Journal of Experimental Psychology:
Human Perception and Performance
2017, Vol. 43, No. 7, 1303–1328

0096-1523/17/$12.00 http://dx.doi.org/10.1037/xhp0000374

The Phonological Unit of Japanese Kanji Compounds: A Masked Priming Investigation

Masahiro Yoshihara and Mariko Nakayama
Waseda University

Rinus G. Verdonschot
Waseda Institute for Advanced Study

Yasushi Hino
Waseda University

Using the masked priming paradigm, we examined which phonological unit is used when naming Kanji compounds. Although the phonological unit in the Japanese language has been suggested to be the mora, Experiment 1 found no priming for mora-related Kanji prime-target pairs. In Experiment 2, significant priming was only found when Kanji pairs shared the *whole sound* of their initial Kanji characters. Nevertheless, when the same Kanji pairs used in Experiment 2 were transcribed into Kana, significant mora priming was observed in Experiment 3. In Experiment 4, matching the syllable structure and pitch-accent of the initial Kanji characters did not lead to mora priming, ruling out potential alternative explanations for the earlier absence of the effect. A significant mora priming effect was observed, however, when the shared initial mora constituted the whole sound of their initial Kanji characters in Experiments 5. Lastly, these results were replicated in Experiment 6. Overall, these results indicate that the phonological unit involved when naming Kanji compounds is not the mora but the whole sound of each Kanji character. We discuss how different phonological units may be involved when processing Kanji and Kana words as well as the implications for theories dealing with language production processes.

Public Significance Statement

As all humans speak one or more languages, it is of great interest to understand phonological encoding, which is one of the important processes involved in human speech production. Previous studies have suggested that the basic unit of phonology used in this process differs across languages (e.g., the phoneme in English, the syllable in Chinese, and the mora in Japanese). It was not well known, however, whether visual information such as script type would influence the phonological encoding process. This article, using Japanese Kanji and Kana words, demonstrates that the difference in script type does matter at least when we read a word aloud. Our study indicates that how a script is mapped from "how-it-looks" to "how-it-sounds" should be taken into account when we investigate the phonological encoding process.

Keywords: phonological unit, masked priming effect, naming tasks, Kanji compounds

Producing a word is a relatively simple task, which most people can complete in about half a second. However, the processes involved are actually quite complex. In language production theories (e.g., Dell, 1988; Levelt, Roelofs, & Meyer, 1999), word production necessitates the preparation of phonology. That is, before a word can be produced, its phonology must be computed and only after phonological preparation is completed the word can be articulated.

In the original model of Levelt et al. (1999), phonological encoding takes place using two pieces of information. One piece contains the basic phonological units and the other specifies the so-called metrical frame, which denotes the number of syllables and the assignment of stress. The phonological unit that is used to fill in the metrical frame in the original model is the phoneme. For instance, when naming a picture depicting the concept of "horses", the phonemes /h/ /ɔ/ /r/ /s/ /i/ /z/ are assembled and incrementally assigned from left to right into their metrical frames σ'σ (σ = syllable, ' = lexical stress) to form the phonological word [h'ɔr][siz].

This article was published Online First March 16, 2017.

Masahiro Yoshihara, Graduate School of Letters, Arts and Sciences, Waseda University; Mariko Nakayama, Faculty of Arts and Sciences, Waseda University; Rinus G. Verdonschot, Waseda Institute for Advanced Study; Yasushi Hino, Faculty of Arts and Sciences, Waseda University.

This research was supported in part by JSPS KAKENHI, Grant-in-aid for JSPS Research Fellow, 16J08422 and a Grant-in-aid for Research Activity start-up, 15H06687.

Correspondence concerning this article should be addressed to Mariko Nakayama, who is now at Department of Psychology, Rikkyo University, 1-2–26 Kitano, Niiza-shi, Saitama 352-8558 Japan. E-mail: mariko_nakayama@rikkyo.ac.jp

Two particular paradigms have been used to measure the phonological unit in speech production research: (a) the *implicit priming* paradigm and (b) the *masked priming* paradigm. In the implicit priming paradigm, the most frequently used task is called "associative cuing" (or "word generation"; e.g., Meyer, 1990, 1991; O'Seaghdha & Frazer, 2014; Roelofs, 2006). This task is composed of two phases: a presentation phase and a test phase. In the presentation phase, participants are asked to remember a small set of word pairs (also termed prompt-response pairs, e.g., magie "magic" - heks "witch"). In the subsequent test phase, a prompt word (e.g., magie) is presented on the screen and participants are asked to produce a response word (e.g., heks) as quickly and accurately as possible. The prompt-response pairs are arranged in two different groups: the homogeneous and heterogeneous conditions. In the homogeneous condition, all of the response words share a phonological feature such as the initial phoneme (e.g., *h*ut, *h*eks, *h*iel "hut, witch, heel"), while in the heterogeneous condition none of the response words share a phonological feature (e.g., hut, dans, klip; "hut, dance, cliff"). In languages such as Dutch (see aforementioned examples) and English, response words are produced significantly faster when they share the initial phoneme than when they do not (e.g., Meyer, 1990, 1991; O'Seaghdha, Chen, & Chen, 2010; Roelofs, 1996). The facilitation observed in the implicit priming paradigm is referred to as *the preparation effect* (or *form-related priming effect*), suggesting that the shared phonology (e.g., /h/) that is prepared in advance facilitates the production of the response words in the homogeneous condition. As phonology of a word is constructed in a left-to-right manner, there was no facilitation in the end-related condition (e.g., meld*ing*, brand*ing*, scheid*ing*, "notice, wave breakers, divorce").

In the masked priming paradigm, on the other hand, a speeded naming task is typically used to investigate the phonological unit (e.g., Chen, Lin, & Ferrand, 2003; Nakayama, Kinoshita, & Verdonschot, 2016; Verdonschot et al., 2011; Verdonschot, Nakayama, Zhang, Tamaoka, & Schiller, 2013a; You, Zhang, & Verdonschot, 2012). In this task, participants are asked to read a target word aloud as quickly and accurately as possible. Before the target word is presented, a prime is presented very briefly (to avoid conscious identification of the prime and thereby strategic influences). Using this task, Forster and Davis (1991) first showed that when the prime and target shared the initial onset phoneme (e.g., *d*ark /dɑrk/ - *D*OCTOR /dɔktər/), naming latencies were significantly shorter than when they did not (e.g., park /pɑrk/ - DOCTOR). Forster and Davis termed this effect the masked onset priming effect (MOPE). Significant MOPEs have been reported in Dutch (e.g., Schiller, 2004, 2007), English (e.g., Forster & Davis, 1991; Kinoshita, 2000), Russian (e.g., Timmer, Ganushchak, Mitlina, & Schiller, 2014), Spanish (e.g., Dimitropoulou, Duñabeitia, & Carreiras, 2010), and Persian (e.g., Timmer, Vahid-Gharavi, & Schiller, 2012). The MOPE is assumed to occur because when a prime is presented, participants automatically prepare the phonology of the prime to some degree, even though the prime is not consciously available to them. Indeed, Forster and Davis (1991) reported that participants occasionally pronounced the initial segments of the primes or even the entire primes, suggesting that participants responded to the primes, rather than to the targets.

There are two types of accounts for the MOPE: the dual-route account and the speech planning (SP) account. According to the dual-route account (e.g., Coltheart, 1978; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Forster & Davis, 1991; Mousikou, Coltheart, Finkbeiner, & Saunders, 2010a; Mousikou, Coltheart, & Saunders, 2010b; Mousikou, Rastle, Besner, & Coltheart, 2015), the MOPE arises due to the computation process from orthography to phonology. The dual-route theory assumes two independent routes for retrieving phonology: the lexical and the nonlexical routes. In the lexical route, the phonology of a word is retrieved from the lexicon. On the other hand, the nonlexical route computes the phonology through the application of grapheme-to-phoneme correspondence (GPC) rules. Forster and Davis (1991), in their seminal study, assumed that the MOPE has its origin in the mapping of orthography to phonology. When a prime is presented, the nonlexical route would first start to compute the phonology of the prime based on the GPC rules in a serial manner. By the time the following target is presented, the phonology of the prime (at least that of the initial letter of the prime) would have been computed. This computed phonology would elicit a conflict with the target when the initial segments of the prime and the target are different. Forster and Davis (1991) posited that this conflict is the origin of the MOPE. In addition, there is another type of account for the MOPE within the dual-route framework. This is based on a computational model of the dual route theory, the dual route cascaded (DRC) model (e.g., Coltheart et al., 2001). According to the DRC model, the MOPE arises because the mismatch in the initial sound between the prime and the target causes a conflict that delays naming responses *and/or* the match in the initial sound between the prime and the target facilitates responses. Although Forster and Davis's (1991) dual-route account and the DRC account are different in their detailed specifications of the mechanisms underlying the effect (for details, see Kinoshita, 2003; Mousikou et al., 2010b), the two accounts attribute the MOPE to the computation of phonology in the nonlexical route.

Conversely, the SP account (e.g., Kinoshita, 2000, 2003; Kinoshita & Woollams, 2002; Malouf & Kinoshita, 2007) assumes that the MOPE reflects a conflict arising "*further downstream at the planning of speech output from abstract phonology*" (cf. Kinoshita, 2003; p. 128), rather than the computation of phonology. That is, when the prime is presented, it is automatically processed to the level at which a speech response is possible. When the target does not share the onset phoneme with the prime, its phonological encoding is delayed, as the mismatch in the onset phonemes delays the segment-to-frame association process, in which phonology is filled incrementally into the metrical frame in order to prepare for a speech output (e.g., Levelt et al., 1999).

Important to the purpose of the present study is that both the dual-route account and the SP account commonly assume that the phoneme is the critical phonological unit in the process of word naming. In addition, implicit and masked priming studies have shown similar results, suggesting the importance of the phoneme as the fundamental phonological unit used in speech production.

The Variability of the Phonological Unit Across Languages

Early research on the phonological unit has typically been conducted using Indo-European languages such as English and Dutch (e.g., Levelt et al., 1999). However, more recent research has started to reveal that a phonological unit used to produce words may not unequivocally be the phoneme, but may be different across languages (e.g., Chen, Chen, & Dell, 2002; Chen, O'Seaghdha, & Chen, 2016; Chen, & Chen, 2013; Kureta, Fushimi, & Tatsumi, 2006; O'Seaghdha et al., 2010; Roelofs, 2015; Verdonschot et al., 2011).

Chen et al. (2002) examined the phonological unit of Chinese word production using the associative-cuing task with the implicit priming paradigm. Unlike previous studies investigating Indo-European languages, a preparation effect was not found in Mandarin when response words only shared the initial phoneme (e.g., 賭博 /*d*u3-bao2/ "gambling", 地獄 /*d*i4-yu4/ "hell", 答慶 /*d*a1-ing4/ "promise"). Instead, a significant preparation effect was observed when response words shared the initial syllable (e.g., 科學 /*ke*1-xue2/ "science", 咳痰 /*ke*2-tan2/ "expectation", 可憐 /*ke*3-lian2/ "pitiful"). Similarly, Chen et al. (2003) reported converging results using the speeded naming task with the masked priming paradigm. In their experiments using single character primes and compound targets, naming latencies were significantly faster when the prime and target shared the initial syllable (e.g., 枯 /*ku*1/ - 酷愛 /*ku*4-ay4/ "craze for") compared with when they did not (e.g., 誇 /*kua*1/ - 酷愛 /*ku*4-ay4/). This was the case even when the syllable-related pairs had smaller phoneme-level overlap than the other type of pairs, as in the above examples. In addition, You et al. (2012) replicated J.-Y. Chen's findings and further demonstrated that the effect can also be observed with picture targets. These results suggest that the phonological unit involved in producing Chinese words is the syllable.

In the Japanese language, the phonological unit prepared in speech production is suggested to be the mora (e.g., Ida, Nakayama, & Lupker, 2015; Kureta et al., 2006; Roelofs, 2015; Verdonschot et al., 2011). This was first proposed by Kureta Fushimi, and Tatsumi (2006) who employed implicit priming associative cuing (word generation) tasks using both Japanese Kana and Kanji words. A significant preparation effect was found when response words shared their initial mora sound (e.g., かつら/*ka*.tu.ra/ "wig", 歌舞伎 /*ka*-bu-ki/ "kabuki", 鞄 /*ka*.ba.N/ "bag"), but not when the words merely shared the initial phoneme (i.e., the consonant or the consonant plus palatal glide; e.g., かつら /*k*a.tu.ra/, くじら /*k*u.zi.ra/ "whale", 古墳 /*k*o-hu.N/ "mound").[1] Using the masked priming naming task, Verdonschot et al. (2011) similarly concluded that the phonological unit of the Japanese language is the mora. In their experiments, naming latencies to Japanese Kana targets (e.g., すし /*s*u.shi/) were not faster when the target was preceded by onset-related Kana primes (e.g., せん /*s*e.N/) than by unrelated Kana primes (e.g., れん /re.N/). In contrast, there was a significant priming effect when Kana targets (e.g., すし /*su*.shi/) were preceded by mora-related primes (e.g., スミ /*su*.mi/) relative to unrelated primes (e.g., グミ /gu.mi/). Furthermore, the same pattern of results was observed even when the stimuli were presented in Romaji (Romanized Japanese), suggesting that the observed mora priming effect did not merely result from the moraic nature of the Kana characters (as each kana character corresponds to a mora-sized phonological component).

To sum up, while the phonological unit used in producing Indo-European languages such as English and Dutch is the phoneme (Levelt et al., 1999), this does not appear to hold for other languages such as Chinese and Japanese. In Chinese, the phonological unit seems to be the syllable, and in Japanese it is the mora. In order to account for these findings, O'Seaghdha et al. (2010) coined the term *proximate unit* to label the differences in phonological unit used in speech production. Specifically, it was stated that the proximate unit reflects "*the first selectable phonological units below the level of the word*" which "*vary across languages and are pivotal in situations such as advance planning and partial preparation*" (p. 282).[2]

Masked Mora Priming Effects With Kanji Compounds

According to the proximate units principle, the phonological unit used in word production varies across languages, which implies that the first selectable unit is determined by *language* but not by *script*.[3] Previous studies investigating the phonological unit of the Japanese language have used either a combination of Kana and Kanji (Kureta et al., 2006) or Kana and Romaji (Verdonschot et al., 2011; see also Ida et al., 2015) and always found the mora to be the phonological unit in Japanese speech production. However, there is no previous study investigating this issue using exclusively Kanji stimuli. In modern Japanese, Kanji script is used to represent content words and two-character Kanji compounds represent approximately 50% of written Japanese vocabulary (e.g., Hino, Miyamura, & Lupker, 2011) and therefore an investigation using solely Kanji stimuli seems warranted.

One important aspect of the Japanese language is that the nature of the character-to-sound correspondences for Kanji words is assumed to be very different from that of Kana words (e.g., Feldman & Turvey, 1980; Frost, 2005; Saito, 1981; Wydell, Butterworth, & Patterson, 1995). While each Kana character typically corresponds to a single mora sound (e.g., a Kana character, か, is always read as /ka/), a Kanji character often corresponds to multiple mora sounds (e.g., a Kanji character, 朝 "morning", is typically pronounced as /a.sa/ when this character is presented alone or in some compound words, such as 朝日 /a.sa-hi/ "morning sun"). In addition, a Kanji character typically has multiple readings, with its correct pronunciation being determined by the context within which the character appears (e.g., the Kanji character, 朝, is pronounced as /tjo.u/ when it appears in a compound word, e.g., 朝刊 /tjo.u-ka.N/ "morning edition"). Because of these characteristics, phonological coding may require more processing effort for Kanji (Verdonschot, La Heij, & Schiller, 2010) compared with Kana. Currently, however, whether or not these Kanji characteristics affect the phonological unit during word naming remains unclear.

[1] When we describe morae for Japanese words, we follow the format from Hino, Miyamura, and Lupker (2011). This format is based on Tamaoka and Makioka (2004) but different in three respects: (a) a period [.] is used for a moraic boundary, (b) a hyphen [-] is used for a morphemic boundary, and (c) capital letters are used for prolonged (long) vowel, instead of /R/ (e.g., /jo-sju.U/ for 予習).

[2] It should be noted that Nakayama et al. (2016) suggested the term "masked initial segment priming effect (MISPE)" as a substitute for the "masked onset priming effect (MOPE)", taking the proximate units principle into consideration.

[3] An anonymous reviewer pointed out that the proximate units principle was developed mainly based on findings from word production tasks that do not involve orthographic processing (e.g., associative-cuing task and picture naming task where the phonology of a target is retrieved from memory) and therefore, the principle would not necessarily say anything specific about the role of script.

Present Study

The present study examined which phonological unit is used when reading aloud Kanji words. We employed the masked priming naming task as this task is assumed to measure automatic processing free from strategic influences (e.g., Forster, 1998; Forster, Mohan, & Hector, 2003; Kinoshita, 2003) and it has been amply used to study the phonological unit of languages (e.g., Chen et al., 2003; Ida et al., 2015; Nakayama et al., 2016; Verdonschot et al., 2011; You et al., 2012). It is important to note that the current versions of the dual-route accounts (e.g., Coltheart et al., 2001; Forster & Davis, 1991) would *not* predict priming from Kanji words. Because Kanji words are orthographically deep (i.e., having complex orthography-phonology mappings), the naming of Kanji words could only be accomplished through the lexical route (e.g., Feldman & Turvey, 1980; Wydell et al., 1995) and, hence, no priming is expected if it is assumed to arise through the nonlexical route. From the viewpoint of the SP account, however, priming is predicted even with Kanji stimuli. That is, because the effects are assumed to arise at the speech planning phase, and hence, priming should be observed even when the phonology of words are (assumed to be) retrieved via the lexical route (e.g., Dimitropoulou et al., 2010; Malouf & Kinoshita, 2007). To our knowledge, there are no previous studies examining the functional phonological unit using *exclusively* Kanji compound words, and our study represents the first attempt to investigate this using the masked priming naming task.

Experiment 1: Mora Priming With Kanji Compounds

Experiment 1 was a direct test of the mora priming effect in the naming of Kanji compounds. Given the results in the previous studies (e.g., Ida et al., 2015; Verdonschot et al., 2011), what corresponds to the MOPE for Japanese Kanji words would be the masked "mora" priming effect. Thus, we compared naming latencies for Kanji word targets when they were preceded by Kanji primes that shared the initial mora sound (e.g., 発案 /*ha*.tu-a.N/ "suggestion" - 博物 /*ha*.ku-bu.tu/ "natural history") and when they were preceded by Kanji primes that did not share the initial sound (e.g., 立案 /ri.tu-a.N/ "planning" - 博物 /ha.ku-bu.tu/). According to the proximate units principle (in concord with the SP account), a significant mora priming effect is expected: naming latencies should be faster for the prime-target pairs sharing the initial mora than for the pairs with different initial morae. In contrast, no effect is expected according to the dual-route account.

Method

Participants. Forty-seven undergraduate and graduate students from Waseda University participated in this experiment. They were paid 500 JPY (about $4) in exchange for their participation. All were native Japanese speakers with normal or corrected-to-normal vision.

Stimuli. Targets were 36 two-character Kanji compounds (see Appendix A). The written word frequency of the targets was, on average, 1.00 per million (Amano & Kondo, 2003b).[4] Each target was primed by either mora related or mora control two-character Kanji compound primes. The mora related primes shared their initial mora with the targets (e.g., 発案 /*ha*.tu-a.N/ - 博物 /*ha*.ku-bu.tu/), but otherwise they were orthographically, morphologically, and semantically unrelated. Mora control primes did not share the initial mora with the targets (e.g., 立案 /ri.tu-a.N/ - 博物 /ha.ku-bu.tu/) and were unrelated otherwise. The mora related and mora control primes always had different first Kanji characters but their second character was always the same with an identical pronunciation (e.g., 発案 /ha.tu-*a.N*/ and 立案 /ri.tu-*a.N*/).

As shown in Table 1, mora related and mora control primes were matched on the following mean lexical characteristics: (a) the number of morae; (b) word frequency (taken from Amano & Kondo, 2003b); (c) orthographic familiarity rating (taken from Amano & Kondo, 2003a); (d) phonological familiarity rating (taken from Amano & Kondo, 2003a); (e) orthographic neighborhood size (calculated using the National Language Research Institute Database, 1993); (f) summed character frequency (taken from Amano & Kondo, 2003b); (g) the number of strokes; and (h) on-reading ratio for the initial character of the primes (taken from Tamaoka, Kirsner, Yanase, Miyaoka, & Kawakami, 2002). The on-reading ratio reflects to what extent a given Kanji character is read in the on-reading pronunciation (as opposed to the Kun-reading pronunciation; e.g., how often 水 "water" is read as $/\mathrm{sui}/_{\mathrm{on}}$ instead of $/\mathrm{mizu}/_{\mathrm{kun}}$) when reading Japanese text.[5] The mora related and mora control primes did not significantly differ on any of these variables (all $F\mathrm{s} < 1$). Two counterbalancing lists were created so that in each list, half of the targets was primed by the mora related primes and the other half was primed by the mora control primes. The pairing was reversed across the two lists.

Apparatus and procedure. Participants were tested individually in a quiet room. The experiment was programmed using the DMDX software package (Forster & Forster, 2003). Participants were asked to read aloud a target word on a CRT monitor as quickly and as accurately as possible. Each trial started with a 50 ms 400 Hz beep signal. After the signal, a forward mask (i.e., ######) was presented on the center of the screen for 1,000 ms. Immediately after the forward mask, a prime was presented for 50 ms, which was then replaced by a target. The target remained on the screen until a response was made or 2,000 ms has elapsed. The intertrial interval was 3 s.

On each trial, primes were presented in a slightly smaller font size than targets: Primes were presented in 11-pt MS-Mincho font and targets were in 12-pt MS-Mincho font. Naming latency was measured from the onset of the target presentation to the onset of the vocal response. The order of trials was randomized for each participant. Prior to the experimental trials, participants received 12 practice items (not used in the main experiment) to familiarize themselves with the task.

[4] Because the word frequency counts in Amano and Kondo's (2003b) database were per 287, 792, 787, the word frequency counts reported in the present study were converted into per million as follows: the raw word frequency counts in Amano and Kondo's database were divided by 287, 792, 787 and multiplied by one million.

[5] All of the initial characters of the compounds used in Experiment 1 (and the most of those used in the following experiments) were read in their on-reading pronunciations. Given that the previous research reported that MOPE depends on the initial sound of words, we decided to control the on-reading ratio as an index for spelling-sound consistency of the initial Kanji characters.

Table 1
Statistical Characteristics of Mora Related and Mora Control Primes Used in Experiment 1

Examples	Mora related prime 発案 – 博物 /*ha*.tu-a.N/ - /*ha*.ku-bu.tu/	Mora control prime 立案 – 博物 /ri.tu-a.N/ - /ha.ku-bu.tu/	
Lexical variables			*p*-value
Mora	3.6	3.6	.50
Freq	45.1	44.7	.99
OFam	5.7	5.7	.76
PFam	5.5	5.5	.96
N	69.7	64.7	.39
CF	1165098	995606	.11
Strokes	17.0	16.5	.58
OnRatio	.9	.9	.89

Note. Mora, Freq, OFam, PFam, N, CF, Strokes, and OnRatio stand for mean number of morae, mean word frequency (per million), mean orthographic familiarity rating, mean phonological familiarity rating, mean orthographic neighborhood size, mean summed character frequency, mean number of strokes, and mean on-reading ratio, respectively.

Results

Responses were preprocessed and manually corrected for voice-key errors via visual inspection of the speech waveform using CheckVocal software (Protopapas, 2007). The data from one participant were excluded because of high error rates (>15%). Response latencies faster than 300 ms or slower than 1,300 ms were regarded as outliers and excluded from the statistical analyses (1.2% of the data). Error responses (5.0%) were also excluded from the latency analyses. The mean naming latencies and error rates are presented in Table 2. Correct response latencies and error rates were separately analyzed with the analyses of variance (ANOVAs) with prime type (mora related prime vs. mora control prime) as a single fixed factor. The factor was a within-subject and within-item factor in the subject and item analyses, respectively.

There was no mora priming effect, as indicated by no main effect of prime type for response latency, $F_s(1, 45) = 1.38$, $p = .247$, $\eta_p^2 = .03$; $F_i < 1$, $\eta_p^2 = .01$, and for errors, $F_s < 1$, $\eta_p^2 = .01$; $F_i(1, 35) = 1.00$, $p = .430$, $\eta_p^2 = .03$. Naming latencies were not significantly faster when the targets were preceded by mora related primes than when preceded by mora control primes (638 ms vs. 644 ms). The error rates were also statistically comparable in the mora related and mora control conditions (4.5% vs. 5.4%).

Discussion

Experiment 1 was conducted to extend the previous findings of mora-based facilitation observed with Kana and Romaji stimuli to Kanji words (e.g., Kureta et al., 2006; Verdonschot et al., 2011). Because it has been assumed that the phonological unit in Japanese is the mora, we expected to observe a significant mora priming effect for Kanji compounds in Experiment 1 as Verdonschot et al. (2011) reported significant effects for Kana and Romaji stimuli using the same task. Contrary to our expectation, however, there was no mora priming effect for Kanji words. Although response latencies were 6 ms faster when the targets were primed by the mora related primes than by the mora control primes, the difference was far from being significant. The null priming effect from Kanji words could suggests that, as the dual-route theory assumes, the underlying mechanism of priming in the masked priming naming task indeed lies in the computation of phonology via the nonlexical route (e.g., Coltheart et al., 2001; Forster & Davis, 1991; Mousikou et al., 2010a, 2010b). That is, because Kanji words must be read via the lexical route, no priming can be observed for these words.

However, when conducting a subsequent item-by-item examination of our data, an interesting pattern emerged which could possibly account for these results. Although there was no priming effect overall, we found that a subset of the mora related prime-target pairs ($n = 9$) did produce a sizable processing advantage relative to their controls (16 ms). What was common to these pairs was that the shared mora sound always corresponded to the *whole sound* of the first characters of the compounds (e.g., 余力 /***jo***-rjo.ku/ "remaining energy" - 予習 /***jo***-sju.U/ "preparation").[6] For the majority of the pairs ($n = 27$), on the other hand, the shared mora sound was only a part of the sounds of the first characters (e.g., 発案 /***ha*.tu**-a.N/ - 博物 /***ha*.ku**-bu.tu/) and there was no priming effect for those pairs.

Although we failed to observe a significant mora priming effect in Experiment 1, this post hoc inspection suggested the possibility that, for Japanese Kanji words, a significant priming effect could be obtained if the prime and target shared the *whole sound* of the first Kanji character. That is, Kanji phonology may be prepared in

Table 2
Mean Naming Latencies in Milliseconds (Error Rates) for Kanji Targets Primed by Character-Sound Match and Control Words, With a Net Priming Effect in Experiment 1

Prime type	Examples	RT (ER)
Related	発案 – 博物 /*ha*.tu-a.N/ - /*ha*.ku-bu.tu/	638 (4.5%)
Control	立案 – 博物 /ri.tu-a.N/ - /ha.ku-bu.tu/	644 (5.4%)
Priming effect		6 (.9%)

Note. RT and ER stand for mean response latencies and error rates, respectively.

[6] In the present article, hereafter, we used the boldface to highlight the phonology of the first character in the words. For instance, /**ka**-rjo.ku/ (火力) means that the initial mora, /**ka**/, corresponds to the pronunciation of the first character (i.e., 火).

chunks containing the entire sound of each character rather than the individual mora. Because the majority of the prime-target pairs in Experiment 1 only shared *a part of the sound* corresponding to their initial Kanji characters, no priming effect was observed. We investigated these possibilities in Experiment 2.

Experiment 2: Character-Sound Priming With Kanji Compounds

In this experiment, Kanji compound targets were preceded by two types of related Kanji compound primes: character-sound primes and mora primes. The character-sound primes shared *the whole sound of their initial Kanji character* with their targets (e.g., 迫害 /***ha.ku***-ga.i/ "persecution" - 博物 /***ha.ku***-bu.tu/). The mora primes, on the other hand, shared *only the initial mora sound* with their targets. In this condition, the shared mora sound was only a part of the sound of their first Kanji characters (e.g., 発案 /***ha*.tu**-a.N/ - 博物 /***ha*.ku**-bu.tu/). If the phonological preparation involved in producing Japanese Kanji words pertains to the entire sound of each Kanji character, then a significant priming effect should emerge in the character-sound prime condition but not in the mora prime condition.

Method

Participants. Thirty-six undergraduate and graduate students from Waseda University participated in this experiment (17 females, age: 20.1 years on average, $SD = 3.0$). None had participated in Experiment 1. They were paid 500 JPY in exchange for their participation. All were native Japanese speakers with normal or corrected-to-normal vision.

Stimuli. Targets were 28 two-character Kanji compounds (see Appendix B). The mean written target word frequency was 1.21 per million (Amano & Kondo, 2003b). The first character of the targets was always two morae in length (e.g., 博物 /**ha.ku**-bu.tu/). For each of the targets, two types of critical primes, mora-related and character-sound-related primes were selected along with their respective control primes. In the mora-related prime condition, the primes shared the initial single mora sound with their targets, but each of the initial characters corresponded to two mora sounds (e.g., 発案 /***ha*.tu**-a.N/ - 博物 /***ha*.ku**-bu.tu/). As in Experiment 1, the mora-related primes were orthographically, morphologically, and semantically unrelated to their targets. In the character-sound-related prime condition, the primes shared the initial two morae with their targets which corresponded to the entire sound of their first Kanji characters (e.g., 迫害 /***ha.ku***-ga.i/ - 博物 /***ha.ku***-bu.tu/). The character-sound-related primes were also orthographically, morphologically, and semantically unrelated to their targets. The two types of control primes (mora-control and character-sound-control primes) were both phonologically identical to their respective critical primes except for their initial mora sounds (e.g., 発案 /**ha.*tu***-a.N/ vs. 立案 /**ri.*tu***-*a.N*/ and 迫害 /**ha.*ku***-*ga.i*/ vs. 薬害 /**ja.*ku***-*ga.i*/). This means that although the character-sound-related prime-target pairs have greater phonological overlap (two morae) than the mora-related primes (one-mora), this difference was equated by their respective control primes. That is, while the character-sound-related primes shared the initial two morae with their targets, their control primes shared the second mora with their targets. In the mora condition, while the mora-related primes shared only the initial mora with their targets, their control primes shared no mora with the targets. As a result, the difference in the number of shared morae between the related and control pairs was just one in both the character-sound and mora conditions. In addition, the first Kanji character of each control prime was different from the respective critical primes but the second Kanji character and its pronunciation were always the same for the control and critical primes (e.g., 発案 vs. 立案 and 迫害 vs. 薬害). As shown in Table 3, the four prime types were matched on the same characteristics as in Experiment 1. One-way ANOVAs confirmed that the four prime types were not significantly different on any lexical variables, all Fs < 1.

Further, in order to make sure that the four types of prime-target pairs were equally semantically unrelated with one another at the whole-word level, semantic relatedness ratings were collected from 40 participants who did not participate in Experiment 2. In the rating task, participants were asked to judge to what extent each of the prime-target pairs was related in meaning using a 7-point scale (1 = not at all related, 7 = extremely related). The mean ratings for the mora-related, mora-control, character-sound-related, and character-sound-control pairs were very similar, 2.1, 2.1, 2.0, and 1.7, respectively. A one-way repeated ANOVA revealed that the four types of primes were not significantly different from one another, $F(3, 81) = 1.58$, $p = .200$.

Four counterbalanced lists were created so that within a list, a quarter of the targets (i.e., seven items out of the 28 targets) was paired with one of the four types of primes, but each target was paired with four types of the primes across the four lists. Each participant received all lists in four separate blocks. The order of blocks was counterbalanced across participants. Within a block, the order of item presentation was randomized for each participant. It should be noted that we employed this procedure (i.e., presented the target set multiple times) following the previous literature that tested the phonological unit. It has been shown that the patterns of priming effects are not affected even when the same set of targets is repeatedly presented across different prime conditions (e.g., Nakayama et al., 2016; Schiller, 1998; Verdonschot et al., 2013a; You et al., 2012).

Apparatus and procedure. Overall procedure including trial sequence was identical to those in Experiment 1 except that the presentation of stimuli and the recording of response latencies were controlled using an MS-DOS computer (see Dlhopolsky, 1988) with a voice key connected through an IO card (Contec, PIO-16/16T-PCI-H).[7]

Results

Response latencies faster than 300 ms and slower than 1,300 ms were regarded as outliers and excluded from the statistical analyses (0.8%). Error responses (2.5%) were also excluded from the latency

[7] There are two reasons why we changed the apparatus in Experiment 2. First, we decided to use voice key to detect vocal responses more sensitively. Second, we aimed to enhance measurement accuracy by using a single-task OS (i.e., MS-DOS) computer instead of a multitask OS (i.e., Windows). Consequently, the primes and the targets were presented in the same font size because it was not possible to alter font sizes on MS-DOS computer. However, this should not affect the critical results as there were no orthographic overlap between primes and targets in the present experiments.

Table 3
Lexical Characteristics of Mora Related, Mora Control Character Sound, and Character Sound Control Primes Used in Experiment 2

	Mora primes		Character sound primes		
Examples	Related 発案 – 博物 /***ha*.tu**-a.N/ - /***ha*.ku**-bu.tu/	Control 立案 – 博物 /**ri.tu**-a.N/ - /**ha.ku**-bu.tu/	Related 迫害 – 博物 /***ha.ku***-ga.i/ - /***ha.ku***-bu.tu/	Control 薬害 – 博物 /**ja.ku**-ga.i/ - /**ha.ku**-bu.tu/	
Variables					*p*-value
Mora	3.9	3.9	3.9	3.9	1.00
Freq	28.0	33.6	31.1	29.4	.97
OFam	5.7	5.7	5.7	5.6	.94
PFam	5.5	5.5	5.4	5.4	.85
N	60.4	60.3	61.3	66.0	.89
CF	896646	967695	875482	990057	.92
Strokes	16.9	16.8	18.0	17.7	.70
OnRatio	.9	.9	.8	.9	.75
Rel	2.1	2.1	2.0	1.7	.20

Note. Mora, Freq, OFam, PFam, N, CF, Strokes, OnRatio, and Rel stand for mean number of morae, mean word frequency (per million), mean orthographic familiarity rating, mean phonological familiarity rating, mean orthographic neighborhood size, mean summed character frequency, mean number of strokes, mean on-reading ratio, and mean semantic relatedness rating, respectively.

analyses. Further, voice-key errors (0.8%) were excluded from the entire analyses. The mean naming latencies and error rates are presented in Table 4.

The data were analyzed by 4 (Block Order: 1, 2, 3, and 4) × 2 (Phonological Overlap: mora vs. character-sound) × 2 (Relatedness: related vs. control) ANOVAs. Block order, phonological overlap, and relatedness were all within-unit factors both in the subject and the item analyses.

For naming latency, there was a significant main effect of block order, $F_s(3, 105) = 155.41$, $p < .001$, $MSE = 3802.7$, $\eta_p^2 = .82$; $F_i(3, 81) = 232.69$, $p < .001$, $MSE = 1964.0$, $\eta_p^2 = .90$. Tests of individual contrasts revealed that mean naming latencies became successively faster from the first to the third blocks, all *p*s < .05. The difference in the latencies of the third and the fourth block was significant only in the item analysis, $t_s(35) = 1.29$, $p = .205$; $t_i(27) = 2.46$, $p = .021$. Importantly, block order did not significantly interact with the patterns of priming effects, all *F*s < 1 (i.e., there was no two-way interaction between block order and relatedness, nor was there three-way interaction between block order, phonological overlap, and relatedness). The main effect of relatedness was significant, $F_s(1, 35) = 9.21$, $p = .005$, $MSE = 1212.5$, $\eta_p^2 = .21$; $F_i(1, 27) = 8.45$, $p = .007$, $MSE = 1122.5$, $\eta_p^2 = .24$. Across phonological overlap, targets preceded by related primes were named significantly faster than targets preceded by their control primes. The main effect of phonological overlap, on the other hand, was not significant, $F_s(1, 35) = 1.01$, $p = .322$, $\eta_p^2 = .03$; $F_i < 1$, $\eta_p^2 = .02$. More importantly, there was a significant interaction between relatedness and phonological overlap, $F_s(1, 35) = 4.31$, $p = .045$, $MSE = 1445.6$, $\eta_p^2 = .11$; $F_i(1, 27) = 8.61$, $p = .007$, $MSE = 723.4$, $\eta_p^2 = .24$. Separate analyses carried out for the mora and for the character-sound conditions revealed that this interaction occurred because a significant priming effect was present in the character-sound condition (15 ms), $F_s(1, 35) = 13.69$, $p < .001$, $MSE = 1244.8$, $\eta_p^2 = .28$; $F_i(1, 27) = 20.16$, $p < .001$, $MSE = 770.7$, $\eta_p^2 = .43$, but no such an effect was present in the mora condition (2 ms), both $F_s < 1$.

For errors, the main effect of block order was again significant, $F_s(3, 105) = 5.44$, $p = .002$, $MSE = 21.5$, $\eta_p^2 = .13$; $F_i(3, 81) = 4.20$, $p = .008$, $MSE = 21.1$, $\eta_p^2 = .13$. Test of individual contrasts showed that error rates were significantly higher in the first block than for the rest of the blocks in the subject analyses, all *p*s < .05, but not in the item analyses, all *t*s < 1. The error rates were not significantly different from one another in the three later blocks, all *t*s < 1. As in the analyses of response latencies, block order did not significantly interact with the patterns of priming effects, all *F*s <

Table 4
Mean Naming Latencies in Milliseconds (Error Rates) for Kanji Targets Primed by Mora Related, Mora Control, Character Sound Related, and Character Sound Control Kanji Words With Net Priming Effects in Experiment 2

	Mora primes		Character sound primes	
Relatedness	Examples	RT (ER)	Examples	RT (ER)
Related	発案 – 博物 /***ha*.tu**-a.N/ - /***ha*.ku**-bu.tu/	612 (2.6%)	迫害 – 博物 /***ha.ku***-ga.i/ - /***ha.ku***-bu.tu/	603 (2.7%)
Control	立案 – 博物 /**ri.tu**-a.N/ - /**ha.ku**-bu.tu/	614 (2.3%)	薬害 – 博物 /**ja.ku**-ga.i/ - /**ha.ku**-bu.tu/	618 (2.6%)
Priming effect		2 (−.3%)		15 (−.1%)

Note. RT and ER stand for mean response latencies and error rates, respectively.

1. No other significant effect was found in the error analyses (all *F*s < 1).

Discussion

As in Experiment 1, there was, once again, no priming effect for the prime-target pairs that merely shared their initial mora sound (i.e., no mora priming effect). In contrast, there was a significant priming effect for the prime-target pairs that *shared the whole sound of their first Kanji characters* (i.e., a significant character-sound priming effect). The significant character-sound priming effect supports the idea that the phonological unit prepared for naming Kanji words is not the mora but the whole sound of each Kanji character.

Although this interpretation seems straightforward, there is an alternative explanation for the results of Experiment 2. That is, the differential patterns of priming effects observed for character-sound-related and mora-related pairs may have been due to the fact that the amount of the phonological overlap was always greater for the character-sound-related pairs than for the mora-related pairs. That is, mora-related pairs only shared one initial mora sound (e.g., 発案 /***ha*.tu**-a.N/ - 博物 /***ha*.ku**-bu.tu/) but the character-sound-related pairs shared two initial morae (e.g., 迫害 /***ha.ku***-ga.i/ - 博物 /***ha.ku***-bu.tu/). We should note, however, that it was unlikely that this aspect of our stimuli affected the priming patterns observed in Experiment 2 because the control primes were selected in such a way that the two types of the related pairs shared exactly one extra mora sound relative to their respective control primes (e.g., 発案 /ha.*tu-a.N*/ vs. 立案 /ri.*tu-a.N*/ and 迫害 /ha.*ku-ga.i*/ vs. 薬害 /ja.*ku-ga.i*/). Nevertheless, it is possible that the priming effect is sensitive to the amount of *consecutive* initial phonological component overlap between the prime-target pairs (e.g., Mousikou et al., 2010a; Schiller, 2008; but see Kinoshita, 2000). Mora-related and character-sound-related pairs were different in that sense, and this difference was not eliminated by their control primes. Thus, it is still possible to assume that a larger priming effect for the character-sound-related pairs was due to their greater amount of shared consecutive sounds.

Experiment 3: Mora Priming With Kana-Transcription Stimuli

Experiment 3 was conducted to examine whether the priming effect size is modulated by the number of shared morae. Here, we transcribed the Kanji stimuli used in Experiment 2 into Kana scripts and compared the priming effect sizes for mora- and character-sound pairs. As mentioned earlier, Verdonschot et al. (2011) showed a significant mora priming effect for Kana-written stimuli, suggesting that in this paradigm, the phonological unit prepared to name Kana is the mora. Thus, when Kanji stimuli are transcribed into Kana, we expect to observe a significant mora priming effect for both types of pairs. The critical question asked in Experiment 3 was whether the priming effect size would be larger when Kana-transcribed prime-target pairs share two *consecutive* initial mora sounds (i.e., character-sound-related pairs in Experiment 2) than when they share only one initial mora sound (i.e., mora-related pairs in Experiment 2). If similar sized priming effects are observed for the two types of primes, then it would mean that the consecutive mora overlap does not enhance priming under a situation where the effect is clearly known to be mora-based. If so, it will be difficult to maintain that the differential patterns of priming observed in Experiment 2 were due to their difference in the amount of consecutive mora overlap.

Method

Participants. Thirty-six undergraduate and graduate students from Waseda University participated in this experiment (21 females, age: 21.0 years on average, *SD* = 3.3). They were paid 500 JPY in exchange for their participation. All were native Japanese speakers with normal or corrected-to-normal vision. None had participated in any of the preceding experiments.

Stimuli. Primes and targets were the same as those used in Experiment 2 but all of the stimuli were transcribed into Kana scripts (see Appendix C). Similar to Verdonschot et al. (2011), primes were transcribed into Katakana and the targets were transcribed into Hiragana. Because Katakana and Hiragana characters are different in appearance, although both have one-to-one correspondence onto morae, this transcription minimized orthographic overlap between the prime and target. Thus, in Experiment 3, a Hiragana-transcribed target (e.g., はくぶつ /ha.ku.bu.tu/) was primed by four types of Katakana-transcribed primes: mora-related (e.g., ハツアン /ha.tu.a.N/), mora-control (e.g., リツアン /ri.tu.a.N/), character-sound-related (ハクガイ /ha.ku.ga.i/), and character-sound-control (e.g., ヤクガイ /ja.ku-.ga.i/). Note that the prime types specified here correspond to those of the Kanji pairs in Experiment 2. Because each Hiragana and Katakana character corresponds to a single mora sound, in Experiment 3, mora-related primes were essentially words sharing an initial single mora with their targets and the character-sound-related primes were words sharing two initial consecutive morae with their targets. It should also be noted that when Kanji written stimuli are transcribed into Kana, they essentially become nonwords in a sense that they have no orthographic level representations (i.e., they are visually unfamiliar to Japanese readers). This was not problematic for the purpose of the present experiments, because priming effects in this task is known to be unaffected by the lexicality of the stimuli (e.g., Horemans & Schiller, 2004; Kinoshita, 2000; Mousikou et al., 2010a).

Apparatus and procedure. The apparatus and procedure were the same as those in Experiment 2.

Results

Response latencies faster than 300 ms and slower than 1,300 ms were regarded as outliers and excluded from the statistical analyses (0.1%). Naming errors (1.3%) were also excluded from the latency analyses and voice-key errors (1.1%) were excluded from the entire analyses. The mean response latencies and error rates are presented in Table 5.

For response latency, the main effect of block order was significant, $F_s(3, 105) = 39.82$, $p < .001$, $MSE = 2893.7$, $\eta_p^2 = .53$; $F_i(3, 81) = 124.13$, $p < .001$, $MSE = 775.1$, $\eta_p^2 = .82$. Overall naming latencies became faster as the block progresses, with the difference from the first to third blocks being all significant, all *p*s < .05. As in Experiment 2, block order did not significantly interact with the pattern of priming effects for naming latency, all *F*s < 2.01, with an exception that there was a marginal two-way interaction between block order and relatedness in the subject

Table 5
Mean Naming Latencies in Milliseconds (Error Rates) for Hiragana-Transcribed Targets Primed by Mora Related, Mora Control, Character Sound Related, and Character Sound Control Katakana-Transcribed Words Along With Priming Effects in Experiment 3

	Mora primes		Character sound primes	
Relatedness	Examples	RT (ER)	Examples	RT (ER)
Related	ハツアン – はくぶつ /*ha*.tu.a.N/ - /*ha*.ku.bu.tu/	533 (1.2%)	ハクガイ– はくぶつ /*ha*.*ku*.ga.i/ - /*ha*.*ku*.bu.tu/	530 (.7%)
Control	リツアン – はくぶつ /ri.tu.a.N/ - /ha.ku.bu.tu/	549 (1.8%)	ヤクガイ – はくぶつ /ja.ku.ga.i/ - /ha.ku.bu.tu/	546 (1.4%)
Priming effect		15 (.6%)		16 (.7%)

Note. RT and ER stand for mean response latencies and error rates, respectively.

analysis, $F_s(3, 105) = 2.46$, $p = .067$, $MSE = 883.8$, $\eta_p^2 = .07$, which was not significant in the item analysis, $F_i(3, 81) = 1.54$, $p = .209$, $\eta_p^2 = .05$. The main effect of relatedness was significant, $F_s(1, 35) = 34.28$, $p < .001$, $MSE = 976.6$, $\eta_p^2 = .49$; $F_i(1, 27) = 31.71$, $p < .001$, $MSE = 770.9$, $\eta_p^2 = .54$; across phonological overlap, targets preceded by the related primes were responded to significantly faster than the same targets preceded by the control primes (532 ms vs. 547 ms). The main effect of phonological overlap was not significant, both Fs < 1. Critically, there was no significant interaction between phonological overlap and relatedness, both Fs < 1.2, indicating that priming effects were statistically equivalent for the pairs sharing the two initial morae (16 ms effect) and for the pairs sharing the initial single mora (15 ms effect).

For errors, the main effect of block order was significant, $F_s(3, 105) = 4.56$, $p = .005$, $MSE = 21.1$, $\eta_p^2 = .12$; $F_i(3, 81) = 4.26$, $p = .008$, $MSE = 18.5$, $\eta_p^2 = .14$. The main effect of relatedness was marginal in the subject analysis, $F_s(1, 35) = 2.98$, $p = .093$, $MSE = 20.6$, $\eta_p^2 = .08$, but not in the item analysis, $F_s(1, 27) = 2.52$, $p = .124$, $\eta_p^2 = .09$. No other significant effect was detected, all Fs < 2.63.

Discussion

When the Kanji prime-target pairs used in Experiment 2 were transcribed into Kana scripts, a significant mora priming effect was observed in Experiment 3. We were, thus, successful to replicate Verdonschot et al.'s (2011) findings which, similarly, used Kana stimuli. In addition, the priming effect sizes were not statistically different for pairs sharing the two initial mora sounds and the one single mora sound. In other words, we demonstrated that an additional mora overlap beyond the initial one provides little extra facilitation (a nonsignificant 1 ms difference) even under the situation where the phonological unit is known to be the mora. The present results therefore suggested that the significant priming effect for the character-sound-related Kanji pairs versus the null priming effect for the mora-related Kanji pairs in Experiment 2 are not likely due to the differential amounts of consecutive mora sound overlap.

Before we go on, we should note that the results of Experiment 3 (with Kana stimuli) were in fact analogous to the pattern of the MOPE observed for English speakers (Kinoshita, 2000). Using the same type of control primes used in the present experiments, Kinoshita (2000) also found that an additional phoneme overlap (the phonological unit in English) beyond the initial phoneme did not result in a greater priming effect. That is, although the naming latencies were 3 ms shorter when her prime-target pairs shared two-letters (e.g., *si*f - *SI*B) than when they shared one-letter (e.g., *s*uf - *S*IB), this difference was statistically not significant. It should also be noted, however, that Mousikou et al. (2010a), using similar control primes, did report a statistically significant priming advantage for English nonword prime-target pairs sharing two consecutive phonemes over the pairs sharing one initial phoneme. However, the size of the advantage was very small (a 4 ms difference). These results appear to suggest that priming effects in this type of naming task are particularly sensitive to the overlap of the initial sound corresponding to the word's phonological unit (i.e., phonemes for English words and morae for Japanese Kana words), and an additional sound overlap provides relatively little extra benefit, at least when the contrast is made between one versus two sound overlap.

In Experiments 1 and 2, a standard mora priming effect did not emerge for Kanji words. In contrast, significant priming effects emerged when the prime-target pairs shared the entire sound of their first Kanji characters (character-sound priming). Experiment 3 suggested that the differential priming patterns for the mora-related versus character-sound-related pairs in Experiment 2 were not due to the amount of consecutive phonological component overlap available between the two types of prime-target pairs. Those results are all consistent with the idea that the phonology prepared to name Kanji compounds is *the whole sound of each Kanji character*.

There are, however, still other potential factors that could have led to the absence of mora priming effects in Experiments 1 and 2 that need addressing.[8] In Japanese, a single syllable could be composed of a mora or two consecutive morae. For instance, whereas a single mora such as /ze/ corresponds to a single syllable, two consecutive morae such as those containing nasal coda, /ze.N/, also correspond to a single syllable. Due to the characteristics, in our experiments, although most of the initial Kanji characters of the related pairs contained two mora sounds, some of the pairs differed in their syllabic structure (about 73% of the stimuli). That is, in some cases, the sound of the prime's initial character was monosyllabic (e.g., 全 /ze.N/ in 全国 **/ze.N**-ko.ku/ "the whole country") whereas that of the target's initial character was bisyl-

[8] We thank Sachiko Kinoshita for pointing out this possibility to us.

labic (e.g., 絶 /ze.tu/ in 絶妙 **/ze.tu**-mjo.u/ "superb") or vice versa. As previously shown using Mandarin, the phonological unit of Chinese words (i.e., logographic characters) is closely linked to the syllable. Given that Kanji are also logographic characters, it is necessary to assess whether our results might have been affected by this property present in a subset of our prime-target pairs. In addition, in Experiments 1 and 2, some of the prime-target pairs also had different pitch accent (i.e., tone) patterns (which we will discuss in more detail below). Although tonal information is assumed to play little role in the selection of the phonological unit (e.g., Roelofs, 2015), empirical support for this assumption comes from studies using the implicit priming paradigm (e.g., O'Seaghdha et al., 2010). We therefore need to verify that this aspect of the stimuli did not affect the observed results obtained in the masked priming paradigm.

Experiment 4: Mora Priming With Kanji Compounds Sharing the Metrical Structure

Experiment 4 was conducted using a set of stimuli that were matched both in the syllabic structure and the pitch accent (i.e., tonal) patterns of the prime-target pairs. The initial Kanji characters of the primes (both related and control) and targets always contained two mora sounds and were dysillabic. The pitch-accent pattern of prime-target pairs was also matched. In Japanese, pitch accent is a property of the language in which pitch variations (low [L]/high [H]) can be used to differentiate between words (e.g., /a.me/ [LH] for "candy" and /a.me/ [HL] for "rain"; see Tamaoka, Saito, Kiyama, Timmer, & Verdonschot, 2014). The critical Kanji prime-target pairs shared the initial mora sound (e.g., 確定 **/*ka*.ku**-te.i/ "settlement" – 辛口 **/*ka*.ra**-ku.ti/ "dry") but did not share the entire sound of the initial Kanji character (identical to the mora related pairs in Experiment 2).

Method

Participants. Thirty-seven undergraduate and graduate students from Waseda University participated in Experiment 4 (12 females; age: 20.1 years on average, $SD = 1.4$) and were paid 500 JPY. All were native Japanese speakers with normal or corrected-to-normal vision. All of the participants were born and raised in either Tokyo, Kanagawa, Saitama, or Chiba prefecture (i.e., those who speak Japanese with the standard "Tokyo" dialect). This restriction was applied because a word's pitch accent pattern can be different depending on dialects across the Japanese language. None had participated in any of the preceding experiments.

Stimuli. Targets were 24 two-character Kanji words (see Appendix D). The mean written word frequency of the targets was 0.83 occurrences per million (Amano & Kondo, 2003b). The initial Kanji characters of the targets always corresponded to two mora sounds and were disyllabic, namely, CVCV (e.g., 辛口 **/ka.ra**-ku.ti/). Each target was primed by either mora related or mora control two-character Kanji compound primes. The initial Kanji characters of the primes (both related and control) also had two mora sounds and were disyllabic. The pitch-accent pattern of the prime-target pairs was also matched according to Amano and Kondo (2003a). The mora related primes shared their initial mora sound with the targets (e.g., 確定 **/*ka*.ku**-te.i/ - 辛口 **/*ka*.ra**-ku.ti/), but otherwise they were orthographically, morphologically, and semantically unrelated. The mora control primes did not share the initial mora sound with the targets (e.g., 特定 **/to.ku**-te.i/ - 辛口 **/ka.ra**-ku.ti/) and were orthographically, phonologically, morphologically, and semantically unrelated. The mora related and their control primes always had different first Kanji characters but always had the same second character of the identical pronunciation (e.g., 確定 **/ka.ku**-*te.i*/ and 特定 **/to.ku**-*te.i*/).

As shown in Table 6, the two types of the primes were matched on a number of variables. One-way ANOVAs showed that there was no significant difference in any of these variables across the two prime types, all $F\text{s} < 1$. Semantic relatedness ratings were also collected from a group of 46 participants (who did not take part in any of the experiments), which confirmed that the two types of prime-target pairs were equally semantically unrelated ($M = 1.8$ and 1.8, for the mora and control pairs, respectively), $F < 1$. Two counterbalancing lists were created so that in one list, half of the targets were primed by mora related primes, and the other half were primed by mora control primes. In the other list, the paring

Table 6
Statistical Characteristics of Mora Related and Mora Control Primes Used in Experiment 4

Examples	Mora related prime 確定 – 辛口 **/*ka*.ku**-te.i/ - **/*ka*.ra**-ku.ti/	Mora control prime 特定 – 辛口 **/to.ku**-te.i/ - **/ka.ra**-ku.ti/	
Lexical variables			*p*-value
Mora	4.0	4.0	1.00
Freq	50.0	43.1	.80
OFam	5.7	5.8	.99
PFam	5.6	5.5	.69
N	58.6	58.5	.64
CF	832141	784770	.80
Strokes	17.7	19.0	.44
OnRatio	.8	.9	.35
Rel	1.8	1.8	.99

Note. Mora, Freq, OFam, PFam, N, CF, Strokes, OnRatio, and Rel stand for mean number of morae, mean word frequency (per million), mean orthographic familiarity rating, mean phonological familiarity rating, mean orthographic neighborhood size, mean summed character frequency, mean number of strokes, mean on-reading ratio, and mean semantic relatedness rating, respectively.

was reversed for each pair. Each participant received the two counterbalancing lists in two separate blocks, with the order of presentation counterbalanced across participants. Within each block, the trial order was randomized for each participant.

Apparatus and procedure. The apparatus and procedure were identical to those in Experiments 2 and 3.

Results

The data from one participant were excluded because of high error rates (>15%). Response latencies faster than 300 ms and slower than 1,300 ms were regarded as outliers and excluded from the statistical analyses (2.6% of the data). Error responses (3.3%) were also excluded from the latency analyses. Furthermore, voice-key errors (1.0%) were also excluded from the entire analyses. The mean response latencies and error rates are presented in Table 7.

The analyses were performed by repeated measures ANOVA with prime type and block order as factors. For response latency, the main effect of block order was significant, $F_s(1, 35) = 127.92$, $p < .001$, $MSE = 3417.2$, $\eta_p^2 = .79$; $F_i(1, 23) = 220.80$, $p < .001$, $MSE = 1428.6$, $\eta_p^2 = .91$. Block order did not interact with prime type, both Fs < 1. Importantly, there was no main effect of prime type in the latency analyses, both Fs < 1, reflecting the fact that no priming effect was detected in the analyses of response latencies.

For errors, the main effect of block order was significant $F_s(1, 35) = 11.08$, $p = .002$, $MSE = 25.9$, $\eta_p^2 = .24$; $F_i(1, 23) = 7.83$, $p = .010$, $MSE = 24.3$, $\eta_p^2 = .25$. Block order did not interact with prime type, both Fs < 1. Consistent with the response latency analysis, the main effect of prime type was not significant, $F_s < 1$; $F_i(1, 23) = 2.16$, $p = .156$, $\eta_p^2 = .09$.

Discussion

Experiment 4 was conducted to rule out two potentially confounding factors which may have affected the earlier results (of Experiments 1 and 2), namely the lack of a mora priming effect may have been due to the mismatch in the syllabic structure and the pitch-accent patterns in the subset of our Kanji prime-target pairs used in Experiments 1 and 2. Replicating the results of Experiments 1 and 2, however, no mora priming effect was found for the prime-target pairs that shared the initial mora sound (but did not share the whole sound of the initial character) even when the prime and target shared the same syllabic structure and the same pitch-accent pattern. This indicates that the differences in syllabic structure and pitch accent patterns were not responsible for the absence of the mora priming effect.

Table 7
Mean Naming Latencies in Milliseconds (Error Rates) for Kanji Targets Primed by Mora Related and Mora Control Words, With a Net Priming Effect in Experiment 4

Prime type	Examples	RT (ER)
Related	確定 – 辛口 /***ka*.ku**-te.i/ - /***ka*.ra**-ku.ti/	710 (3.2)
Control	特定 – 辛口 /**to.ku**-te.i/ - /**ka.ra**-ku.ti/	712 (3.7)
Priming effect		2 (.5)

Note. RT and ER stand for mean response latencies and error rates, respectively.

Experiment 5: "Mora" Priming With Kanji Compounds

The results in Experiment 1–4 so far have been all consistent with the idea that the phonology prepared to name Kanji compounds is *the whole sound of each Kanji character*. Yet, support for this hypothesis was mainly derived from Kanji prime-target pairs that had two mora sounds in their first characters. The most straightforward and strongest support for this proposal would come from a demonstration of "a mora priming effect" with Kanji words: Facilitation from a mora-related Kanji prime in the naming of a Kanji target when the shared single mora sound corresponds to the whole sound of the pair's first characters (as was observed in the subset of the prime-target pairs used in Experiment 1). Experiment 5 attempted to examine whether this effect is found for Kanji words.

In Experiment 5, the critical pairs were Kanji prime-target pairs that shared their initial mora sound, and that the mora sound was the whole sound of their first Kanji characters, such as 化石 (/***ka***-se.ki/ "fossil") - 火力 (/***ka***-rjo.ku/ "heating power") pair. Further, we also included another type of Kanji prime-target pairs, namely, the pairs that shared their initial mora sound, but the mora sound was *not the whole sound of the prime's first character*, such as 確保 (/***ka*.ku**-ho/ "securement") - 火力 (/***ka***-rjo.ku/). Because the phonology prepared from the prime does not match the phonological unit used when naming the target, no priming effect would emerge for this type of prime-target pairs.

Method

Participants. Thirty-six undergraduate and graduate students from Waseda University participated in Experiment 5 (16 females, age: 21.1 years on average, $SD = 1.6$) and were paid 500 JPY. All were native Japanese speakers with normal or corrected-to-normal vision. None had participated in any of the preceding experiments.

Stimuli. Targets were 48 two-character Kanji words (see Appendix E). The mean written word frequency of the targets was 1.18 occurrences per million (Amano & Kondo, 2003b). The initial Kanji characters of the targets always corresponded to a single mora sound (e.g., 火力 /**ka**-rjo.ku/, 会釈 /**e**-sja.ku/). For each target, three types of primes were selected: a mora-related character-sound match prime (henceforth a character-sound match prime), a mora-related character-sound mismatch prime (henceforth a character-sound mismatch prime), and a control prime. A character-sound match prime shared the initial mora sound with its target and the shared mora was the whole sound of their first Kanji characters (e.g., 化石 /***ka***-se.ki/ - 火力 /***ka***-rjo.ku/). A character-sound mismatch prime also shared the initial mora with its target but the sound of the prime's and target's first characters did not match (e.g., 確保 /***ka*.ku**-ho/ - 火力 /***ka***-rjo.ku/). The control prime did not share any mora sound with its target (e.g., 直視 /**cho.ku**-si/ "direct sight" - 火力 /***ka***-rjo.ku/). Among 48 control primes, 23 control primes involved the first character whose pronunciation consisted of a single mora and the rest of the control primes involved the first character whose pronunciation consisted of two morae. Across the three prime types, none of the prime-target pairs

Table 8
Lexical Characteristics of Character-Sound Match, Character-Sound Mismatch and Control Primes Used in Experiment 5

	Character-sound match	Character-sound mismatch	Control	
Examples	化石 – 火力 /***ka***-se.ki/ - /***ka***-rjo.ku/	確保 – 火力 /***ka***-**ku**.ho/ - /***ka***-rjo.ku/	直視 – 火力 /**cjo.ku**-si/ - /**ka**-rjo.ku/	
Variables				*p*-value
Mora	3.00	3.00	3.00	1.00
Freq	38.6	38.3	36.9	.98
OFam	5.8	5.8	5.9	.82
PFam	5.7	5.6	5.7	.75
N	43.6	46.2	45.8	.91
CF	583956	565317	629041	.84
Strokes	18.2	18.8	18.7	.81
OnRatio	.9	.9	.9	.96
Rel	1.7	1.7	1.8	.90

Note. Mora, Freq, OFam, PFam, N, CF, Strokes, OnRatio, Rel stand for mean number of morae, mean word frequency (per million), mean orthographic familiarity rating, mean phonological familiarity rating, mean orthographic neighborhood size, mean summed character frequency, mean number of strokes, mean on-reading ratio, and mean semantic relatedness rating, respectively.

contained the same Kanji character and, hence, they were all orthographically, morphologically, and semantically unrelated.

As shown in Table 8, the three prime types were matched on the relevant lexical variables. One-way ANOVAs confirmed that the three prime types were not significantly different on any of those variables (all *F*s < 1). In order to make sure that three types of prime-target pairs are equally semantically unrelated at the whole word level, semantic relatedness ratings were collected from a group of 45 participants who did not participate in any of the experiments. The mean ratings for the character-sound match, character-sound mismatch, and control pairs were 1.7, 1.7, and 1.8, respectively. A one-way ANOVA revealed that the three types of primes were not significantly different from one another on the semantic relatedness ratings ($F < 1$).

In the naming task, three counterbalancing lists were created. Within each list, one third of the critical targets were primed by either the character-sound match, the character-sound mismatch, or the control primes. Across the three lists, therefore, all the targets were primed by each of the three types of the primes only once. In order to equate the proportion of the initial sound-related (i.e., character-sound match and mismatch pairs) and unrelated (i.e., control) pairs, an additional set of 16 unrelated prime-target pairs were added to each list as fillers. In addition, we presented 64 targets (48 critical and 16 filler targets) three times, so that each participant received three counterbalancing lists in three separate blocks. The block order was counterbalanced across participants. Within each block, the trial order was randomized for each participant.

Apparatus and procedure. The Apparatus and procedure were identical to those in Experiments 2, 3, and 4.

Results

Response latencies faster than 300 ms and slower than 1,300 ms were regarded as outliers and excluded from the statistical analyses (0.7% of the data). Error responses (3.1%) were also excluded from the latency analyses. Furthermore, voice-key errors (0.8%) were excluded from the entire analyses. The mean response latencies and error rates are presented in Table 9.

In the analyses, we did not use an omnibus ANOVA because the experimental design was not orthogonal (there were no separate control primes for the two critical prime types: the character-sound match and mismatch primes). Instead, priming effects were assessed separately for the character-sound match pairs and for the character-sound mismatch pairs using 3 (Block Order: 1, 2, and 3) × 2 (Relatedness: related vs. control) repeated measures ANOVAs.

Character-sound match pairs. For naming latencies, the main effect of block order was significant, $F_s(2, 70) = 47.25$, $p < .001$, $MSE = 1994.5$, $\eta_p^2 = .57$; $F_i(2, 94) = 135.42$, $p < .001$, $MSE = 974.0$, $\eta_p^2 = .74$. Block order did not interact with relatedness, both *F*s < 1. Critically, there was a significant effect of relatedness, $F_s(1, 35) = 11.45$, $p = .002$, $MSE = 464.0$, $\eta_p^2 = .25$; $F_i(1, 47) = 10.25$, $p = .003$, $MSE = 1253.7$, $\eta_p^2 = .18$. When the prime-target pairs shared their initial mora sound *and* the shared

Table 9
Mean Naming Latencies in Milliseconds (Error Rates) for Targets Primed by Mora Related Character-Sound Match, Mora Related Character-Sound Mismatch, and Control Words Along With Priming Effects in Experiment 5

Prime type	Examples	RT (ER)
Character-sound match	化石 – 火力 /***ka***-se.ki/ - /***ka***-rjo.ku/	611 (2.0%)
Character-sound mismatch	確保 – 火力 /***ka***.**ku**-ho/ - /***ka***-rjo.ku/	626 (2.4%)
Control	直視 – 火力 /**cho.ku**-si/ - /**ka**-rjo.ku/	623 (3.0%)
Priming effect (match)		12 (1.0%)
Priming effect (mismatch)		−3 (.6%)

Note. RT and ER stand for mean response latencies and error rates, respectively. RT and ER for filler stimuli were 630 ms and 5.2%, respectively.

sound corresponded to the whole sound of their first Kanji characters (e.g., 化石/***ka***-se.ki/- 火力/***ka***-rjo.ku/), there was a significant 12-ms mora priming effect.

For errors, the main effect of block order was significant, $F_s(2, 70) = 7.21$, $p = .001$, $MSE = 14.2$, $\eta_p^2 = .17$; $F_i(2, 94) = 4.28$, $p = .017$, $MSE = 31.8$, $\eta_p^2 = .08$. Consistent with the naming latency data, block order did not interact with relatedness, both *F*s < 1.1. The main effect of relatedness was significant in the subject analysis, $F_s(2, 70) = 5.41$, $p = .003$, $MSE = 9.6$, $\eta_p^2 = .13$, although marginal in the item analysis, $F_i(2, 94) = 3.57$, $p = .065$, $MSE = 19.3$, $\eta_p^2 = .07$.

Character-sound mismatch pairs. For naming latencies, the main effect of block order was significant, $F_s(2, 70) = 72.74$, $p < .001$, $MSE = 1630.7$, $\eta_p^2 = .68$; $F_i(2, 94) = 185.87$, $p < .001$, $MSE = 927.8$, $\eta_p^2 = .80$. The main effect of relatedness was not significant (a −3 ms difference), both *F*s < 1.8. Unlike the character-sound match pairs, there was a significant interaction between block order and relatedness, $F_s(2, 70) = 3.16$, $p = .048$, $MSE = 503.4$, $\eta_p^2 = .08$; $F_i(2, 94) = 3.18$, $p = .046$, $MSE = 743.2$, $\eta_p^2 = .06$. Follow-up analyses of the interaction revealed that the priming effect was inhibitory in the first block, $F_s(1, 35) = 8.01$, $p = .008$, $MSE = 452.3$, $\eta_p^2 = .19$; $F_i(1, 47) = 5.70$, $p = .021$, $MSE = 1046.5$, $\eta_p^2 = .11$, while no significant priming effect emerged in the second and the third blocks, all *F*s < 1.

For errors, the main effect of block order was significant, $F_s(2, 70) = 15.37$, $p < .001$, $MSE = 20.2$, $\eta_p^2 = .31$; $F_i(2, 94) = 9.40$, $p < .001$, $MSE = 42.4$, $\eta_p^2 = .17$. The main effect of relatedness was not significant, both *F*s < 1.9. There was no interaction between block order and relatedness, both *F*s < 1.4. Overall, there was no mora priming effect for the character-sound mismatch prime-target pairs. That is, even if prime-target pairs shared the initial mora sound, no facilitation was observed when the sounds of the prime's and target's first Kanji characters do not match (e.g., 確保 /***ka*.ku**-ho/ - 火力 /***ka***-rjo. ku/). If anything, the priming effect tended to be inhibitory.

Discussion

When the shared mora comprised the whole sound of the initial Kanji characters for the prime and the target (e.g., 化石 /***ka***-se.ki/ - 火力 /***ka***-rjo.ku/), a significant mora priming effect was observed. This suggests that a single mora overlap is sufficient to produce a significant priming effect even with Kanji prime-target pairs. Critically, however, the shared mora must correspond to the whole sound of their initial Kanji character. When the first characters' entire sound was different between the prime and target, the initial mora overlap did not produce a priming effect (e.g., 確保 /***ka*.ku**-ho/ - 火力/***ka***-rjo.ku/). This indicates that, at least in the masked priming paradigm, the phonological unit prepared in naming Kanji compounds is *the whole sound of each Kanji character*. Thus, a priming effect is observed only when the size of phonology activated by a prime is the same as the one used in the naming of a target.

Experiment 6: Replication of the Mora Priming Effect Using a Different Stimulus Set

The data from Experiment 5 have important implications concerning the phonological unit used in the production of Kanji words. Although these results were clear-cut, we did believe that a replication of the effect is necessary in order to strengthen this novel finding (i.e., the phonological unit prepared for Kanji words corresponds to the whole sound of each Kanji character). Therefore, Experiment 6 was conducted to assess the reliability of the effect using a new set of stimuli and a different group of participants, testing exclusively the mora priming effect using the character-sound match pairs.

Method

Participants. Thirty-six undergraduate and graduate students from Waseda University participated in Experiment 6 (17 females, age: 20.6 years on average, $SD = 1.6$). They were paid a small amount of money (500 JPY) in exchange for their participation. All were native Japanese speakers with normal or corrected-to-normal vision. None had participated in any of the preceding experiments.

Stimuli. Targets were 50 two-character Kanji compounds (see Appendix F). The mean written word frequency of the targets was 1.70 occurrences per million (Amano & Kondo, 2003b). The initial Kanji characters of the targets always corresponded to a single mora sound (e.g., 字幕 /**zi**-ma.ku/). For each target, two types of primes were selected: character-sound match and control primes. As in Experiment 5, the character-sound match prime shared the initial mora sound with its target *and* the mora sound was the entire sound of the first character (e.g., 地盤 /***zi***-ba.N/ "ground" - 字幕 /***zi***-ma.ku/ "subtitles"). The control prime was phonologically identical to the character-sound match prime except for the initial mora sound being different (e.g., 基盤 /**ki**-ba.N/ "basis"). The character-sound match and control primes had different first Kanji characters but they shared the same second Kanji character with the identical pronunciation (e.g., 地盤 /**zi**-*ba.N*/ vs. 基盤 /**ki**-*ba.N*/). Across the prime types, none of the prime-target pairs had the same Kanji character and they were all orthographically, morphologically, and semantically unrelated with each other.

As shown in Table 10, the two types of the primes were matched on a number of variables. One-way ANOVAs assured that there were no significant differences in any of these variables across the two prime types, all *F*s < 1. Semantic relatedness ratings were also collected from a group of 30 participants (who did not take part in any of the experiments), which confirmed that the two types of prime-target pairs were equally unrelated with each other ($M = 1.8$ and 2.1, for the character-sound match and control pairs, respectively), $F(1, 49) = 2.78$, $p = .102$. In the naming task, two counterbalancing lists were created such that in one list, half of the targets were primed by character-sound match primes, and the other half was primed by control primes. In the other list, the paring was reversed for each pair. Each participant received the two counterbalancing lists in two separate blocks, with the order of presentation counterbalanced across participants. Within each block, the trial order was randomized for each participant.

Apparatus and procedure. The apparatus and procedure were identical to those in Experiments 2, 3, 4, and 5.

Results

Response latencies faster than 300 ms and slower than 1,300 ms were regarded as outliers and excluded from the statistical

Table 10
Lexical Characteristics of Character-Sound Match and Control Primes Used in Experiment 6

Examples	Character-sound match 地盤 – 字幕 /***zi***-ba.N/ - /***zi***-ma.ku/	Control 基盤 – 字幕 /**ki**-ba.N/ - /**zi**-ma.ku/	
Lexical variables			*p*-value
Mora	2.9	2.9	1.00
Freq	31	33	.76
OFam	5.8	5.8	.80
PFam	5.6	5.5	.90
N	51.0	49.6	.74
CF	674341	653335	.82
Strokes	18.2	18.0	.87
OnRatio	.8	.8	.84
Rel	1.8	2.1	.10

Note. Mora, Freq, OFam, PFam, N, CF, Strokes, OnRatio, and Rel stand for mean number of morae, mean word frequency (per million), mean orthographic familiarity rating, mean phonological familiarity rating, mean orthographic neighborhood size, mean summed character frequency, mean number of strokes, mean on-reading ratio, and mean semantic relatedness rating, respectively.

analyses of the response latencies (0.9% of the data). Error responses (2.6%) were also excluded from the latency analyses and voice-key errors (0.4%) were excluded from the entire analyses. The mean response latencies and error rates are presented in Table 11.

The analyses were performed by repeated measures ANOVA with prime type and block order as factors. For response latency, the main effect of block order was significant, $F_s(1, 35) = 144.44$, $p < .001$, $MSE = 1354.6$, $\eta_p^2 = .80$; $F_i(1, 49) = 221.68$, $p < .001$, $MSE = 1230.4$, $\eta_p^2 = .82$. Block order did not interact with prime type, all Fs < 1. Replicating the finding of Experiment 5, the main effect of prime type was significant in the latency analyses, $F_s(1, 35) = 21.04$, $p < .001$, $MSE = 293.4$, $\eta_p^2 = .38$; $F_i(1, 49) = 15.35$, $p < .001$, $MSE = 1104.3$, $\eta_p^2 = .24$. Naming latencies were, on average, 13 ms faster when the targets were preceded by the character-sound match primes than by the control primes.

For errors, the main effect of block order was significant $F_s(1, 35) = 11.82$, $p = .002$, $MSE = 15.8$, $\eta_p^2 = .25$; $F_i(1, 49) = 7.37$, $p = .009$, $MSE = 35.2$, $\eta_p^2 = .13$. Block order did not interact with prime type, both Fs < 1. Error rates were very small and the main effect of prime type was not significant in either analysis, all Fs < 1.

Table 11
Mean Naming Latencies in Milliseconds (Error Rates) for Kanji Targets Primed by Character-Sound Match and Control Words, With a Net Priming Effect in Experiment 6

Prime type	Examples	RT (ER)
Character-sound match	地盤 – 字幕 /***zi***-ba.N/ - /***zi***-ma.ku/	617 (3.2%)
Control	基盤 – 字幕 /**ki**-ba.N/ - /**zi**-ma.ku/	630 (3.7%)
Priming effect		13 (.5%)

Note. RT and ER stand for mean response latencies and error rates, respectively.

Discussion

Again, the results were clear. In Experiment 6, we successfully replicated the significant mora priming effect observed in Experiment 5. That is, there was a significant priming effect when the prime-target pairs shared their initial mora sound that corresponded to the entire sound of their initial Kanji characters. The results contrasted sharply with those in Experiment 1, where the majority of the pairs shared only a part of the sounds of the initial Kanji characters. Our conclusion therefore held up to the test and we propose that the phonological unit involved in the naming of Kanji words is the whole sound of each Kanji character, instead of the mora.

General Discussion

The phonological unit involved in phonological encoding has typically been assumed to be the phoneme (e.g., Dell, 1986; Levelt et al., 1999; Meyer, 1990, 1991; Roelofs, 1996). Recent studies, however, are starting to show that the specific unit is different across languages. The phonological unit in Chinese has been proposed to be the syllable (e.g., Chen et al., 2002, 2003; O'Seaghdha et al., 2010) and the mora in Japanese (e.g., Kureta et al., 2006; Verdonschot et al., 2011). To accommodate these recent findings, O'Seaghdha et al. (2010) proposed the concept of "*proximate units*" which are the initially selectable phonological units used in speech production processes that can vary across languages. The proximate unit has mainly been investigated using the implicit priming and the masked priming paradigms.

As noted earlier, it has been shown that the mora plays a functional role in Japanese word production (e.g., Ida et al., 2015; Kureta et al., 2006; Verdonschot et al., 2011). These results were obtained using Japanese Kana, Romaji, and a set of mixed stimuli consisting of Kana and Kanji words. The present experiments reexamined the phonological unit for Japanese Kanji words. Because the proximate units principle assumes that the first selectable unit is different across languages, but not taking into account script types, it was unclear whether the phonological unit of Japanese words is always the mora irrespective of script type. The present study investigated this in six masked priming experiments by examining mora priming effects for Kanji words.

The results can be summarized as follows: In Experiment 1, there was no mora priming effect for Kanji word pairs. In Experiment 2, however, a significant priming effect was observed when the prime and the target shared the whole sound of their first Kanji characters. One of the possible explanations for these findings was that the character-sound-related priming effects were due to larger phonological overlap for the character-sound-related pairs (e.g., 迫害 ***/ha.ku***-ga.i/ - 博物 ***/ha.ku***-bu.tu/) than for the mora-related pairs (e.g., 発案 ***/ha*****.tu**-a.N/ - 博物 ***/ha*****.ku**-bu.tu/). However, this explanation was refuted in Experiment 3 because when the stimuli used in Experiment 2 were transcribed into Kana, the two types of prime-target pairs produced equivalent priming effects. Another possible account for the absence of the mora priming effect in Experiments 1 and 2 concerned the mismatch in the syllabic structure and the pitch pattern in the subsets of the prime-target pairs used in these experiments. The results in Experiment 4, however, ruled out these possibilities because there was no mora priming effect even when those aspects of the stimuli were eliminated. In addition, in Experiments 5 and 6, we found a significant mora priming effect for Kanji word pairs when the shared initial mora corresponds to the whole sound of the first characters of the prime and target (e.g., 化石 ***/ka***-se.ki/ - 火力 ***/ka***-rjo.ku/). On the other hand, a priming effect was not found when the target was preceded by the prime which shared their initial mora sound with the target but the shared mora sound was not the entire sound of the prime's first character (e.g., 確保 ***/ka*****.ku**-ho/ - 火力 ***/ka***-rjo.ku/).[9]

Based on these findings, we conclude that the phonological unit computed in the naming of Japanese Kanji words is not the mora but the whole sound of a Kanji character. Figure 1 delineates how Kanji primes intersect with targets in the masked priming naming task. According to Chen et al. (2016), who extended the proximate units principle to the masked priming paradigm, Chinese character (word) primes would first activate corresponding syllable as the proximate units. We suggest that, therefore, when a Japanese Kanji word prime is presented (e.g., 博物 **/ha.ku**-bu.tu/), phonological units corresponding to each Kanji character are first activated (e.g., /ha.ku/). Similarly, the target would also first activate their phonological units at the "character-sized" level. Thus, when primes and targets have the same "character-sized" unit (e.g., /ha.ku/ for 迫害 - 博物 pair), there would be a significant priming effect (Figure 1A), as was observed in Experiments 2 (for the character-sound related pairs), 5 (for the character-sound match pairs), and 6. By contrast, when the same "character-sized" unit is not activated, there would be no priming effect (Figure 1B), as in Experiments 1, 2 (for the mora related pairs), 4, and 5 (for the character-sound mismatch pairs). It should be noted that, as proposed by Chen et al. (2016), the "character-sized" units (e.g., /ha.ku/) would be subsequently decomposed into each mora (e.g., /ha/ and /ku/) and perhaps into segments (e.g., /h/, /a/, /k/, and /u/) in order to be articulated.

Different Phonological Units for Kana and Kanji Stimuli?

Our results suggested that in a masked priming naming task, the first selectable phonological unit used to prepare the speech output in Japanese is not always the mora, but may depend on the script type in which the stimuli are presented. The contrasting results in Experiments 2 and 3 highlight this aspect. That is, in Experiment 2 using Kanji stimuli, a significant priming effect was observed for the character-sound-related pairs (but not for the mora-related pairs) whereas in Experiment 3, using a Kana transcribed version of the Kanji stimuli used in Experiment 2, a significant priming effect was observed for the mora-related pairs (and also the character-sound-related pairs). Those results indicate that in the naming of Kanji words, the whole sound of a Kanji character is prepared, whereas it is the mora that is prepared in the naming of Kana words. Nevertheless, with Kanji compounds, a mora priming effect was observed when the shared mora was the whole sound of the compounds' first characters (in Experiments 5 and 6). These results indicate that although the actual phonological unit prepared can be different for Kana and Kanji (and even within Kanji), a significant priming effect always emerges when the prime-target pairs shared the initial sound possessed by their first characters.

How then are phonological units for Kanji and Kana words determined? Here, we would like to refer to the *psycholinguistic grain size* theory (e.g., Goswami, Ziegler, Dalton, & Schneider, 2003; Ziegler & Goswami, 2005, 2006; Ziegler, Perry, Jacobs, & Braun, 2001) to help account for the development of different-sized phonological units for Kanji and Kana words. According to this theory, the phonological grain size which is computed from orthography differs depending on the nature of orthographic-phonological relationships (which vary across languages). For languages with consistent grapheme-to-phoneme relationships (e.g., Greek, German, and Spanish), phonological coding would be based mainly on grapheme-phoneme conversion as they are reliable in these languages. For languages with inconsistent grapheme-to-phoneme relationships (e.g., French and English), on

[9] One may argue that the target's initial mora must be activated by the prime to obtain a significant mora priming effect. That is, for those primes whose initial Kanji characters correspond to a target's single onset mora, there would be a priming effect as the primes would activate only the relevant mora (e.g., /ka/ for 火力 **/ka**-rjo.ku/), rather than the whole sequence of morae which includes the critical mora in the first position (e.g., /ka.N/ for 漢字 **/ka.N**-zi/). Thus, we conducted a new experiment using a different stimulus set ($N = 40$) in which initial Kanji characters of the primes comprised a single mora (e.g., 火力 **/ka**-rjo.ku/) and those of the targets comprised two morae (e.g., 確保 **/ka.ku**-ho/). If the above-mentioned reasoning was indeed correct, a significant priming effect would arise and we thank an anonymous reviewer for suggesting this experiment to us. Thirty-six undergraduate and graduate students from Waseda University participated (19 females; age: 21.0 years on average, $SD = 1.8$). The related and control Kanji word primes were selected for each target in the similar manner as in the preceding experiments. The apparatus, procedure, and analyses were identical to those in Experiment 6. Mean response latencies and error rates were comparable for the related pairs (635 ms, 1.28%) and for the unrelated pairs (635 ms, 1.53%), all $Fs < 1$. The results clearly indicated that the activation of the initial mora of the target from the prime was not sufficient to produce a priming effect for Kanji word pairs. Rather, the results were in line with the idea that a priming effect arises only when the shared initial mora between the prime and target corresponds to the whole sound of the initial Kanji characters of the prime and target.

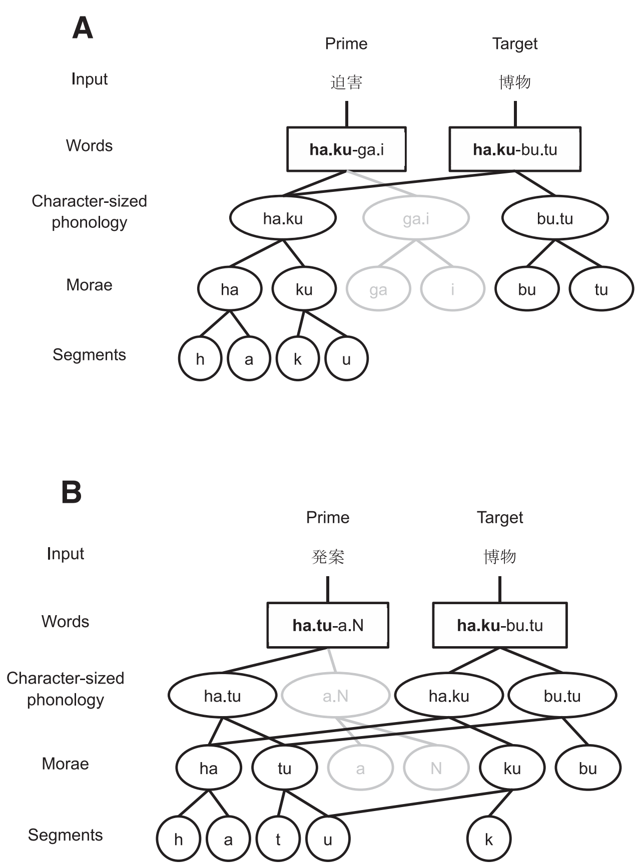

Figure 1. Schematic models of processing phonological units in the masked priming naming task. Adapted from "The primacy of abstract syllables in Chinese word production," by J.-Y. Chen, P. G. O'Séaghdha, and T.-M. Chen, 2016, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*, p. 828. Copyright 2016 by the American Psychological Association. Gray units stand for phonological representations for the second characters of the primes because it is not clear whether they are activated by a brief presentation (i.e., 50 ms). (A) Character-sound match prime: The prime activates the lexical word representation and the corresponding "character-sized" proximate unit. As the target also access the same unit, a priming effect should be observed. Mora and phonemic segment encoding follow. (B) Character-sound mismatch prime: the prime activates the lexical word representation and the corresponding "character-sized" proximate unit. However, because the target accesses the different unit, a priming effect should not be observed. Facilitation by sharing the same mora and segment units might occur, but they would not be strong enough to have an influence on the behavioral indices (i.e., response latency and accuracy).

the other hand, orthographic-phonological conversions with larger grain sizes may also develop (i.e., bodies and rhymes) because the grapheme-phoneme conversions do not always produce correct pronunciations of words. Note that this does not mean that smaller grain sizes (e.g., phoneme) would not develop for French and English native speakers. They do acquire grapheme-phoneme conversion rules, although they would take longer to develop compared to people who learn more consistent languages. Therefore, skilled English readers would still show a MOPE.

By applying the grain size theory to the Japanese language, Kana (Hiragana/Katakana) to mora conversion would be easily acquired as most of Kana characters correspond to single morae. In contrast, according to Hino, Kusunose, Miyamura, and Lupker (2016), at least more than 60% of Kanji characters correspond to multiple mora sounds. Furthermore, most Kanji characters have multiple pronunciations which depend on intraword and sentence context (see Verdonschot et al., 2013b). For instance, as noted in the Introduction, a Kanji character, 朝, can be pronounced as /a.sa/ in certain compound words (e.g., 朝日 /**a.sa**-hi/), however, the same character can also be pronounced as /tjo.u/ in other compound words (e.g., 朝刊 /**tjo.u**-ka.N/). These aspects of Kanji seem to make the character-mora conversions quite ineffective. Instead, Japanese readers would use the relationships between Kanji characters and their pronunciations in order to compute phonology for Kanji words. Consequently, while the mora-sized phonology would be activated in the naming of Kana words, the phonology with larger grain sizes (i.e., character-sized phonology) would be activated in the naming of Kanji words.

An issue that should also be discussed concerns the fact that Verdonschot et al. (2011) did not observe the MOPE with Romaji stimuli. That is, naming responses were not faster for prime-target pairs sharing initial consonant (e.g., *k*oto - *K*AZE) than those sharing no phoneme (e.g., soto - KAZE). If a phonological unit is determined by the size of phonology carried by the orthographic form, one would expect a priming effect with Romaji stimuli. However, because Romaji stimuli are transcriptions of Kana characters using Roman alphabets, one mora sound is typically represented by multiple Roman letters (e.g., か = ka, そ = so, きゃ = kya, etc.). This means that when Japanese readers learn to read Romaji, letter-phoneme conversions do not take place except for a few cases (e.g., vowels and nasal coda). Consequently, a phoneme unit would not readily develop for Romaji. Instead, a mora unit would develop as a result of mapping from a group of roman letters onto a single mora sound. Romaji stimuli should then behave similarly to Kana stimuli, and this was indeed found in Verdonschot et al. (2011). Another reason concerning the lack of a MOPE with Romaji stimuli may stem from the fact that Japanese speakers seem to have very weak phoneme-sized phonological representations. For instance, Nakayama et al. (2016) showed that bilingual Japanese-English participants did not produce a MOPE with English stimuli, unless bilinguals were very proficient in their L2 (English). The Japanese-English bilinguals, who failed to show a MOPE instead showed a CV (i.e., mora) priming effect, suggesting that they may have carried over to a "Romaji" (mora) based strategy when processing L2 English words.

Masked Priming Paradigm Versus Implicit Priming Paradigm

The masked priming naming task and the implicit priming associative cuing task have been assumed to tap into the same underlying mechanism, that is, the phonological unit used in phonological encoding (e.g., Chen et al., 2003; Nakayama et al., 2016; Verdonschot et al., 2011). In fact, converging results have been reported using the two tasks in the previous literature (e.g., Forster & Davis, 1991 and O'Seaghdha et al., 2010 for English; Chen et al., 2002 and Chen et al., 2003 for Chinese; see also Schiller, 2004 and Meyer, 1991 for Dutch). However, the results in the current Kanji naming experiments with masked primes were not consistent with the previous implicit priming experiments using Japanese stimuli, suggesting that the two tasks may in fact reflect different processes (e.g., You et al., 2012). As noted previously, Kureta et al. (2006) reported a significant mora-based facilitation in their implicit priming associative cuing task, using a set of mixed stimuli including Kanji and Kana words. That is, the preparation effect was observed when the response words shared their initial mora sound even though the critical response words did not share the whole sound of their first characters (e.g., トカゲ /***to***.ka.ge/ "lizard", 灯油 /***to*****.u**-ju/ "oil", 床屋 /***to*****.ko**-ja/ "barber"). Therefore, we need to consider why different results arise depending on the experimental tasks.

One possible cause of the discrepancy is the procedural difference between the masked priming naming and the implicit priming associative cuing tasks. The most apparent difference would be in how phonology of a word is retrieved in each task. When naming a visually presented word (in the masked priming naming task), the process starts from analyzing visually presented letter strings and then sublexical/lexical information of a word become available. On the contrary, when generating a word for a cue (in the implicit priming associative cuing task), phonology of the word is retrieved from memory. Therefore, in the naming task with masked primes, the phonological codes activated by the visual stimuli may be strongly tied to its orthographic form, and this immediate information would be used to prepare for vocal responses. On the other hand, when responding from memory traces in the associative cuing tasks with the implicit priming paradigm, the phonological code of a word might have been detached from its orthographic form in memory. As a result of these aspects, a mora priming effect emerges for Kanji stimuli in the implicit priming paradigm (an implication for this is that the mora is indeed the default phonological unit in memory unless it is directly derived from visual inputs).

Several studies have reported evidence indicating that phonological codes are affected by orthography when reading aloud, but not when speaking (e.g., Alario, Perre, Castel, & Ziegler, 2007; Bi, Wei, Janssen, & Han, 2009; Roelofs, 2006; but see Damian & Bowers, 2003). For instance, using Dutch, Roelofs (2006) showed that when a phonologically homogeneous set (e.g., /s/) contained orthographically inconsistent initial letters (e.g., *s*igaar [si'xar] "cigar", *s*oldaat [sɔl'dat] "soldier", and *c*itroen [si'trun] "lemon"; i.e., s vs. c), no priming effect was observed when the task was to read aloud the written words. In contrast, using the same stimulus set, significant priming effects *were observed* in the associative cuing and the picture naming tasks in which words are not visually presented when making overt naming responses. These results indicate that orthographic information does exert a substantial influence when a task requires deriving phonology directly from a visual stimulus but not when retrieving its phonology from memory (e.g., in response to a cue or picture). Future research should investigate whether the procedural/task differences could explain the discrepancies between the present experiments and Kureta et al.'s (2006).

The difference in the results between the two tasks may also stem from the difference in terms of strategic processing. In a masked priming naming task, participants are not aware of any relationships between the prime and target, and thus the effects reflect relatively automatic processes (e.g., Forster, 1998; Forster et al., 2003). In an implicit priming associative cuing task, on the other hand, participants may recognize the phonological relationship across the target words and then actively use the information to facilitate responses. That is, because participants would have known the appropriate pronunciations of the targets in advance, thus may have become aware of the fact that the response words in the homogenious condition share their initial sound regardless of their script types. Consequently, they may have been able to strategically prepare for the vocal responses through phonological encoding, phonetic encoding, and/or articulation. As a result, the responses would be facilitated when the initial sound (i.e., mora, phoneme) was shared by these critical words.

In fact, Kureta, Fushimi, Sakuma, and Tatsumi (2015) found a significant preparation effect for word-onset phonemes using Japanese Romaji stimuli using an implicit priming associative cuing task when both the prompt and the response words were presented in Romaji. Kureta et al. (2015) suggested that the phoneme preparation effect was observed as a result of a strategic processing at later phases such that a subset of participants actively used the shared letters to aid the task performance. Therefore, it is possible that the mora priming effect in the implicit priming associative-cuing task (i.e., Kureta et al., 2006) may have been due to the strategic use of the shared initial mora across the response words. Accordingly, this may account for differential results observed for Kanji words in the Kureta et al.'s (2015) study and the present study.[10]

Note also that masked priming naming task and implicit priming associative cuing tasks can be sensitive to orthographic properties of the words in different ways. Consequently, whether the two types of tasks tap on the same first selectable phonological unit in Kanji word production is still in need of further empirical research. To be fair to the proximate units principle (O'Seaghdha et al., 2010), we should mention that this principle has been developed mainly based on findings from the implicit priming associative cuing tasks (although Chen et al., 2016 used the masked priming paradigm, their task was a picture naming task rather than a word naming task). Therefore, the possibility remains that the present results strongly reflect the *reading processes* involved when naming aloud a Kanji word and that how phonology is utilized could be different when a task is to generate a Kanji word from memory. An implicit priming associative task using exclusively Kanji words or experimental tasks that do not involve the visual presentation of Kanji words (such as picture naming task) will be needed to further appreciate the intricacies of the speech production processes.

Mechanism of the Masked Priming Naming Effects

The present results also have implications for general underlying mechanisms of how masked priming effects come about in a naming task. As noted in the Introduction, two different types of accounts have been proposed for the MOPE (MISPE): the dual-route account (e.g., Coltheart, 1978; Coltheart et al., 2001; Forster & Davis, 1991; Mousikou et al., 2010a, 2010b) and the SP account (e.g., Kinoshita, 2000, 2003; Kinoshita & Woollams, 2002;

[10] Kureta et al. (2015) also pointed out the possibility that the use of Romaji stimuli enhanced activation and utilization of phonemic information, which led to the significant phoneme preparation effect. The use of Romaji stimuli, however, did not result in significant onset-based priming in masked priming naming experiments (e.g., Ida et al., 2015; Verdonschot et al., 2011), again suggesting that the two tasks may be tapping different underlying processes.

Malouf & Kinoshita, 2007). In the following section, we will consider whether these accounts can explain the patterns of data observed with Kanji words.

The dual-route account has some difficulty in accounting for the present results. According to the dual-route account, the effect originates in the computation of phonology via the nonlexical route (e.g., Coltheart et al., 2001; Forster & Davis, 1991; Mousikou et al., 2010a, 2010b, 2015). Because most Kanji characters have multiple pronunciations and the correct pronunciations vary according to the context in which the character appears, the GPC rules are not readily applied in the naming of Kanji words (Verdonschot et al., 2013b). Therefore, assuming that Japanese Kanji words are read via the lexical route (e.g., Feldman & Turvey, 1980; Wydell et al., 1995; but see also Kayamoto, Yamada, & Takashima, 1998), the dual-route account, by principle, cannot explain why a significant priming effect arises for Kanji words.[11]

The results of the present study are mostly in line with the SP account. This account assumes that the MOPE (and presumably also the MISPE) arises at the phonological encoding stage of speech production, more specifically, at the segment-to-frame association process that occurs after the computation of phonology (e.g., Kinoshita, 2000, 2003; Kinoshita & Woollams, 2002; Malouf & Kinoshita, 2007). One reason that the present results are consistent with the SP account is that the account can predict priming even when words are processed via the lexical route (Dimitropoulou et al., 2010; Malouf & Kinoshita, 2007). That is, the effect can occur even after the lexical-level phonology has been retrieved. Although additional research is needed to more clearly explain how the segment-to-frame association process occurs for Kanji words, the present results can be explained by assuming that the phonological component (segment) prepared for naming Japanese Kanji words correspond to the whole sound of each Kanji character. For instance, when the prime, **化石 /ka**-se.ki/, is presented in a naming task, the phonology is (automatically) prepared as /ka/ and /seki/ for speech output. Thus, when the target's initial character have the same character-sized phonology (e.g., /ka/ for **火力 /ka**-rjo.ku/), there would be no delay because the phonological components are the same. On the other hand, for the same target, when the prime's initial character has different character-sized phonology (e.g., /ka.ku/ for **確保 /ka.ku**-ho/), the size of the phonological components created by the prime does not match with those of the target and, hence, would result in a delay. As a result, a priming effect would be observed for the former, but not for the latter.

The Functional Phonological Unit of Japanese Kanji, Chinese Hànzì, and Korean Hanja

Before concluding, it is important to discuss the results of the present experiments in relation to the previous findings observed for Chinese and Korean language production, as Japanese Kanji, Chinese Hànzì, and Korean Hanja are similar logographic characters. As noted earlier, many studies involving Chinese words have shown that the phonological unit for Chinese is the syllable (e.g., Chen et al., 2002, 2003; Chen & Chen, 2015; O'Seaghhda et al., 2012; You et al., 2012; but see also Verdonschot, Lai, Chen, Tamaoka, & Schiller, 2015). Here we point out that each Chinese character corresponds to a single syllable (e.g., Chen et al., 2003; Chen & Chen, 2013) and thus the phonological unit for Chinese Hànzì may also correspond to the whole sound of the character. That is, priming effects for Chinese might also be explained in terms of the match/mismatch of the entire sound of the character, rather than syllables themselves, especially when the task requires to immediately name aloud visually presented words.

In Korean speech production, similar results have been reported. Kim and Davis (2002) observed a homophone priming effect but no MOPE for Korean Hangul prime–Hanja target pairs using the masked priming naming tasks. That is, naming latencies were faster when the Hanja targets (e.g., 江 /kang/) were preceded by the homophonic Hangul primes (e.g., 강 /kang/) than when the targets were preceded by the control primes (e.g., 노 /no/). However, there was no priming effect when the related Hangul primes shared the initial onset (e.g., 고 /ko/) or the initial consecutive phonemes (e.g., 가 /ka/) with the same Hanja targets. These results seem to indicate that the phonology prepared for naming Korean Hanja also corresponds to the whole sound of the character. However, it would be, again, difficult to distinguish between the syllable and the whole sound of the character because each Korean Hanja character also corresponds to a single syllable like Chinese Hànzì does (Kim & Davis, 2002). As such, disentangling these two possibilities in the Chinese and Korean languages is very difficult. However, further investigation on this issue will certainly be worthwhile in light of the present data.

Conclusions

In the present study, we investigated the phonological unit of Japanese Kanji compound words using the masked priming technique. In contrast to previous studies suggesting that the mora is the phonological unit in Japanese, priming effects were not observed when our prime-target pairs merely shared their initial mora. We found a significant priming effect when *the whole sound of the initial Kanji character* overlapped between the prime and target. These results appear to be difficult to reconcile with the proximate units principle as it does not assume that the first selectable phonological unit varies across the script types within a language. However, the differential phonological units used in the naming of Japanese Kana and Kanji words may reflect differential grain sizes that have developed to suit the characteristics of each script type, and therefore the principle would still apply to many other languages (e.g., those that do not entertain multiple scripts). In addition, we suggest the possibility that phonology might be different between reading a word aloud (as in the masked priming naming task) and using spontaneous speech (as in the implicit priming task), in terms of how they are influenced by orthography. Finally, our results are most readily explained by the SP account of masked priming. At the same time, the original idea of the MOPE (e.g., Forster & Davis, 1991) remains insightful in assuming that the effect originates in the mapping of letter (character) onto phonology, despite the as-

[11] It should also be noted that there is no DRC model for reading of Japanese. Thus, it is unsure whether DRC can account for the current results as it is not clear how a GPC route would work for Japanese Kanji.

sumption that the effect originates in the nonlexical route is difficult to accommodate in Kanji reading.

References

Alario, F.-X., Perre, L., Castel, C., & Ziegler, J. C. (2007). The role of orthography in speech production revisited. *Cognition, 102,* 464–475. http://dx.doi.org/10.1016/j.cognition.2006.02.002

Amano, N., & Kondo, K. (2003a). *NTT Detabesu Shirizu: Nihongo No Goi-tokusei Dai 1-ki CD-ROM-ban* [NTT database series: Lexical Properties of Japanese, Vol. 1, CD-ROM Version]. Tokyo, Japan: Sanseido.

Amano, N., & Kondo, K. (2003b). *NTT Detabesu Shirizu: Nihongo No Goi-tokusei Dai 2-ki CD-ROM-ban* [NTT database series: Lexical Properties of Japanese, Vol. 2, CD-ROM Version]. Tokyo, Japan: Sanseido.

Bi, Y., Wei, T., Janssen, N., & Han, Z. (2009). The contribution of orthography to spoken word production: Evidence from Mandarin Chinese. *Psychonomic Bulletin & Review, 16,* 555–560. http://dx.doi.org/10.3758/PBR.16.3.555

Chen, J.-Y., Chen, T.-M., & Dell, G. S. (2002). Word-Form encoding in Mandarin Chinese as assessed by the implicit priming task. *Journal of Memory and Language, 46,* 751–781. http://dx.doi.org/10.1006/jmla.2001.2825

Chen, J.-Y., Lin, W.-C., & Ferrand, L. (2003). Masked priming of the syllable in Mandarin Chinese syllable production. *Chinese Journal of Psychology, 45,* 107–120.

Chen, J.-Y., O'Séaghdha, P. G., & Chen, T.-M. (2016). The primacy of abstract syllables in Chinese word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42,* 825–836. http://dx.doi.org/10.1037/a0039911

Chen, T.-M., & Chen, J.-Y. (2013). The syllable as the proximate unit in Mandarin Chinese word production: An intrinsic or accidental property of the production system? *Psychonomic Bulletin & Review, 20,* 154–162. http://dx.doi.org/10.3758/s13423-012-0326-7

Chen, T.-M., & Chen, J.-Y. (2015). The phonological planning in Mandarin spoken production of mono- and bimorphemic words. *The Japanese Psychological Research, 57,* 81–89. http://dx.doi.org/10.1111/jpr.12059

Coltheart, M. (1978). Lexical access in simple reading tasks. In G. Underwood (Ed.), *Strategies of information processing* (pp. 151–216). London, UK: Academic Press.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108,* 204–256. http://dx.doi.org/10.1037/0033-295X.108.1.204

Damian, M. F., & Bowers, J. S. (2003). Effects of orthography on speech production in a form-preparation paradigm. *Journal of Memory and Language, 49,* 119–132. http://dx.doi.org/10.1016/S0749-596X(03)00008-1

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review, 93,* 283–321. http://dx.doi.org/10.1037/0033-295X.93.3.283

Dell, G. S. (1988). The retrieval of phonological forms in production: Tests of predictions from a connectionist model. *Journal of Memory and Language, 27,* 124–142. http://dx.doi.org/10.1016/0749-596X(88)90070-8

Dimitropoulou, M., Duñabeitia, J. A., & Carreiras, M. (2010). Influence of prime lexicality, frequency, and pronounceability on the masked onset priming effect. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 63,* 1813–1837. http://dx.doi.org/10.1080/17470210903540763

Dlhopolsky, J. G. (1988). C language functions for millisecond timing on the IBM PC. *Behavior Research Methods, Instruments, & Computers, 20,* 560–565. http://dx.doi.org/10.3758/BF03203909

Feldman, L. B., & Turvey, M. T. (1980). Words written in Kana are named faster than the same words written in Kanji. *Language and Speech, 23,* 141–147.

Forster, K. I. (1998). The pros and cons of masked priming. *Journal of Psycholinguistic Research, 27,* 203–233. http://dx.doi.org/10.1023/A:1023202116609

Forster, K. I., & Davis, C. (1991). The density constraint on form-priming in the naming task: Interference effects from a masked prime. *Journal of Memory and Language, 30,* 1–25. http://dx.doi.org/10.1016/0749-596X(91)90008-8

Forster, K. I., & Forster, J. C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers, 35,* 116–124. http://dx.doi.org/10.3758/BF03195503

Forster, K. I., Mohan, K., & Hector, J. (2003). The mechanics of masked priming. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: The state of the art* (pp. 2–21). New York, NY: Psychology Press.

Frost, R. (2005). Orthographic systems and skilled word recognition processes in reading. In M. J. Snowling & C. Hulmes (Eds.), *The science of reading: A handbook* (pp. 272–295). Malden, MA: Blackwell. http://dx.doi.org/10.1002/9780470757642.ch15

Goswami, U., Ziegler, J. C., Dalton, L., & Schneider, W. (2003). Nonword reading across orthographies: How flexible is the choice of reading units? *Applied Psycholinguistics, 24,* 235–247. http://dx.doi.org/10.1017/S0142716403000134

Hino, Y., Kusunose, Y., Miyamura, S., & Lupker, S. J. (2016). Phonological-orthographic consistency for Japanese words and its impact on visual and auditory word recognition. *Journal of Experimental Psychology: Human Perception and Performance*. Advance online publication. http://dx.doi.org/10.1037/xhp0000281

Hino, Y., Miyamura, S., & Lupker, S. J. (2011). The nature of orthographic-phonological and orthographic-semantic relationships for Japanese kana and kanji words. *Behavior Research Methods, 43,* 1110–1151. http://dx.doi.org/10.3758/s13428-011-0101-0

Horemans, I., & Schiller, N. O. (2004). Form-priming effects in nonword naming. *Brain and Language, 90,* 465–469. http://dx.doi.org/10.1016/S0093-934X(03)00457-7

Ida, K., Nakayama, M., & Lupker, S. J. (2015). The functional phonological unit of Japanese-English bilinguals is language dependent: Evidence from masked onset and mora priming effects. *The Japanese Psychological Research, 57,* 38–49. http://dx.doi.org/10.1111/jpr.12066

Kayamoto, Y., Yamada, J., & Takashima, H. (1998). The consistency of multiple-pronunciation effects in reading: The case of Japanese logographs. *Journal of Psycholinguistic Research, 27,* 619–637. http://dx.doi.org/10.1023/A:1023227904895

Kim, J., & Davis, C. (2002). Using Korean to investigate phonological priming effects without the influence of orthography. *Language and Cognitive Processes, 17,* 569–591. http://dx.doi.org/10.1080/01690960143000281

Kinoshita, S. (2000). The left-to-right nature of the masked onset priming effect in naming. *Psychonomic Bulletin & Review, 7,* 133–141. http://dx.doi.org/10.3758/BF03210732

Kinoshita, S. (2003). The nature of masked onset priming effects in naming: A review. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: The state of the art* (pp. 223–238). New York, NY: Psychology Press.

Kinoshita, S., & Woollams, A. (2002). The masked onset priming effect in naming: Computation of phonology or speech planning? *Memory & Cognition, 30,* 237–245. http://dx.doi.org/10.3758/BF03195284

Kureta, Y., Fushimi, T., Sakuma, N., & Tatsumi, I. F. (2015). Orthographic influences on the word-onset phoneme preparation effect in native Japanese speakers: Evidence from the word-form prepatation paradigm. *The Japanese Psychological Research, 57,* 50–60. http://dx.doi.org/10.1111/jpr.12067

Kureta, Y., Fushimi, T., & Tatsumi, I. F. (2006). The functional unit in phonological encoding: Evidence for moraic representation in native Japanese speakers. *Journal of Experimental Psychology: Learning,* *Memory, and Cognition, 32,* 1102–1119. http://dx.doi.org/10.1037/0278-7393.32.5.1102

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22,* 1–38. http://dx.doi.org/10.1017/S0140525X99001776

Malouf, T., & Kinoshita, S. (2007). Masked onset priming effect for high-frequency words: Further support for the speech-planning account. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 60,* 1155–1167. http://dx.doi.org/10.1080/17470210600964035

Meyer, A. S. (1990). The time course of phonological encoding in language production: The encoding of successive syllables of a word. *Journal of Memory and Language, 29,* 524–545. http://dx.doi.org/10.1016/0749-596X(90)90050-A

Meyer, A. S. (1991). The time course of phonological encoding in language production: Phonological encoding inside a syllable. *Journal of Memory and Language, 30,* 69–89. http://dx.doi.org/10.1016/0749-596X(91)90011-8

Mousikou, P., Coltheart, M., Finkbeiner, M., & Saunders, S. (2010a). Can the dual-route cascaded computational model of reading offer a valid account of the masked onset priming effect? *The Quarterly Journal of Experimental Psychology, 63,* 984–1003. http://dx.doi.org/10.1080/17470210903156586

Mousikou, P., Coltheart, M., & Saunders, S. (2010b). Computational modelling of the masked onset priming effect in reading aloud. *The European Journal of Cognitive Psychology, 22,* 725–763. http://dx.doi.org/10.1080/09541440903052798

Mousikou, P., Rastle, K., Besner, D., & Coltheart, M. (2015). The locus of serial processing in reading aloud: Orthography-to-phonology computation or speech planning? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41,* 1076–1099. http://dx.doi.org/10.1037/xlm0000090

Nakayama, M., Kinoshita, S., & Verdonschot, R. G. (2016). The emergence of a phoneme-sized unit in L2 speech production: Evidence from Japanese–English bilinguals. *Frontiers in Psychology, 7,* 175. http://dx.doi.org/10.3389/fpsyg.2016.00175

National Language Research Institute. (1993). *Bunrui-goi hyou (Furoppi Ban)* [Thesaurus (Floppy Disk Version)]. Tokyo, Japan: Shuei Shuppan.

O'Seaghdha, P. G., Chen, J.-Y., & Chen, T.-M. (2010). Proximate units in word production: Phonological encoding begins with syllables in Mandarin Chinese but with segments in English. *Cognition, 115,* 282–302. http://dx.doi.org/10.1016/j.cognition.2010.01.001

O'Séaghdha, P. G., & Frazer, A. K. (2014). The exception does not rule: Attention constrains form preparation in word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 797–810. http://dx.doi.org/10.1037/a0035576

Protopapas, A. (2007). CheckVocal: A program to facilitate checking the accuracy and response time of vocal responses from DMDX. *Behavior Research Methods, 39,* 859–862. http://dx.doi.org/10.3758/BF03192979

Roelofs, A. (1996). Serial order in planning the production of successive morphemes of a word. *Journal of Memory and Language, 35,* 854–876. http://dx.doi.org/10.1006/jmla.1996.0044

Roelofs, A. (2006). The influence of spelling on phonological encoding in word reading, object naming, and word generation. *Psychonomic Bulletin & Review, 13,* 33–37. http://dx.doi.org/10.3758/BF03193809

Roelofs, A. (2015). Modeling of phonological encoding in spoken word production: From Germanic languages to Mandarin Chinese and Japanese. *The Japanese Psychological Research, 57,* 22–37. http://dx.doi.org/10.1111/jpr.12050

Saito, H. (1981). Kanji to kana no yomi niokeru keitaitekifugouka oyobi onintekifugouka no kentou [Use of graphemic and phonemic encoding in reading kanji and kana]. *Japanese Journal of Phycology, 52,* 266–273.

Schiller, N. O. (1998). The effect of visual masked syllable primes on the naming latencies of words and pictures. *Journal of Memory and Language, 39,* 484–507. http://dx.doi.org/10.1006/jmla.1998.2577

Schiller, N. O. (2004). The onset effect in word naming. *Journal of Memory and Language, 50,* 477–490. http://dx.doi.org/10.1016/j.jml.2004.02.004

Schiller, N. O. (2007). Phonology and orthography in reading aloud. *Psychonomic Bulletin & Review, 14,* 460–465. http://dx.doi.org/10.3758/BF03194089

Schiller, N. O. (2008). The masked onset priming effect in picture naming. *Cognition, 106,* 952–962. http://dx.doi.org/10.1016/j.cognition.2007.03.007

Tamaoka, K., Kirsner, K., Yanase, Y., Miyaoka, Y., & Kawakami, M. (2002). A Web-accessible database of characteristics of the 1,945 basic Japanese kanji. *Behavior Research Methods, Instruments, & Computers, 34,* 260–275. http://dx.doi.org/10.3758/BF03195454

Tamaoka, K., & Makioka, S. (2004). Frequency of occurrence for units of phonemes, morae, and syllables appearing in a lexical corpus of a Japanese newspaper. *Behavior Research Methods, Instruments, & Computers, 36,* 531–547. http://dx.doi.org/10.3758/BF03195600

Tamaoka, K., Saito, N., Kiyama, S., Timmer, K., & Verdonschot, R. G. (2014). Is pitch accent necessary for comprehension by native Japanese speakers? – An ERP investigation. *Journal of Neurolinguistics, 27,* 31–40. http://dx.doi.org/10.1016/j.jneuroling.2013.08.001

Timmer, K., Ganushchak, L. Y., Mitlina, Y., & Schiller, N. O. (2014). Trial by trial: Selecting first or second language phonology of a visually masked word. *Language, Cognition and Neuroscience, 29,* 1059–1069. http://dx.doi.org/10.1080/01690965.2013.824994

Timmer, K., Vahid-Gharavi, N., & Schiller, N. O. (2012). Reading aloud in Persian: ERP evidence for an early locus of the masked onset priming effect. *Brain and Language, 122,* 34–41. http://dx.doi.org/10.1016/j.bandl.2012.04.013

Verdonschot, R. G., Kiyama, S., Tamaoka, K., Kinoshita, S., La Heij, W., & Schiller, N. O. (2011). The functional unit of Japanese word naming: Evidence from masked priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 1458–1473. http://dx.doi.org/10.1037/a0024491

Verdonschot, R. G., Lai, J., Chen, F., Tamaoka, K., & Schiller, N. O. (2015). Constructing initial phonology in Mandarin Chinese: Syllabic or subsyllabic? A masked priming investigation. *The Japanese Psychological Research, 57,* 61–68. http://dx.doi.org/10.1111/jpr.12064

Verdonschot, R. G., La Heij, W., & Schiller, N. O. (2010). Semantic context effects when naming Japanese kanji, but not Chinese hànzì. *Cognition, 115,* 512–518. http://dx.doi.org/10.1016/j.cognition.2010.03.005

Verdonschot, R. G., La Heij, W., Tamaoka, K., Kiyama, S., You, W. P., & Schiller, N. O. (2013b). The multiple pronunciations of Japanese kanji: A masked priming investigation. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 66,* 2023–2038. http://dx.doi.org/10.1080/17470218.2013.773050

Verdonschot, R. G., Nakayama, M., Zhang, Q., Tamaoka, K., & Schiller, N. O. (2013a). The proximate phonological unit of Chinese-English bilinguals: Proficiency matters. *PLoS One, 8,* e61454. http://dx.doi.org/10.1371/journal.pone.0061454

Wydell, T. N., Butterworth, B., & Patterson, K. (1995). The inconsistency of consistency effects in reading: The case of Japanese Kanji. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 1155–1168. http://dx.doi.org/10.1037/0278-7393.21.5.1155

You, W., Zhang, Q., & Verdonschot, R. G. (2012). Masked syllable priming effects in word and picture naming in Chinese. *PLoS ONE, 7,* e46595. http://dx.doi.org/10.1371/journal.pone.0046595

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

Ziegler, J. C., & Goswami, U. (2006). Becoming literate in different languages: Similar problems, different solutions. *Developmental Science, 9,* 429–436. http://dx.doi.org/10.1111/j.1467-7687.2006.00509.x

Ziegler, J. C., Perry, C., Jacobs, A. M., & Braun, M. (2001). Identical words are read differently in different languages. *Psychological Science, 12,* 379–384. http://dx.doi.org/10.1111/1467-9280.00370

Appendix A

Prime-Target Pairs Used in Experiment 1 Along With Their English Translations

Target	Mora related	Mora control
	Word, Pronunciation, English translation	
馬券 **/ba**-ke.N/ "betting ticket"	場面 **/ba**-me.N/ "scene"	画面 **/ga**-me.N/ "screen"
微熱 **/bi**-ne.tu/ "slight fever"	美術 **/bi**-zju.tu/ "art"	技術 **/gi**-zju.tu/ "technique"
墓標 **/bo**-hjo.u/ "grave marker"	母国 **/bo**-ko.ku/ "homeland"	祖国 **/so**-ko.ku/ "homeland"
脱獄 **/da.tu**-go.ku/ "breakout"	断念 **/da.N**-ne.N/ "giving up"	残念 **/za.N**-ne.N/ "too bad"
毒舌 **/do.ku**-ze.tu/ "abuse"	同一 **/do.u**-i.tu/ "identical"	統一 **/to.u**-i.tu/ "unity"
概論 **/ga.i**-ro.N/ "introduction"	学者 **/ga.ku**-sja/ "academic"	作者 **/sa.ku**-sja/ "author"
劇的 **/ge.ki**-te.ki/ "dramatic"	月収 **/ge.Q**-sju.U/ "monthly income"	撤収 **/te.Q**-sju.U/ "retreat"
偽名 **/gi**-me.i/ "anonym"	議論 **/gi**-ro.N/ "argument"	理論 **/ri**-ro.N/ "doctrine"
極楽 **/go.ku**-ra.ku/ "nirvana"	合弁 **/go.u**-be.N/ "joint management"	答弁 **/to.u**-be.N/ "account"
偶数 **/gu.U**-su.U/ "even number"	軍備 **/gu.N**-bi/ "armament"	準備 **/zju.N**-bi/ "preparation"
博愛 **/ha.ku**-a.i/ "philanthropy"	発動 **/ha.tu**-do.u/ "invocation"	活動 **/ka.tu**-do.u/ "activity"
編著 **/he.N**-tjo/ "the author and editor"	平年 **/he.i**-ne.N/ "average year"	例年 **/re.i**-ne.N/ "annual"
筆談 **/hi.tu**-da.N/ "communication by writing"	品種 **/hi.N**-sju/ "breed"	人種 **/zi.N**-sju/ "race"
補欠 **/ho**-ke.tu/ "fill-in"	保有 **/ho**-ju.U/ "retention"	固有 **/ko**-ju.U/ "inherence"
神風 **/ka.mi**-ka.ze/ "Kamikaze"	開発 **/ka.i**-ha.tu/ "development"	再発 **/sa.i**-ha.tu/ "recurrence"
欠乏 **/ke.tu**-bo.u/ "absence"	決意 **/ke.tu**-i/ "resolution"	熱意 **/ne.tu**-i/ "eagerness"
傷口 **/ki.zu**-gu.cji/ "wound"	勤務 **/ki.N**-mu/ "service"	任務 **/ni.N**-mu/ "commission"
交番 **/ko.u**-ba.N/ "police box"	国産 **/ko.ku**-sa.N/ "home-grown"	特産 **/to.ku**-sa.N/ "local specialty"
前髪 **/ma.e**-ga.mi/ "front hair"	枚数 **/ma.i**-su.U/ "the number of"	回数 **/ka.i**-su.U/ "number of times"
未熟 **/mi**-zju.ku/ "immaturity"	魅力 **/mi**-rjo.ku/ "charm"	気力 **/ki**-rjo.ku/ "spirit"
中庭 **/na.ka**-ni.wa/ "inner garden"	内外 **/na.i**-ga.i/ "in and out"	海外 **/ka.i**-ga.i/ "overseas"
熱望 **/ne.tu**-bo.u/ "desire"	年数 **/ne.N**-su.U/ "the number of years"	件数 **/ke.N**-su.U/ "number of cases"
荷車 **/ni**-gu.ru.ma/ "cart"	二分 **/ni**-bu.N/ "dichotomy"	身分 **/mi**-bu.N/ "position"
軒先 **/no.ki**-sa.ki/ "eaves"	農民 **/no.u**-mi.N/ "farmer"	公民 **/ko.u**-mi.N/ "civics"
楽園 **/ra.ku**-e.N/ "paradise"	来日 **/ra.i**-ni.ti/ "visiting to Japan"	在日 **/za.i**-ni.ti/ "residing in Japan"
礼金 **/re.i**-ki.N/ "reward"	連日 **/re.N**-zi.tu/ "successive days"	先日 **/se.N**-zi.tu/ "the other day"
殺意 **/sa.tu**-i/ "intention to kill"	債務 **/sa.i**-mu/ "obligation"	外務 **/ga.i**-mu/ "foreign affairs"
設問 **/se.tu**-mo.N/ "question"	責任 **/se.ki**-ni.N/ "responsibility"	歴任 **/re.ki**-ni.N/ "to hold various posts"
速達 **/so.ku**-ta.tu/ "express"	創立 **/so.u**-ri.tu/ "foundation"	擁立 **/jo.u**-ri.tu/ "to back up"
退路 **/ta.i**-ro/ "escape route"	宅地 **/ta.ku**-cji/ "housing area"	各地 **/ka.ku**-chi/ "various regions"
突撃 **/to.tu**-ge.ki/ "dash"	特定 **/to.ku**-te.i/ "attribution"	測定 **/so.ku**-te.i/ "measure"
夜食 **/ja**-sjo.ku/ "midnight snack"	野球 **/ja**-kju.U/ "baseball"	打球 **/da**-kju.U/ "batted ball"
予習 **/jo**-sju.U/ "preparation"	余力 **/jo**-rjo.ku/ "remaining energy"	努力 **/do**-rjo.ku/ "effort"
雑用 **/za.tu**-jo.u/ "chore"	在学 **/za.i**-ga.ku/ "in school"	大学 **/da.i**-ga.ku/ "university"
絶妙 **/ze.tu**-mjo.u/ "superb"	全国 **/ze.N**-ko.ku/ "the whole country"	建国 **/ke.N**-ko.ku/ "founding of nation"
続編 **/zo.ku**-he.N/ "sequel"	増税 **/zo.u**-ze.i/ "increased tax"	納税 **/no.u**-ze.i/ "tax payment"

(*Appendices continue*)

Appendix B

Prime-Target Pairs Used in Experiment 2 Along With Their English Translations

Target	Mora related	Mora control
	Word, Pronunciation, English translation	
厚紙 **/a.tu**-ga.mi/ “cardboard”	案内 **/a.N**-na.i/ “guide sign”	年内 **/ne.N**-na.i/ “within the year”
英訳 **/e.i**-ja.ku/ “English translation”	演出 **/e.N**-sju.tu/ “production”	検出 **/ke.N**-sju.tu/ “detection”
快晴 **/ka.i**-se.i/ “fine weather”	観念 **/ka.N**-ne.N/ “conception”	断念 **/da.N**-ne.N/ “giving up”
街路 **/ga.i**-ro/ “street”	学内 **/ga.ku**-na.i/ “on campus”	国内 **/ko.ku**-na.i/ “interior”
禁断 **/ki.N**-da.N/ “forbidden”	基盤 **/ki.ba**-N/ “foundation”	地盤 **/zi**.ba-N/ “ground”
敬礼 **/ke.i**-re.i/ “salute”	権力 **/ke.N**-rjo.ku/ “authority”	電力 **/de.N**-rjo.ku/ “elecricity”
厳密 **/ge.N**-mi.tu/ “rigor”	月末 **/ge.tu**-ma.tu/ “end of month”	結末 **/ke.tu**-ma.tu/ “ending”
刻印 **/ko.ku**-i.N/ “engraved mark”	購入 **/ko.u**-nju.U/ “buy”	導入 **/do.u**-nju.U/ “installation”
財宝 **/za.i**-ho.u/ “treasure”	惨敗 **/za.N**-pa.i/ “cruhing defeat”	連敗 **/re.N**-pa.i/ “consecutive losses”
散策 **/sa.N**-sa.ku/ “roam”	細部 **/sa.i**-bu/ “detail”	内部 **/na.i**-bu/ “inside”
新春 **/si.N**-sju.N/ “the new year”	失望 **/si.tu**-bo.u/ “disappointment”	絶望 **/ze.tu**-bo.u/ “desperation”
陣痛 **/zi.N**-tu.U/ “birth pangs”	実務 **/zi.tu**-mu/ “practical operations”	執務 **/si.tu**-mu/ “at work”
推論 **/su.i**-ro.N/ “inference”	寸前 **/su.N**-ze.N/ “close to”	戦前 **/se.N**-ze.N/ “prewar”
節電 **/se.tu**-de.N/ “to save power”	責任 **/se.ki**-ni.N/ “responsibility”	歴任 **/re.ki**-ni.N/ “to hold various posts”
蔵書 **/zo.u**-sjo/ “book stock”	続発 **/zo.ku**-ha.tu/ “a frequent occurrence”	告発 **/ko.ku**-ha.tu/ “accusation”
僧侶 **/so.u**-rjo/ “Buddist monk”	速球 **/so.Q**-kju.U/ “fastball”	卓球 **/ta.Q**-kju.U/ “table tennis”
暖炉 **/da.N**-ro/ “fireplace”	大学 **/da.i**-ga.ku/ “university”	在学 **/za.i**-ga.ku/ “in school”
退席 **/ta.i**-se.ki/ “walk-off”	端末 **/ta.N**-ma.tu/ “terminal”	年末 **/ne.N**-ma.tu/ “year-end”
竹林 **/ti.ku**-ri.N/ “bamboo grove”	鎮圧 **/ti.N**-a.tu/ “suppression”	弾圧 **/da.N**-a.tu/ “oppression”
低音 **/te.i**-o.N/ “low-pitch sound”	点数 **/te.N**-su.U/ “score”	年数 **/ne.N**-su.U/ “the number of years”
同数 **/do.u**-su.U/ “same number”	毒物 **/do.ku**-bu.tu/ “poison”	薬物 **/ja.ku**-bu.tu/ “drug”
忍者 **/ni.N**-zja/ “ninja”	日中 **/ni.Q**-tju.U/ “daytime”	熱中 **/ne.Q**-tju.U/ “addiction”
番頭 **/ba.N**-to.u/ “bath attendant”	売却 **/ba.i**-kja.ku/ “sale”	冷却 **/re.i**-kja.ku/ “cooling”
博物 **/ha.ku**-bu.tu/ “natural history”	発案 **/ha.tu**-a.N/ “suggestion”	立案 **/ri.tu**-a.N/ “planning”
貧民 **/hi.N**-mi.N/ “the poor”	必着 **/hi.Q**-tja.ku/ “not later than”	発着 **/ha.Q**-tja.ku/ “landing and takeoff”
返金 **/he.N**-ki.N/ “pay back”	平年 **/he.i**-ne.N/ “average year”	来年 **/he.i**-ne.N/ “next year”
放任 **/ho.u**-ni.N/ “letting alone”	本質 **/ho.N**-si.tu/ “essence”	変質 **/he.N**-si.tu/ “transmutation”
輪郭 **/ri.N**-ka.ku/ “contour”	陸上 **/ri.ku**-zjo.u/ “on shore”	北上 **/ho.ku**-zjo.u/ “to travel north”

Target	Character-sound related	Character-sound control
	Word, Pronunciation, English translation	
厚紙 **/a.tu**-ga.mi/ “cardboard”	圧力 **/a.tu**-rjo.ku/ “pressure”	実力 **/zi.tu**-rjo.ku/ “raw power”
英訳 **/e.i**-ja.ku/ “English translation”	営業 **/e.i**-gjo.u/ “business transaction”	廃業 **/ha.i**-gjo.u/ “going out of business”
快晴 **/ka.i**-se.i/ “fine weather”	開幕 **/ka.i**-ma.ku/ “curtain-up”	閉幕 **/he.i**-ma.ku/ “closing”
街路 **/ga.i**-ro/ “street”	外国 **/ga.i**-ko.ku/ “foreign country”	大国 **/ta.i**-ko.ku/ “big power”
禁断 **/ki.N**-da.N/ “forbidden”	勤務 **/ki.N**-mu/ “service”	任務 **/ni.N**-mu/ “commission”
敬礼 **/ke.i**-re.i/ “salute”	啓発 **/ke.i**-ha.tu/ “enlightnment”	再発 **/sa.i**-ha.tu/ “recurrence”
厳密 **/ge.N**-mi.tu/ “rigor”	限定 **/ge.N**-te.i/ “circumscription”	暫定 **/za.N**-te.i/ “transitional”
刻印 **/ko.ku**-i.N/ “engraved mark”	穀物 **/ko.ku**-mo.tu/ “cereal”	作物 **/sa.ku**-mo.tu/ “crop”
財宝 **/za.i**-ho.u/ “treasure”	在日 **/za.i**-ni.ti/ “residing in Japan”	来日 **/ra.i**-ni.ti/ “visiting to Japan”
散策 **/sa.N**-sa.ku/ “roam”	山中 **/sa.N**-tju.U/ “in the mountains”	連中 **/re.N**-tju.U/ “those guys”
新春 **/si.N**-sju.N/ “the new year”	診断 **/si.N**-da.N/ “diagnosis”	判断 **/ha.N**-da.N/ “judgment”
陣痛 **/zi.N**-tu.U/ “birth pangs”	人類 **/zi.N**-ru.i/ “the human race”	分類 **/bu.N**-ru.i/ “classification”
推論 **/su.i**-ro.N/ “inference”	水域 **/su.i**-i.ki/ “water area”	海域 **/ka.i**-i.ki/ “marine area”
節電 **/se.tu**-de.N/ “to save power”	説明 **/se.tu**-me.i/ “explanation”	発明 **/ha.tu**-me.i/ “invention”
蔵書 **/zo.u**-sjo/ “book stock”	増税 **/zo.u**-ze.i/ “increased tax”	納税 **/no.u**-ze.i/ “tax payment”
僧侶 **/so.u**-rjo/ “Buddist monk”	送金 **/so.u**-ki.N/ “money transfer”	料金 **/rjo.u**-ki.N/ “fee”
暖炉 **/da.N**-ro/ “fireplace”	団員 **/da.N**-i.N/ “members”	満員 **/ma.N**-i.N/ “cram”
退席 **/ta.i**-se.ki/ “walk-off”	体力 **/ta.i**-rjo.ku/ “physical strength”	兵力 **/he.i**-rjo.ku/ “force strength”
竹林 **/ti.ku**-ri.N/ “bamboo grove”	畜産 **/ti.ku**-sa.N/ “animal industry”	国産 **/ko.ku**-sa.N/ “home-grown”
低音 **/te.i**-o.N/ “low-pitch sound”	定住 **/te.i**-zju.U/ “residence”	永住 **/e.i**-zju.U/ “parmanent residence”
同数 **/do.u**-su.U/ “same number”	道具 **/do.u**-gu/ “instrument”	用具 **/jo.u**-gu/ “materials”
忍者 **/ni.N**-zja/ “ninja”	任命 **/ni.N**-me.i/ “assignment”	延命 **/ni.N**-me.i/ “life extension”
番頭 **/ba.N**-to.u/ “bath attendant”	晩年 **/ba.N**-ne.N/ “last days”	元年 **/ga.N**-ne.N/ “the first year”
博物 **/ha.ku**-bu.tu/ “natural history”	迫害 **/ha.ku**-ga.i/ “persecution”	薬害 **/ja.ku**-ga.i/ “chemical injury”
貧民 **/hi.N**-mi.N/ “the poor”	品目 **/hi.N**-mo.ku/ “item of goods”	演目 **/e.N**-mo.ku/ “act”
返金 **/he.N**-ki.N/ “pay back”	変動 **/he.N**-do.u/ “variation”	運動 **/u.N**-do.u/ “exercise”
放任 **/ho.u**-ni.N/ “letting alone”	法務 **/ho.u**-mu/ “legal work”	業務 **/gjo.u**-mu/ “operation”
輪郭 **/ri.N**-ka.ku/ “contour”	隣接 **/ri.N**-se.tu/ “adjacence”	面接 **/me.N**-se.tu/ “interview”

(*Appendices continue*)

Appendix C

Prime-Target Pairs Used in Experiment 3 Along With Their English Translations

Target	Mora related	Mora control
	Word, Pronunciation	
あつがみ /a.tu.ga.mi/	アンナイ /a.N.na.i/	ネンナイ /ne.N.na.i/
えいやく /e.i.ja.ku/	エンシュツ /e.N.sju.tu/	ケンシュツ /ke.N.sju.tu/
かいせい /ka.i.se.i/	カンネン /ka.N.ne.N/	ダンネン /da.N.ne.N/
がいろ /ga.i.ro/	ガクネイ /ga.ku.na.i/	コクナイ /ko.ku.na.i/
きんだん /ki.N.da.N/	キバン /ki.ba.N/	ジバン /zi.ba.N/
けいれい /ke.i.re.i/	ケンリョク /ke.N.rjo.ku/	デンリョク /de.N.rjo.ku/
げんみつ /ge.N.mi.tu/	ゲツマツ /ge.tu.ma.tu/	ケツマツ /ke.tu.ma.tu/
こくいん /ko.ku.i.N/	コウニュウ /ko.u.nju.R/	ドウニュウ /do.u.nju.R/
ざいほう /za.i.ho.u/	ザンパイ /za.N.pa.i/	レンパイ /re.N.pa.i/
さんさく /sa.N.sa.ku/	サイブ /sa.i.bu/	ナイブ /na.i.bu/
しんしゅん /si.N.sju.N/	シツボウ /si.tu.bo.u/	ゼツボウ /ze.tu.bo.u/
じんつう /zi.N.tu.u/	ジツム /zi.tu.mu/	シツム /si.tu.mu/
すいろん /su.i.ro.N/	スンゼン /su.N.ze.N/	センゼン /se.N.ze.N/
せつでん /se.tu.de.N/	セキニン /se.ki.ni.N/	レキニン /re.ki.ni.N/
ぞうしょ /zo.u.sjo/	ゾクハツ /zo.ku.ha.tu/	コクハツ /ko.ku.ha.tu/
そうりょ /so.u.rjo/	ソッキュウ /so.Q.kju.R/	タッキュウ /ta.Q.kju.R/
だんろ /da.N.ro/	ダイガク /da.i.ga.ku/	ザイガク /za.i.ga.ku/
たいせき /ta.i.se.ki/	タンマツ /ta.N.ma.tu/	ネンマツ /ne.N.ma.tu/
ちくりん /ti.ku.ri.N/	チンアツ /ti.N.a.tu/	ダンアツ /da.N.a.tu/
ていおん /te.i.o.N/	テンスウ /te.N.su.R/	ネンスウ /ne.N.su.R/
どうすう /do.u.su.R/	ドクブツ /do.ku.bu.tu/	ヤクブツ /ja.ku.bu.tu/
にんじゃ /ni.N.zja/	ニッチュウ /ni.Q.tju.R/	ネッチュウ /ne.Q.tju.R/
ばんとう /ba.N.to.u/	バイキャク /ba.i.kja.ku/	レイキャク /re.i.kja.ku/
はくぶつ /ha.ku.bu.tu/	ハツアン /ha.tu.a.N/	リツアン /ri.tu.a.N/
ひんみん /hi.N.mi.N/	ヒッチャク /hi.Q.tja.ku/	ハッチャク /ha.Q.tja.ku/
へんきん /he.N.ki.N/	ヘイネン /he.i.ne.N/	ライネン /he.i.ne.N/
ほうにん /ho.u.ni.N/	ホンシツ /ho.N.si.tu/	ヘンシツ /he.N.si.tu/
りんかく /ri.N.ka.ku/	リクジョウ /ri.ku.zjo.u/	ホクジョウ /ho.ku.zjo.u/

Target	Character-sound related	Character-sound control
	Word, Pronunciation	
あつがみ /a.tu.ga.mi/	アツリョク /a.tu.rjo.ku/	ジツリョク /zi.tu.rjo.ku/
えいやく /e.i.ja.ku/	エイギョウ /e.i.gjo.u/	ハイギョウ /ha.i.gjo.u/
かいせい /ka.i.se.i/	カイマク /ka.i.ma.ku/	ヘイマク /he.i.ma.ku/
がいろ /ga.i.ro/	ガイコク /ga.i.ko.ku/	タイコク /ta.i.ko.ku/
きんだん /ki.N.da.N/	キンム /ki.N.mu/	ニンム /ni.N.mu/
けいれい /ke.i.re.i/	ケイハツ /kei.ha.tu/	サイハツ /sa.i.ha.tu/
げんみつ /ge.N.mi.tu/	ゲンテイ /ge.N.te.i/	ザンテイ /za.N.te.i/
こくいん /ko.ku.i.N/	コクモツ /ko.ku.mo.tu/	サクモツ /sa.ku.mo.tu/
ざいほう /za.i.ho.u/	ザイニチ /za.i.ni.ti/	ライニチ /ra.i.ni.ti/
さんさく /sa.N.sa.ku/	サンチュウ /sa.N.tju.R/	レンチュウ /re.N.tju.R/
しんしゅん /si.N.sju.N/	シンダン /si.N.da.N/	ハンダン /ha.N.da.N/
じんつう /zi.N.tu.u/	ジンルイ /zi.N.ru.i/	ブンルイ /bu.N.ru.i/
すいろん /su.i.ro.N/	スイイキ /su.i.i.ki/	カイイキ /ka.i.i.ki/
せつでん /se.tu.de.N/	セツメイ /se.tu.me.i/	ハツメイ /ha.tu.me.i/
ぞうしょ /zo.u.sjo/	ゾウゼイ /zo.u.ze.i/	ノウゼイ /no.U.ze.i/
そうりょ /so.u.rjo/	ソウキン /so.u.ki.N/	リョウキン /rjo.u.ki.N/
だんろ /da.N.ro/	ダンイン /da.N.i.N/	マンイン /ma.N.i.N/
たいせき /ta.i.se.ki/	タイリョク /ta.i.rjo.ku/	ヘイリョク /he.i.rjo.ku/
ちくりん /ti.ku.ri.N/	チクサン /ti.ku.sa.N/	コクサン /ko.ku.sa.N/
ていおん /te.i.o.N/	テイジュウ /te.i.zju.R/	エイジュウ /e.i.zju.R/
どうすう /do.u.su.R/	ドウグ /do.u.gu/	ヨウグ /jo.u.gu/
にんじゃ /ni.N.zja/	ニンメイ /ni.N.me.i/	エンメイ /ni.N.me.i/
ばんとう /ba.N.to.u/	バンネン /ba.N.ne.N/	ガンネン /ga.N.ne.N/
はくぶつ /ha.ku.bu.tu/	ハクガイ /ha.ku.ga.i/	ヤクガイ /ja.ku.ga.i/
ひんみん /hi.N.mi.N/	ヒンモク /hi.N.mo.ku/	エンモク /e.N.mo.ku/
へんきん /he.N.ki.N/	ヘンドウ /he.N.do.u/	ウンドウ /u.N.do.u/
ほうにん /ho.u.ni.N/	ホウム /ho.u.mu/	ギョウッム /gjo.u.mu/
りんかく /ri.N.ka.ku/	リンセツ /ri.N.se.tu/	メンセツ /me.N.se.tu/

(*Appendices continue*)

Appendix D

Prime-Target Pairs Used in Experiment 4 Along With Their English Translations

Target	Mora related	Mora control
	Word, Pronunication, English translation	
格安 **/ka.ku**-ja.su/ “cheap”	活動 **/ka.tu**-do.u/ “action”	発動 **/ha.tu**-do.u/ “operation”
辛口 **/ka.ra**-ku.ti/ “dry”	確定 **/ka.ku**-te.i/ “settlement”	特定 **/to.ku**-te.i/ “identification”
撃退 **/ge.ki**-ta.i/ “repel”	月末 **/ge.tu**-ma.tu/ “end of month”	結末 **/ke.tu**-ma.tu/ “ending”
腰骨 **/ko.si**-bo.ne/ “hipbone”	国立 **/ko.ku**-ri.tu/ “national”	独立 **/do.ku**-ri.tu/ “independence”
骨盤 **/ko.tu**-ba.N/ “pelvis”	告発 **/ko.ku**-ha.tu/ “prosecution”	続発 **/zo.ku**-ha.tu/ “sequence”
粉雪 **/ko.na**-ju.ki/ “powder snow”	穀物 **/ko.ku**-mo.tu/ “cereal”	作物 **/sa.ku**-mo.tu/ “crop”
殺伐 **/sa.tu**-ba.tu/ “sanguinary”	作品 **/sa.ku**-hi.N/ “a work”	薬品 **/ja.ku**-hi.N/ “medicine”
里芋 **/sa.to**-i.mo/ “taro”	昨年 **/sa.ku**-ne.N/ “last year”	学年 **/ga.ku**-ne.N/ “school year”
死神 **/si.ni**-ga.mi/ “reaper”	失業 **/si.tu**-gjo.u/ “unemployment”	卒業 **/so.tu**-gjo.u/ “graduation”
赤道 **/se.ki**-do.u/ “equator”	切断 **/se.tu**-da.N/ “cutting”	決断 **/ke.tu**-da.N/ “determination”
銭形 **/ze.ni**-ga.ta/ “a mold to coin money”	絶望 **/ze.tu**-bo.u/ “despair”	失望 **/si.tu**-bo.u/ “disappointment”
殿様 **/to.no**-sa.ma/ “lord”	特産 **/to.ku**-sa.N/ “special product”	畜産 **/ti.ku**-sa.N/ “stockbreeding”
泥水 **/do.ro**-mi.zu/ “muddy water”	毒物 **/do.ku**-bu.tu/ “poison”	薬物 **/ja.ku**-bu.tu/ “drug”
偽札 **/ni.se**-sa.tu/ “counterfeit note”	肉体 **/ni.ku**-ta.i/ “body”	国体 **/ko.ku**-ta.i/ “national polity”
白線 **/ha.ku**-se.N/ “white line”	発明 **/ha.tu**-me.i/ “invention”	説明 **/se.tu**-me.i/ “explanation”
針金 **/ha.ri**-ga.ne/ “wire”	八月 **/ha.ti**-ga.tu/ “August”	七月 **/si.ti**-ga.tu/ “July”
昼飯 **/hi.ru**-me.si/ “lunch”	人柄 **/hi.to**-ga.ra/ “personality”	事柄 **/ko.to**-ga.ra/ “matter”
矛先 **/ho.ko**-sa.ki/ “spearhead”	北上 **/ho.ku**-zjo.u/ “to travel north”	陸上 **/ri.ku**-zjo.u/ “on shore”
物腰 **/mo.no**-go.si/ “manner”	黙認 **/mo.ku**-ni.N/ “silent approval”	確認 **/ka.ku**-ni.N/ “ascertainment”
桃色 **/mo.mo**-i.ro/ “pink”	目撃 **/mo.ku**-ge.ki/ “witnessing”	爆撃 **/ba.ku**-ge.ki/ “bombing”
安物 **/ya.su**-mo.no/ “cheap article”	躍進 **/ja.ku**-si.N/ “progress”	促進 **/so.ku**-si.N/ “promotion”
山芋 **/ya.ma**-i.mo/ “yam”	薬害 **/ja.ku**-ga.i/ “chemical injury”	迫害 **/ha.ku**-ga.i/ “persecution”
力作 **/ri.ki**-sa.ku/ “great work”	立案 **/ri.tu**-a.N/ “planning”	発案 **/ha.tu**-a.N/ “suggestion”
劣悪 **/re.tu**-a.ku/ “infirior”	歴任 **/re.ki**-ni.N/ “to hold various posts”	責任 **/se.ki**-ni.N/ “responsibility”

(*Appendices continue*)

Appendix E

Prime-Target Pairs Used in Experiment 5 Along With Their English Translations

Target	Character-sound match	Character-sound mismatch	Control
	Word, Pronunciation, English translation		
胃袋 /**i**-bu.ku.ro/ “stomach”	遺族 /**i**-zo.ku/ “the bereaved”	痛手 /**i.ta**-de/ “harm”	由来 /**ju**-ra.i/ “derivation”
羽毛 /**u**-mo.u/ “feather”	右翼 /**u**-jo.ku/ “right field”	運輸 /**u.N**-ju/ “transportation”	代打 /**da.i**-da/ “pinch hitter”
会釈 /**e**-sja.ku/ “bow”	絵本 /**e**-ho.N/ “picture book”	援助 /**e.N**-zjo/ “assist”	利害 /**ri**-ga.i/ “interest”
御礼 /**o**-re.i/ “gratitude”	汚染 /**o**-se.N/ “pollution”	応募 /**o.u**-bo/ “application”	戦後 /**se.N**-go/ “postwar era”
画伯 /**ga**-ha.ku/ “artist”	我慢 /**ga**-ma.N/ “patience”	外部 /**ga.i**-bu/ “exterior”	巨人 /**kjo**-zi.N/ “giant”
火力 /**ka**-rjo.ku/ “firepower”	化石 /**ka**-se.ki/ “fossil”	確保 /**ka.ku**-ho/ “securement”	直視 /**tjo.ku**-si/ “direct sight”
奇妙 /**ki**-mjo.u/ “oddness”	規約 /**ki**-ja.ku/ “constitution”	近所 /**ki.N**-zjo/ “neighbotod”	麻薬 /**ma**-ja.ku/ “drug”
挙式 /**kjo**-si.ki/ “holding a ceremony”	去年 /**kjo**-ne.N/ “last year”	教諭 /**kjo.u**-ju/ “teacher”	学者 /**ga.ku**-sja/ “academic”
偽名 /**gi**-me.i/ “anonym”	疑惑 /**gi**-wa.ku/ “suspicion”	銀座 /**gi.N**-za/ “Ginza”	被告 /**hi**-ko.ku/ “the accused”
句点 /**ku**-te.N/ “point”	区域 /**ku**-i.ki/ “section”	空気 /**ku.U**-ki/ “air”	極秘 /**go.ku**-hi/ “top secret”
愚問 /**gu**-mo.N/ “foolish question”	具体 /**gu**-ta.i/ “concrete”	軍備 /**gu.N**-bi/ “armament”	補給 /**ho**-kju.U/ “refill”
毛糸 /**ke**-i.to/ “wool”	気配 /**ke**-ha.i/ “glimpse”	権利 /**ke.N**-ri/ “right”	灯油 /**to.u**-ju/ “heating oil”
解毒 /**ge**-do.ku/ “detoxication”	下旬 /**ge**- -zju.N/ “late”	現場 /**ge.N**-ba/ “job site”	意欲 /**i**-jo.ku/ “motivation”
呉服 /**go**-hu.ku/ “dry goods”	護衛 /**go**-e.i/ “safeguard”	合意 /**go.u**-i/ “agreement”	激化 /**ge.ki**-ka/ “aggravation”
古文 /**ko**-bu.N/ “classic literature”	孤立 /**ko**-ri.tu/ “isolation”	根拠 /**ko.N**-kjo/ “grounds”	苦労 /**ku**-ro.u/ “pain”
鎖国 /**sa**-ko.ku/ “national isolation”	査定 /**sa**-te.i/ “assessment”	作者 /**sa.ku**-sja/ “author”	震度 /**si.N**-do/ “earthquake intensity”
自爆 /**zi**-ba.ku/ “destruct”	字幕 /**zi**-ma.ku/ “subtitle”	実務 /**zi.tu**-mu/ “affairs”	母校 /**bo**-ko.u/ “alma mater”
樹齢 /**zju**-re.i/ “tree age”	授業 /**zju**-gjo.u/ “class”	重視 /**zju-U**.si/ “emphasizing”	英語 /**e.i**-go/ “English”
除菌 /**zjo**-ki.N/ “sterilization”	序盤 /**zjo**-ba.N/ “early stage”	常務 /**zjo-u**.mu/ “regular buisiness”	身元 /**mi**-mo.to/ “antecedents”
試着 /**si**-tja.ku/ “try-on”	志願 /**si**-ga.N/ “application”	審査 /**si.N**-sa/ “review”	翻後 /**ro.u**-go/ “golden years”
守衛 /**sju**-e.i/ “guard”	主役 /**sju**-ja.ku/ “protagonist”	修理 /**sju.U**-ri/ “repair”	歌手 /**ka**-sju/ “singer”
書式 /**sjo**-si.ki/ “format”	所有 /**sjo**-ju.U/ “possession”	消費 /**sjo.u**-hi/ “consumption”	賛否 /**sa.N**-pi/ “pros and cons”
背骨 /**se**-bo.ne/ “spine”	世代 /**se**-da.i/ “generation”	設備 /**se.tu**-bi/ “equipment”	任意 /**ni.N**-mu/ “at wil”
疎通 /**so**-tu.U/ “connectivity”	祖国 /**so**-ko.ku/ “homeland”	即座 /**so.ku**-za/ “readiness”	免許 /**me.N**-kjo/ “license”
多忙 /**ta**-bo.u/ “business”	他人 /**ta**-ni.N/ “stranger”	単位 /**ta.N**-i/ “credit”	治療 /**ti**-rjo.u/ “remedy”
駄作 /**da**-sa.ku/ “stinker”	打撃 /**da**-ge.ki/ “batting”	男女 /**da.N**-zjo/ “male and female”	王者 /**o.u**-zja/ “monarch”
稚魚 /**ti**-gjo/ “alevin”	地点 /**ti**-te.N/ “spot”	秩序 /**ti.tu**-zjo/ “cosmos”	部品 /**bu**-hi.N/ “part”
著名 /**tjo**-me.i/ “note”	貯蔵 /**tjo**-zo.u/ “storage”	長寿 /**tjo.u**-zju/ “longevity”	対話 /**ta.i**-wa/ “dialogue”
途方 /**to**-ho.u/ “step”	都内 /**to**-na.i/ “in Tokyo”	問屋 /**to.N**-ja/ “warehouser”	最中 /**mo**-na.ka/ “Monaka (the name of a Japanese sweet stuff)”
度胸 /**do**-kjo.u/ “courage”	努力 /**do**-rjo.ku/ “effort”	道具 /**do.u**-gu/ “tool”	偶然 /**gu.U**-ze.N/ “by chance”
二段 /**ni**-da.N/ “two stage”	荷物 /**ni**-mo.tu/ “baggage”	認可 /**ni.N**-ka/ “approval”	宇宙 /**u**-tju.U/ “the universe”
覇者 /**ha**-sja/ “master”	派閥 /**ha**-ba.tu/ “clique”	配慮 /**ha.i**-rjo/ “solicitude”	職場 /**sjo.ku**-ba/ “workplace”
馬術 /**ba**-zju.tu/ “riding”	場面 /**ba**-me.N/ “scene”	爆破 /**ba.ku**-ha/ “blowup”	負担 /**hu**-ta.N/ “burden”
秘伝 /**hi**-de.N/ “esotericism”	比率 /**hi**-ri.tu/ “ratio”	広場 /**hi.ro**-ba/ “open space”	倉庫 /**so.u**-ko/ “warehouse”
舞踏 /**bu**-to.u/ “dancing”	武力 /**bu**-rjo.ku/ “a military power”	分離 /**bu.N**-ri/ “detachment”	家賃 /**ja**-ti.N/ “house rent”
譜面 /**hu**-me.N/ “musical score”	不在 /**hu**-za.i/ “absence”	噴火 /**hu.N**-ka/ “eruption”	独自 /**do.ku**-zi/ “unique”
簿記 /**bo**-ki/ “booking”	募集 /**bo**-sju.U/ “recruitment”	牧師 /**bo.ku**-si/ “minister”	事業 /**zi**-gjo.u/ “project”
歩兵 /**ho**-he.i/ “infantry”	保安 /**ho**-a.N/ “security”	本社 /**ho.N**-sja/ “head office”	神社 /**zi-N**.zja/ “Shinto shrine”
真夏 /**ma**-na.tu/ “midsummer”	摩擦 /**ma**-sa.tu/ “friction”	漫画 /**ma.N**-ga/ “comic”	技法 /**gi**-ho.u/ “technique”
魅惑 /**mi**-wa.ku/ “fascination”	未明 /**mi**-me.i/ “the wee hours”	民主 /**mi.N**-sju/ “democracy”	暴露 /**ba.ku**-ro/ “disclosure”
夢中 /**mu**-tju.U/ “enthusiasm”	矛盾 /**mu**-zju.N/ “contradiction”	息子 /**mu.su**-ko/ “son”	期日 /**ki**-zi.tu/ “deadline”
女神 /**me**-ga.mi/ “goddess”	目玉 /**me**-da.ma/ “feature”	名誉 /**me.i**-jo/ “honor”	欠如 /**ke.tu**-zjo/ “deficiency”
喪服 /**mo**-hu.ku/ “mourning”	模様 /**mo**-jo.u/ “pattern”	文句 /**mo.N**-ku/ “complaint”	与党 /**jo**-to.u/ “ruling party”
夜食 /**ja**-sjo.ku/ “midnight meal”	野球 /**ja**-kju.U/ “baseball”	役場 /**ja.ku**-ba/ “office”	準備 /**zju.N**-bi/ “preparation”
油性 /**ju**-se.i/ “oiliness”	輸入 /**ju**-nju.U/ “import”	猶予 /**ju.U**-jo/ “extension”	無罪 /**mu**-za.i/ “innocence”
余熱 /**jo**-ne.tu/ “residual heat”	予定 /**jo**-te.i/ “schedule”	用途 /**jo.u**-to/ “use”	候補 /**ko.u**-ho/ “a candidate”
履歴 /**ri**-re.ki/ “career”	理論 /**ri**-ro.N/ “doctorine”	力士 /**ri.ki**-si/ “sumoist”	波乱 /**ha**-ra.N/ “turbulent”
露出 /**ro**-sju.tu/ “exposure”	路線 /**ro**-se.N/ “line”	論理 /**ro.N**-ri/ “logic”	周囲 /**sju.U**-i/ “environment”

(*Appendices continue*)

Appendix F

Prime-Target Pairs Used in Experiment 6 Along With Their English Translations

Target	Character-sound match	Control
	Word, Pronunciation, English translation	
偉大 /**i**-da.i/ “greatness”	医者 /**i**-sja/ “doctor”	著者 /**tjo**-sja/ “author”
尾根 /**o**-ne/ “edge”	汚職 /**o**-sjo.ku/ “corruption”	辞職 /**zi**-sjo.ku/ “resignation”
過信 /**ka**-si.N/ “overconfidence”	可決 /**ka**-ke.tu/ “passage”	否決 /**hi**-ke.tu/ “rejection”
花瓶 /**ka**-bi.N/ “vase”	貨物 /**ka**-mo.tu/ “cargo”	荷物 /**ni**-mo.tu/ “baggage”
我流 /**ga**-rju.U/ “self-taught”	画面 /**ga**-me.N/ “screen”	地面 /**zi**-me.N/ “ground surface”
既婚 /**ki**-ko.N/ “married”	記入 /**ki**-nju.U/ “fill-in”	加入 /**ka**-nju.U/ “affiliation”
技法 /**gi**-ho.u/ “technique”	議席 /**gi**-se.ki/ “legislative seat”	座席 /**za**-se.ki/ “seat”
危害 /**ki**-ga.i/ “disservice”	気力 /**ki**-rjo.ku/ “vigor”	威力 /**i**-rjo.ku/ “power”
拒絶 /**kjo**-ze.tu/ “refusal”	居住 /**kjo**-zju.U/ “habitation”	移住 /**i**-zju.U/ “immigration”
苦学 /**ku**-ga.ku/ “to work one”s way”	区民 /**ku**-mi.N/ “inhabitants of ward”	庶民 /**sjo**-mi.N/ “common people”
愚問 /**gu**-mo.N/ “foolish question”	具合 /**gu**-a.i/ “health”	試合 /**si**-a.i/ “game”
毛虫 /**ke**-mu.si/ “caterpillar”	懸念 /**ke**-ne.N/ “anxiety”	疑念 /**gi**-ne.N/ “skepticism”
解熱 /**ge**-ne.tu/ “decline of fever”	下旬 /**ge**-zju.N/ “late”	初旬 /**sjo**-zju.N/ “beginning”
後光 /**go**-ko.u/ “aureola”	語学 /**go**-ga.ku/ “language”	私学 /**si**-ga.ku/ “private school”
小鳥 /**ko**-to.ri/ “tomtit”	個室 /**ko**-si.tu/ “private room”	自室 /**zi**-si.tu/ “one”s room”
砂丘 /**sa**-kju.U/ “sand hill”	差額 /**sa**-ga.ku/ “a difference”	巨額 /**kjo**-ga.ku/ “huge amount”
鎖国 /**sa**-ko.ku/ “national isolation”	査定 /**sa**-te.i/ “assessment”	所定 /**sjo**-te.i/ “prescribed”
始発 /**si**-ha.tu/ “first train”	資本 /**si**-ho.N/ “capital”	絵本 /**e**-ho.N/ “picture book”
字幕 /**zi**-ma.ku/ “subtitles”	地盤 /**zi**-ba.N/ “ground”	基盤 /**ki**-ba.N/ “basis”
車道 /**sja**-do.u/ “street”	社員 /**sja**-i.N/ “staff”	委員 /**i**-i.N/ “commissioner”
種族 /**sju**-zo.ku/ “tribe”	主力 /**sju**-rjo.ku/ “main force”	魅力 /**mi**-rjo.ku/ “fascination”
書斎 /**sjo**-sa.i/ “study room”	諸国 /**sjo**-ko.ku/ “countries”	四国 /**si**-ko.ku/ “Shikoku (the name of Japanese island)”
図鑑 /**zu**-ka.N/ “picture book”	頭脳 /**zu**-no.u/ “brain”	首脳 /**sju**-no.u/ “summit”
酢豚 /**su**-bu.ta/ “sweet-sour pork”	素顔 /**su**-ga.o/ “natural face”	笑顔 /**e**-ga.o/ “smile”
世襲 /**se**-sju.U/ “heredity”	背中 /**se**-na.ka/ “back”	最中 /**mo**-na.ka/ “Monaka (the name of a Japanese sweet stuff)”
疎遠 /**so**-e.N/ “alienation”	阻害 /**so**-ga.i/ “inhibition”	被害 /**hi**-ga.i/ “damage”
粗末 /**so**-ma.tu/ “rough”	措置 /**so**-ti/ “step”	処置 /**sjo**-ti/ “treatment”
他殺 /**ta**-sa.tu/ “murder”	多数 /**ta**-su.U/ “many”	戸数 /**ko**-su.U/ “number of houses”
遅刻 /**ti**-ko.ku/ “tardiness”	知識 /**ti**-si.ki/ “knowledge”	意識 /**i**-si.ki/ “consciousness”
血筋 /**ti**-su.zi/ “lineage”	治安 /**ti**-a.N/ “security”	不安 /**hu**-a.N/ “anxiety”
度胸 /**do**-kjo.u/ “courage”	土器 /**do**-ki/ “clay pot”	武器 /**bu**-ki/ “weapon”
塗装 /**to**-so.u/ “paint”	登山 /**to**-za.N/ “climbing”	火山 /**ka**-za.N/ “volcano”
徒歩 /**to**-ho/ “walk”	都内 /**to**-na.i/ “in Tokyo”	市内 /**si**-na.i/ “city center”
奈落 /**na**-ra.ku/ “abyss”	名前 /**na**-ma.e/ “name”	手前 /**te**-ma.e/ “this side”
寝顔 /**ne**-ga.o/ “sleeping face”	値段 /**ne**-da.N/ “price”	普段 /**hu**-da.N/ “everyday”
派生 /**ha**-se.i/ “derivation”	破産 /**ha**-sa.N/ “bankruptcy”	資産 /**si**-sa.N/ “property”
秘策 /**hi**-sa.ku/ “secret plan”	比重 /**hi**-zju.U/ “specific gravity”	二重 /**ni**-zju.U/ “doubleness”
美女 /**bi**-zjo/ “beauty”	備蓄 /**bi**-ti.ku/ “stock”	貯蓄 /**tjo**-ti.ku/ “saving”
非番 /**hi**-ba.N/ “off-duty”	飛行 /**hi**-ko.u/ “flight”	旅行 /**rjo**-ko.u/ “trip”
侮辱 /**bu**-zjo.ku/ “insult”	部品 /**bu**-hi.N/ “part”	遺品 /**i**-hi.N/ “memento”
婦長 /**hu**-tjo.u/ “head nurse”	浮上 /**hu**-zjo.u/ “levitation”	路上 /**ro**-zjo.u/ “street level”
譜面 /**hu**-me.N/ “musical score”	不正 /**hu**-se.i/ “irregularity”	是正 /**ze**-se.i/ “correction”
捕獲 /**ho**-ka.ku/ “capture”	保存 /**ho**-zo.N/ “preservation”	依存 /**i**-zo.N/ “abuse”
補欠 /**ho**-ke.tu/ “substitute”	歩調 /**ho**-tjo.u/ “pace”	口調 /**ku**-tjo.u/ “tone of voice”
母性 /**bo**-se.i/ “maternity”	募金 /**bo**-ki.N/ “fund-raise”	預金 /**jo**-ki.N/ “pay-in”
見本 /**mi**-ho.N/ “sample”	味方 /**mi**-ka.ta/ “favor”	仕方 /**si**-ka.ta/ “fashon”
夢中 /**mu**-tju.U/ “preoccupation”	無料 /**mu**-rjo.u/ “charge-free”	肥料 /**hi**-rjo.u/ “manure”
夜空 /**jo**-zo.ra/ “night sky”	予想 /**jo**-so.u/ “anticipation”	理想 /**ri**-so.u/ “ideal”
離島 /**ri**-to.u/ “isolated island”	利点 /**ri**-te.N/ “merit”	打点 /**da**-te.N/ “run batted in”
和食 /**wa**-sjo.ku/ “Japanese food”	話題 /**wa**-da.i/ “topic”	課題 /**ka**-da.i/ “assignment”

Received April 14, 2016
Revision received December 7, 2016
Accepted December 11, 2016 ■