificant effects are not likely explained by the lack of power. Finally, some of the arguments presented would be more convincing if we had followed the same sample of children for two years rather than include two separate samples with one overlapping measurement point. While we cannot rule out cohort effect as an alternative explanation for the differences between the groups, we note that the Time 2 means of the Grade 4 sample are very similar to Time 1 means of the Grade 5 sample. Finally, we did not assess students' English language skills and it is possible that some of the effects reflect those.

However, given that our cross-sectional sample shows only small differences in phoneme awareness scores from Grade 2 (after the initial English instruction) to Grade 4, we find it unlikely that the clear Grade 5 jump would be explained by English instruction.

In conclusion, our study shows rapid development of phoneme awareness in Sinhala directly related to phoneme-level instruction that draws students' attention from the whole akshara to the internal phonemic details of akshara. This suggests that phoneme awareness is particularly sensitive to the method of reading instruction and raises the question whether students learning to read akshara orthographies would benefit from receiving direct instruction about the diacritics in the akshara symbol block sooner. To speculate, we would predict that earlier attention to these phonemic markers would boost a more analytic approach to akshara learning, which would then improve word recognition and phoneme awareness. Earlier consolidation of word recognition skills might then further impact reading comprehension, a frequently noted area of concern in children learning to read in akshara orthographies. Further, these findings both confirm and contradict findings from alphabetic languages and thereby add to the already complex picture of the interrelations between reading development and phonological development in the world's languages. On the assumption that literacy per se drives the growth of phonemic awareness, our findings from the Sinhala alphasyllabary suggest that while gaining literacy may lead to some spontaneous phoneme-level insights, it is the nature of instruction that influences the associations more. On the finding of bidirectional effects between knowledge of orthographic units and phonological development, we found no evidence – in the Sinhala alphasyllabary the effects are unidirectional from akshara knowledge and word reading to phoneme awareness. Thus, while it is likely that children in all languages benefit from analytic

and explicit instruction of the writing system, the bidirectional effects between reading and phoneme awareness may not be true for all languages.

References

Bright, W. (1996). Kannada and Telugu writing. In P. Daniels & W. Bright (Eds.), *The world's writing systems* (pp. 413–419). New York: Oxford University Press.

Burgess, S. B., & Lonigan, C. J. (1998). Bidirectional relations of phonological sensitivity and prereading abilities: Evidence from a preschool sample. *Journal of Experimental Child Psychology, 70,* 117-141. doi: 10.1006/jecp.1998.2450

Caravolas, M., Lervåg, A., Defior, S., Seidlova Malkova, G., & Hulme, C. (2013). Different patterns, but equivalent predictors of growth in reading in consistent and inconsistent orthographies. *Psychological Science, 24,* 1398–1407. doi: 10.1177/0956797612473122

Champely, S. (2017). *pwr: Basic functions for power analysis*. R package version 1.2-1. Retrieved from http://cran.r-project.org/web/packages/pwr/.

Daniels, P. T. (1996). The study of writing systems. In P. T. Daniels and W. Bright (Eds.), *The world's writing systems* (pp. 3-17). New York: Oxford University Press.

Daniels, P. T., & Share, D. L. (2017). Writing system variation and its consequences for reading and dyslexia. *Scientific Studies of Reading, 22,* 101-116. doi: 10.1080/10888438.2017.1379082

Gair, J. W., & Paolillo, J. C. (I997). *Sinhala*. Munich: Lincom Europa.

Hulme, C., Bowyer-Crane, C., Carroll, J. M., Duff, F. J., & Snowling, M. J. (2012). The causal role of phoneme awareness and letter-sound knowledge in learning to read: Combining intervention studies with mediation analyses. *Psychological Science, 23,* 572-577. doi: 10.1177/0956797611435921

Hulme, C., Hatcher, P. J., Nation, K., Brown, A., Adams, J., & Stuart, G. (2002). Phoneme awareness is a better predictor of early reading skill than onset-rime awareness. *Journal of Experimental Child Psychology, 82,* 2-28. doi: 10.1006/jecp.2002.2670

Lerner, M. D., & Lonigan, C. J. (2016). Bidirectional relations between phonological awareness and letter knowledge in preschool revisited: A growth curve analysis of the co-development of code-related skills. *Journal of Experimental Child Psychology*, *144,* 166-183. doi: 10.1016/j.jecp.2015.09.023

Mishra, R., & Stainthorp, R. (2007). The relationship between phonological awareness and word reading accuracy in Oriya and English: A study of Oriya speaking fifth-graders. *Journal of Research in Reading, 30,* 23-37. doi: 10.1111/j.1467-9817.2006.00326.x

Muthén, L. K., & Muthén, B. O. (1998–2015). *Mplus User's Guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.

Nag, S. (2007). Early reading in Kannada: the pace of acquisition of orthographic knowledge and phonemic awareness. *Journal of Research in Reading, 30,* 7-22. doi: 10.1111/j.1467-9817.2006.00329.x

Nag, S. (2011). The akshara languages: What do they tell us about children's literacy learning? In R. Mishra & N. Srinivasan (Eds.), *Language-Cognition: State of the Art* (pp. 291–310). Germany: Lincom Publishers.

Nag, S. (2017). Learning to read alphasyllabaries. In K. Cain, D. Compton, & R. Parrila (eds.), *Theories of reading development* (pp.75-98) Amsterdam: Benjamins.

Nag, S., & Snowling, M. J. (2011). Cognitive profiles of poor readers of Kannada. *Reading and Writing: An Interdisciplinary Journal, 24,* 657-676. doi: 10.1007/s11145-010-9288-1

Nag, S., & Snowling, M. J. (2012). Reading in an alphasyllabary: Implications for a language-universal theory of learning to read. *Scientific Studies of Reading, 16,* 404–423. doi: 10.1080/10888438.2011.576352

Nag, S., Treiman, R., & Snowling, M. J. (2010). Learning to spell in an alphasyllabary: The case of Kannada. *Writing Systems Research, 1,* 1-12. doi: 10.1093/wsr/wsq001

Nag-Arulmani, S. (2003). Reading difficulties in Indian languages. In N. Goulandris (Ed.), *Dyslexia in different languages: Cross linguistic comparisons* (pp. 255–276). London and Philadelphia: Whurr Publishers.

Nakamura, P. R., Joshi, R. M., & Ji, X. R. (2017). Investigating the asymmetrical role of syllabic and phonemic awareness in akshara processing. *Journal of Learning Disabilities*. doi: 10.1177/0022219417718201

Nakamura, P. R., Koda, K., & Joshi, M. R. (2014). Biliteracy acquisition in Kannada and English: A developmental study. *Writing Systems Research, 6,* 132-147. doi: 10.1080/17586801.2013.855620

Paolillo, J. C. (1997). Sinhala diglossic variation: Continuous or discrete? *Language in Society, 26,* 269-296.

Prakash, P., Rekha, D., Nigam, R., & Karanth, P. (1993). Phonological awareness, orthography and literacy. In R. Scholes (Ed.), *Literacy: Linguistic and cognitive perspectives* (pp. 55–70). Hillsdale, NJ: Lawrence Erlbaum.

R Core Team (2016). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing

Read, C., Zhang, Y., Nie, H., & Ding, B. (1986). The ability to manipulate speech sounds depends on knowing the alphabetic writing. *Cognition, 24*, 31-44. doi:10.1016/0010-0277(86)90003-X

Sircar S., & Nag S. (2013). Akshara-syllable mappings in Bengali: A language-specific skill for reading. In H. Winskel & P. Padakannaya (Eds.), *South and South-East Asian Psycholinguistics*, (pp. 202-211). Cambridge, UK: Cambridge University Press.

Tabachnick, B. G., & Fidell, L. S. (2012). *Using Multivariate Statistics* (6th ed.). Boston, MA: Pearson.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology, 30,* 73-87. doi:10.1037/0012-1649.30.1.73

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin, 131,* 3–29. doi: 10.1037/0033-2909.131.1.3

Table 1

Descriptive Statistics of the Measures in Grades 4 and 5.

	Grade 4			Grade 5		
Measures	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Time 1						
Phoneme awareness	22.60	6.81	14–49	29.52	12.30	15–58
Akshara knowledge	63.44	7.51	45–77	69.08	7.29	47–77
Word reading accuracy	76.90	15.62	44–104	91.70	15.72	52–110
Time 2						
Phoneme awareness	26.90	9.03	12–57	46.56	10.92	20–60
Akshara knowledge	67.19	6.83	49–77	71.10	6.57	52–80
Word reading accuracy	92.92	13.71	58–108	100.82	9.82	71–110

Note. For the Grade 4 sample, Time 1 measures were administered at the end of grade 3 and Time 2 measures at the end of grade 4. For the grade 5 sample, the respective times were the end of grade 4 and the end of grade 5.

Table 2

Correlations among the Measures in Grades 4 and 5.

		1.	2.	3.	4.	5.	6.
1.	Phoneme awareness_T1		.05	.02	.33*	.10	-.09
2.	Akshara knowledge_T1	.30*		.59**	.42**	.93**	.65**
3.	Word reading accuracy_T1	.39*	.62**		.51**	.58**	.72**
4.	Phoneme awareness_T2	.70**	.30*	.29*		.48**	.55**
5.	Akshara knowledge_T2	.34*	.85**	.62**	.27		.72**
6.	Word reading accuracy_T2	.28	.57**	.67**	.24	.57**	

Note. Correlations below the diagonal are from the Grade 4 group, whereas correlations above the diagonal are from the Grade 5 group. T1 = Time 1; T2 = Time 2.

*$p < .05$. **$p < .01$.

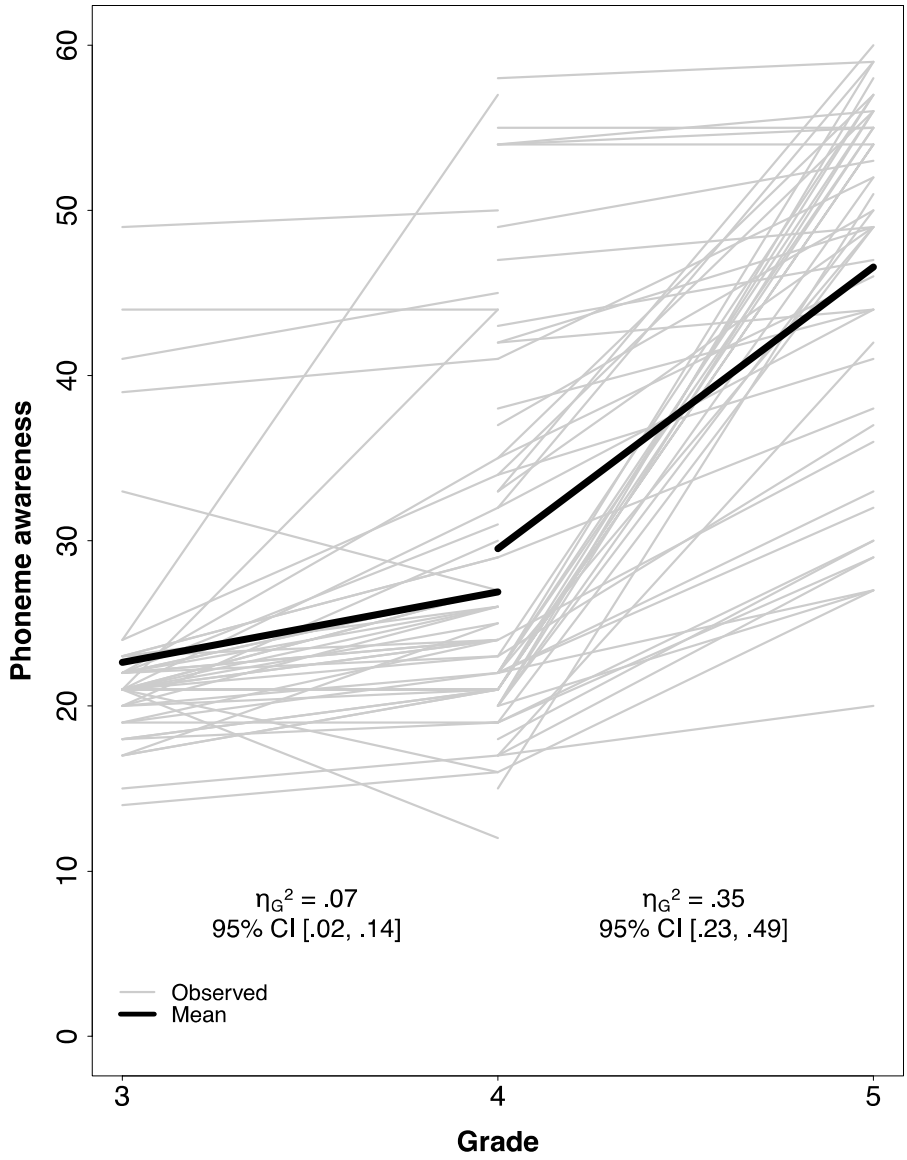

Figure 1. Growth in phoneme awareness in Grades 4 and 5.

Note: Growth is shown from prior to entry into a given grade through to end of the year in that grade. For Grade 4 receiving whole akshara instruction results are from end of Grade 3 to end of Grade 4, and for Grade 5 receiving diacritic instruction from end of Grade 4 to end of Grade 5.

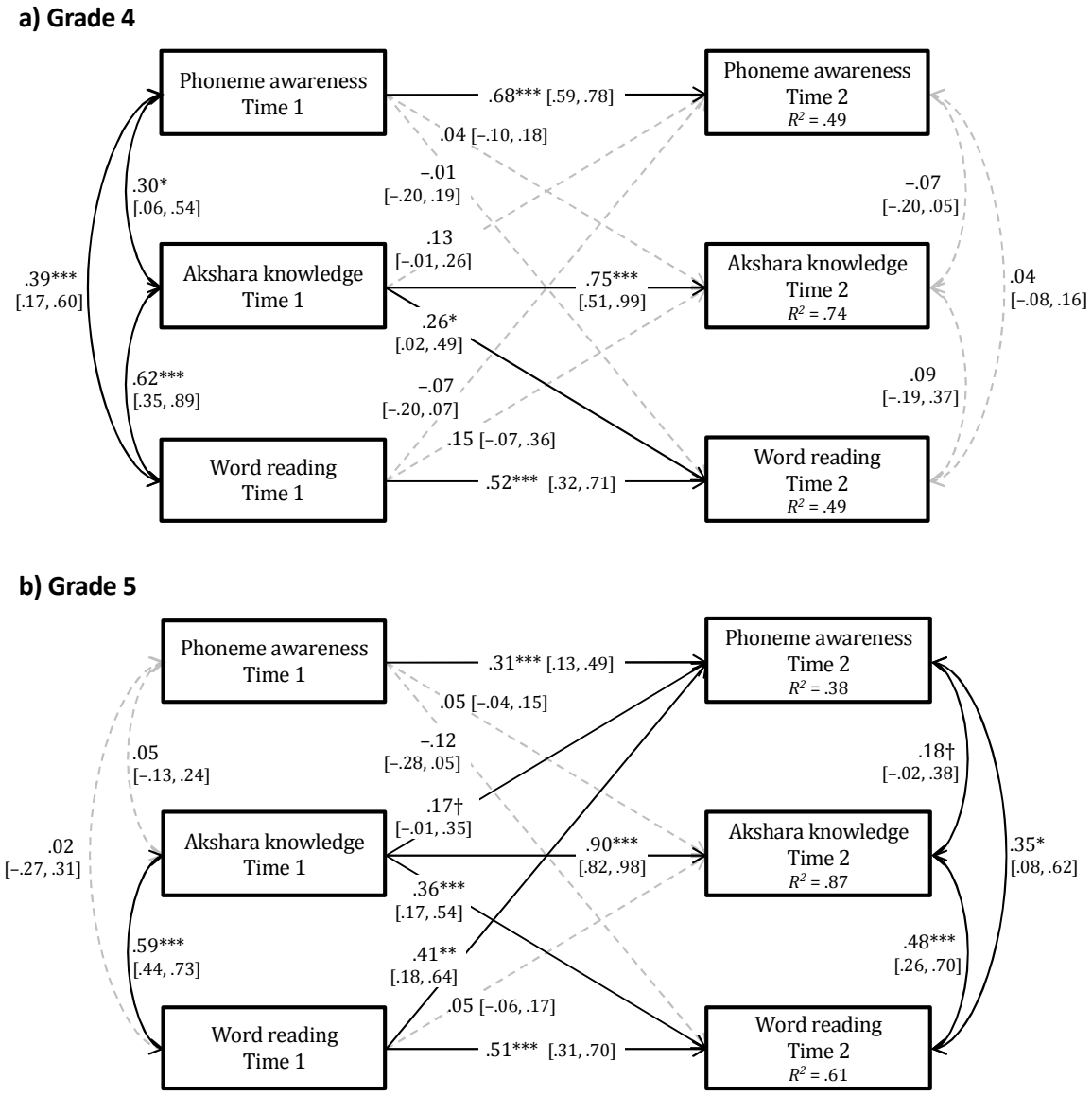

Figure 2. Cross-lagged associations between phoneme awareness, akshara knowledge, and word reading accuracy in the Grade 4 group (a) and the Grade 5 group (b). Standardized coefficients are shown. Solid lines represent significant coefficients and dashed lines represent nonsignificant coefficients.
†$p < .10$ *$p < .05$. **$p < .01$. ***$p < .001$.

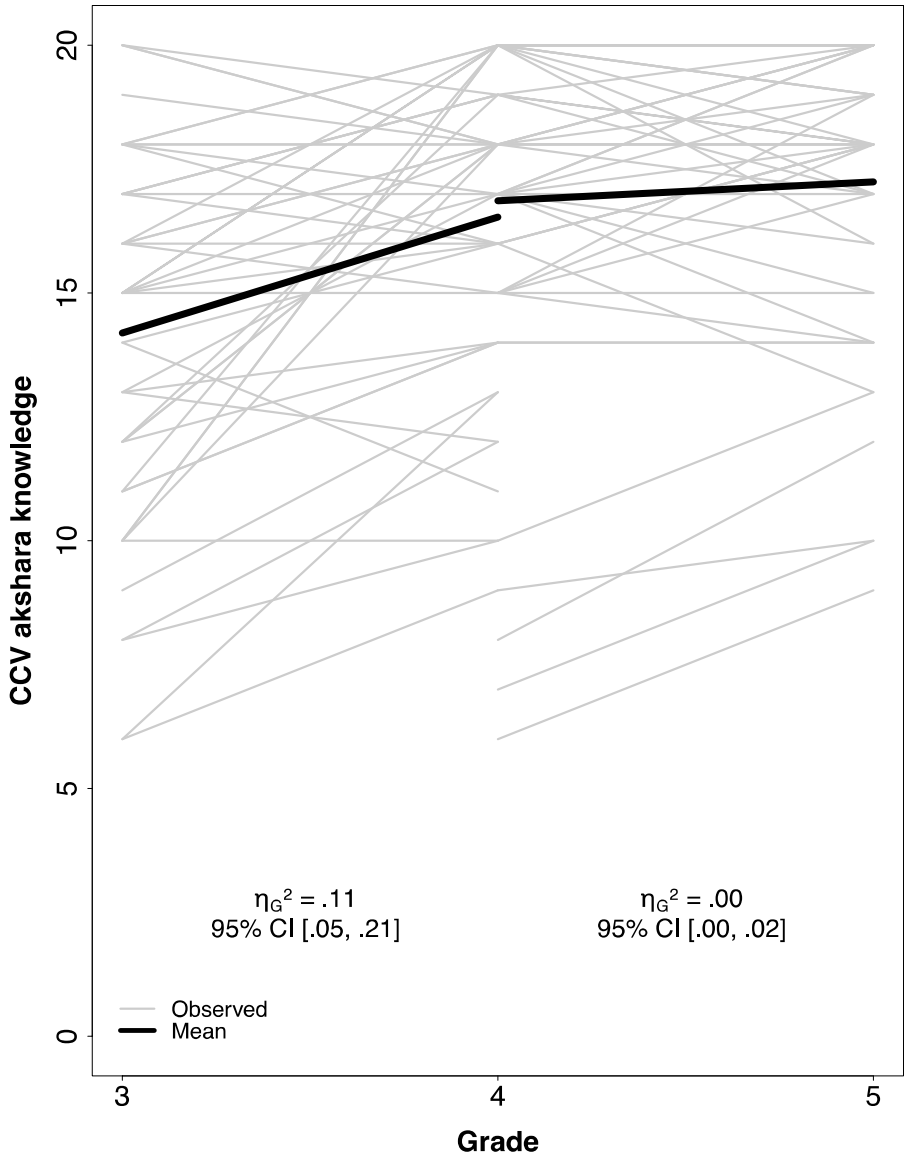

Figure 3. Growth in CCV akshara knowledge in Grades 4 and 5.

Note: Growth is shown from prior to entry into a given grade through to end of the year in that grade. For Grade 4 receiving whole akshara instruction results are from end of Grade 3 to end of Grade 4, and for Grade 5 receiving diacritic instruction from end of Grade 4 to end of Grade 5

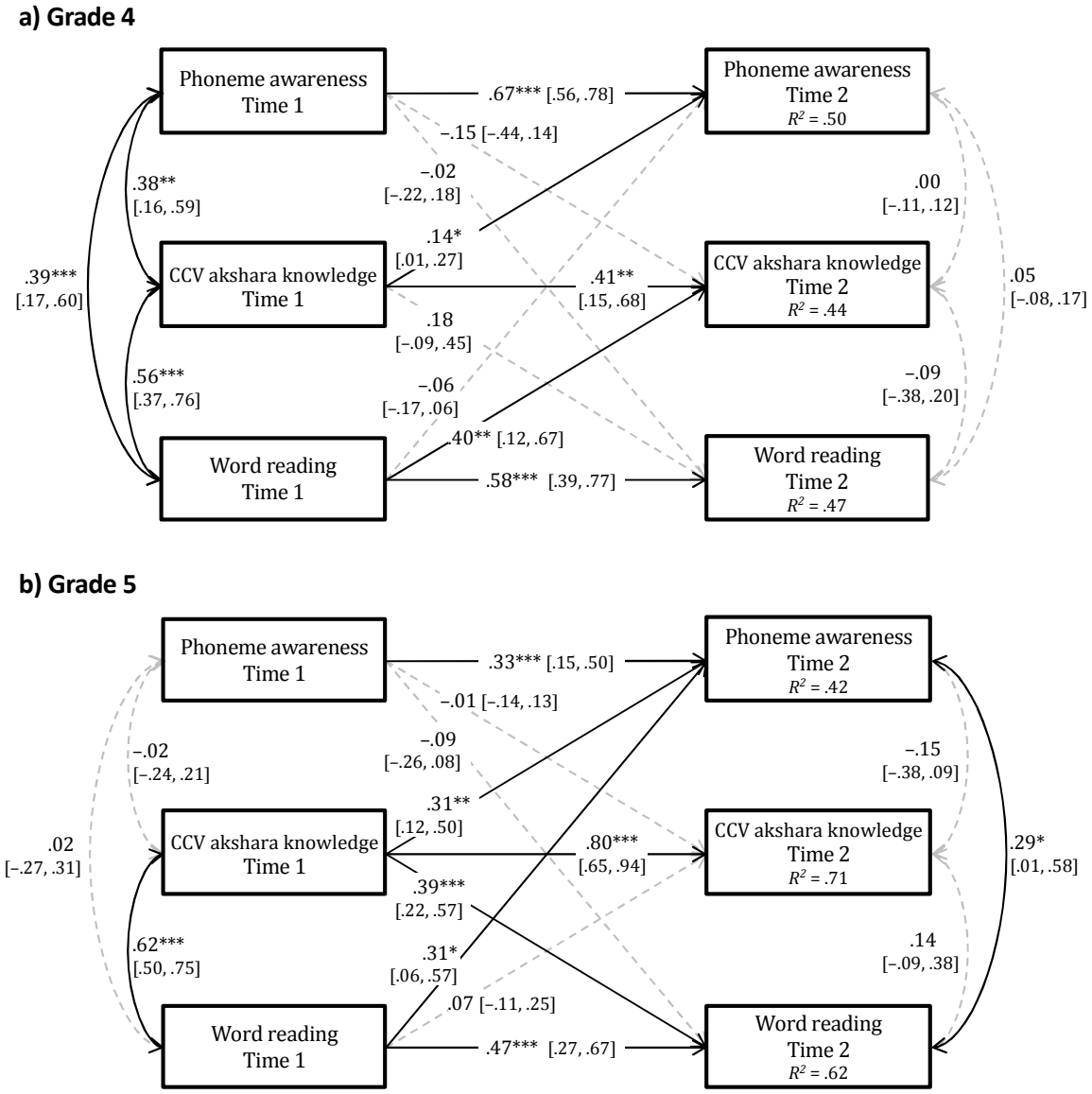

Figure 4. Cross-lagged associations between phoneme awareness, knowledge of complex akshara, and word reading accuracy in the Grade 4 group (a) and the Grade 5 group (b). Standardized coefficients are shown. Solid lines represent significant coefficients and dashed lines represent nonsignificant coefficients.
*p < .05. **p < .01. ***p < .001.