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Predicting the Early Growth of Word and Nonword Reading Fluency in a Consistent Syllabic Orthography

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The data that support the findings of this study are available from the corresponding author upon reasonable request.

Abstract

Background: The present study aimed to examine the early growth of word and nonword reading fluency and their cognitive predictors in a consistent syllabic orthography (Japanese Hiragana).

Method: One hundred sixty-nine Grade 1 Japanese children (M_{age} = 80.12 months, *SD* = 3.62) were followed until the middle of Grade 2 and assessed four times on word and nonword reading fluency in Hiragana. Nonverbal IQ, vocabulary, phonological awareness, rapid automatized naming (RAN), phonological memory, and morphological awareness were also assessed at the beginning of Grade 1.

Results: Growth curve analysis showed that growth was faster in word reading than in nonword reading, and the lexicality effect increased over time. RAN, phonological memory, and morphological awareness were associated with the initial status and rate of growth in word and nonword reading. Furthermore, the initial status and the growth rates were highly correlated between word and nonword reading, even when the effects of the cognitive skills were controlled.

Conclusions: These findings suggest that, despite the remarkable differences in the growth trajectories of word and nonword reading fluency, they share at least a part of their underlying processes and develop closely in tandem during this period.

Keywords: word reading, reading fluency, growth trajectory, syllabary, Japanese

Implications for Practice

What is already known about this topic

- The growth of word reading skills is modulated by language and writing system.
- Growth is faster for word reading than for nonword reading across alphabetic orthographies.
- Phonological awareness and rapid automatized naming (RAN) play a prominent role in reading development in both alphabetic and non-alphabetic orthographies.

What this paper adds

- Growth was faster for word reading than for nonword reading in the Japanese syllabary (Hiragana).
- RAN, phonological memory, and morphological awareness, but not phonological awareness, were associated with both Hiragana word and nonword reading.
- The initial status and the growth rates were highly correlated between word and nonword reading even after controlling for the effects of the cognitive skills.

Implications for theory, policy or practice

- Word and nonword reading fluency in Hiragana rely on similar underlying processes.
- The lexicality effect in reading fluency in a consistent syllabary may reflect lexical reading strategies or increased predictability in serial processing.
- Early assessment of phonological memory can provide additional information for identifying children who will later struggle in becoming faster readers.

Predicting the Early Growth of Word and Nonword Reading Fluency in a Consistent Syllabic Orthography

A growing number of cross-linguistic studies have revealed both language-specific and universal patterns in the growth of word reading skills, with the observed differences frequently reflecting the orthographic consistency of the writing system (Caravolas, Lervåg, Defior, Seidlova Malkova, & Hulme, 2013; Seymour, Aro, & Erskine, 2003). However, most previous studies have been conducted in alphabetic orthographies and we were not able to locate any studies examining the growth patterns of word reading skills in non-alphabetic orthographies. The present study examined whether the growth patterns of word reading skills and their cognitive predictors in a consistent syllabic orthography (Japanese Hiragana) are similar to those reported for alphabetic orthographies. This is theoretically important because graphemic parsing, an important source of variability in the growth patterns of word reading skills in alphabetic orthographies (Coltheart & Ulicheva, 2018), is visually signaled in syllabic Hiragana (for details, see below).

Growth of Word and Nonword Reading in Alphabetic Orthographies

According to the dual-route model of reading (Coltheart, 2005), word-level reading in most alphabetic orthographies depends on both item-specific knowledge used to read irregular words (e.g., *island*, *yacht*) and generative spelling–sound knowledge used to read regular words and nonwords (e.g., *brec*, *nolf*). The model also postulates that the extent to which readers rely on each of the two knowledge bases to read words can differ as a function of orthographic consistency. Specifically, in consistent orthographies, all words and nonwords can be read correctly by employing a grapheme to sound conversion strategy. In contrast, in inconsistent orthographies, readers cannot solely rely on smaller orthographic units as inconsistency is typically higher for smaller units than for larger units (compare e.g., the <ea> sequence in <read> and <react>). As a result, it takes longer for children learning to read an inconsistent orthography to develop flexible unit size recoding strategies, such as grapheme–phoneme correspondence, morphological units, analogy, and whole-word recognition (Carlisle & Kearns, 2017; Ziegler & Goswami, 2005).

In support of these predictions, Seymour et al. (2003) showed that children can master spelling–sound correspondences more quickly in consistent orthographies than in inconsistent orthographies, and this leads to a faster growth of word and nonword reading skills in the former than in the latter (e.g., Caravolas et al., 2013). Additionally, a recent cross-linguistic study by Caravolas (2017) showed that, despite growth being faster for word reading than for nonword reading across orthographies, the lexicality effect, defined as the difference between word reading and nonword reading speed, was larger in English (an inconsistent orthography) than in Czech and Slovak (relatively consistent orthographies) mainly due to the slower growth of nonword reading fluency in English. Taken together, these findings suggest that whereas readers of an inconsistent orthography rely more on larger orthographic units for word than for nonword reading, readers of a consistent orthography rely on a grapheme to sound conversion strategy for both word and nonword reading, at least at the early phases of fluency development (Landerl & Wimmer, 2008; Zoccolotti et al., 2005).

Word and Nonword Reading in Hiragana Orthography

In the Japanese writing system, children's early literacy depends solely on Hiragana, a syllabic script. The modern Hiragana orthography consists of 108 graphemes (characters or pairs of characters): (a) 46 basic characters that represent five vowels (/a/, /o/, /u/, /e/, /i/), 40 consonant-vowel (CV) combinations (e.g., は /ha/), and one nasal sound /n/; (b) 25 secondary characters that represent voiced and semi-voiced syllables and are formed by adding two kinds of diacritical markers to the right top of basic characters (e.g., ば /ba/, ぱ /pa/); (c) 37 exceptional notations that represent CV syllables by pairs of Hiragana characters (e.g., しゃ /sha/, きゅ /kyu/). In the Japanese phonology, the number of syllable-like phonological units called *mora* (see Iwasaki, 2013) is almost the same as the number of Hiragana graphemes, and this leads to the nearly perfect consistency in the Hiragana orthography (Koda, 2017). In addition, the Japanese phonology does not use consonant clusters or closed syllables, except when a syllable ends in the nasal consonant /n/. These characteristics of the Hiragana orthography and the Japanese phonology make Hiragana very easy for children to learn to read. Indeed, about 95% of Japanese children learn to read the 46 basic characters before they receive formal instruction in Grade 1 as Hiragana characters are frequently introduced at home and in kindergarten informally (Ota, Uno, & Inomata, 2018). Hiragana is taught first when formal reading instruction commences at the beginning of Grade 1 (Ministry of Education, Culture, Sports, Science and Technology, 2015) with a particular emphasis on the correspondences between characters or pairs of characters and the sounds represented by them. Most children master Hiragana orthography within the first few months of Grade 1 and the focus of reading instruction then shifts to Kanji, which is a morphographic orthography originated from Chinese characters and used in combination with Hiragana in the Japanese writing (see Taylor & Taylor, 2014, for a more detailed description of the Kanji orthography).

Similar to the findings from alphabetic orthographies, previous cross-sectional studies examining word and nonword reading skills in Japanese have consistently reported a robust lexicality effect in Hiragana (e.g., Kobayashi et al., 2010; Sambai et al., 2012). Specifically, the studies have shown that the difference between the reading speed of words and nonwords becomes more evident as children become older, particularly from Grade 2 onwards (Kurokawa, Sambai, & Uno, 2014; Sambai et al., 2012). These results are usually interpreted, in light of the dual-route model of reading, as evidence of the developmental shift of reading strategies from non-lexical serial processes to lexical parallel processes. However, none of these studies have longitudinally examined the developmental relations between word reading and nonword reading, and thus whether non-lexical and lexical reading processes develop separately or in tandem with each other remains unclear.

Predictors of Word and Nonword Reading Fluency

A wealth of evidence from previous studies has established that phonological awareness, phonological memory, rapid automatized naming (RAN), and morphological awareness play an important role in predicting reading development in both alphabetic (e.g., Georgiou, Torppa, Manolitsis, Lyytinen, & Parrila, 2012; Moll et al., 2014) and non-alphabetic (e.g., McBride-Chang et al., 2005; Nag & Snowling, 2012) orthographies. In particular, despite the substantial differences in the rate of learning to read between languages, phonological awareness and RAN have been shown to play a prominent role in early reading development across languages (see Araújo, Reis, Petersson, & Faísca, 2015; Melby-Lervåg, Lyster, & Hulme, 2012, for meta-analyses).

Previous studies in Japanese have also shown that (a) phonological awareness is associated with word and nonword reading in Hiragana, but its role may be relatively limited and developmentally transient (Inoue, Georgiou, Muroya, Maekawa, & Parrila, 2017; Ogino et al., 2017); (b) RAN plays an important role in fluency development for both words and nonwords (Haruhara, Uno, Asahi, Kaneko, & Awaya, 2011; Wakamiya et al., 2011); (c) phonological memory is associated with word and nonword reading in Hiragana, particularly at the initial stage of reading development (Inomata, Uno, & Haruhara, 2013; Kakihana Ando, Koyama, Iitaka, & Sugawara, 2009); and (d) morphological awareness contributes to early word and nonword reading skills in Hiragana (Muroya et al., 2017).

However, previous studies in Japanese have some important limitations. First, most existing studies are cross-sectional, with a few exceptions that have covered a limited developmental span (Inoue et al., 2017; Ogino et al., 2017). In order to examine the developmental trajectories of word and nonword reading fluency without the potential biases due to cohort effects, further longitudinal studies that cover a longer developmental period are clearly needed. Second, cognitive predictors of word and nonword reading growth rates have never been examined in Japanese Hiragana. Finally, many of the previous studies have not adequately controlled potential confounding variables, such as nonverbal IQ and vocabulary.

Current Study

In this study, we examined the early growth of word and nonword reading fluency and their cognitive predictors in syllabic Hiragana in a sample of Japanese children followed from Grade 1 to Grade 2. Specifically, we examined whether the growth patterns of word reading skills in Hiragana and their cognitive predictors are similar or different from those in alphabetic orthographies. We focused on reading fluency because, as in other consistent orthographies, most children master Hiragana quickly in the first few months of Grade 1 (Inoue et al., 2017; Sambai et al., 2012), and reading fluency becomes a more important determinant of later reading development. Based on a previous longitudinal study in alphabetic orthographies (Caravolas, 2017) and the previous cross-sectional studies in Japanese (Kobayashi et al., 2010; Sambai et al., 2012), we hypothesized that growth would be faster for word reading fluency than for nonword reading fluency, and the lexicality effect would increase over time. We also hypothesized that RAN and morphological awareness would be associated with both word and nonword reading fluency (Haruhara et al., 2011; Muroya et al., 2017). Finally, we expected that phonological awareness and phonological memory would have a limited impact on word reading fluency, but a stronger impact on nonword reading fluency (Takasaki et al., 2015).

Method

Participants

One hundred sixty-nine Grade 1 Japanese-speaking children (83 girls and 86 boys;

M_{age} = 80.12 months, *SD* = 3.62) participated in this study. The children were initially recruited for a larger study on early literacy acquisition in Japanese (Inoue et al., 2017). All of them were native speakers of Japanese and attended public elementary schools. Each year, our sample decreased due to attrition attributed mainly to children moving out of the study area. As a result, the number of children assessed at each time point were 153 at the middle of Grade 1, 146 at the beginning of Grade 2, and 135 at the middle of Grade 2. The children who withdrew did not differ significantly from those who were tested at all measurement points on any cognitive/reading measures described below (all *p*s > .10). Parents' written consent was obtained prior to testing.

Materials

Nonverbal IQ and vocabulary. Nonverbal IQ and vocabulary were assessed with the Block Design and the Vocabulary subtests, respectively, from the Japanese version of Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV; Japanese WISC-IV Publication Committee, 2010). In Block Design, children were asked to produce a series of two-color (red and white) designs within specified time limits. In Vocabulary, children were asked to provide a definition for a given word. Scaled scores were calculated based on the national norm. The Cronbach's alpha reliabilities in our sample were .78. and .73 for Block Design and Vocabulary, respectively.

Phonological awareness. Elision-Word and Elision-Nonword (Inoue et al., 2017) were administered. Each test consisted of four blocks of six items each: The first two blocks required children to say a word/nonword without saying one of its morae (e.g., /hanko/ 'stamp' without the /n/ is /hako/ 'box'); the next two blocks required the children to say a CVCV word/nonword without saying one of its consonants (e.g., /same/ 'shark' without the /s/ is /ame/ 'candy'). The correct answers in Elision-Word were real words, while those in Elision-Nonwords were nonwords. Each test was discontinued after four errors within a block. The score for each test was the total number correct (max = 24). The Cronbach's alpha reliabilities for Elision-Word and Elision-Nonword were .88 and .89, respectively.

Phonological memory. Forward Digit Span and Nonword Repetition were used. Forward Digit Span was adopted from WISC-IV (Japanese WISC-IV Publication Committee, 2010). Children were presented strings of digits orally and required to repeat the digits in each string in the correct order. The strings started with two digits, and one digit was added for each new digit string. The task was discontinued when the child failed both trials of a given length. Scaled score was calculated based on the national norm. The Cronbach's alpha reliability was .71. Nonword Repetition consisted of two practice items (four-mora nonwords) and 18 test items (six each of five-, seven-, and nine-mora nonwords; Kakihana et al., 2009; Saito, Saito, & Yoshimura, 2000). One item at a time was read aloud and the child was asked to listen carefully and repeat the nonword as clearly and correctly as possible. The task was discontinued after four consecutive errors. The score was the total number of correctly repeated nonwords (max = 18). The Cronbach's alpha reliability was .78.

Rapid automatized naming (RAN). Digit Naming and Color Naming were administered. In Digit Naming, children were asked to name as fast as possible four recurring digits (2, 4, 5, and 7; pronounced /ni/, /yon/, /go/, and /nana/). In Color Naming, children were asked to name as fast as possible four recurring colors (blue, green, read, and yellow; pronounced /ao/, /midori/, /aka/, and /kiiro/). The digits/colors were arranged semi-randomly in four rows of six for a total of 24 stimuli on each of two separate pages. For each task, the two pages were timed separately and the score was the mean of the two times. Because only a few errors occurred in both tasks (less than one per participant per page), they were not considered further. The correlations between the two trials in each task were .85 and .72 for Digit Naming and Color Naming, respectively.

Morphological awareness. Two versions of the Word Analogy task were administered: Derivation Analogy and Inflection Analogy (Muroya et al., 2017). Each task consisted of three practice items and 10 test items (see Muroya et al., 2017, for a complete list of the items). In each task, children were presented a pair of derivationally/inflectionally related words (e.g., /taberu/ ‘eat’ - /tabeta/ ‘ate’) orally, then given a new word (e.g., /ochiru/ ‘drop’) and asked to transform it to match the model of the first word pair (e.g., /ochita/ ‘dropped’). Each task was discontinued after four consecutive errors. The score for each task was the total number correct (max = 10). The Cronbach’s alpha reliabilities for Derivation Analogy and Inflection Analogy were .77 and .76, respectively.

Reading fluency. Word and nonword reading fluency tests were administered. The word reading fluency test consisted of 104 high-frequency words that were taken from Grade 1 language arts textbooks (National Institute for Japanese Language and Linguistics, 2009): 60 single-morpheme, 40 two-morpheme, and four three-morpheme words (mean number of morphemes = 1.5, *SD* = 0.6). The nonword reading fluency test consisted of 63 four-character nonwords. The numbers of the items in each task were decided based on pilot data collected prior to this study indicating that children in Grades 1 and 2 read on average one four-character word and 0.5 four-character nonwords per second. The nonwords were formed by recombining the characters included in the word reading fluency test semi-randomly to make all the nonwords pronounceable and match the phonological compositions of the nonwords with those of the words. All the words and nonwords consisted of four characters and each word/nonword consisted of three or four morae (*M* = 3.9, *SD* = 0.3). The child was given the words/nonwords, divided into four/three columns, and asked to read them as fast as possible. The score was the total number of words/nonwords read correctly in 45 seconds. Scores on each test were highly correlated across the time points (*r*s were .80–.90 and .73–.86 for word reading fluency and nonword reading fluency, respectively; see Table 2), suggesting good stability over the period.

Procedure

The children were assessed four times with six-month intervals: the beginning (Time 1) and the middle (Time 2) of Grade 1 and the beginning (Time 3) and the middle (Time 4) of Grade 2. Nonverbal IQ, vocabulary, phonological awareness, phonological memory, RAN, morphological awareness, and word and nonword reading fluency were assessed in Time 1. From Time 2 onward, only word and nonword reading fluency were assessed. All testing took place in quiet rooms in the children's schools and was conducted by trained examiners. Testing lasted roughly 40 minutes in Time 1 and 10 minutes from Time 2 onwards. The study received ethics approval from the Research Ethics Board at Seigakuin University (#2013-001).

Statistical Analysis

The analyses were performed using Mplus 8 (Muthén & Muthén, 1998–2017) in two steps. First, univariate latent growth curve models (LGCMs) were estimated to assess the initial status (level), the linear growth rate (linear trend), and the quadratic growth (quadratic trend) for word and nonword reading fluency (Figure 1). Second, a conditional bivariate LGCM predicting the initial status and the growth rates of word and nonword reading fluency by the cognitive skill constructs was estimated (Figure 2). All analyses handled missing data by the full information maximum likelihood estimation (Graham, 2009). Model fits were assessed using the chi-square value, the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root-mean-square error of approximation (RMSEA), and the standardized root-mean-square residual (SRMR). A non-significant chi-square value, CFI and TLI values above .95, and RMSEA and SRMR values below .06 indicate good model fit (Kline, 2015).

Results

Preliminary Data Analysis

Descriptive statistics for the measures used in the study are shown in Table 1. Prior to conducting further analyses, we examined the distributional properties of the measures. The skewness and kurtosis values were in the acceptable range (Kline, 2015). The one or two outliers in some measures (scores more than 3 *SD*s above/below the mean of the sample) were moved to the tails of the distributions to avoid overemphasizing their effects on the results. The correlations among the observed variables are shown in Table 2. In general, the correlations between the reading fluency measures were strong and ranged from .66 to .90.

Latent Growth Curve Models for Word and Nonword Reading Fluency

The estimated parameter values of the univariate LGCMs for word and nonword reading fluency are presented in Table 3. The residual variances of the quadratic trends in both models were fixed to zero as they were not statistically significant in either model. Both models showed excellent fit: word reading fluency: $\chi^2(4) = 0.85$, $p = .93$, CFI = 1.00, TLI = 1.01, RMSEA = .00, SRMR = .02; nonword reading fluency: $\chi^2(4) = 4.76$, $p = .31$, CFI = 1.00, TLI = 1.00, RMSEA = .04, SRMR = .05. As expected, the growth was faster for word reading than for nonword reading fluency, and the difference between the two increased over the four time points (see Figure 3). The initial status and the linear growth rate were negatively correlated for word reading fluency ($r = -.41$), indicating that the higher the initial level of word reading fluency, the less improvement there was during the period. In contrast, the initial status and the growth rate were positively correlated for nonword reading fluency ($r = .69$), indicating that the higher the initial level of nonword reading fluency, the more improvement there was.

Finally, the conditional bivariate LGCM (Figure 2) was estimated. Following the modification indices, we allowed the residual covariance between word and nonword reading fluency at Time 4. The final model showed a good fit, $\chi^2(117) = 134.05$, $p = .13$, CFI = .99, TLI = .99, RMSEA = .03, SRMR = .04. RAN and morphological awareness were uniquely associated with the initial status of word and nonword reading fluency after controlling for nonverbal IQ and vocabulary. Phonological memory was also uniquely associated with the initial status of word reading fluency, and it predicted the growth rate of nonword reading fluency even when its initial status was taken into account. In contrast, phonological awareness was not associated with the latent growth factors for word or nonword reading fluency. Additionally, the initial status and the growth rates were highly correlated between word reading fluency and nonword reading fluency (rs = .51–.80), even when the effects of the cognitive skills were controlled.

Given the fact that syllable/mora awareness could be more closely associated with reading in syllabic Hiragana (Inagaki, Hatano, & Otake, 2000), we repeated the estimation of the conditional LGCM by using the Elision-Word and Elision-Nonword scores for the mora elision items alone (see Methods). The results replicated those with the total Elision scores, indicating that neither syllable/mora awareness nor phoneme awareness uniquely predicted the growth of word or nonword reading fluency.

Discussion

We examined the early growth of word and nonword reading fluency and their cognitive predictors in Japanese Hiragana, a consistent syllabic orthography. Consistent with a previous study in alphabetic orthographies (Caravolas, 2017), we first found that growth was faster for word reading than for nonword reading fluency, and this resulted in an increase in the lexicality effect over time. Similar to children in consistent alphabetic orthographies (Landerl & Wimmer 2008; Zoccolotti et al., 2005), Japanese children may develop a lexical reading strategy utilizing larger orthographic units (e.g., character clusters or whole words) to read words quickly, despite the fact that the nearly perfect consistency of the Hiragana orthography does not force them to do so. However, given that the lexicality effect has always been observed with multi-character words and many of the participants were in the early phase of reading development in which they still rely largely on a serial reading strategy even for short words (Sambai et al., 2012), a possible alternative explanation is that the lexicality effect may result from increasing predictability when processing characters in sequence. That is, after reading the first few characters of a word the parafoveal preview of the remaining characters may be enough for word recognition (Kajii & Osaka, 2000; Jones, Ashby, & Branigan, 2012), whereas the same benefit would not be there for nonwords. In fact, if the first few characters of a nonword match a possible word creating an expectation of what the remaining characters are, seeing something different should elicit an inhibition effect and longer processing times. In other words, recognizing a multi-character word in parallel as a single unit may not be the only source of the lexicality effect (Rastle, Havelka, Wydell, Coltheart, & Besner, 2009; Wydell, Vuorinen, Helenius, & Salmelin, 2003). However, further experimental studies, particularly ones in which the psycholinguistic parameters (e.g., familiarity, length, bi-character frequency) of word/nonword items are manipulated in a more systematic way, are needed to test whether this is the case in word reading in consistent orthographies, including Hiragana.

Second, the variances in the initial status and the growth rate were significantly larger for word reading fluency than for nonword reading fluency (see Table 3), indicating a larger variability in the growth trajectories in word reading fluency during this developmental period. The greater deal of uniformity in nonword reading fluency may be due to the fact that graphemic parsing and phoneme assignment, the two main sources of variability in nonword reading in alphabetic orthographies (Coltheart & Ulicheva, 2018), are not needed when reading syllabic Hiragana, and this may have reduced the variability in reading strategies for nonwords. The results also showed that whereas the initial status and the growth rate were negatively correlated for word reading fluency, the opposite was true for nonword reading fluency. There are at least two explanations for this finding. First, children may reach a plateau earlier in word reading fluency than in nonword reading fluency, and this might have resulted in the earlier deceleration of the growth rate in those with initially higher skills (Protopapas, Parrila, & Simos, 2016). Second, nonword reading difficulties may be relatively persistent in a subgroup of initially lower-performing children (Van den Broeck, Geudens, & van den Bos, 2010), and this might have led to the slower observed growth of nonword reading fluency among them (Pfost, Hattie, Dörfler, & Artelt, 2014).

Our results further indicated that, among the cognitive predictors examined in this study, RAN had the strongest impact on the initial status of word and nonword reading fluency. This result, together with the findings of previous cross-linguistic studies (Altani et al., 2017; Caravolas et al., 2013) and meta-analyses on the RAN-reading relationship (Araújo et al., 2015; Song, Georgiou, Su, & Shu, 2016), suggests that RAN may be a universal correlate of word-level reading fluency across alphabetic and non-alphabetic writing systems, possibly independent of the orthographic consistency and the phonological complexity of the languages. Additionally, the results showed that the effect of RAN on the initial status was relatively stronger for nonwords than for words. This finding challenges the notion that RAN is related to reading because it contributes to the development of orthographic processing (Bowers & Wolf, 1993). Instead, the results are more in line with the idea that the sequential processing of a series of stimuli that are simultaneously available may be a potential link in the RAN-reading fluency relationship (Protopapas, Katopodi, Altani, & Georgiou, 2018).

Similarly, morphological awareness was uniquely associated with the initial status of both word and nonword reading fluency. The association of morphological awareness with word reading fluency may reflect the fact that the items used in the word reading fluency task have common character strings that can be decoded as morphemic units. The items of the nonword reading fluency task also incidentally contained characters or character strings that could be decoded as morphemic units (e.g., しまそく /shimasoku/ contains しま /shima/ ‘island’ or ‘stripe’), and this, in turn, may facilitate nonword reading (see Angelelli, Marinelli,

& Burani, 2014, for a similar finding in a consistent alphabetic orthography).

Consistent with previous studies in Japanese (Inomata et al., 2013; Kakihana et al., 2009), phonological memory was associated with the initial status of word reading fluency. This suggests that the beginning readers may lack the advantage of lexical reading processes to support their decoding of words, and as a result, children need to rely on phonological memory to keep in mind the already decoded characters in words (Elbro & de Jong, 2017). The results further showed that phonological memory predicted the growth rate of nonword reading fluency even after controlling for its initial status. One possible interpretation for this result is that phonological memory provides children a push to become faster nonword readers by allowing them to keep in mind the already decoded characters in nonwords and to process the remaining characters in the parafoveal preview. Taken together, these associations between phonological memory and word and nonword reading fluency are compatible with the interpretation that beginning readers rely more on serial processing in both word and nonword reading.

Finally, in contrast to the findings of previous studies in alphabetic orthographies (Caravolas et al., 2013; Moll et al., 2014), phonological awareness was not uniquely associated with the growth factors of word or nonword reading fluency in Hiragana. Interestingly, a limited role of phonological awareness in word reading skills has also been found in consistent alphabetic orthographies (Georgiou et al., 2012), as well as in non-alphabetic orthographies where the rhythmic units of the spoken languages are primarily based on syllables (i.e., syllable-timed languages such as Chinese and Sinhala; McBride-Chang et al., 2005; Wijaythilake, Parrila, Inoue, & Nag, 2018). Given the high consistency of the character–sound mappings in the Hiragana orthography and the Japanese phonology that has a small inventory of simple sounds, phonological awareness may not play a pivotal role in fluency development in Hiragana.

Our results have some important educational and theoretical implications. From an educational viewpoint, early assessment of phonological memory would likely provide additional information for identifying children who will later struggle in becoming faster readers of Hiragana. This is particularly important given the present findings showing a cumulative pattern in the development of nonword reading fluency during this period (Pfost et al., 2014; Stanovich, 1986). From a theoretical viewpoint, children who learn to read a consistent syllabary are likely to rely on similar underlying processes for word and nonword reading, at least during the early phases of reading development. Indeed, our results showed that the same set of cognitive skills were associated with both word and nonword reading, and the initial status and the growth rates were highly correlated between word and nonword reading fluency even when the effects of the cognitive skills were taken into account. These findings may be more in line with the interpretation that the lexicality effect in reading fluency in a consistent syllabary can be at least partly explained by postulating a serial component (Rastle et al., 2009; Wydell et al., 2003). However, the predictors we included left a significant amount of variance in both the initial level and the growth coefficient unaccounted for, and further studies are clearly needed to verify the mechanisms responsible for the increasing lexicality effect.

The study has limitations that require consideration. First, the sample size was relatively small given the complexity of the models tested, and caution is needed when interpreting our findings. Second, we focused only on the first two years of formal reading instruction and the developmental trajectories in word and nonword fluency in Hiragana need to be examined over a longer developmental period. It would also be important to examine the predictive role of initial Hiragana knowledge before school entry in the growth of word and nonword reading fluency during later school years. Third, we assessed nonverbal IQ and vocabulary with single measures that had a moderate reliability. SEM analyses using observed variables assume that the measures have perfect reliability coefficients, which clearly is not the case. Finally, the model in our study accounted for less variance in word and nonword reading fluency than similar models in alphabetic orthographies (e.g., Caravolas et al., 2013). Adding to the model other cognitive predictors that are possibly more sensitive to lexical processing (e.g., orthographic processing) may improve its explanatory power (Rakhlin, Mourgues, Cardoso-Martins, Kornev, & Grigorenko, 2019).

In conclusion, this study examined the early growth of word and nonword reading fluency and their cognitive predictors in a consistent syllabary (Japanese Hiragana). The results show that, in line with the evidence from alphabetic orthographies (Caravolas, 2017), growth is faster in word reading than in nonword reading, and the lexicality effect increased over time. RAN, phonological memory, and morphological awareness were uniquely associated with the growth of word and nonword reading fluency. Furthermore, the initial status and the growth rates in word and nonword reading were highly correlated, even when the effects of the cognitive skills were controlled. Taken together, our findings suggest that, despite the remarkable differences in the growth trajectories between word and nonword reading fluency in the syllabic Hiragana orthography, they likely share at least a part of their underlying processes and develop closely in tandem during this developmental period.

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Table 1

Descriptive Statistics for the Cognitive and Reading Fluency Measures

Measure (Max)	*M*	*SD*	Min	Max	Skewness	Kurtosis
Time 1 (beginning of Grade 1)						
Age in months	80.12	3.62	73	87	–0.11	–1.08
Block Design (19)	10.65	3.67	2	19	0.12	–0.27
Vocabulary (19)	10.46	3.88	2	19	0.16	–0.60
Elision-Word (24)	9.05	4.19	0	22	0.04	0.67
Elision-Nonword (24)	7.88	4.62	0	23	0.33	0.33
Digit Span (19)	9.21	2.53	1	15	–0.18	0.33
Nonword Repetition (20)	9.79	3.23	2	18	–0.05	–0.65
RAN-Digits	14.84	3.29	8	24.6	0.75	0.51
RAN-Colors	22.77	5.40	11	38.6	1.08	1.20
Word Analogy-Derivation (10)	4.76	2.64	0	10	–0.17	–0.88
Word Analogy-Inflection (10)	5.23	2.64	0	10	–0.15	–0.79
Word reading fluency (104)	33.60	14.05	3	71	0.38	–0.43
Nonword reading fluency (63)	17.12	5.21	5	31	0.32	0.08
Time 2 (middle of Grade 1)						
Word reading fluency (104)	42.82	13.75	17	75	0.09	–0.69
Nonword reading fluency (63)	20.39	5.53	9	34	0.36	–0.44
Time 3 (beginning of Grade 2)						
Word reading fluency (104)	49.49	12.91	21	82	0.09	–0.36
Nonword reading fluency (63)	22.67	6.29	12	38	0.46	–0.40
Time 4 (middle of Grade 2)						
Word reading fluency (104)	54.54	13.00	22	87	–0.11	–0.69
Nonword reading fluency (63)	24.70	6.72	12	44	0.39	–0.55

Table 2

Correlations among the Cognitive and Reading Fluency Measures

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. T1 BD																	
2. T1 Vocabulary	.08																
3. T1 Elision-W	.30	.29															
4. T1 Elision-NW	.29	.27	.79														
5. T1 DS	.11	.16	.29	.28													
6. T1 NWRep	.22	.26	.37	.34	.50												
7. T1 RAN-D	–.10	.00	–.16	–.11	–.12	–.10											
8. T1 RAN-C	–.07	–.10	–.16	–.21	–.02	–.12	.61										
9. T1 WA-D	.14	.02	.36	.35	.25	.32	–.16	–.06									
10. T1 WA-I	.14	.07	.28	.23	.20	.24	–.12	–.14	.60								
11. T1 WRF	.25	.18	.37	.32	.21	.38	–.41	–.30	.35	.27							
12. T2 WRF	.13	.11	.35	.34	.24	.38	–.32	–.31	.36	.29	.89						
13. T3 WRF	.13	.17	.33	.32	.21	.36	–.37	–.41	.34	.28	.86	.89					
14. T4 WRF	.10	.15	.29	.31	.17	.31	–.33	–.38	.29	.27	.80	.88	.90				
15. T1 NWRF	.18	.09	.33	.32	.08	.24	–.38	–.31	.30	.25	.74	.69	.67	.66			
16. T2 NWRF	.04	–.03	.31	.29	.17	.32	–.33	–.28	.37	.28	.72	.78	.74	.73	.78		
17. T3 NWRF	.04	.04	.30	.27	.15	.35	–.40	–.42	.28	.21	.79	.78	.79	.76	.78	.86	
18. T4 NWRF	.08	.08	.31	.29	.11	.32	–.36	–.39	.22	.17	.69	.74	.71	.79	.73	.83	.84

Note. Correlations lower than .17 are nonsignificant; correlations between .17 and .22 are significant at the .05 level; and correlations higher than .22 are significant at the .01 level. BD = Block Design; EL-W = Elision-Word; EL-NW = Elision-Nonword; RAN-D = RAN-Digits; RAN-C = RAN-Colors; DS = Digit Span; NWRep = Nonoword Repetition; WA-D = Word Analogy-Derivation; WA-I = Word Analogy-Inflection; WRF = word reading fluency; NWRF = nonword reading fluency.

Table 3

Results of Growth Curve Modeling for Word and Nonword Reading Fluency

	Word reading fluency			Nonword reading fluency		
Parameter	Unstandardized estimate	SE	95% CI	Unstandardized estimate	SE	95% CI
$\alpha_{1\ \text{level}}$	34.17***	1.16	[31.90, 36.44]	17.37***	0.43	[16.52, 18.21]
$\alpha_{2\ \text{linear}}$	9.45***	0.57	[8.33, 10.56]	3.30***	0.32	[2.67, 3.93]
$\alpha_{3\ \text{quadratic}}$	–0.93***	0.16	[–1.25, –0.61]	–0.28**	0.10	[–0.47, –0.10]
ψ_{11}	187.56***	23.00	[142.48, 232.63]	21.25***	3.00	[15.40, 27.10]
ψ_{22}	4.57***	1.09	[2.43, 6.71]	0.59*	0.27	[0.07, 1.11]
ψ_{33}	0[a]	–	–	0[a]	–	–
ψ_{12}	–11.87**	3.62	[–18.96, –4.78]	2.45***	0.64	[1.20, 3.70]
ψ_{13}	–	–	–	–	–	–
ψ_{23}	–	–	–	–	–	–

Note. α_1–α_3 = estimated mean values of the latent growth factors; ψ_{11}–ψ_{33} = variances of the latent factors; ψ_{12}–ψ_{23} = covariances between the latent factors; CI = confidence interval.
[a] = fixed.
**p* < .05; ***p* < .01; ****p* < .001.

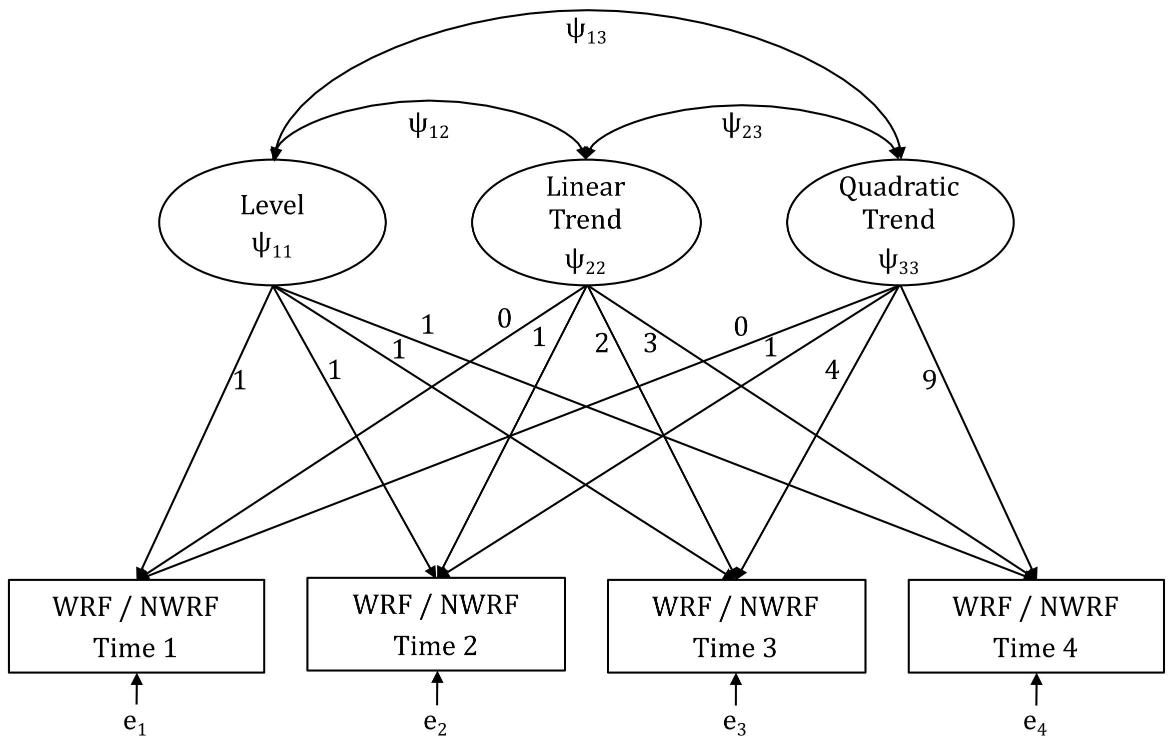

Figure 1. Unconditional latent growth curve model for word and nonword reading fluency with the initial status (level), the linear growth rate (linear trend), and the quadratic growth rate (quadratic trend) components.

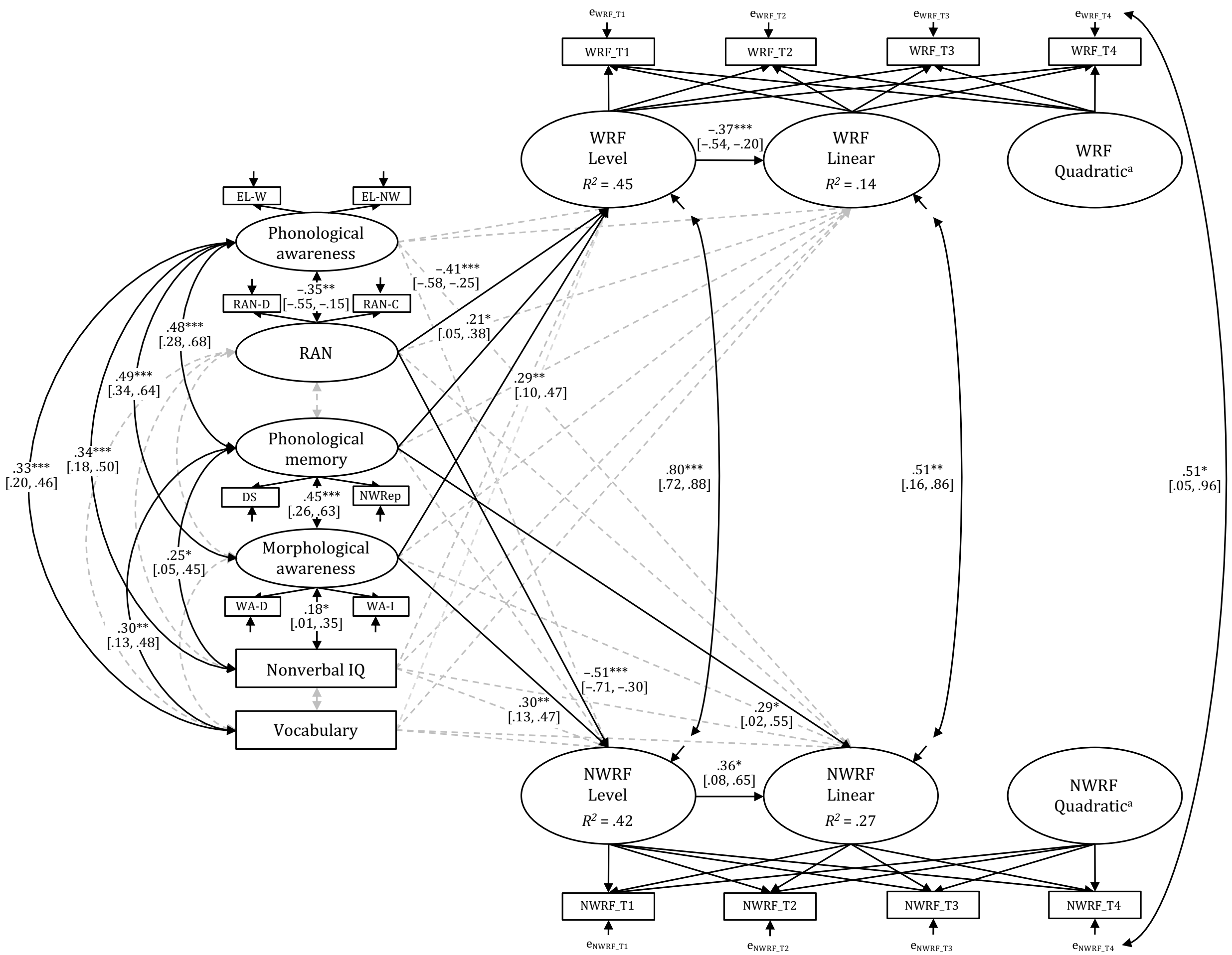

Figure 2. Conditional bivariate latent growth curve model for word and nonword reading fluency. Solid lines indicate significant paths and dashed lines indicate nonsignificant paths. EL-W = Elision-Word; EL-NW = Elision-Nonword; RAN-D = RAN-Digits; RAN-C = RAN-Colors; DS = Digit Span; NWRep = Nonoword Repetition; WA-D = Word Analogy-Derivation; WA-I = Word Analogy-Inflection; WRF = word reading fluency; NWRF = nonword reading fluency.

[a] = residual variance was fixed to zero.

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

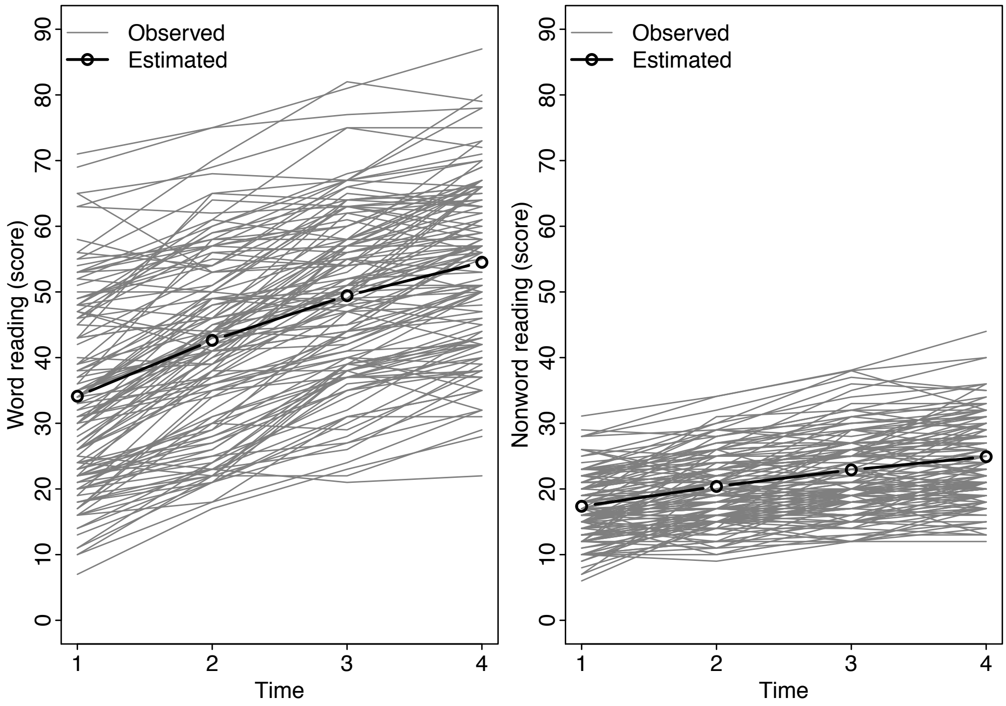

Figure 3. Estimated (latent growth curve models) and observed (raw scores) growth trajectories in word (left) and nonword (right) reading fluency.