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Abstract

We examined whether akshara knowledge, phonological awareness, phonological memory, and RAN predict variability in word and nonword reading skills in Grade 1 to 4 children (N = 200) learning to read Sinhala. Hierarchical regression analyses showed that akshara knowledge had the strongest unique association with both word and nonword reading accuracy across grades. Akshara knowledge and RAN predicted word and nonword reading fluency. The impact of phonological memory and syllable awareness on reading was mostly mediated by akshara knowledge, and phoneme awareness was not uniquely associated with word reading skills in any grade. These results suggest that there are multiple cognitive correlates of accurate and fluent word reading in Sinhala, and akshara knowledge is the most important predictor of learning to read words. The findings have implications for the literacy acquisition, development, and instruction in alphasyllabaries.

KEYWORDS: word reading; reading acquisition; alphasyllabaries; akshara knowledge; phonological awareness; rapid naming; phonological memory

Introduction

One in every four primary school-age children in the world, that is 168 million children as estimated by the UNICEF (2015), lives in South Asia and learns to read an Indic alphasyllabary. The existing reading studies in alphasyllabaries suggest that word reading development of young readers follows at least a somewhat different developmental pathway compared to the reading development of readers of alphabetic or morphosyllabic orthographies due to the unique structural and functional features of akshara, the orthographic symbols in alphasyllabaries (Nag, 2007; Nag & Snowling, 2012; Nakamura, Koda & Joshi, 2014; see Daniels & Share, 2017, for a discussion). For example, the majority of vowels in Indic alphasyllabaries are not marked as full-sized symbols but are either inherent (and therefore left unmarked) or appear as diacritics attached to the full-sized base consonant; in contrast, the majority of consonants are full-sized akshara (Share & Daniel, 2016). Akshara can simultaneously represent sounds both at the levels of syllables and phonemes, with the initial instruction focusing on learning the akshara as a whole (Nag, 2007, 2017). In contrast to morphosyllabaries, akshara do not frequently map to morphemes, but learning the relatively large akshara set (about 200 to 700 across orthographies) is similarly a prolonged process (Nag, 2007; Nag, 2014; Nag & Snowling, 2011, 2012; Tiwari, Nair, & Krishnan, 2011). Currently, we know very little about the factors that influence early word reading development in alphasyllabaries. The purpose of this study was to examine the predictors of word reading development in Sinhala-speaking Grade 1 to 4 children in Sri Lanka.

Predictors of Reading in Alphasyllabaries

There are only a handful of studies that have examined the associations between word reading skills, akshara knowledge, and the cognitive correlates of word reading in akshara

orthographies. Nag and Snowling (2012) assessed Kannada word reading skills in Grade 4 to 6 with a composite measure of individual word and nonword reading tests and reading words presented in passages. Their result indicated that akshara knowledge, syllable awareness, phoneme awareness, and rapid naming (RAN) were all associated with word reading accuracy, and akshara knowledge, phoneme awareness, and RAN were the strongest associates of reading fluency. Nag and Snowling (2011) further noted that poor readers had deficits in one or more of these domains and more severe reading problems were associated with multiple deficits; the single most common area of deficit was akshara knowledge.

A few other studies have also showed slow akshara learning as a defining characteristic of poor readers (e.g., Gupta, 2004; Nag, 2007; Tiwari et al., 2011; Vasanta, 2004) and phonological awareness, in turn, may be associated with the pace of the acquisition of akshara knowledge (Nag, 2007). Syllable awareness has had a strong consistent correlation with reading scores across primary grades in most studies (e.g., Nag, 2007; Nag & Snowling, 2012; Nakamura, Joshi, & Ji, 2017). Phoneme awareness seems to emerge slowly in earlier stages of reading development (Nag, 2007; Nag & Snowling, 2011; Prakash, Rekha, Nigam, & Karanth, 1993) and may be associated with parallel instruction in English (Mishra & Stainthorp, 2007; Nag-Arulmani, 2003; Prakash et al., 1993). Nag (2007) and Nag and Snowling (2012) reported moderate correlations (.48–.68) between knowledge of complex akshara and phoneme awareness at later stages of reading development. Nag (2017) explains that the nature of the writing system promotes syllable level representations making phoneme level processing slow to emerge. When children pay more attention to phonemic markers as a result of their increasing knowledge of CV and CCV/CCCV akshara types, which require knowledge of phonemic markers and ligaturing rules, a stronger relationship between reading and phonemic awareness becomes apparent. Most

recently, Wijaythilake, Parrila, Inoue, and Nag (2018) reported that in Grade 4 and 5 Sinhala learners, phoneme awareness showed strong growth and a significant relationship with akshara knowledge and word reading only after the students had received direct instruction in the diacritic markers of akshara signifying phonemes. Further, while both earlier word reading and akshara knowledge predicted phoneme awareness a year later, the opposite was not true, suggesting minor role for phoneme awareness in reading development. Similarly, a recent study of Grade 1 to 5 children learning to read Kannada or Telugu showed that while phoneme awareness was significantly correlated with word/nonword decoding accuracy across the grades, it made no unique contribution after syllable awareness was controlled. Further, the contribution of phoneme awareness declined with grade level whereas the contribution of syllable awareness increased (Nakamura et al., 2017). Given the possibly significant variation in instructional practices across schools and in the tasks used by the researchers to assess phoneme awareness and reading, a further examination of the role of phoneme and syllable awareness seems warranted. Theoretically, phoneme awareness should explain more variance in accuracy than in rate of reading, and in nonword decoding than in word recognition. In the current study, we have included all four conditions to better estimate the role of phoneme awareness.

Even fewer studies have examined how phonological memory and rapid naming speed (RAN) are associated with word reading development in akshara orthographies. Wijayathilake and Parrila (2014) reported that phonological memory correlated with word reading accuracy in Grade 3 Sinhala readers. Ramaa, Miles, and Lalithamma (1993) showed that 8–10-year-old Kannada-speaking dyslexic and non-dyslexic struggling readers had difficulties with the digit span task as compared to good readers. However, as the digit span task allows for long-term memory (LTM) support (e.g., Hulme, Roodenrys, Brown, & Mercer, 1995), it is unclear whether

a phonological memory measure that allows for less LTM support (and thus may assess phonological memory more directly) would produce similar associations. In the current study, we asked children to remember series of high- and low-frequency akshara, reasoning that the abstract syllables they capture would have less LTM support than digits.

The few studies that have examined the relationship between RAN and reading in akshara orthographies have indicated that RAN is uniquely correlated with word reading in primary school-aged Kannada readers (Nag & Snowling, 2011, 2012). Nag, Snowling, Quinlan, and Hulme (2014) reported further that RAN was associated with akshara recognition concurrently and 8 months later after controlling for time 1 akshara knowledge. In Wijaythilake and Parrila (2014), RAN was more strongly associated with reading accuracy for shorter words with simple akshara than for longer words, and for struggling than for good readers in Grade 3, pointing to the possibility that RAN-reading relationship in alphasyllabaries is affected by the slowly developing automaticity of akshara processing as well.

In sum, akshara knowledge, syllable awareness, phoneme awareness, RAN, and phonological memory have emerged as unique correlates of word reading accuracy in alphasyllabaries, whereas word reading fluency has not been sufficiently studied. No study has examined akshara knowledge, syllable awareness, phoneme awareness, RAN, and phonological memory simultaneously. As a result, how their association with reading development changes across the primary school grades is unknown, with the notable exception of syllable and phoneme awareness examined in Nakamura et al. (2017). Their outcome measure was a word reading task where each item was scored categorically for both accuracy and fluency. In the current study, we include both word and nonword reading measures and assess list reading accuracy and rate.

Sinhala Orthography

Sinhala is written with a unique akshara orthography derived from ancient Indian Brahmi script. The orthography is largely consistent in that each akshara represents the same sound(s) across all words. Spelling, however, is complicated by one-to-many correspondence from sounds to akshara as spoken Sinhala no longer have phonemic equivalents for multiple akshara still in use in written Sinhala, and significant differences between the spoken and literary forms of the language that make Sinhala strongly diglossic.

Each vowel in Sinhala has an independent primary symbol, used when the vowel is in the initial position of a word, and a secondary diacritic sign (vowel marker). Each consonant also has a distinct symbol that is pronounced with an inherent vowel /a/. When a consonant is written with a vowel other than /a/, the secondary vowel marker is attached to the consonant symbol and the inherent /a/ is dropped from the pronunciation. When consonant clusters are formed, vowels and the second consonants can be ligatured to the first consonant using their secondary diacritic forms. The diacritic for the second consonant of the cluster is always attached to the bottom of the first consonant and some vowel diacritics of the cluster are attached to the top or before the first consonant. Example 1 shows five different akshara with the same base consonant.

Example 1:

(a) /k/ with inherent vowel:  /ka/

(b) /k/ with /i/:  /ki/

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

(d) /kr/ with /i/  /kri/

(e) /kr/ with /e:/  /kre/

Line *a* shows the full-sized base consonant with an inherent vowel that is unmarked. 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 and on top of the consonant marker. 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.

Individual diacritics have a designated location in the akshara that is predictable and rule-governed. The predictability of the location of diacritics eases the memory load for Sinhala readers once they master the ligaturing rules. According to Chandralal (2010), contemporary literary Sinhala can be written with about 54 independent symbols (16 primary vowels and 38 primary consonants) combined with 18 diacritics, whereas 38 symbols (12 primary vowels and 26 primary consonants), combined with the same diacritics, are sufficient to represent colloquial Sinhala. The Sinhala orthography includes over 600 akshara; our analyses of the Grade 1 to 6 Sinhala language arts textbooks identified 411 individual akshara that children are taught by the end of Grade 6. One akshara can represent a single vowel or consonant (/V/, /C/), a consonant or consonant cluster with the inherent vowel /a/ (/Ca/, /CCa/, /CCCa/), or a consonant or consonant cluster with a vowel other than the inherent vowel (/CV/, /CCV/, /CCCV/). In the same language arts books, words with V, Ca, and CV structure were the most common whereas consonant clusters appeared less frequently. Further, the lack of VC akshara results in written words where the orthographic syllable doesn't align fully with oral syllable, as in the /ammaa/ example below.

A more detailed explanation of Sinhala orthography is available in Wijaythilake and Parrila (in press).

Literacy Instruction in Sinhala

The literacy instruction in Sinhala in Sri Lanka follows a fixed sequence. Consonants with the inherent vowel and primary vowels are introduced first in the beginning of Grade 1. Instruction of CV akshara with ligaturing rules for vowels starts at the end of the first grade and continues for the next grades followed by instruction on frequently used CCV akshara. In Grade 4, consonant clusters are formally introduced for the first time. In Grade 5, students further practice using clusters and are explicitly taught how to decompose CV and CCV akshara into their phonemic components (phoneme-level instruction of akshara formation), thus opening the door to a more combinatorial understanding of Sinhala orthography. Students additionally receive English instruction for several periods during the school week from the second grade onwards in line with the language education policy of Sri Lanka.

Current Study

In the current study, we examine the effects of akshara knowledge, syllable and phoneme awareness, phonological memory, and RAN on word and nonword reading development in a sample of Sinhala-speaking children from Grade 1 to 4[1]. We hypothesize that akshara knowledge is strongly associated with word and nonword reading accuracy and fluency across the primary school years given the crucial role it plays in learning to read in alphasyllabaries (Nag, 2007; Nag & Snowling, 2011, 2012). In contrast, we expect that syllable and phoneme awareness will have a more limited role in predicting word and nonword reading when akshara knowledge is controlled, but we expect both to be associated with akshara knowledge, with syllable awareness taking the leading role. The association of phonological memory with reading should be evident

throughout the grades due to the length of the words in Sinhala, whereas RAN is likely less important early when automaticity with akshara is still developing.

To our knowledge, this is the first study that examines the cognitive correlates of word and nonword reading in Sinhala in early grades, and the first in akshara orthographies that examines akshara knowledge, syllable and phoneme awareness, RAN, and phonological memory in the same study. We include Grade 1 to 4 children to examine whether the expected changes in relationships can be observed as reading skills develop. The current study has the potential to enhance our knowledge of the factors involved in reading development and, together with studies in other akshara orthographies, will inform reading instruction and future reading experiments.

Method

Participants

Two hundred (98 females) Grade 1 to 4 (between ages 5 years 11 months and 9 years 9 months; see Table 1 for means and *SD*s for each grade) Sinhala-speaking children from two well-functioning government schools in Kandy and Kegalle districts in Sri Lanka participated in this study. Both schools were suburban schools serving families from middle to upper-middle socioeconomic backgrounds. All teachers had tertiary education and were Government certified. Fifty students with no documented sensory or behavioural difficulties from each of the first four grades were selected and assessed. Students' first language and the medium of instruction was Sinhala. Students additionally received English and Tamil instruction for several periods during the school week from Grade 2 onwards in line with the language education policy of Sri Lanka.

Materials

Akshara Recognition.

Participants were asked to name aloud 80 akshara taken from Grade 1 to 6 language arts books. The books included 124,132 total akshara and over 400 unique akshara. The study included 10 high- and 10 low-frequency akshara each from four different akshara categories (Ca, CV, V and CCV). The 40 high-frequency akshara appeared on average 1361 times (*SD* = 1482) in the examined books and the 40 low-frequency akshara appeared on average 15 times (*SD* = 28). The akshara were presented on paper and the score was the total number of correctly named akshara. Cronbach's alpha reliability ranged from .90 to .95 across the grades.

Word Reading and Nonword Reading.

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. The akshara in the real words were arranged in a different order to make the nonwords for the Nonword Reading test. A five-word practice list was given to children prior to the actual test to ensure all children understood the instructions.

For the word and nonword reading fluency tests, the participant was asked to read the words/nonwords aloud as quickly and accurately as possible for one minute and their total score for the fluency test was the total number of words/nonwords read correctly within that time. Reading accuracy was then measured using the same test. Participants were asked to reread words/nonwords they misread in the fluency test and then continue reading from where fluency test ended. Both tasks were discontinued after 10 consecutive errors. A participant's reading accuracy score was the total number of correctly read words/nonwords. Cronbach's alpha reliabilities for the current sample ranged from .86 to .97.

Phonological awareness.

Phonological awareness was assessed with two deletion tasks – Phoneme Deletion (60 items) and Syllable Deletion (60 items) – that had the same test format. The phoneme deletion task required the participant to repeat words (30) and nonwords (30) after removing the designated sound from the beginning (10), middle (10) or end (10) of the item. Cronbach's alpha reliability ranged from .80 to .96. Syllable deletion task required the participant to repeat the item without saying the designated syllable. In the phoneme deletion task, all correct responses were nonwords. For the syllable deletion task, there was a mix of words (39) and nonwords (21), and the deleted syllable mapped onto an akshara. Cronbach's alpha reliability ranged from .94 to .98. Total score was the number of correctly pronounced items after removing the designated sound/syllable. If the participant responded incorrectly to four consecutive items, the task was discontinued.

Rapid automatized naming (RAN).

RAN was assessed with Digit and Object Naming tasks. Digit and Object Naming tasks were taken from RAN/RAS test battery (Wolf & Denckla, 2005) and required children to say as fast as possible the names of five digits (2, 7, 4, 9, 6) or objects (book, chair, dog, hand, star – all highly familiar bisyllabic words in Sinhala) arranged semi-randomly in five rows of 10. Wolf and Denckla (2005) reported test-retest reliability across ages for Object and Digit Naming to be .84, and .92, respectively. Prior to beginning the timed naming, children were asked to name the stimuli in a practice trial to ensure familiarity. Children's score in RAN was the time taken to name all items. The correlation between Digit and Object Naming across the grade levels ranged from .46 to .77.

Phonological memory.

Phonological memory was assessed with a two-part syllable repetition task. The first 18 items were strings of syllables made of high-frequency akshara; the number of syllables in the strings increased from 2 to 14, and the presentation was discontinued after three consecutive errors. The second 19 items were strings of syllables made of low-frequency akshara and varied in length from two to nine syllables. One syllable string at a time was read aloud to a child and the child was asked to listen carefully and repeat the string as clearly and correctly as possible. A participant's score was the total number of correctly repeated syllable strings (max =37). Cronbach's alpha reliability ranged from .69 (Grade 4) to .98 (Grade 1).

Procedure

All participants were examined during the last term of the school year in September-December. Each participant was tested individually in a quiet room in their school by trained graduate students who were native Sinhala speakers and received extensive training on test administration. Testing was completed within 40–60 minutes divided over one to two sessions depending on how long a participant wanted to work. The tests were administered in a fixed order.

Statistical Analyses

To examine the relative importance of akshara knowledge, syllable awareness, phoneme awareness, phonological memory, and RAN in predicting children's word/nonword reading skills in Sinhala, we performed several hierarchical regression analyses. Separate regression models were constructed for predicting word/nonword reading accuracy and fluency in each grade. Akshara knowledge, syllable awareness, phoneme awareness, and phonological memory were entered alone one at a time in the first step, with all the remaining predictors entered at the second step. To reduce the number of the variables, we used a composite RAN score calculated by averaging *z*-scores of Object and Digit Naming tasks.

Next, we examined the relative importance of the cognitive skills (i.e., syllable awareness, phoneme awareness, phonological memory, and RAN) in predicting akshara knowledge. All cognitive skills were entered simultaneously in these regression models. Finally, we constructed simple mediation models in each grade where all cognitive skills were allowed to predict reading both directly and indirectly via akshara knowledge. All analyses were performed using R (R Core Team, 2018).

Results

Descriptive Statistics

Descriptive statistics for each grade are shown in Table 1 and the results of one-way ANOVAs with grade as a factor are shown in Table 2. As would be expected, the effect of grade was significant in every task (see Table 2). The effect sizes from the pairwise comparisons indicated that akshara knowledge and the cognitive skills (except for RAN-objects) showed a large improvement from Grade 1 to Grade 2 (*Hedges' g*s = 0.88–2.77). From Grade 2 onwards, there was steady growth in akshara knowledge (*g*s = 0.76–0.78), phoneme awareness (*g*s = 0.72–0.97), and word and nonword reading skills (*g*s = 0.31–1.35). Table 1 also shows that word and nonwords were read with similar accuracy across the grades, but the rate of reading words was slightly faster.

A closer examination of the distributional properties of the tasks indicated several problems[2]. Syllable awareness showed a ceiling effect in Grade 2 to 4 (38%, 32%, and 80% of the children in Grade 2 to 4, respectively, had a perfect score). Reflect and log transformations (Tabachnick & Fidell, 2013) were performed on the scores in Grade 2 and 3, whereas a binary transformation (0 = made at least one mistake, 1= all correct) was performed on the score in Grade 4 as log transformation did not result in normal distribution. Akshara knowledge and

nonword reading accuracy in Grade 4 were negatively skewed. However, none of the children had a perfect score on akshara knowledge and only four children had a perfect score on nonword reading accuracy. Reflect and log transformations were performed on both scores. Similarly, phonological memory in Grade 1 and 3 were negatively skewed. Reflect and square root transformations were performed on the scores. The transformed scores were used in the subsequent analyses.

Correlation and Regression Analyses

The zero-order correlations among the variables are shown in Table 3. Word and nonword reading accuracy were highly correlated in Grade 1 and 2 (*r*s = .88 – .90), but less in Grade 3 and 4 (*r*s = .66 – .74). Correlations between the two fluency measures varied from .56 in Grade 3 to .87 in Grade 1. Akshara knowledge showed the highest correlations with word and nonword reading skills across grades (*r*s = .24–.80). Syllable awareness correlated with word and nonword reading accuracy and fluency in Grade 1 (*r*s = .31–.44), word and nonword reading accuracy in Grade 2 (*r*s = .37–.43), and word reading accuracy in Grade 4 (*r* = .36). Phoneme awareness correlated with word and nonword reading accuracy in Grade 2 and 3 (*r*s = .24–.39). Phonological memory correlated significantly with most reading measures in Grade 1 to 3, and with word reading accuracy in Grade 4. RAN-objects correlated with word/nonword reading accuracy in Grade 2 and 4 (*r*s = -.32– -.50) and reading fluency in Grade 2 to 4 (*r*s = -.25– -.56). RAN-digits correlated with word/nonword reading accuracy and fluency across grades (*r*s = -.20– -.51). It should be noted that the correlations among akshara knowledge and the cognitive skills were weak to moderate (*r*s = .00–.51), except for those between RAN-objects and RAN-digits, suggesting that there was no evidence of multicollinearity (Tabachnick & Fidell, 2013).

The results of the regression analyses for predicting word and nonword reading accuracy and fluency are presented in Tables 4 (word reading accuracy), 5 (nonword reading accuracy), 6 (word reading fluency), and 7 (nonword reading fluency). The total explained variances in each grade ranged from .44 to .76 for accuracy and from .29 to .66 for fluency, respectively. Among the independent variables, akshara knowledge had the strongest association with word and nonword reading accuracy in all grades. When entered first, syllable awareness was a significant predictor of word reading accuracy variance in Grade 1, 2, and 4, and nonword reading accuracy variance in Grade 1 and 2; phoneme awareness was a significant predictor of word reading accuracy variance in Grade 2 and 3 and nonword reading variance in Grade 2. Phonological memory and RAN accounted for significant word reading accuracy variance in all grades; in terms of nonword reading accuracy, phonological memory was a significant predictor in Grades 1 to 3 and RAN in Grade 2 and 4. Importantly, when akshara knowledge was in the model, only RAN explained additional unique variance in word reading accuracy, and only RAN and phonological memory and only in Grade 2 explained additional variance in nonword reading accuracy. In sum, these analyses indicate that both word and nonword reading accuracy are heavily dependent on akshara knowledge across the first four years of schooling.

Word and nonword reading fluency results (see Tables 6 and 7) were somewhat different in that akshara knowledge was the strongest predictor of both in Grade 1 and 3, whereas RAN was the strongest predictor in Grade 2 and 4. When akshara knowledge was controlled, RAN explained additional unique variance in Grade 1, 3, and 4, whereas syllable awareness was a significant predictor in Grade 3. When syllable awareness was entered first, it explained unique variance only in Grade 1 word reading fluency, and phoneme awareness did not explain unique variance in any grade in either fluency measure. Phonological memory contributed unique

variance particularly in Grade 1, and for nonword reading fluency. These analyses indicate that akshara knowledge and RAN both contribute the word and nonword reading fluency development.

Finally, the results of the regression analyses for predicting akshara knowledge are presented in Table 8. Syllable awareness had a significant association with akshara knowledge across grades (βs = .29–.45). In addition, phonological memory was uniquely associated with akshara knowledge in Grade 1 and 2 (βs = .43 and .29 for Grade 1 and 2, respectively). On the other hand, RAN had the strongest association with akshara knowledge in Grade 4 (β = -.44). In contrast, phoneme awareness was not uniquely associated with akshara knowledge across grades (βs = -.05–.15). Given that syllable awareness, phonological memory, and RAN were associated with akshara knowledge, we estimated the indirect effects they may have on reading measures via akshara knowledge. The results of these analyses are presented in Table 9. They are in line with a theoretical model suggesting that syllable awareness, phonological memory, and RAN affect early reading development via akshara knowledge.

Discussion

We examined the cognitive correlates of word reading development in Grade 1 to 4 Sinhala primary school children in Sri Lanka. Our first research question was whether akshara knowledge is uniquely associated with word and nonword reading accuracy and fluency across primary school years. The results showed that akshara knowledge had the strongest unique association with word and nonword reading accuracy, and, together with RAN, was a unique predictor of word and nonword reading fluency as well. Our results are in line with the previous studies (Nag, 2007; Nag & Snowling, 2011, 2012) concluding that akshara knowledge is the most robust predictor of reading in alphasyllabaries and difficulties with akshara knowledge

impact reading accuracy, reading fluency, and reading comprehension. Compared to the letter learning process in alphabetic orthographies that reaches ceiling quickly (e.g., Seymour, 2005), readers of akshara orthographies take time to master the akshara set due to a large symbol registry (e.g., over 600 in Sinhala) and the visual and phonological complexity of akshara themselves (Nag, Treiman, & Snowling, 2010; Nag et al., 2014; Tiwari et al., 2011). That is, in all grade levels, children will encounter not only new words but also new akshara in those words that they may or may not be able to decipher on the basis of their existing akshara knowledge, and the deciphering process itself is not an instructional focus before Grade 5.

Our second hypothesis was that syllable and phoneme awareness have a limited role in predicting word and nonword reading when akshara knowledge is controlled, but both were expected to predict akshara knowledge. In general, syllable awareness and phoneme awareness did not have a significant impact on accuracy or fluency when akshara knowledge was controlled; when akshara knowledge was not included in the model, syllable awareness predicted between 6 and 18% of word reading accuracy variance and 5 and 19% of nonword reading accuracy variance, with the larger numbers in Grade 1 and 2. Phoneme awareness, in turn, predicted up to 16% of word reading (in Grade 2) and 15% (also in Grade 2) of nonword reading accuracy variance. Thus, our results do not support the idea that the importance of syllable awareness or phoneme awareness increases with grade, although with the provision that our syllable awareness task showed a ceiling effect which may have masked its role in Grade 4. This was not true for the phoneme awareness task and our results clearly suggest that phoneme awareness makes at best a limited contribution to word and nonword reading skills in Sinhala in early grades (see also Table 9). It is important to keep in mind that the literacy instruction focuses on introducing the akshara as a whole until Grade 5 when the focus changes to the

phonemic markers. Wijaythilake et al. (2018) recently showed that instruction in the phonemic markers in Sinhala akshara improved Grade 5 students' phoneme awareness significantly, suggesting that phoneme awareness may contribute to Sinhala reading development at later grades than what has been examined in this study. It is also possible that instructional differences, either in how akshara is taught or how English is taught, could explain differences in reported results in previous studies. However, we don't have access to sufficiently detailed information on instructional practices to assess this possibility further at this time.

In line with previous research in alphasyllabaries (Nag & Snowling, 2011, 2012; Wijaythilake & Parrila, 2014), RAN predicted both word reading accuracy and fluency and nonword reading fluency (with an exception of Grade 3), supporting its role as a predictor of reading across writing systems (see e.g., Finnish: Lepola, Poskiparta, Laakkonen & Niemi, 2005; Greek, English & Chinese: Georgiou, Parrila & Liao, 2008; Japanese: Inoue, Georgiou, Muroya, Maekawa, & Parrila, 2017; Korean: Cho & Chiu, 2015; Norwegian: Lervåg & Hulme, 2009). The observed correlations naturally do not allow any conclusions about the underlying mechanisms. Future studies should examine whether RAN is related to reading in alphasyllabaries for the same reasons as in alphabetic orthographies; we suspect this might not be the case due to the differences in phonological access and visual feature discrimination demands of akshara (Nag, 2017). Thus, a closer examination of RAN–reading relationship in an alphasyllabary may help to understand RAN-reading relationship in general by testing the limits of current theories (see e.g., Kirby, Georgiou, Martinussen, & Parrila, 2010, for a review) in a novel reading context.

Phonological memory had a stronger association with word and nonword reading accuracy and fluency in Sinhala in Grade 1 and 2 than in Grade 3 and 4. To date, there is a

paucity of research that has examined the developmental dynamics between phonological memory and word reading in alphasyllabaries. A previous study in Sinhala (Wijaythilake & Parrila, 2014) indicated that phonological memory was robustly associated with word reading in Grade 3 Sinhala readers, a finding our results only partially replicated. The possible reason for early influence could be that the beginning readers lack the advantage of sub-syllabic level reading instruction to support their decoding of akshara; an instructional advantage readily available only for the advanced readers in Sinhala. As a result, beginning and possibly intermediate readers arguably rely more on phonological memory not only to keep in mind the already decoded akshara in long words and the occasional phonological complexity of some of the akshara, but also to compensate for the possible need to manipulate the orthographic order of phonemes in the akshara symbol block to match the spoken order (see Example 1, line *e*).

Further, our analyses indicated that syllable awareness and phonological memory were uniquely associated with akshara knowledge. This is perhaps not surprising given that spoken Sinhala is syllable-timed and the instruction children are exposed to until Grade 5 builds on syllables. In essence, children are asked to recite and remember as a whole the new akshara, most of which correspond to spoken syllables already in their repertoire. The mediation analyses (Table 9) showed that syllable awareness (in all grades) and phonological memory (in Grade 1 and 3) may also influence reading indirectly via akshara knowledge. Taken together, a plausible theoretical model fitting this pattern of data would then be one where syllable awareness would mainly influence reading via akshara learning, phonological memory both via akshara learning and directly, and RAN mainly directly. We should note, however, that our data was not longitudinal and therefore the results of mediation analyses should be interpreted with caution.

The results of this study should be interpreted against its limitations. First, it is not clear how generalizable these results are given that our study focused on only Grade 1 to 4, and was conducted within an instructional setting where decipherment of the akshara was not explicitly taught during those years. As alluded to above, it is possible that phoneme awareness in particular could be more important if the instruction, in any of the languages children are learning, focused more on orthographic units representing phonemes. Second, our syllable awareness task showed a ceiling effect and the importance of syllable awareness is likely underestimated because of it. Students also performed at a very high level on the phonological memory task that required them to repeat back strings of spoken syllables; it seems that Sinhala speaking children are very good with oral tasks involving syllables and the memory differences became apparent only with very long items (10 and more). This performance level was reached much earlier (Grade 2) than we expected and it is not clear if a different kind of phonological memory task would have shown larger differences between Grade 2, 3, and 4. Although we piloted many of the tests, syllable awareness and phonological memory were late additions and the pilot sample was clearly insufficient. More broadly, the measurement issues indicate the importance and complexity of task development for orthographies that do not have a ready pool of tested tasks available. We hope that our tasks can provide a starting point for such development in Sinhala. Further, our sample included only 50 children from each targeted grade. With six variables in some of the regression models, a replication with larger samples is clearly warranted. We suspect that some of the year-to-year variation in significant predictors may reflect the sample size we had access to and may disappear with a larger sample. A replication should also sample children from a larger variety of schools – most of the participants in this study came from middle or upper-middle SES backgrounds, which limits the generalizability of

the results. The fact that the schools they came from were well-functioning and all the teachers were professionally trained may itself limit the generalizability of the results to different schooling contexts.

In conclusion, more scientific studies are needed in all aspects of literacy acquisition and development in akshara orthographies focusing on akshara knowledge, word recognition, phonological and other cognitive skills, reading comprehension, vocabulary, and visual processing skills. Given the crucial role of akshara knowledge as the major predictor of reading accuracy and fluency, the dearth of experimental akshara learning studies is particularly troubling. The current instructional methods are based more on tradition than on scientific evidence, and we believe that the impact of early instruction on analysing akshara into their constituent phonological and orthographic components needs to be examined. We argue that learning to read in Sinhala (and other alphasyllabaries) is a different process from learning to read in alphabetic orthographies, and a process that available models and theories of reading in alphabetic orthographies are unable to explain (but see Nag, 2017). This study suggests that, apart from learning the akshara set in an extensive Sinhala orthography being a demanding process by itself, it is likely that the cognitive skills employed during different stages of reading development are at least partly different from those needed to learn contained alphabetic orthographies.

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Footnotes

1 We collected data also from Grade 5 and 6 students. That data is not reported here due to ceiling effects with some of the measures.

2 Given the relatively small sample size of this study (N = 50 for each grade), we used a conservative cutoff value of ±3.29 (α = .001) for skewness/kurtosis values divided by its standard error (Kim, 2013; Tabachnick & Fidell, 2013).

Table 1
Descriptive Statistics of the Measures Used in the Study.

	Grade 1				Grade 2				Grade 3				Grade 4			
Measures	*M*	*SD*	Skew/*SE*	Kurt/*SE*	*M*	*SD*	Skew/*SE*	Kurt/*SE*	*M*	*SD*	Skew/*SE*	Kurt/*SE*	*M*	*SD*	Skew/*SE*	Kurt/*SE*
Age in months	77.20	2.87	–0.60	–1.23	89.96	3.22	–2.46	–0.35	100.98	2.92	0.00	–1.67	114.08	3.33	–0.43	–1.58
Akshara knowledge (80)	35.60	10.67	1.54	0.10	56.42	10.26	–2.49	–0.07	63.46	7.46	–1.71	–0.51	69.10	7.23	–4.86	3.45
Syllable awareness (60)	28.04	14.66	1.37	–0.97	55.08	6.72	–4.34	1.86	54.22	8.02	–4.77	2.81	59.60	0.88	–5.63	3.59
Phoneme awareness (60)	7.66	4.21	1.54	–0.52	18.42	4.19	–2.89	–0.06	20.88	2.32	–2.46	0.80	29.52	12.30	2.43	–0.81
Phonological memory (37)	24.18	11.73	–3.34	–0.36	32.38	2.95	–2.69	0.20	32.00	3.63	–3.34	0.70	34.28	1.82	–3.06	0.49
RAN-objects (in seconds)	63.61	13.63	2.71	0.75	55.95	11.21	2.31	0.36	47.74	9.21	2.29	–0.22	51.77	14.31	2.97	0.93
RAN-digits (in seconds)	55.21	17.35	3.97	1.93	42.67	9.92	3.06	1.43	32.35	5.80	1.63	0.23	37.20	9.94	0.77	–1.13
Word reading accuracy (110)	17.44	11.11	1.77	–0.84	63.12	21.84	–0.94	–1.61	76.90	15.62	–1.00	–1.30	91.74	15.62	–3.11	0.62
Word reading fluency (80)	12.68	6.03	0.00	–1.28	24.68	4.93	–0.51	–0.41	32.50	6.45	0.66	–1.01	35.32	11.19	0.71	–0.46
Nonword reading accuracy (110)	21.52	12.43	2.60	0.33	68.22	20.15	–1.34	–1.09	81.30	19.96	–1.89	–1.13	100.40	11.02	–5.34	3.75
Nonword reading fluency (80)	13.56	4.97	–0.46	–1.70	21.00	4.19	1.31	0.78	26.36	5.30	–0.89	–1.10	28.90	7.93	–0.17	–1.07

Note. Numerals in parentheses indicate the possible maximum scores in each measure. Skew = skewness; Kurt = Kurtosis; SE = standard error.

Table 2
Results of One-Way Analysis of Variance and Effect Sizes for the Pairwise Grade Comparisons.

	Main effect of grade		Pairwise comparison (Hedges' *g*)		
	$F(3, 196)$	η_G^2	G1 vs. G2	G2 vs. G3	G3 vs. G4
Akshara knowledge	131.13***	.67	1.97	0.78	0.76
		[.57, .73]	[1.49, 2.45]	[0.37, 1.19]	[0.36, 1.17]
Syllable awareness	126.22***	.66	2.35	−0.12	0.94
		[.54, .75]	[1.84, 2.86]	[−0.51, 0.28]	[0.52, 1.35]
Phoneme awareness	84.39***	.56	2.54	0.72	0.97
		[.50, .62]	[2.01, 3.07]	[0.32, 1.12]	[0.55, 1.38]
Phonological memory	24.52***	.27	0.95	−0.11	0.79
		[.18, .37]	[0.54, 1.36]	[−0.51, 0.28]	[0.38, 1.20]
RAN-objects	15.29***	.19	−0.61	−0.79	0.33
		[.10, .27]	[−1.01, −0.21]	[−1.20, −0.39]	[−0.06, 0.73]
RAN-digits	36.48***	.36	−0.88	−1.26	0.59
		[.28, .43]	[−1.29, −0.47]	[−1.69, −0.83]	[0.19, 0.99]
Word reading accuracy	189.47***	.74	2.62	0.72	0.94
		[.69, .78]	[2.08, 3.15]	[0.32, 1.12]	[0.53, 1.36]
Word reading fluency	90.29***	.58	2.16	1.35	0.31
		[.49, .64]	[1.67, 2.66]	[0.92, 1.79]	[−0.09, 0.70]
Nonword reading accuracy	208.96***	.76	2.77	0.65	1.18
		[.71, .80]	[2.22, 3.32]	[0.24, 1.05]	[0.75, 1.60]
Nonword reading fluency	69.04***	.51	1.61	1.11	0.37
		[.42, .59]	[1.16, 2.06]	[0.69, 1.53]	[−0.02, 0.77]

Note. G1 = Grade 1; G2 = Grade 2; G3 = Grade 3; G4 = Grade 4. Numerals in brackets are 95% confidence intervals.

Table 3
Correlations among the Measures in Each Grade.

	1	2	3	4	5	6	7	8	9	10
Grades 1 and 2										
1. Akshara knowledge		.43*	.34*	.47**	–.22	–.24	.74**	.51**	.78**	.24
2. Syllable awareness	.47**		.28	.35*	–.09	.14	.43**	.18	.37*	–.15
3. Phoneme awareness	.17	.39**		.46**	–.16	–.18	.39**	.17	.39*	.18
4. Phonological memory	.51**	.13	.12		–.18	–.10	.52**	.29*	.57**	.15
5. RAN-objects	.00	.27	.23	.00		.51**	–.32*	–.45**	–.42**	–.37*
6. RAN-digits	–.26	–.08	–.01	–.26	.53**		–.39**	–.46**	–.49**	–.43**
7. Word reading accuracy	.80**	.40**	.24	.47**	–.10	–.38*		.46**	.88**	.31*
8. Word reading fluency	.73**	.37*	.20	.54**	–.18	–.48**	.90**		.59**	.62**
9. Nonword reading accuracy	.82**	.44**	.25	.50**	–.05	–.35*	.90**	.84**		.37*
10. Nonword reading fluency	.61**	.31*	.26	.58**	–.24	–.49**	.74**	.87**	.76**	
Grades 3 and 4										
1. Akshara knowledge		.38*	.04	.32*	–.46**	–.34*	.71**	.49**	.63**	.53**
2. Syllable awareness	.41**		–.04	.40**	–.10	.04	.36*	.21	.23	.22
3. Phoneme awareness	.29*	.28		.04	–.09	–.19	.03	–.06	.00	.00
4. Phonological memory	.35*	.20	.16		–.09	–.03	.36*	.03	.23	.02
5. RAN-objects	–.08	.11	–.19	–.11		.77**	–.50**	–.53**	–.47**	–.56**
6. RAN-digits	–.17	–.03	–.18	–.18	.46**		–.44**	–.49**	–.35*	–.51**
7. Word reading accuracy	.62**	.25	.36*	.29*	–.25	–.35*		.71**	.66**	.69**
8. Word reading fluency	.52**	–.05	.22	.25	–.25	–.20	.46**		.60**	.75**
9. Nonword reading accuracy	.65**	.23	.24	.40*	–.04	–.30*	.74**	.40**		.56**
10. Nonword reading fluency	.45**	–.15	.16	.29*	–.29*	–.29*	.31*	.56**	.43**	

Note. Correlations below the diagonal are from Grades 1 and 3, respectively, whereas those above the diagonal are from Grades 2 and 4, respectively.
*$p < .05$; **$p < .01$.

Table 4

Results of Multiple Regression Analysis for Predicting Word Reading Accuracy.

	Grade 1			Grade 2			Grade 3			Grade 4		
Step	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI
1. Akshara knowledge	.64***	.80***	[.62, .97]	.55***	.74***	[.55, .94]	.38***	.62***	[.39, .85]	.50***	.71***	[.50, .91]
2. Syllable awareness	.05	.04	[–.18, .25]	.10*	.13	[–.07, .34]	.09	–.01	[–.26, .24]	.09	.09	[–.13, .32]
Phoneme awareness		.12	[–.07, .31]		.06	[–.15, .27]		.15	[–.09, .39]		–.03	[–.23, .17]
Phonological memory		.07	[–.13, .27]		.16	[–.06, .38]		.04	[–.20, .28]		.15	[–.07, .37]
RAN		–.21*	[–.42, –.01]		–.27*	[–.49, –.05]		–.27	[–.54, .00]		–.29*	[–.53, –.05]
Total R^2	.69			.65			.47			.59		
1. Syllable awareness	.16**	.41**	[.14, .67]	.18**	.43***	[.16, .69]	.06	.25	[–.03, .53]	.13*	.36*	[.09, .63]
2. Akshara knowledge	.53***	.70***	[.47, .93]	.47***	.52***	[.30, .75]	.41***	.53***	[.27, .79]	.46***	.51***	[.27, .75]
Phoneme awareness		.12	[–.07, .31]		.06	[–.15, .27]		.15	[–.09, .39]		–.03	[–.23, .17]
Phonological memory		.07	[–.13, .27]		.16	[–.06, .38]		.04	[–.20, .28]		.15	[–.07, .37]
RAN		–.21*	[–.42, –.01]		–.27*	[–.49, –.05]		–.27	[–.54, .00]		–.29*	[–.53, –.05]
Total R^2	.69			.65			.47			.59		
1. Phoneme awareness	.06	.24	[–.05, .52]	.16**	.40**	[.13, .66]	.13*	.36*	[.09, .63]	.00	.03	[–.26, .32]
2. Akshara knowledge	.63***	.70***	[.47, .93]	.49***	.52***	[.30, .75]	.34***	.53***	[.27, .79]	.59***	.51***	[.27, .75]
Syllable awareness		.04	[–.18, .25]		.13	[–.07, .34]		–.01	[–.26, .24]		.09	[–.13, .32]
Phonological memory		.07	[–.13, .27]		.16	[–.06, .38]		.04	[–.20, .28]		.15	[–.07, .37]
RAN		–.21*	[–.42, –.01]		–.27*	[–.49, –.05]		–.27	[–.54, .00]		–.29*	[–.53, –.05]
Total R^2	.69			.65			.47			.59		
1. Phonological memory	.22***	.47***	[.21, .73]	.27***	.52***	[.27, .77]	.08*	.29*	[.01, .56]	.13**	.36**	[.09, .63]
2. Akshara knowledge	.47***	.70***	[.47, .93]	.38***	.52***	[.30, .75]	.39***	.53***	[.27, .79]	.46***	.51***	[.27, .75]
Syllable awareness		.04	[–.18, .25]		.13	[–.07, .34]		–.01	[–.26, .24]		.09	[–.13, .32]
Phoneme awareness		.12	[–.07, .31]		.06	[–.15, .27]		.15	[–.09, .39]		–.03	[–.23, .17]
RAN		–.21*	[–.42, –.01]		–.27*	[–.49, –.05]		–.27	[–.54, .00]		–.29*	[–.53, –.05]
Total R^2	.69			.65			.47			.59		
1. RAN	.08*	–.32*	[–.64, .00]	.17**	–.47**	[–.78, –.17]	.12*	–.41*	[–.73, –.09]	.25***	–.53***	[–.80, –.27]
2. Akshara knowledge	.61***	.70***	[.47, .93]	.48***	.52***	[.30, .75]	.35***	.53***	[.27, .79]	.34***	.51***	[.27, .75]
Syllable awareness		.04	[–.18, .25]		.13	[–.07, .34]		–.01	[–.26, .24]		.09	[–.13, .32]
Phoneme awareness		.12	[–.07, .31]		.06	[–.15, .27]		.15	[–.09, .39]		–.03	[–.23, .17]
Phonological memory		.07	[–.13, .27]		.16	[–.06, .38]		.04	[–.20, .28]		.15	[–.07, .37]
Total R^2	.69			.65			.47			.59		

Note. CI = confidence intervals. *p < .05; **p < .01; ***p < .001.

Table 5

Results of Multiple Regression Analysis for Predicting Nonword Reading Accuracy.

	Grade 1			Grade 2			Grade 3			Grade 4		
Step	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI
1. Akshara knowledge	.67***	.82***	[.65, .98]	.60***	.78***	[.59, .96]	.42***	.65***	[.43, .87]	.40***	.63***	[.41, .86]
2. Syllable awareness	.04	.07	[–.14, .28]	.16***	.06	[–.11, .23]	.05	–.06	[–.31, .19]	.04	.00	[–.26, .26]
Phoneme awareness		.11	[–.08, .29]		.01	[–.16, .18]		.03	[–.21, .27]		–.06	[–.29, .18]
Phonological memory		.11	[–.08, .31]		.24*	[.06, .42]		.19	[–.05, .43]		.05	[–.21, .30]
RAN		–.15	[–.35, .04]		–.39***	[–.57, –.20]		–.08	[–.36, .19]		–.23	[–.51, .04]
Total R^2	.71			.76			.47			.44		
1. Syllable awareness	.19**	.44**	[.18, .70]	.14**	.37**	[.10, .64]	.05	.23	[–.06, .51]	.05	.23	[–.05, .51]
2. Akshara knowledge	.52***	.69***	[.47, .91]	.62***	.55***	[.36, .73]	.42***	.59***	[.33, .85]	.39***	.52***	[.24, .80]
Phoneme awareness		.11	[–.08, .29]		.01	[–.16, .18]		.03	[–.21, .27]		–.06	[–.29, .18]
Phonological memory		.11	[–.08, .31]		.24*	[.06, .42]		.19	[–.05, .43]		.05	[–.21, .30]
RAN		–.15	[–.35, .04]		–.39***	[–.57, –.20]		–.08	[–.36, .19]		–.23	[–.51, .04]
Total R^2	.71			.76			.47			.44		
1. Phoneme awareness	.06	.25	[–.04, .53]	.15**	.39**	[.12, .66]	.06	.24	[–.05, .52]	.00	.00	[–.29, .29]
2. Akshara knowledge	.65***	.69***	[.47, .91]	.61***	.55***	[.36, .73]	.41***	.59***	[.33, .85]	.44***	.52***	[.24, .80]
Syllable awareness		.07	[–.14, .28]		.06	[–.11, .23]		–.06	[–.31, .19]		.00	[–.26, .26]
Phonological memory		.11	[–.08, .31]		.24*	[.06, .42]		.19	[–.05, .43]		.05	[–.21, .30]
RAN		–.15	[–.35, .04]		–.39***	[–.57, –.20]		–.08	[–.36, .19]		–.23	[–.51, .04]
Total R^2	.71			.76			.47			.44		
1. Phonological memory	.25***	.50***	[.25, .75]	.33***	.57***	[.34, .81]	.16**	.40**	[.13, .67]	.05	.23	[–.06, .51]
2. Akshara knowledge	.46***	.69***	[.47, .91]	.43***	.55***	[.36, .73]	.31***	.59***	[.33, .85]	.39***	.52***	[.24, .80]
Syllable awareness		.07	[–.14, .28]		.06	[–.11, .23]		–.06	[–.31, .19]		.00	[–.26, .26]
Phoneme awareness		.11	[–.08, .29]		.01	[–.16, .18]		.03	[–.21, .27]		–.06	[–.29, .18]
RAN		–.15	[–.35, .04]		–.39***	[–.57, –.20]		–.08	[–.36, .19]		–.23	[–.51, .04]
Total R^2	.71			.76			.47			.44		
1. RAN	.06	–.26	[–.59, .06]	.27***	–.60***	[–.88, –.31]	.04	–.24	[–.57, .10]	.19**	–.47**	[–.74, –.19]
2. Akshara knowledge	.65***	.69***	[.47, .91]	.49***	.55***	[.36, .73]	.43***	.59***	[.33, .85]	.25**	.52***	[.24, .80]
Syllable awareness		.07	[–.14, .28]		.06	[–.11, .23]		–.06	[–.31, .19]		.00	[–.26, .26]
Phoneme awareness		.11	[–.08, .29]		.01	[–.16, .18]		.03	[–.21, .27]		–.06	[–.29, .18]
Phonological memory		.11	[–.08, .31]		.24*	[.06, .42]		.19	[–.05, .43]		.05	[–.21, .30]
Total R^2	.71			.76			.47			.44		

Note. CI = confidence intervals. *p < .05; **p < .01; ***p < .001.

Table 6

Results of Multiple Regression Analysis for Predicting Word Reading Fluency.

	Grade 1			Grade 2			Grade 3			Grade 4		
Step	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI
1. Akshara knowledge	.54***	.73***	[.54, .93]	.26***	.51***	[.26, .76]	.27***	.52***	[.28, .77]	.24***	.49***	[.24, .75]
2. Syllable awareness	.12**	.08	[–.14, .30]	.17*	.03	[–.24, .29]	.13	–.33*	[–.60, –.06]	.18*	.14	[–.13, .40]
Phoneme awareness		.09	[–.10, .29]		–.09	[–.35, .18]		.10	[–.16, .35]		–.12	[–.36, .11]
Phonological memory		.21	[.00, .42]		.08	[–.20, .36]		.07	[–.18, .33]		–.14	[–.40, .12]
RAN		–.32***	[–.54, –.11]		–.50***	[–.78, –.21]		–.15	[–.44, .14]		–.47***	[–.74, –.19]
Total R^2	.66			.43			.40			.42		
1. Syllable awareness	.13**	.37**	[.09, .64]	.03	.18	[–.11, .46]	.00	–.05	[–.34, .24]	.05	.21	[–.07, .50]
2. Akshara knowledge	.53***	.53***	[.29, .77]	.40***	.38**	[.09, .66]	.40***	.59***	[.31, .86]	.37***	.30*	[.02, .59]
Phoneme awareness		.09	[–.10, .29]		–.09	[–.35, .18]		.10	[–.16, .35]		–.12	[–.36, .11]
Phonological memory		.21	[.00, .42]		.08	[–.20, .36]		.07	[–.18, .33]		–.14	[–.40, .12]
RAN		–.32***	[–.54, –.11]		–.50***	[–.78, –.21]		–.15	[–.44, .14]		–.47***	[–.74, –.19]
Total R^2	.66			.43			.40			.42		
1. Phoneme awareness	.04	.20	[–.08, .49]	.03	.17	[–.12, .46]	.05	.22	[–.07, .50]	.00	–.06	[–.35, .23]
2. Akshara knowledge	.62***	.53***	[.29, .77]	.40***	.38**	[.09, .66]	.35***	.59***	[.31, .86]	.42***	.30*	[.02, .59]
Syllable awareness		.08	[–.14, .30]		.03	[–.24, .29]		–.33*	[–.60, –.06]		.14	[–.13, .40]
Phonological memory		.21	[.00, .42]		.08	[–.20, .36]		.07	[–.18, .33]		–.14	[–.40, .12]
RAN		–.32***	[–.54, –.11]		–.50***	[–.78, –.21]		–.15	[–.44, .14]		–.47***	[–.74, –.19]
Total R^2	.66			.43			.40			.42		
1. Phonological memory	.30***	.54***	[.30, .79]	.09*	.29*	[.01, .57]	.06	.25	[–.03, .53]	.00	.03	[–.26, .32]
2. Akshara knowledge	.36***	.53***	[.29, .77]	.34***	.38**	[.09, .66]	.34***	.59***	[.31, .86]	.42***	.30*	[.02, .59]
Syllable awareness		.08	[–.14, .30]		.03	[–.24, .29]		–.33*	[–.60, –.06]		.14	[–.13, .40]
Phoneme awareness		.09	[–.10, .29]		–.09	[–.35, .18]		.10	[–.16, .35]		–.12	[–.36, .11]
RAN		–.32***	[–.54, –.11]		–.50***	[–.78, –.21]		–.15	[–.44, .14]		–.47***	[–.74, –.19]
Total R^2	.66			.43			.40			.42		
1. RAN	.14**	–.43***	[–.73, –.12]	.28***	–.61***	[–.89, –.32]	.07	–.31	[–.64, .02]	.30***	–.58***	[–.84, –.32]
2. Akshara knowledge	.52***	.53***	[.29, .77]	.15*	.38**	[.09, .66]	.33***	.59***	[.31, .86]	.12	.30*	[.02, .59]
Syllable awareness		.08	[–.14, .30]		.03	[–.24, .29]		–.33*	[–.60, –.06]		.14	[–.13, .40]
Phoneme awareness		.09	[–.10, .29]		–.09	[–.35, .18]		.10	[–.16, .35]		–.12	[–.36, .11]
Phonological memory		.21	[.00, .42]		.08	[–.20, .36]		.07	[–.18, .33]		–.14	[–.40, .12]
Total R^2	.66			.43			.40			.42		

Note. CI = confidence intervals. *p < .05; **p < .01; ***p < .001.

Table 7

Results of Multiple Regression Analysis for Predicting Nonword Reading Fluency.

	Grade 1			Grade 2			Grade 3			Grade 4		
Step	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI	ΔR^2	β	95% CI
1. Akshara knowledge	.37***	.61***	[.38, .84]	.06	.24	[–.04, .52]	.21***	.45**	[.20, .71]	.28***	.53***	[.28, .77]
2. Syllable awareness	.24***	.08	[–.15, .32]	.23*	–.27	[–.57, .03]	.20**	–.39**	[–.66, –.13]	.18*	.15	[–.11, .40]
Phoneme awareness		.18	[–.03, .39]		.10	[–.20, .40]		.05	[–.21, .30]		–.06	[–.29, .17]
Phonological memory		.34***	[.11, .56]		.04	[–.28, .35]		.15	[–.10, .40]		–.17	[–.42, .08]
RAN		–.40**	[–.62, –.17]		–.43***	[–.75, –.12]		–.24	[–.52, .05]		–.46***	[–.73, –.19]
Total R^2	.61			.29			.41			.46		
1. Syllable awareness	.10*	.31*	[.04, .59]	.02	–.15	[–.44, .14]	.02	–.14	[–.43, .14]	.05	.22	[–.06, .51]
2. Akshara knowledge	.51***	.32*	[.07, .58]	.27**	.21	[–.11, .52]	.39***	.52***	[.25, .79]	.41***	.34*	[.07, .62]
Phoneme awareness		.18	[–.03, .39]		.10	[–.20, .40]		.05	[–.21, .30]		–.06	[–.29, .17]
Phonological memory		.34***	[.11, .56]		.04	[–.28, .35]		.15	[–.10, .40]		–.17	[–.42, .08]
RAN		–.40**	[–.62, –.17]		–.43***	[–.75, –.12]		–.24	[–.52, .05]		–.46***	[–.73, –.19]
Total R^2	.61			.29			.41			.46		
1. Phoneme awareness	.07	.26	[–.02, .54]	.03	.18	[–.10, .47]	.03	.16	[–.13, .45]	.00	.00	[–.29, .29]
2. Akshara knowledge	.54***	.32*	[.07, .58]	.26**	.21	[–.11, .52]	.38***	.52***	[.25, .79]	.46***	.34*	[.07, .62]
Syllable awareness		.08	[–.15, .32]		–.27	[–.57, .03]		–.39**	[–.66, –.13]		.15	[–.11, .40]
Phonological memory		.34***	[.11, .56]		.04	[–.28, .35]		.15	[–.10, .40]		–.17	[–.42, .08]
RAN		–.40**	[–.62, –.17]		–.43***	[–.75, –.12]		–.24	[–.52, .05]		–.46***	[–.73, –.19]
Total R^2	.61			.29			.41			.46		
1. Phonological memory	.34***	.59***	[.35, .82]	.02	.15	[–.14, .43]	.09*	.29*	[.02, .57]	.00	.02	[–.27, .31]
2. Akshara knowledge	.27***	.32*	[.07, .58]	.27**	.21	[–.11, .52]	.32***	.52***	[.25, .79]	.46***	.34*	[.07, .62]
Syllable awareness		.08	[–.15, .32]		–.27	[–.57, .03]		–.39**	[–.66, –.13]		.15	[–.11, .40]
Phoneme awareness		.18	[–.03, .39]		.10	[–.20, .40]		.05	[–.21, .30]		–.06	[–.29, .17]
RAN		–.40**	[–.62, –.17]		–.43***	[–.75, –.12]		–.24	[–.52, .05]		–.46***	[–.73, –.19]
Total R^2	.61			.29			.41			.46		
1. RAN	.17**	–.47**	[–.78, –.17]	.22***	–.54***	[–.83, –.24]	.11*	–.39*	[–.71, –.07]	.32***	–.61***	[–.86, –.35]
2. Akshara knowledge	.44***	.32*	[.07, .58]	.07	.21	[–.11, .52]	.30***	.52***	[.25, .79]	.14*	.34*	[.07, .62]
Syllable awareness		.08	[–.15, .32]		–.27	[–.57, .03]		–.39**	[–.66, –.13]		.15	[–.11, .40]
Phoneme awareness		.18	[–.03, .39]		.10	[–.20, .40]		.05	[–.21, .30]		–.06	[–.29, .17]
Phonological memory		.34***	[.11, .56]		.04	[–.28, .35]		.15	[–.10, .40]		–.17	[–.42, .08]
Total R^2	.61			.29			.41			.46		

Note. CI = confidence intervals. *p < .05; **p < .01; ***p < .001.

Table 8
Results of Multiple Regression Analysis for Predicting Akshara Knowledge.

	Grade 1		Grade 2		Grade 3		Grade 4	
Predictors	β	95% CI	β	95% CI	β	95% CI	β	95% CI
DV: Akshara knowledge								
Syllable awareness	.45***	[.20, .70]	.31*	[.05, .58]	.33*	[.05, .60]	.29*	[.03, .56]
Phoneme awareness	–.05	[–.29, .20]	.08	[–.20, .35]	.15	[–.13, .42]	–.02	[–.26, .23]
Phonological memory	.43***	[.20, .66]	.29*	[.00, .57]	.24	[–.02, .51]	.17	[–.10, .44]
RAN	–.14	[–.41, .12]	–.25	[–.53, .04]	–.11	[–.42, .20]	–.44***	[–.70, –.17]
Adjusted R^2	.39		.30		.21		.28	

Note. DV = dependent variable; CI = confidence intervals.
*p < .05; **p < .01; ***p < .001.

Table 9

The Indirect Effects of the Cognitive Skills on Word and Nonword Reading Skills via Akshara Knowledge.

	Word Reading Accuracy		Nonword Reading Accuracy		Word Reading Fluency		Nonword Reading Fluency	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Grade 1								
Syllable awareness	**.31**	**[.14, .53]**	**.31**	**[.13, .53]**	**.24**	**[.08, .46]**	**.14**	**[.02, .35]**
Phoneme awareness	–.03	[–.23, .16]	–.03	[–.25, .15]	–.03	[–.20, .11]	–.02	[–.14, .06]
Phonological memory	**.30**	**[.12, .55]**	**.30**	**[.11, .54]**	**.23**	**[.09, .43]**	**.14**	**[.03, .32]**
RAN	–.09	[–.22, .07]	–.09	[–.21, .07]	–.07	[–.18, .05]	–.04	[–.14, .02]
Grade 2								
Syllable awareness	**.16**	**[.02, .36]**	**.17**	**[.02, .37]**	**.12**	**[.02, .30]**	.06	[–.02, .23]
Phoneme awareness	.04	[–.11, .19]	.04	[–.12, .18]	.03	[–.07, .17]	.02	[–.03, .20]
Phonological memory	.15	[–.02, .34]	.16	[–.02, .34]	.11	[–.01, .30]	.06	[–.03, .37]
RAN	–.11	[–.28, .01]	–.12	[–.26, .02]	–.08	[–.20, .00]	–.04	[–.21, .02]
Grade 3								
Syllable awareness	**.17**	**[.05, .37]**	**.19**	**[.06, .37]**	**.19**	**[.03, .39]**	**.17**	**[.02, .40]**
Phoneme awareness	.08	[–.06, .25]	.09	[–.06, .29]	.09	[–.08, .27]	.08	[–.06, .26]
Phonological memory	**.13**	**[.02, .28]**	**.14**	**[.03, .30]**	**.14**	**[.02, .27]**	**.13**	**[.02, .27]**
RAN	–.05	[–.29, .09]	–.05	[–.31, .09]	–.05	[–.24, .12]	–.05	[–.22, .10]
Grade 4								
Syllable awareness	**.15**	**[.04, .32]**	**.15**	**[.02, .34]**	.09	[.00, .24]	**.10**	**[.01, .26]**
Phoneme awareness	–.01	[–.14, .10]	–.01	[–.14, .11]	–.01	[–.10, .06]	–.01	[–.10, .08]
Phonological memory	.09	[–.04, .24]	.09	[–.05, .24]	.05	[–.02, .17]	.06	[–.02, .17]
RAN	**–.21**	**[–.39, –.06]**	**–.22**	**[–.38, –.08]**	**–.12**	**[–.28, –.01]**	**–.14**	**[–.28, –.04]**

Note. CI = confidence intervals. The estimates for each indirect effect were considered to be statistically significant at the 5% significance level when the confidence intervals did not include zero (shown in bold; Shrout & Bolger, 2002).