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Cross-script transfer of word reading fluency in a mixed writing system: Evidence from a longitudinal study in Japanese

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ABSTRACT
We examined the cross-lagged relations between word reading fluency in the two orthographic systems of Japanese: phonetic (syllabic) Hiragana and morphographic Kanji. One hundred forty-two Japanese-speaking children were assessed on word reading fluency twice in Grade 1 (Times 1 and 2) and twice in Grade 2 (Times 3 and 4). Nonverbal IQ, vocabulary, phonological awareness, morphological awareness, and rapid automatized naming were also assessed in Time 1. Results of path analysis revealed that Time 1 Hiragana fluency predicted Time 2 Kanji fluency after controlling for the cognitive skills. Time 2 Hiragana fluency did not predict Time 3 Kanji fluency or vice versa after the autoregressor was controlled, but Hiragana and Kanji fluency were reciprocally related between Times 3 and 4. These findings provide evidence for a cross-script transfer of word reading fluency across the two contrastive orthographic systems, and the first evidence of fluency in a morphographic script predicting fluency development in a phonetic script within the same language.

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According to the psycholinguistic grain size theory (PGST; Ziegler & Goswami, 2005, 2006), reading development across languages is influenced by the consistency (e.g., transparent and opaque) and the granularity (e.g., whole words, letter clusters, and single letters) of the orthography–phonology mappings. PGST also postulates that, for children to become fluent in reading, they must find the most efficient grain size unit in their orthography (Goswami & Ziegler, 2006). For example, children learning to read English should develop reading strategies at more than one grain size unit because English is a morphophonemic orthography, in which the orthography–phonology mappings are particularly inconsistent with respect to smaller grain size units (compare, e.g., the <ea> sequence in <read> and <react>; Bowers & Bowers, 2017; Carlisle & Goodwin, 2013). In contrast, beginning readers of a relatively transparent orthography (e.g., Finnish or Greek) can focus exclusively on small grain size units (Manolitsis, Grigorakis, & Georgiou, 2017; Müller & Brady, 2001).

A growing body of cross-linguistic research has demonstrated that the consistency and the granularity of the orthography–phonology mappings impact the rate and duration of reading development (Ellis et al., 2004; Seymour, Aro, & Erskine, 2003) and its cognitive basis (Caravolas, Lervåg, Defior, Málková, & Hulme, 2013; Georgiou, Aro, Liao, & Parrila, 2016; McBride-Chang et al., 2005) across languages. However, current theories of reading development, including PGST, have not proposed how reading develops when children must learn two orthographic systems that are contrastive in the consistency and the granularity at the same time. Does learning one system influence learning the second system and vice versa? The present study aimed to address this theoretical gap in a language (Japanese) that offers a unique opportunity because children must learn two orthographic systems representing different grain size units within the same language.

The Japanese writing system is a mixed system that employs two functionally distinct subsystems: Hiragana and Kanji (Akamatsu, 2005; Smith, 1996). Hiragana is a transparent phonetic syllabary in which each character corresponds to the same mora (a syllable-like phonological unit on which the rhythm of the Japanese language is based; see Taylor & Taylor, 2014, for a detailed description) in all words. In contrast, Kanji, which has originated from Chinese characters, is a morphography in which a character can represent multiple morphemes, and has multiple readings depending on the context (e.g., 上 can mean "above," "top," "over," "superior," and "going up," and it can be read as /ue/, /uwa/, /kami/, /a/, /nobo/, and /jou/). The two scripts are therefore highly contrastive not only in the consistency but also in the granularity of the orthography–phonology mappings: Hiragana primarily represents smaller grain size units (single syllables), whereas Kanji exclusively represents larger grain size units (morphemes or whole words that are frequently multisyllabic) in the Japanese language (Taylor & Taylor, 2014). In addition, the two systems are contrastive in terms of the size of symbol sets: whereas Hiragana consists of 46 basic characters with some additional special notations, Kanji includes more than 2,000 different characters (Coulmas, 2003; Taylor & Taylor, 2014).

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Because of these characteristics of the two scripts, Hiragana is taught first when formal reading instruction commences in school (Ministry of Education, Culture, Sports, Science and Technology, 2015), and most children master Hiragana quickly within the first few months of Grade 1. The focus of reading instruction then shifts to teaching Kanji. Hiragana is also used to help children to learn Kanji characters by indicating their possible readings (e.g., when children learn the Kanji character 花 /hana/ "flower," its Hiragana transcription はな /ha-na/ is also presented in small size besides the Kanji character as a phonetic guide).[1] By the end of Grade 6, children learn a total of 1,006 Kanji characters. Children's early texts are frequently written only in Hiragana (e.g., おとこ /o-to-ko/ "man," せんせい /se-n-se-i/ "teacher"), and the rate of Kanji use in texts gradually increases as children advance in grades (e.g., 男 /otoko/ and 先生 /sen-sei/).

There are two other writing systems in which two types of scripts (a phonetic script and a morphographic script) are used within one language: Pinyin/Zhuyin and Chinese characters in mainland China/Taiwan (Hanley, 2005) and Hangul and Hanja (Chinese characters) in Korea (Taylor & Taylor, 2014). Several studies in Chinese have shown that children's early proficiency in Pinyin is associated with later success in Chinese word reading (Lin et al., 2010; Pan et al., 2011; Wang & McBride, 2016; Wang, McBride-Chang, & Chan, 2014; Yin et al., 2011; see also Wang, Lam, Mo, & McBride-Chang, 2014, for a review). However, it should be noted that whereas one of the two scripts in these writing systems is an auxiliary system and its use is limited (Pinyin and Zhuyin are exclusively used as an aid to learn Chinese characters; Korean children are not typically taught to read Hanja until secondary school; DeFrancis, 1989; Hanley, 2005), Japanese Hiragana and Kanji are used in combination throughout most reading materials. In particular, in contrast to Pinyin/Zhuyin in Chinese, Japanese Hiragana is a full-fledged system that is being used in texts for school-age children and adults (Coulmas, 2003; Taylor & Taylor, 2014).

Previous studies in bilingual contexts have also suggested an association between word reading skills in two different orthographies such as English and Chinese (Pasquarella, Chen, Gottardo, & Geva, 2015; Shum, Ho, Siegel, & Au, 2016; Tong & McBride-Chang, 2010). For example, in a longitudinal study with Chinese–English bilinguals, Pasquarella et al. (2015) showed that Grade 1 Chinese word reading fluency predicted Grade 2 English word reading fluency and vice versa, but the same was not true for word reading accuracy. There is, however, an important difference between learning to read in bilingual contexts and Japanese: whereas only semantics of words can be shared between two orthographies in bilingual contexts, both semantics and phonology are shared between the two orthographic systems in Japanese. Taken together, the hybrid writing system in Japanese offers a unique opportunity to examine the relationship between the learning processes of the two contrastive orthographic systems within the same language.

Existing studies in Japanese have consistently reported a positive relationship between reading skills in Hiragana and Kanji (Inoue, Georgiou, Muroya, Maekawa, & Parrila, 2017; Kobayashi, Haynes, Macaruso, Hook, & Kato, 2005; Ogino et al., 2017; see also Koda, 2017, for a review). For example, Kobayashi

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et al. (2005) showed that Hiragana naming speed was moderately correlated with Kanji naming speed in Grade 1 children ($r = .51$). Ogino et al. (2017) showed that preschooler's Hiragana knowledge was associated with Kanji knowledge in Grade 2. A common assumption in these studies is that the relationship between reading in Hiragana and Kanji is unidirectional, namely, the former (i.e., script primarily representing smaller grain units) is viewed as a predictor of the latter (i.e., script representing larger grain units). Nevertheless, we are not aware of any studies that have examined the effects of early reading skills in a morphographic script to later reading skills in a phonetic script within one language. However, given that learning morphographic Kanji characters can result in the reconstruction of a child's orthographic lexicon based on the morphological structures of written words (Hatano, Kuhara, & Akiyama, 1997; Nunes & Hatano, 2004; see also McBride-Chang et al., 2008), it is possible that earlier Kanji reading will facilitate later Hiragana reading by potentially emphasizing larger grain size units (morphemes) in Hiragana words. For example, learning the Kanji characters 一 /ichi/ "one," 年 /nen/ "year," and 生 /sei/ "learner" may result in shifting children's focus from single characters to morphemic units (いち /i-chi/ "one," ねん /ne-n/ "year," and せい /se-i/ "learner") when they read the Hiragana word いちねんせい /i-chi-ne-n-se-i/ "first graders." This can provide children a push to become faster readers despite the fact that the transparent orthography of Hiragana does not inherently require them to develop a lexical reading strategy in which they utilize larger orthographic units to read words.

Consequently, in this longitudinal study, we examined the cross-lagged relations between word reading fluency in Hiragana and Kanji. We followed the same children for 2 years from the beginning of Grade 1 and assessed them four times on reading fluency, two times in Grade 1 and two times in Grade 2 (Times 1 to 4; see below). We focused on this period because previous cross-sectional studies in Japanese have indicated that word reading fluency, particularly in Hiragana, develops rapidly during this period (Kobayashi et al., 2010; Sambai et al., 2012). Given the findings of previous studies showing that nonverbal IQ (Koyama, Hansen, & Stein, 2008), vocabulary (Ogino et al., 2017), phonological awareness (Inoue et al., 2017; Ogino et al., 2017), morphological awareness (Hatano et al., 1997; Muroya et al., 2017), and rapid automatized naming (RAN; Kobayashi et al., 2005; Wakamiya et al., 2011) are associated with word reading skills in either or both of the two scripts, these skills were also assessed and used as covariates in the analysis.

Based on the findings of existing studies in Japanese, Chinese, and bilingual contexts reviewed above, we expected that

1. Initial Hiragana reading would foster subsequent Kanji reading by serving as a phonetic guide to the pronunciations of Kanji characters (Hypothesis 1; Lin et al., 2010; Ogino et al., 2017; Pan et al., 2011); and
2. Kanji reading would facilitate later Hiragana reading, possibly by emphasizing larger grain size units (morphemes) in Hiragana words, and this may be particularly the case once some proficiency in Kanji is achieved (Hypothesis 2; Nunes & Hatano, 2004; Pasquarella et al., 2015; Shum et al., 2016).

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METHOD

Participants

The participants were 142 Japanese children (71 girls and 71 boys; mean age = 80.2 months, *SD* = 3.6 at the first measurement point) who were initially recruited for a larger study on early literacy acquisition in Japanese (Inoue et al., 2017; Muroya et al., 2017). The children attended 32 public elementary schools in Japan and were followed from the beginning of Grade 1 to the middle of Grade 2.[2] Seven children (4.9% of initial sample) withdrew from the study over the two years. The children who withdrew did not differ significantly on Time 1 word reading skills from those who were tested at all measurement points (Brunner–Munzel test, all ps $> .10$). Parents' written consent was obtained prior to testing.

The reading instruction in the schools that participated in this study followed a fixed sequence of the national curriculum (Ministry of Education, Culture, Sports, Science and Technology, 2015) stating which Hiragana or Kanji characters the children are taught in each term of Grades 1 to 6. All 46 basic Hiragana characters with some additional rules are taught in the first few months of Grade 1. Instruction in Kanji starts in the middle of Grade 1 with the 80 most common characters (e.g., 人 /hito/ "human" and 水 /mizu/ "water") followed by 160 and 200 characters in Grades 2 and 3, respectively (a more detailed explanation is available in Inoue et al., 2017).

Materials

Hiragana reading fluency. In the Hiragana reading fluency test, children were given a list of 104 words and were asked to read them as fast and accurately as possible. All the words were four-character nouns taken from Grade 1 language arts textbooks and were the most familiar words for Grades 1 and 2 (e.g., ともだち /tomodachi/ "friend " and がっこう /gakkou/ "school"; National Institute for Japanese Language and Linguistics, 2009). Each word consisted of three or four morae ($M = 3.8$, $SD = 0.4$) and one (e.g., いもうと /imouto/ "younger sister") to three (e.g., おひさま /ohisama/ "sun" that consists of the honorific prefix お /o/, the base word ひ /hi/ "sun," and the honorific suffix さま /sama/) morphemes ($M = 1.5$, $SD = 0.6$). A short, eight-word practice list was presented before the test. A child's score was the total number of words read correctly in 45 s. The scores were highly correlated across testing points (rs $> .80$; see Table 2), suggesting good stability.

Kanji reading fluency. In the Kanji reading fluency test, children were asked to read a list of 100 words as fast and accurately as possible. All the words were nouns taken from Grade 1 language arts textbooks and all the characters had been introduced in school by the middle of Grade 1 (the second measurement point in this study). Of the 100 words, 96 were one-character/morpheme words (e.g., 山 /yama/ "mountain" or 車 /kuruma/ "car") and four were two-character/morpheme words (e.g., 学校 /gakkou/ "school," or 先生 /sensei/ "teacher"). Each word consisted of one to four morae ($M = 1.9$, $SD = 0.6$). The words were presented on paper and arranged semirandomly in five columns with 10 items per column on

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two separate pages. A practice list with eight items was presented first. All possible readings of Kanji characters were considered correct for the single-character words (e.g., both /naka/ and /chuu/ were considered correct for 中). For the two-character words, the response was considered correct only when participants produced the specific reading of each Kanji character required by the word context (e.g., /sensei/ was the only correct answer for 先生, which has possible alternative readings /saki/ and /nama/ for the first and the second characters, respectively). A child's score was the total number of items read correctly in 45 s. Scores in each testing point were moderately to highly correlated with each other (*r*s = .54–.73; see Table 2).

Nonverbal IQ. Nonverbal IQ was assessed with the block design subtest from the Japanese version of the Wechsler Intelligence Scale for Children—Fourth Edition (WISC-IV; Japanese WISC-IV Publication Committee, 2010). Children were asked to produce a series of two-color (red and white) designs within specified time limits. Scaled scores were calculated based on the national norm. The reliability coefficient in the norm sample was .72 (Japanese WISC-IV Publication Committee, 2010).

Vocabulary. Vocabulary was assessed with the vocabulary subtest from the WISC-IV (Japanese WISC-IV Publication Committee, 2010). Children were asked to provide a definition for a given word. Scaled scores were calculated based on the national norms. The reliability coefficient in the norm sample was .70 (Japanese WISC-IV Publication Committee, 2010).

Phonological awareness. Phonological awareness was assessed with the elision task (Inoue et al., 2017). The test consisted of four blocks of six items each: the first two blocks required children to say a word 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 without saying one of its consonants (e.g., /same/ "shark" without the /s/ is /ame/ "candy"). Testing was discontinued after four errors within a block. A child's score was the number of correct responses. The Cronbach's α reliability coefficient for the task was .87.

Rapid automatized naming (RAN). RAN was assessed with the digit naming task. Children were asked to name as fast as possible four recurring digits (2, 4, 5, and 7; pronounced /ni/, /yon/, /go/, and /nana/, respectively). The digits were arranged semirandomly in four rows of six for a total of 24 stimuli on each of two separate pages. A child's score was the average time to name the digits across the two pages. Because only a few naming errors occurred (mean number of errors was less than one), they were not considered further. The correlation coefficient between the two trials was .82.

Morphological awareness. Morphological awareness was assessed with the word analogy task (Muroya et al., 2017). Children were asked to produce the missing word in a target pair on the basis of the morphological relationship

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between two words in the immediately preceding pair (e.g., "If I say /taberu/ 'eat' and then I say /tabeta/ 'ate'; then I say /ochiru/ 'drop,' so then what should I say?": The correct answer is /ochita/ 'dropped'). The test consisted of two blocks of 10 items each: in the first block children were given the items that involved derivational changes (e.g., /kirei/ "clean": /kireini/ "cleanly":: /shizuka/ "quiet": /shizukani/ "quietly"); in the second block children were given the items that involved inflectional changes (e.g., /hirou/ "pick up": /hirotta/ "picked up":: /aruku/ "walk": /aruita/ "walked"; see Muroya et al., 2017, for a complete list of the items). Each block was discontinued after four consecutive errors. A child's score was the total number of correctly derived and inflected items. The Cronbach's α reliability coefficient for the task was .85.

Procedure

The children were assessed four times over two years with six months in between the measurement points: the beginning (May/June; Time 1) and the middle (November/December; Time 2) of Grade 1, and the beginning (May/June; Time 3) and the middle (November/December; Time 4) of Grade 2 (in Japan, the school year starts in April and ends in March). The cognitive skills (nonverbal IQ, vocabulary, phonological awareness, morphological awareness, and RAN) and Hiragana reading fluency were assessed in Time 1. Kanji reading fluency was not assessed in Time 1 because no Kanji characters were introduced in school by that time and because pilot data we had collected prior to this study indicated that only few children could read any Kanji characters at that time. From Time 2 onward, both Hiragana and Kanji reading fluency were assessed. All the children were tested individually by trained experimenters in their respective schools during school hours or immediately afterschool. Testing on these measures lasted roughly 40 min in Time 1 and 20 min from Time 2 onward.

Statistical analysis

To examine the cross-lagged relations between word reading fluency in Hiragana and Kanji, we performed path analysis using Mplus (Version 8; Muthén & Muthén, 1998–2017; see Figure 1). The cognitive skills in Time 1 were included in the model as control variables. Missing data for each measure ranged from 2.1% (nonverbal IQ, phonological awareness, and morphological awareness in Time 1) to 6.3% (Hiragana and Kanji reading fluency in Time 4). The Little's test of missing completely at random (Little, 1988) showed that the data were missing at random, χ^2 (95) = 113.70, $p = .09$. Thus, we used the full-information maximum likelihood estimation (Muthén & Muthén, 1998–2017) that allowed the use of all observations in the data set to estimate the parameters in the models. Further, in order to calculate confidence intervals (CIs) for standardized beta coefficients, we employed a bootstrapping method with 2,000 iterations (Preacher & Hayes, 2008). Model fit was examined using chi-square values, 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; see Kline, 2015, for interpretation).

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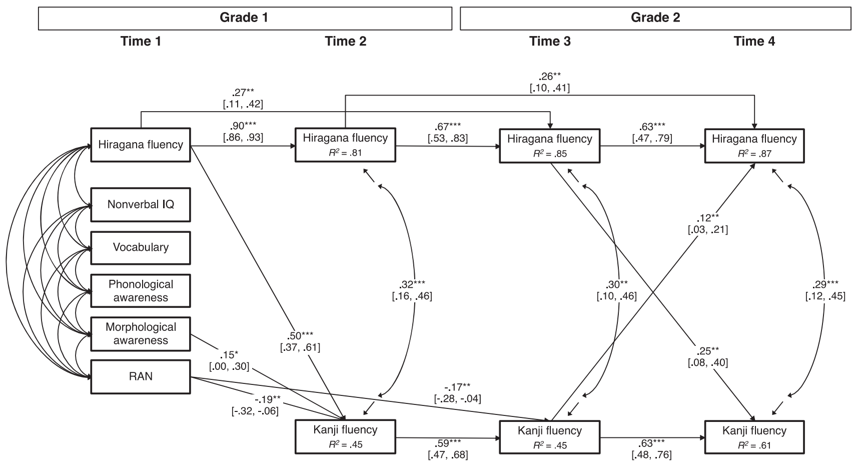

Figure 1. Cross-lagged relations between word reading fluency in Hiragana and Kanji. Standardized beta coefficients are shown. Numerals in brackets represent lower and upper limits of 95% confidence intervals. *$p < .05$. **$p < .01$. ***$p < .001$.

RESULTS

Preliminary data analysis

Table 1 presents the descriptive statistics for the measures used in the study. All the variables were normally distributed with the absolute values of skewness and kurtosis being less than 1 (Kline, 2015). No multivariate outliers were detected, and the one outlier on Kanji reading fluency in Time 2 was moved to the tail of the distribution to avoid overemphasizing its effect on the results.

The results of analysis of variance showed that both Hiragana and Kanji reading fluency developed significantly over the two years, F (3, 130) = 447.1, $p < .001$, $\eta_p^2 = .77$, and F (2, 130) = 266.7, $p < .001$, $\eta_p^2 = .67$, respectively. Table 2 presents the correlations between all the variables. Hiragana reading fluency was weakly to moderately correlated with the cognitive skills (|r|s = .09–.40). Similarly, Kanji reading fluency was weakly to moderately correlated with the cognitive skills (|r|s = .13–.40), except for nonverbal IQ and vocabulary. As expected on the basis of previous studies in Japanese (Inoue et al., 2017; Kobayashi et al., 2005; Ogino et al., 2017), Hiragana and Kanji reading fluency were moderately to highly correlated across measurement points (rs = .43–.67).

Cross-lagged analyses

The final cross-lagged model for reading fluency in Hiragana and Kanji is shown in Figure 1. Nonsignificant paths were removed from the model. In addition, following the model's modification indices, and given the method covariance that results from using exactly the same measure over time (Kelloway, 2015;

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Table 1. *Descriptive statistics for the measures in the study*

	M	*SD*	Range	Skewness	Kurtosis
Age at Time 1 (in months)	80.23	3.62	73–87	–0.14	–1.06
Cognitive skills					
Nonverbal IQ (19)	10.65	3.51	3–19	0.20	–0.30
Vocabulary (19)	10.37	3.95	2–19	0.19	–0.66
Phonological awareness (24)	9.08	3.95	0–20	–0.12	0.36
Morphological awareness (20)	9.81	4.72	0–20	–0.14	–0.75
RAN (in seconds)	14.71	3.17	8–26	0.77	0.74
Hiragana fluency (104)					
Time 1	33.82	14.03	7–71	0.43	–0.51
Time 2	42.22	13.54	17–75	0.12	–0.67
Time 3	49.08	12.71	21–82	0.08	–0.35
Time 4	54.52	13.02	22–87	–0.11	–0.67
Kanji fluency (100)					
Time 2	34.24	7.52	13–57	0.13	0.40
Time 3	45.73	9.40	18–67	–0.16	0.05
Time 4	48.97	9.78	21–72	–0.16	0.25

Note: RAN, rapid automatized naming. Numerals in parentheses represent the possible maximum scores for each measure.

Kline, 2015), the higher order stability paths from Hiragana reading fluency in Time 1 to Time 3 and from Time 2 to Time 4 were added to the model. The model fit was excellent, χ^2 (35) = 31.89, $p = .62$, CFI = 1.00, TLI = 1.00, RMSEA = .00, 90% CI [.00, .06], SRMR = .03.

Hiragana reading fluency in Time 1 predicted both Hiragana ($\beta = .90$, $p < .001$) and Kanji ($\beta = .50$, $p < .001$) reading fluency in Time 2. Time 2 word reading fluency in Hiragana and Kanji did not predict each other in Time 3, but did show a reciprocal relationship from Time 3 to Time 4: Time 3 Hiragana fluency predicted Time 4 Kanji fluency ($\beta = .25$, $p < .01$) and Time 3 Kanji fluency predicted Time 4 Hiragana fluency ($\beta = .12$, $p < .01$). While the estimate for the cross-lagged effect for Hiragana is almost twice the size of the estimate for Kanji, constraining the two paths to be equal did not significantly alter the model fit ($\Delta\chi^2 = 0.06$, $df = 1$, $p = .81$), indicating that the effects were not significantly different.

DISCUSSION

We examined the cross-lagged relations between word reading fluency in the two orthographic systems of Japanese: phonetic (syllabic) Hiragana and morphographic Kanji. As expected, initial Hiragana reading had a strong impact on subsequent Kanji reading even after controlling for the cognitive skills (Hypothesis 1). This finding is consistent with previous studies in Japanese

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Table 2. *Correlations between the measures in the study*

	1	2	3	4	5	6	7	8	9	10	11	12
1. Age												
2. NVIQ	.05											
3. Vocabulary	–.06	.06										
4. PA	.05	.27**	.32**									
5. MA	.14	.14	.07	.33**								
6. RAN	–.29**	–.05	.01	–.16	–.14							
7. Hiragana_T1	.16	.22*	.19*	.37**	.35**	–.40**						
8. Hiragana_T2	.13	.15	.11	.36**	.35**	–.32**	.89**					
9. Hiragana_T3	.10	.18*	.18*	.35**	.35**	–.36**	.86**	.91**				
10. Hiragana_T4	.02	.09	.14	.29**	.31**	–.33**	.80**	.88**	.90**			
11. Kanji_T2	.09	.07	.15	.34**	.37**	–.37**	.61**	.67**	.63**	.65**		
12. Kanji_T3	.01	.06	.08	.20*	.17	–.40**	.43**	.50**	.55**	.59**	.66**	
13. Kanji_T4	.09	.00	.10	.25**	.13	–.38**	.51**	.57**	.59**	.67**	.54**	.73**

Note: NVIQ, nonverbal IQ. PA, phonological awareness. MA, morphological awareness. RAN, rapid automatized naming. Hiragana, Hiragana reading fluency. Kanji, Kanji reading fluency. T1, Time 1. T2, Time 2. T3, Time 3. T4, Time 4. *$p < .05$. **$p < .01$.

(Inoue et al., 2017; Ogino et al., 2017) and Chinese (Lin et al., 2010; McBride-Chang et al., 2012; Pan et al., 2011; Wang & McBride, 2016), suggesting that phonetic Hiragana plays a similar role to auxiliary phonetic scripts (Pinyin and Zhuyin) in the initial learning of Chinese characters (Lin et al., 2010; McBride-Chang et al., 2012; Pan et al., 2011). In other words, by serving as a phonetic guide to readings of morphographic Kanji characters, Hiragana characters may initially act as a cross-script "self-teaching device" (Share, 1999, 2008) for learning Kanji characters. Another possible explanation is that the transparent orthography of Hiragana offers children a bridge between the printed forms of Kanji characters and their spoken forms, which in turn give them access to their meanings that already exist in the lexicon. This may assist them in learning new Kanji characters (McBride, 2016; Wang et al., 2014).

The results further indicated that word reading fluency in Hiragana and Kanji did not predict each other from Time 2 to Time 3. Given that the measures in the two scripts had the same format, this is rather surprising. In contrast, word reading fluency in the two scripts had a reciprocal relation from Time 3 to Time 4, and the effects were not significantly different across the two directions (Hypothesis 2; see Figure 1). To our knowledge, this is the first study showing that earlier fluency in a morphographic script predicts fluency development in a phonetic script within one language. There are at least two explanations, not mutually exclusive, for these findings. First, children's proficiency in Kanji reading may help children to develop a lexical reading strategy for Hiragana reading in which they utilize larger grain units (morphemes or whole words) in Hiragana words, possibly by facilitating morphological decomposition of Hiragana words (Nunes & Hatano, 2004). This, in turn, may provide them a push to become faster readers despite the fact that the transparent orthography of Hiragana does not inherently require them to develop a lexical reading strategy. This interpretation is consistent with the findings of previous studies suggesting that the lexical process in Hiragana reading becomes apparent from Grade 2 onward (Kurokawa, Sambai, & Uno, 2014; Sambai et al., 2012). Second, it is possible that Japanese children rely on two separate cognitive bases for developing early decoding skills in Hiragana and Kanji (Inoue et al., 2017; Koyama et al., 2008), but then rely on relatively similar bases for fluency development in both scripts (Kobayashi et al., 2005). Previous meta-analyses have shown, for example, that RAN and morphological awareness are likely to be universal correlates of word reading fluency across writing systems (Araújo, Reis, Petersson, & Faísca, 2015; Ruan, Georgiou, Song, Li, & Shu, 2018). The parallel development in the earlier phase may be due to the fact that although word reading fluency is largely a script-universal process, it involves a script-specific component for less fluent readers because they apply decoding skills to read unfamiliar words in the fluency test (see Pasquarella et al., 2015, for a similar finding in Chinese–English bilinguals). However, further research is clearly warranted to examine whether this is the case in reading in the mixed writing system of Japanese.

These findings, if replicated, contribute to current theories of reading development across languages. Current theories, including PGST, postulate that

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reading development across languages is influenced by the characteristics of the writing systems (Frost, 2012; Perfetti & Harris, 2013; Ziegler & Goswami, 2005, 2006). Our examination of the learning of two orthographic systems within one language provide further support for the idea that whereas the nature of each orthography impacts the cognitive bases in the early phase of reading development (Georgiou, Torppa, Manolitsis, Lyytinen, & Parrila, 2012; McBride-Chang et al., 2005; Moll et al., 2014; Ziegler et al., 2010), children may utilize relatively similar bases for fluent reading across different orthographies (Caravolas et al., 2013; Georgiou et al., 2016; Vaessen et al., 2010).

Our results have important educational implications. First, the current results, together with those of previous studies on the role of other auxiliary phonetic scripts in learning Chinese characters (Lin et al., 2010; McBride-Chang et al., 2012; Pan et al., 2011; Wang & McBride, 2016), suggest that fostering reading fluency in a transparent phonetic script can be beneficial for the initial learning of an opaque morphography. Second, early assessment of reading fluency in the phonetic script would likely help identify children who will later struggle acquiring reading skills in morphographic characters (in our sample, Time 1 Hiragana fluency had a significant indirect effect on Time 4 Kanji fluency via those in Times 2 and 3, $\beta = .40$, $p < .001$, 90% CI [.27, .52]). If this finding is replicated, it can provide valuable information on the design of early identification measures.

Some limitations of the present study are worth noting. First, because the children in our sample attended many different schools and their participation was on a voluntary basis, a selection bias cannot be ruled out. The findings need to be replicated with a possibly more representative sample. Second, we examined only reading fluency and not reading accuracy. This was necessary because, as in other transparent orthographies, reading accuracy in Hiragana reaches ceiling in the first few months of Grade 1 (e.g., Sambai et al., 2012). Third, we focused only on the first two years of formal reading instruction. In order to more fully reveal the developmental relationships, future studies in Japanese should capture the two developmental processes ranging from prereading to fluent reading for each of Hiragana and Kanji, possibly in different time frames. Fourth, the lexical properties of words (e.g., word length, number of morae, and morphemic structure) were not strictly comparable between Hiragana words and Kanji words used in the reading measures. Future studies should consider using exactly the same set of words in both scripts, although complete matching may be still impossible because of the syllabic nature of Hiragana and the multisyllabic nature of Kanji. Fifth and finally, it remains unclear whether and to what extent learning two scripts representing the same language can foster word reading skills in each script that may not be available to children learning two scripts representing two different languages (i.e., bilingual contexts). The findings of this study are in line with those of a study that examined cross-script relations in word reading in Chinese–English bilinguals (Pasquarella et al., 2015). Future studies should directly examine the reciprocal relations between word reading skills in two scripts in both within- and between-language biscriptal contexts.

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To conclude, the present study is the first to examine cross-lagged relations in word reading fluency between contrastive scripts within the same language. It shows the important role a phonetic script can play in learning to read a morphographic script. The results further indicate that whereas word reading in Hiragana and Kanji may develop in parallel in the earlier phase of reading development, they are reciprocally related in Grade 2. These findings provide a first evidence for transfer from a morphographic to a phonetic script in one language. As Japanese children learn a hybrid orthography using both scripts, cross-script transfer of word reading fluency across the two contrastive orthographic systems is potentially highly beneficial for developing efficient text reading skills.

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NOTES

1. This is similar to the role the auxiliary phonetic script (Pinyin/Zhuyin) plays in Chinese (Hanley, 2005).
2. We approached this number of schools in order to obtain a sample of about 200 children. This was because our previous experience, as well as reports from other studies in Japanese (e.g., Ogino et al., 2017; Seki, Kassai, Uchiyama, & Koeda, 2008), indicate that the participation rate in research studies is relatively low.

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