

Investigating the Asymmetrical Roles of Syllabic and Phonemic Awareness Role in Akshara
Processing

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Abstract

In this study, we examine the relative contributions of syllabic awareness, phonemic awareness, and oral vocabulary knowledge in early akshara reading ability from Grade 1 to Grade 5. The performance of 488 students in two states of South India, Karnataka (Kannada language) and Andhra Pradesh (Telugu language) was measured. Results from a commonality analysis indicate that there was an increasing independent contribution of syllabic awareness to Kannada and Telugu decoding through the five grades, but the unique contribution of phonemic awareness steadily declined through the five grades, as it became subsumed within syllabic awareness ability. The contribution of oral vocabulary knowledge did not present a clear pattern across the five grades. This study builds on a growing body of literature on the akshara orthographies to shed light on the precise nature of the developmental asymmetry in the dual syllabic and phonemic representation in akshara reading.

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Introduction

There is a growing body of research on the psycholinguistic underpinnings of learning to read akshara¹, the Brahmi-derived orthography used across most of South and Southeast Asia (Nag & Perfetti, 2014; Share & Daniels, 2016). The emerging perspective is that akshara, which have been referred to as alphasyllabaries (along with Korean Hangul), abugida (along with Ethiopian Fidel), sub-syllabic, semi-syllabic, and semi-alphabetic writing systems, are neither alphabetic nor syllabic. Rather, the orthographic underpinnings of processing akshara are unique in a variety of ways (Share & Daniels, 2016). In this paper, we examine one of those postulated differences: the asymmetrical dual nature of syllabic and phonemic sensitivity, and how that sensitivity is different across the first few years of reading acquisition in Kannada and Telugu, two Brahmi-derived orthographies used primarily in two states of South India.

Phonological awareness (PA) is a well-documented powerful predictor of early reading ability in various alphabetic languages (Goswami & Bryant, 1990; Ziegler & Goswami, 2005). Studies with alphabetic languages have also demonstrated a hierarchical sensitivity to phonological units from syllable, to onset-rime, to phoneme level (e.g., Seymour & Evans, 1994; Høien, Lundberg, Stanovich, & Bjaalid, 1995; Treiman & Zukowski, 1991). The importance of PA and its language-dependent contribution to word reading has also been shown in morphosyllabic (McBride-Chang et al., 2004; Nagy & Anderson, 1999) and alphasyllabic languages (Cho & McBride-Chang, 2005; Cho, McBride-Chang, & Park, 2008). In Korean, for instance, both syllable and phoneme level awareness is required for Hangul decoding;

¹ The word 'akshara' is often used for several Indic languages, but is called slightly different words in each language, including, for example, 'aksharamu' in Telugu, 'akshara' in Kannada, and 'akshar' in Hindi.

furthermore, the body-coda sub-syllabic structure is particularly significant for decoding and spelling development, due to its salience in Korean (Kim, 2007). Taken together, it is evident that PA is a universal predictor of early reading and spelling achievement; but its contribution is dependent on linguistic and orthographic properties.

The development of PA in akshara is relatively less studied. The akshara orthographies encode sounds primarily at the syllable level, with identifiable sub-syllabic markers (e.g., □ /k/+shwa/, □□ /ki/, □□□□ , /kri/ ²). The sub-syllabic information is not uniform in the way it is represented, necessitating a possibly more cognitively demanding sound-symbol mapping process to access this information compared to accessing the syllabic phonological information. The sub-syllabic information may be encoded as ‘matras’ – vowel phonemic markers – which temporally follow a consonant, but may precede the consonant, or be placed above, below, or after the consonant in spatial representation. For example, in Hindi, /i/ is placed before /b/ for /bi/ òÉ, /o/ is placed to the right of /b/ for /bo/ oÉÉâ, /u/ is placed below /b/ for /bu/ oÉÑ and /ɪ:/ is placed to the right of /b/ for /bɪ:/ oÉÏ. In Kannada and Telugu, the ‘matras’ are usually placed to the right of or above the sound they follow (e.g., the /i/ vowel diacritic is placed above /b/ for /bi/ □□ and the /o/ diacritic is placed to the right of /b/ for /bo/ □□). ‘Matras’ are visually smaller than their original graphemic representation, but do not clearly resemble their original versions (e.g., □□ /bi/ has a small circular loop on the top right corner of the syllable cluster representing the vowel diacritic /i/; whereas the original form of the vowel is □ /i/). ‘Uttakshara’ are consonant phonemic markers, which are also smaller versions of their original forms, but are more visually representative of their original versions (e.g., □□□ /ch/+shwa with a consonant diacritic /ch/ at the bottom right corner of the syllable cluster for the sound /ch/+shwa) or □□□ (/da/+shwa with a consonant diacritic /da/ at the bottom right corner of the syllable cluster for the

² For illustrative purposes all examples are in Kannada, unless otherwise noted.

sound /dd/+shwa). A third example is inherent vowels (or schwa), which temporally follow stand-alone consonants, and have no graphemic representation in the writing system (e.g., □ /r/+shwa or □ /m/+shwa, in which the shwa is not graphically encoded). This non-uniform way in which sub-syllabic phonemic information is encoded is likely to present challenges for early akshara decoding acquisition.

Reflecting these grapho-phonological properties, studies of akshara processing have shown that both syllable and phoneme awareness are predictive of word decoding (Joshi, 2014; Nag, 2007; Reddy & Koda, 2013; Sircar & Nag, 2013; Tiwari, Nair, & Krishnan, 2011), but that the pace of acquisition of syllabic awareness is faster, with increasing sensitivity to sub-syllabic information developing slower than syllable level awareness (Nag, 2007; Vasanta, 2004). While most studies suggest that decomposing and analyzing phonemic information is predictive of future reading and spelling ability in akshara (Nag, 2007; Nag & Snowling, 2011); studies with monolingual Oriya speakers show that only syllable awareness was predictive of word reading (Mishra & Stainthorp, 2007). Reddy and Koda (2013) also found that while both syllable-level awareness and phoneme-level awareness were significant predictors of Kannada decoding, when syllable-level awareness was entered into a step-wise regression before phoneme-level awareness, phoneme-level awareness did not predict any additional unique variance in Kannada decoding. Finally, Kandhadai and Sproat (2010) found that the spatial and temporal misalignment at the phoneme level leads to further difficulties in segmenting phonemic information in akshara. These studies together point to the dual syllabic and phonemic requirements for decoding acquisition in akshara, and suggest that this relationship is different at different levels of reading mastery. However, the relative extent to which syllabic awareness and sub-syllabic awareness predict decoding across the primary school grades has not been previously studied.

Another characteristic of the akshara orthographies that can be expected to influence decoding acquisition is the number of symbols that need to be learned. Nag (2007) estimates that there are over 400 consonant + vowel aksharas that need to be acquired in Kannada. As reading mastery progresses, more phonemic diacritics are added into single syllable clusters. Thus, although transparent, the large symbol set size makes the acquisition process of word reading prolonged, with word reading fluency being achieved closer to Grade 4, provided access to good instruction (Nag, 2007). This increasingly visually complex orthography also provides a theoretical basis for the expectation that the relative contributions of syllabic and sub-syllabic awareness will be susceptible to developmental changes.

In addition to the phonological and orthographic processes that underpin decoding development, vocabulary is also important in predicting later reading comprehension, at the higher levels of reading (Ouellette, 2006; Ouellete & Beers, 2010; Scarborough, 2001; Sénéchal, Ouelette, & Rodney, 2006), but has also been identified as significant at the word reading level (Perfetti & Hart, 2002). Therefore, an examination of beginning akshara processing, especially in young multilingual children, warrants an investigation of the relative role of vocabulary to phonological processing. Given the transparency of the language coupled with the orthographic complexity of the akshara orthography, it is expected that grapho-phonological processes will take precedence over vocabulary in akshara decoding; however, as children become more adept at fluently recognizing the akshara, it can be expected that oral vocabulary skills will become increasingly important in predicting word reading skills.

Stemming from these theoretical foundations, we hypothesized that the contributions of syllabic awareness, phonemic awareness, and oral vocabulary knowledge will shift over time, and asked the following research questions:

1. What are the relative contributions of syllabic awareness, phonemic awareness, and oral vocabulary knowledge in akshara (Kannada and Telugu) decoding?
2. Does the relative predictive power of these three variables change across the grades?

Method

Participants

The data for this study were collected as part of a larger study examining various predictors of reading ability in multilingual children across Karnataka and Andhra Pradesh in South India. The data relevant for this study were collected from 488 children in Grades 1-5 (Grade 1 $n = 96$; $M_{\text{age}} = 6.125$, $SD = 0.98$; Grade 2 $n = 106$, $M_{\text{age}} = 6.98$, $SD = 1.03$; Grade 3 $n = 105$; $M_{\text{age}} = 8.54$, $SD = 1.55$; Grade 4 $n = 82$; $M_{\text{age}} = 9.31$, $SD = 1.43$; Grade 5 $n = 99$, $M_{\text{age}} = 10.82$, $SD = 1.78$). There were a total of 13 schools, both government and private, representing urban, peri-urban, and rural areas. At the time of the study, all participants were learning to read only in Kannada (the regional official language of Karnataka) or Telugu (the regional official language of Andhra Pradesh), as it was the medium of instruction in school. Approximately 15% of the sample reported having a mother tongue that was different from the language of the school. Kannada or Telugu was the medium of instruction for all students, and English was studied as an additional language in school for varying amounts of time at the time of the study. Given that multilingualism is typical in India, data from all the students were included in our analyses. All children were from very low-income communities. Table 1 presents more detailed demographic information by state.

[Insert Table 1 about here]

While Kannada and Telugu are different languages, they are very similar orthographically (some symbols look slightly different □, Oμ /k/+shwa in Kannada and Telugu,

respectively), have similar oral language properties in terms of syntax, morphological rules, cognates etc., and most importantly for this paper, they have the exact same sound-symbol mapping rules. This is particular to Kannada and Telugu. Although there are other pairs like this in India (e.g., Gujarati and Hindi), this is not true for any pair of Indian languages.

Materials and Procedure

Deletion. An investigator-developed phonological deletion test was used to measure syllabic awareness and phonemic awareness. In this task, participants were required to repeat out loud a word that the assessor said, and then say the same word after removing a phonological segment—either syllable or phoneme—from it. For example, children were asked to say /naadu/ □□□□ and then asked to say /naadu/ □□□□ without the /du/ □□ for a syllabic deletion task, and without /u/ for a phonemic deletion task. Deletion of syllables and phonemes occurred in the beginning, middle, and end of the word. There were 16 syllable deletion items in Kannada and 15 in Telugu, and 12 phoneme deletion items in both languages. Internal consistency of the test was measured using Cronbach’s alpha, and the result for Kannada was .96 for syllable deletion and .93 for phoneme deletion, and for Telugu it was .94 for syllable deletion and .93 for phoneme deletion.

Oral vocabulary knowledge. Receptive oral vocabulary knowledge was assessed using a format similar to the Peabody Picture Vocabulary Test- Revised (PPVT-R; Dunn & Dunn, 1981). Individually, each child was shown a card with four images and the data collector said one of the words out loud and asked the child to point to the picture that matched that word. Forty words were used in Kannada and 49 in Telugu. The words were selected from a word bank generated from the textbooks that were used in government schools in each state. The test was piloted twice with different samples of low-income children in India, before the final set of words was

selected. Like the PPVT-R, items were presented in order of difficulty. Difficulty was assessed by a combination of frequency of appearance in the text book, the grade level at which the word was introduced in the school, and due to the arbitrariness of the textbooks, the familiarity of the concepts to children from low-income communities in India was judged by either teachers or the NGO staff supporting data collection activities. They were given a score of 1 or 0. Cronbach's alphas were .94 and .96 in Kannada and Telugu, respectively, indicating high internal consistency for each of the two tests.

Decoding. A researcher-generated decoding test was utilized to estimate children's ability to sound out word with ease and accuracy. Children were shown a flashcard with a word printed in large, black font and were asked to say the word out loud as clearly and smoothly as they could. Scores of 1, 0.5, and 0 were given depending on how accurately and quickly the word was decoded. If the word was decoded correctly and without an unnaturally long stop in the middle of the word, they were given 1 point. If the word was accurate but very slowly decoded with unnaturally long stops before the end of the word, or if the word had only one phoneme pronounced like a similar-sounding phoneme, .5 was given (e.g. □□ /eeka/ pronounced as □□ /ika/ or □□□□ /naathu/ (aspirated) pronounced as □□□□ /naathu/ (non-aspirated), and if more than one such error occurred 0 points were given. The test included both real words ($n = 15$ in Kannada and Telugu) and pseudo words ($n = 15$ in Kannada and Telugu). The word lists included single akshara units (consonant+shwa, e.g., □ /m/+shwa), vowels, (e.g., □ /a/) and more complex akshara units (e.g. consonant+vowel syllable cluster, e.g., □□ /mi/) up to the most complex akshara units (consonant+consonant+vowel syllable cluster □□□ /pya/; and consonant+consonant+consonant+vowel syllable cluster □□□□□ /sthri/). Cronbach's alphas were .98 and .97 in Kannada and Telugu, respectively.

Procedure

Data collectors were recruited from the same communities as participants. They went through rigorous training and re-training for all data collection activities, and passed two stages of interviews and testing before beginning data collection. Data collectors always worked in pairs, were supported by supervisors, and all data collection activities were carried out under Institutional Review Board-approved protocols. All testing was done on school campuses during breaks, in a room or outdoors in a quiet space. The tests (not task items) were presented in counterbalanced order in order to avoid fatigue effects. All children received a small grade-level appropriate book and stationary set as compensation for participating in the study.

Results

Table 2 presents the means, standard deviations, and bivariate correlations by state (language group) and grade. To control the strong floor effect in measures, we invoked median regression analysis along with bootstrap resampling method for standard error estimates. (Petrill, Logan, Sawyer, & Justice 2014; Petscher & Logan, 2013). Both conventional regression (i.e., conditional means model) and median regression results are presented in Table 3. Except for some difference in the points estimate and statistical testing results, the resulting effect sizes are highly comparable between these two models. Hence, in the present study, the result interpretations are based on conventional regression models.

[Insert Table 2 about here]

In order to determine the relative contributions of syllabic awareness, phonemic awareness, and oral vocabulary knowledge in akshara decoding across grades, we conducted a commonality analysis. Commonality coefficients (i.e., unique and common effects) were used to construct a comprehensive profile of the regression effect (i.e., R-squared) for each grade level

(see Table 3). Additionally, we computed structure coefficients and their squared forms. The squared structure coefficients quantify the magnitude of the regression effect that can be explained by a given predictor (i.e., $r_s^2 = r^2_{X \text{ with } Y} / R^2$; Thompson, 2006).

Unique Effects and Common Effects

As shown in Table 3, phonemic awareness with other predictors had smaller unique variance (i.e., unique effects) as grade level increased. At Grade 5, phonemic awareness has near-zero unique contribution to the regression model. Conversely, the unique contribution of syllabic awareness remains large. From Grade 3 to Grade 5, the syllable deletion task accounts for 43% (i.e., .17/.40) to 52% (i.e., .24/.46) of R^2_{Single} . However, oral vocabulary knowledge did not show any salient patterns across the five grades.

[Insert Table 3 around here]

Relative Importance of Predictors (Syllable Deletion, Phoneme Deletion, and Oral Vocabulary Knowledge)

We employed beta weights and (squared) structure coefficients (r_s^2) to evaluate the relative importance of predictors in the regression model (see Table 3). The finding that a predictor that has a near-zero beta weight and a near-zero structure coefficient suggests that it does not make any contribution to the regression model. In contrast, a predictor with a large absolute beta weight value and a large squared structure coefficient is a powerful predictor. Conversely, a predictor that has a near-zero beta weight and a large squared structure coefficient indicates that it might be a good predictor. In this case, the near-zero beta weight might be due to multicollinearity (i.e., other predictors share its predictive power). On the contrary, a predictor with a large absolute value of beta weight and a near-zero structure coefficient is one that

indirectly increases the predictive power of other predictors (i.e., suppressor effect; Courville & Thompson, 2001).

Beta weights for syllabic awareness were statistically significant at the level of 0.05 from Grade 2 to Grade 5. The non-significant result at Grade 1 is most likely due to the multicollinearity. However, as can be seen in Table 3, syllabic awareness makes more than 50 percent of the contribution to the regression model at all grade levels. Especially from Grade 3 to Grade 4, more than 80 percent of the regression effect is accounted for by syllabic awareness. Hence, syllabic awareness has a very strong predictive power in akshara decoding skill across all the grade levels. Conversely, beta weights for phonemic awareness were not statistically significant from Grade 1 through Grade 5 in reference to the statistical testing based on bootstrap median regression. The predictive power was shared by the multicollinearity. At Grade 5, phonemic awareness shared almost all of its predictive power with other predictors (i.e., near-zero unique variance). However, phonemic awareness is still a good predictor, with squared structure coefficients ranging from 37.16 to 76.73. Interestingly, the predictive power of phonemic awareness in predicting decoding skill is gradually being shared by other variables; while the predictive power of syllabic awareness remains larger as grade level increased, with reference to both unique effects and squared structure coefficients.

Discussion

In this study, we sought to examine the relative predictive power of syllabic awareness, phonemic awareness and oral vocabulary knowledge in explaining decoding ability in two akshara languages – Kannada and Telugu. The findings corroborated previous studies, and reflected akshara orthographic properties by showing the importance of both syllabic and phonemic awareness in decoding ability. Syllabic awareness, phonemic awareness, and oral

vocabulary knowledge together explained from 43% to 53% of the variance in decoding, and that remained relatively consistent across the grades.

Interestingly, there is a general growth trend in the contribution of syllable deletion throughout the five grades. Over time and exposure to the primary syllabic akshara orthography, children appear to be sharpening their syllabic level phonological sensitivity. In contrast, the unique contribution of phonemic awareness is generally decreasing through the grades, and although it remains a significant predictor of Kannada and Telugu decoding at the end of elementary school, the commonality analysis results suggests that the variance explained by phonemic awareness is shared with the other predictors, especially syllabic awareness. This finding allows us to hypothesize that as akshara decoding ability improves, even if children are becoming more adept at handling phonemic level phonological information, that ability is being overshadowed by the need for syllabic segmentation and manipulation ability. This can be explained by the nearly equal salience of syllables and phonemes in the Indic oral languages; compared to the unequal salience of syllables and phonemes in the orthographic properties of akshara. This finding helps us understand the asymmetric nature of syllable-phoneme duality in akshara decoding. While studies have shown that only syllabic awareness is important in akshara decoding, and others have demonstrated that the importance of phonemic awareness increases through the grades, our results show that in fact phonemic awareness is increasingly subsumed within the relationship between syllabic awareness and decoding. In other words, both syllabic awareness and phonemic awareness are important for decoding through the grades; however, as akshara decoding ability develops, the acuity of syllabic level representation of phonology increasingly incorporates phonemic level representations.

The role of oral vocabulary knowledge does not present a clear pattern in our results. This may suggest that due to the orthographic complexity of akshara, most cognitive resources are taken up in decoding the complex grapho-phonological aspects of the script, and the transparency allows for the words to be decoded without necessarily relying on oral vocabulary knowledge. Future studies might examine how this changes developmentally after the primary grades, or as a predictor of later reading success, wherein vocabulary is likely to play a larger role (Scarborough, 2001; Sénéchal, 2001).

This study was conducted with a small number of participants per grade, and we collapsed results from two states into one analysis based on the linguistic similarities of the two languages; future research should attempt to conduct similar studies with larger sample sizes in order to have more power to make conclusions within each language. The study also did not include a measure of non-verbal intelligence or other measures of cognitive abilities, which should be addressed in future research. Despite these limitations, however, this study builds on a growing body of literature on the akshara orthographies (Nag & Perfetti 2014; Share & Daniels, 2016), to shed light on the precise nature of the developmental asymmetry in the dual syllable and phoneme representation in akshara reading.

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Table 1. Demographic Information by States

	Karnataka	Andhra Pradesh
Number of Schools	9	4
Number of Participants	247	170
Standards	1–5	1–5
Urbanicity	4 urban and 5 peri-urban	2 urban, 1 peri-urban, and 1 rural
Type of School	6 government and 3 private	3 government and 1 private
Mother Tongue Groups	Kannada = 70; Telugu = 119; Tamil = 41; Urdu = 9; Marathi = 5; Hindi = 3	Telugu = 164; Tamil = 2; Urdu = 4