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RESEARCH REPORT

Phonologically-Based Priming in the Same-Different Task With L1 Readers

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The present experiment provides an investigation of a promising new tool, the masked priming same-different task, for investigating the orthographic coding process. Orthographic coding is the process of establishing a mental representation of the letters and letter order in the word being read which is then used by readers to access higher-level (e.g., semantic) information about that word. Prior research (e.g., Norris & Kinoshita, 2008) had suggested that performance in this task may be based entirely on orthographic codes. As reported by Lupker, Nakayama, and Perea (2015a), however, in at least some circumstances, phonological codes also play a role. Specifically, even though their 2 languages are completely different orthographically, Lupker et al.'s Japanese-English bilinguals showed priming in this task when masked L1 primes were phonologically similar to L2 targets. An obvious follow-up question is whether Lupker et al.'s effect might have resulted from a strategy that was adopted by their bilinguals to aid in processing of, and memory for, the somewhat unfamiliar L2 targets. In the present experiment, Japanese readers responded to (Japanese) Kanji targets with phonologically identical primes (on "related" trials) being presented in a completely different but highly familiar Japanese script, Hiragana. Once again, significant priming effects were observed, indicating that, although performance in the masked priming same-different task may be mainly based on orthographic codes, phonological codes can play a role even when the stimuli being matched are familiar words from a reader's L1.

Keywords: Japanese scripts, masked priming, orthographic coding, phonological priming, same-different task

Successful reading, regardless of the script that the words appear in, requires that the reader determine both the identities and order of the letters/characters in the words being read. The process of establishing a mental representation (i.e., a code) of letter/character identities and order, from which all subsequent processing (e.g., phonological, lexical, semantic/conceptual) can emerge, has come to be called "orthographic coding" (Grainger, 2008). In recent years, interest in examining the nature of this process (and the nature of the code that is produced by the process) has attracted considerable research attention. The goal of the present research is to further examine a promising technique for investigating the orthographic coding process.

Until recently, most research on orthographic coding involved the masked priming lexical-decision task (Forster & Davis, 1984). In this task a prime is presented for a brief time period (e.g., 50 ms) prior to the presentation of a visible target to which participants must make a lexical decision. The target serves as a backward mask for the prime and, therefore, participants are typically unaware of the prime's existence. In the "related" condition, the prime and target are orthographically similar to one another, whereas in the "unrelated" condition, they are not. A difference in response latency between conditions, typically involving more rapid responding in the related condition (i.e., a "priming" effect), is taken as evidence that the orthographic code of the target is similar to that of the prime.

Initially, the assumption was that the size of the priming effect would be a direct measure of the similarity of the prime's and target's orthographic codes. Hence, the technique would be a useful way of examining predictions of the various models of orthographic coding. More recently, however, it has become clear that priming effect sizes in this task are affected by other factors. One such factor is the lexicality of the prime. Prime-target pairs that would seem to be equally similar according to virtually all models of orthographic coding produce quite different size priming effects if the prime is a word (e.g., prime: able, target: AXLE) than if it is a nonword (e.g.,

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prime: asle, target: AXLE). In fact, orthographically similar word primes will often inhibit target processing, whereas nonword primes will often facilitate it (Davis & Lupker, 2006; Segui & Grainger, 1990). Further, other nonorthographically based variables such as target frequency and prime or target neighborhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977) can also affect the size of the priming effect (Nakayama, Sears, & Lupker, 2008). Clearly, other paradigms are needed in order to provide a clearer examination of the orthographic coding process.

Two such paradigms have emerged over the past decade. One, the sandwich priming paradigm (Lupker & Davis, 2009), involves presenting the target very briefly prior to the presentation of the prime of interest on every trial. One presumed impact is to minimize any inhibitory processes with the typical result being an increase in the size of the priming effect (Davis & Lupker, in press; Lupker & Davis, 2009). This task is, however, less than a perfect solution because a lexical decision is required and lexical-decision making (and, hence, performance in the sandwich priming task) can be influenced by nonorthographically based factors such as semantic context. Therefore, steps must be taken to evaluate the contribution of such factors in order to isolate the prime's impact on the orthographic coding process.

The other paradigm is the masked priming same-different task. In this task a "reference stimulus" is initially presented. A brief masked prime is then presented followed by a target. The task is to indicate whether the reference stimulus and the target are the same or different. When the trial is a "same" trial and the prime is orthographically similar to the target/reference stimulus (e.g., table-nable-TABLE), large priming effects are observed, and those effects are typically independent of target lexicality, target frequency, and any morphological relationship between the prime and target (Duñabeitia, Kinoshita, Carreiras, & Norris, 2011; Kinoshita & Norris, 2009). On "different" trials (i.e., when the reference stimulus and the target are not the same), the related primes can be similar to either the reference stimulus or the target. When the primes are orthographically similar to the target (e.g., field-table-TABLE), no priming effect is observed. When the related primes are orthographically similar to the reference stimulus (e.g., field-field-TABLE, the "zero-contingency" technique), however, an inhibition effect emerges (Kinoshita & Norris, 2010; Lupker, Nakayama, & Perea, 2015a; Lupker, Perea, & Nakayama, 2015b: Perea, Moret-Tatay, & Carreiras, 2011). As Duñabeitia et al. (2011) state, these results indicate that "The same-different task is based on a comparison of the target and reference strings at a purely orthographic level" (p. 525). If true, the implication is that the task may do a very good job of documenting the similarity of the orthographic codes of the prime and the reference stimulus, allowing the task to be a very useful tool for evaluating the various models of orthographic coding.

More recently, however, Lupker et al. (2015a, 2015b) have demonstrated that, in at least some circumstances, priming in the same-different task can be driven by nonorthographic factors. Participants in both sets of studies were Japanese-English bilinguals who were asked to carry out a same-different task using English reference stimuli and targets. What Lupker et al. (2015b) demonstrated was priming (i.e., facilitation on "same" trials and inhibition on "different" trials) from Japanese noncognate translation equivalent primes (written in Kanji), indicating that lexical/conceptual information from the prime can affect processing. What Lupker et al. (2015a) demonstrated was priming from phonologically similar word and nonword primes (written in Katakana), indicating that phonological information from the prime can affect processing.

The data from Lupker et al. (2015a, 2015b), therefore, provide good evidence that, at least in some situations, effects in the same-different task cannot be unambiguously interpreted as being due to the relationship between the prime's and target's orthographic codes. What should be noted, however, is that participants in both sets of studies were performing the task in their L2 (English). The task of matching a target and a reference stimulus in L2 may be somewhat different than matching in L1 especially when the two languages use different orthographies (i.e., scripts).

More specifically, it may have been somewhat difficult for Japanese readers to remember/work with the orthographic codes of English reference words given that those words were written in the Roman alphabet, a writing system that Japanese readers do not see frequently. Therefore, a reasonable hypothesis would be that the Japanese readers had recruited additional codes to use in the matching process. Phonological codes would be obvious ones to recruit and use because English phonological codes are at least somewhat similar to Japanese phonological codes (i.e., the two languages share many phonemes). Lexical/conceptual codes might even be of some use given that the words used by Lupker et al. (2015b) named simple, familiar concepts. If this hypothesis is correct, the finding that phonological and lexical/conceptual codes influence performance in the masked priming same-different task may not generalize to readers performing the task in their L1. The present experiment, therefore, was an attempt to determine whether codes other than orthographic codes are involved when participants perform the task in their L1.

The Japanese language provides a good means for examining this question. Written Japanese involves three different scripts, Kanji, Hiragana, and Katakana. Any given word is typically only written in one of these scripts. Because Hiragana and Katakana are syllabic scripts, however, any Kanji word can be transcribed into either Hiragana or Katakana. Therefore, it is possible to present reference stimuli and targets in Kanji and primes in a completely different script/orthography (in the present experiment, Hiragana) while at the same time having primes on related trials being phonologically identical to their reference stimuli/targets (e.g., 記号-きごう-記号, where 記号 and きごう are both pronounced /ki.go.u/). As a result, any priming effects observed could not be orthographic and would most likely be phonological. As will be discussed in the Discussion, however, in theory, it is also possible that any priming effect might be, to some degree, lexical/conceptual as that type of information may be activated by the prime through some sort of phonologically mediated process.

The "related" primes used here were Hiragana transcriptions of the reference/target stimuli on "same" trials. On "different" trials, the "zero-contingency" technique was used in that the related trials involved Hiragana transcriptions of the reference stimuli, rather than transcriptions of the targets. The expectation, if the priming in the same-different task is purely orthographically based (i.e., if the claims of Norris & Kinoshita, 2008, and Duñabeitia et al., 2011, are correct), is that there will be no priming from these Hiragana transcription primes. In contrast, if phonological information (and, potentially, lexical/conceptual information derived from the primes' phonological codes) can influence performance in this task, priming effects should emerge (i.e., a facilitation effect on "same" trials and an inhibition effect on "different" trials).

In experiments using alphabetic languages, the reference stimuli and the targets are typically written in different cases (e.g., reference stimuli in lowercase, targets in uppercase) in order to prevent participants from basing their matches on visual information (e.g., Kinoshita, Robidoux, Guilbert, & Norris, 2015), which could, in theory, diminish the role of the orthographic codes in the process. Kanji has only one case, however. Therefore, it was not possible to implement a parallel manipulation here. Instead, the font type/size relationship between the reference stimuli and the targets was manipulated. For one group of participants, the reference and target stimuli were visually identical (i.e., they were presented in the same font type and size). For the other group, the two stimuli were presented in a different font type and size. Potentially, evidence of priming from our Hiragana transcription primes would be less likely to emerge for the former group.

Method

Participants

Sixty university students at Waseda University participated in the experiment. For 28 students the reference stimuli and targets were presented in the identical font type and size, and for 32 students the reference stimuli and targets were presented in different font types and sizes. All of the participants had normal or corrected-to-normal vision.

Stimuli

Eighty Japanese two-character Kanji words were selected as the reference/target stimuli to create the "same" trials. The average word frequency and familiarity rating for these words were 2.7 occurrences per million (Amano & Kondo, 2003b, which is a set of norms based on 287,792,787 tokens) and 5.5 (on a 7-point scale, Amano & Kondo, 2003a), respectively. The average number of strokes in the words was 18.6. Related primes (e.g., きごう, /ki.go.u/) were the Hiragana transcriptions of the Kanji words (e.g., 記号, /ki.go.u/, *symbol*); the related Hiragana primes and Kanji reference/target stimuli are phonologically identical. Related primes were, on average, 3.7 characters in length and had 3.5 morae. Unrelated primes (e.g., ますい, /ma.su.i/) were the Hiragana transcriptions of two-character Kanji words that were not presented in the experiment (e.g., 麻酔, /ma.su.i/, anesthetic) and were neither phonologically nor semantically similar to their reference/target stimuli. Unrelated Hiragana transcription primes were matched to the related Hiragana transcription primes in terms of mean character length ($M = 3.7$) and number of morae ($M = 3.5$). Further, the original Kanji words, from which the unrelated transcription primes were created, were similar to the Kanji reference/target stimuli in terms of word frequency ($M = 2.6$), familiarity rating ($M = 5.5$,) and number of strokes ($M = 18.4$).

Eighty pairs of two-character Kanji words were selected to create the "different" response trials. One of the words in the pair served as the reference stimulus and the other as the target. The reference stimuli and the targets had matching word frequencies (both Ms = 2.7), familiarity ratings (both Ms = 5.5), and stroke numbers (both Ms = 18.7). For the prime manipulation, we employed the "zero-contingency" technique, in which related primes were the transcriptions of the reference stimuli rather than the targets (Perea et al., 2011). Related primes were, on average 3.7 characters in length and had 3.5 morae. Unrelated primes, which were matched on character length ($M = 3.7$) and morae ($M = 3.5$) with the related primes, were the Hiragana transcriptions of two-character Kanji words that were not presented in the experiment. Unrelated primes were neither phonologically nor semantically similar to either their reference stimuli or their targets. There were two counterbalanced presentation lists. Within each list, half of the primes were Hiragana transcriptions of their reference stimuli, and the other half were unrelated Hiragana transcriptions, with the pairings of the reference stimulus-prime relationships being reversed in the other list. A complete list of the stimuli used in this experiment are contained in the Appendix.

Procedure

Participants were tested individually. The presentation of the stimuli was controlled by DMDX (Forster & Forster, 2003). The sequence of each trial was as follows: a reference stimulus (e.g., "記号", /ki.go.u/, *symbol*) was presented above a forward mask, which was a row of the visually complex and very unfamiliar Chinese/Kanji character "齾齾齾". A string of these characters was used as a forward mask in attempt to increase the efficacy of visual masking (e.g., Wang & Forster, 2015). This character is rarely used in Japan and thus was essentially a pseudocharacter to our participants. After 1 second, the reference stimulus was removed and the forward mask was replaced by the prime (e.g., "きごう", /ki.go.u/), which remained on the screen for 50 ms. Finally, the target stimulus (e.g., "記号", /ki.go.u/, *symbol*) appeared in the same position as the prime and remained on the screen until the participant responded or until 2 s had elapsed. In the identical font type/size condition, the reference/target stimuli were presented in 12 pt. MS Mincho (e.g., 記号 and 記号). In the different font type/size condition, the reference stimuli were presented in 14 pt. HGSSoeiKakupoptai and the targets in 12 pt. MS Mincho (e.g., **記号** and 記号). Primes were always presented in 10 pt. MS Mincho (e.g., きごう). Finally, because the primes were sometimes slightly longer than the targets, a dollar sign was added to the right and left sides of the reference stimuli and targets to ensure that the primes were effectively masked (e.g., $記号$-きごう-$記号$, was a reference-prime-target triplet, e.g., Nakayama, Sears, Hino, & Lupker, 2014). Participants were asked to decide whether the reference and target stimuli were the same word. Participants received 16 practice items to familiarize themselves with the task prior to the experimental session. None of the items in the practice trials were used in the experimental trials. This experiment received approval from the REB at Western University.

Results

Correct response latencies faster than 250 ms or slower than 1000 ms were removed from the latency analyses (0.3% of the "same" trials and 0.3% of the "different" trials). Data from one participant were removed because that participant was exceptionally slow (more than 3.0 SDs slower than the group mean). The rest of the correct response latencies and error rates were analyzed by ANOVAs with Prime Relatedness (Related, Unrelated) and Reference-Target Font type/size (Identical, Different) as factors. In the subject analyses, Prime Relatedness was a within-subject factor and Reference-Target Font type/size was a between-subjects factor. In the item analyses, both factors

Table 1
Response Latencies in Milliseconds (SDs) and Error Rates for "Same" and "Different" Trials for Kanji Targets as a Function of Prime Relatedness and Reference-Target Font Type and Size

	Same trials		Different trials	
Measure	RTs	Errors	RTs	Errors
Same font type/size				
Related	447 (64)	3.7	485 (58)	3.2
Unrelated	460 (68)	5.7	471 (61)	2.0
Priming	13	2.0	−14	−1.2
Different font types/sizes				
Related	450 (56)	2.6	487 (56)	2.5
Unrelated	466 (53)	5.2	468 (59)	1.8
Priming	16	2.6	−19	−.7
Font type/size collapsed				
Related	449 (60)	3.1	486 (56)	2.8
Unrelated	463 (58)	5.4	469 (58)	1.9
Priming	14	2.3	−17	−.9

were within-item factors. Analyses were run separately for the "same" trials and for the "different" trials. The means and standard deviations for both types of trials are presented in Table 1.

"Same" Trials

For response latency, the main effect of Prime Relatedness was significant, $F_s(1, 58) = 32.29$, $p < .001$, $MSE = 186.2$; $F_i(1, 79) = 38.59$, $p < .001$, $MSE = 485.6$. The "same" judgments were 14 ms faster when primes were Hiragana transcriptions of the reference-target words than when they were unrelated (449 ms vs. 463 ms). There was no effect of Reference-Target Font type/size, both Fs < 1, nor was there a significant interaction, both Fs < 1. Parallel results were found for errors; there was a significant main effect of Prime Relatedness, $F_s(1, 58) = 12.13$, $p = .001$, $MSE = 12.7$; $F_i(1, 79) = 13.81$, $p < .001$, $MSE = 21.2$, with error rates being 2.3% smaller when primes were Hiragana transcriptions (3.1% vs. 5.4%). There was no main effect of Reference-Target Font type/size, both Fs < 1, and no interaction, both Fs < 1.3.

"Different" Trials

For response latency, the main effect of Prime Relatedness was significant, $F_s(1, 58) = 36.67$, $p < .001$, $MSE = 232.2$; $F_i(1, 79) = 36.61$, $p < .001$, $MSE = 689.4$. Consistent with previous studies using a zero-contingency technique (e.g., Perea et al., 2011) the "different" judgments were 17 ms slower when the primes were Hiragana transcriptions of the reference stimuli than when they were unrelated (486 ms vs. 469 ms). The Reference-Target Font type/size factor was not significant, both Fs < 1, nor was the interaction, both Fs < 1. Finally, for errors, the main effect of Prime Relatedness was marginally significant in the subject analysis and significant in the item analysis, $F_s(1, 58) = 3.22$, $p < .08$, $MSE = 8.1$; $F_i(1, 79) = 4.92$, $p < .05$, $MSE = 14.2$. As expected, the direction of the priming effect was inhibitory (2.8% vs. 1.9% for related and unrelated primes, respectively). No other effects were significant, all Fs < 1.5.

Discussion

The results are quite clear. Hiragana transcriptions of Kanji words do produce priming in the same-different task. That is, they produce facilitation on "same" trials and inhibition on "different" trials. This result indicates that, for readers processing in their L1, priming can emerge in this task even though there is no orthographic similarity between the prime and the reference stimulus.

Also worth noting is the fact that there was no significant interaction between Prime Relatedness and Reference-Target Font type/size. The implication is that the group for whom the font types/sizes were identical was unlikely to have been performing the matching task based solely on the visual representations of the reference stimulus and target but, as hoped, was typically using higher level representations. Nevertheless, it should be noted that, numerically, the priming effects were slightly (on average, 4 ms) smaller for the group for whom the font types and sizes were identical for the target and reference stimulus. Thus, one cannot entirely rule out the possibility that a few responses for that group may have been based on visual similarity, preventing a phonologically related prime from having an effect on those trials.

General Discussion

The question investigated in the present experiment was whether codes other than orthographic codes are involved when participants perform the same-different task in their L1. More specifically, the present experiment was an attempt to determine whether the impact of phonological (and lexical/conceptual) factors observed by Lupker et al. (2015a, 2015b) in this task arose merely because the task was based on L2 stimuli. The present results clearly show that priming effects in the masked priming same-different task can be driven by nonorthographic factors when participants are responding to stimuli presented in their L1. Therefore, it appears that even L1 readers are not performing the task simply on the basis of orthographic codes and, hence, even for those individuals, the task will not provide as clear window on the nature of the orthographic code as was hoped.

This result, although seemingly unfortunate, is not completely unexpected. The literature on matching tasks is extensive and it contains considerable evidence that the matching of letter strings is not inevitably performed at the orthographic level. Chambers and Forster (1975), for example, using a simultaneous presentation task (i.e., the reference stimulus and the target are presented at the same time) provided evidence that allowed them to argue that matching in the same-different task is actually done simultaneously at the letter, letter cluster and word levels. Kelly, van Heuven, Pitchford, and Ledgeway (2013) have also argued that matching is at times done at the word level based on the fact that they observed more rapid matching for words than for nonwords. Proctor (1981), when discussing sequential matches (when the target follows the reference stimulus in time as was the case in the present experiment), provided evidence causing him to argue that "All sequential matches are apparently based on name codes" (p. 302).[1]

In spite of the existence of data indicating that orthographic codes are not the sole basis for matching in the same-different task, it must be acknowledged that there is considerable evidence that orthographic factors do play the major role in this task, at least in the specific

[1] In Proctor's analysis, "name codes" simply refers to the names of the stimuli, so, for example, responding "same" to the letters A and a would involve making a "name match." Needless to say, Proctor realized that stimuli that do not have obvious name codes, such as unfamiliar symbols, would have to be matched in a different fashion.

version of that paradigm used here. As noted, Norris and Kinoshita (2008) and Kinoshita and Norris (2009) have demonstrated that priming in that task is independent of both target frequency and lexicality. Furthermore, Duñabeitia et al. (2011) have demonstrated that priming is also independent of early morphological processing. Such results are clearly consistent with those authors' claims concerning the central role of orthographic codes in the matching process.

A theoretical resolution would, therefore, seem to be required. Consistent with Chambers and Forster's (1975) argument, it seems likely that participants would be attempting to determine whether the target matches the reference stimulus on a number of levels. Presumably, viewing the reference stimulus allows participants to set up to-be-matched codes at multiple levels. When the target is presented, matching at the various levels would then go on simultaneously and, hence, "same" responses could either occur as a result of a successful match on any of the levels or as a result of an accumulation of evidence from all the levels.

Importantly, however, the different levels would not be expected to finish processing at the same time (or to contributed equally to the ultimate decision) because of how target processing itself unfolds. Rather, the first target information to emerge (and to be considered in the matching process) will be orthographic. Prelexical phonological information would start to emerge next and lexical/conceptual information would only emerge later. Regardless of whether one conceives of the overall process in terms of a horse race or in terms of an evidence accumulation process, the crucial point is that decision making will be mainly driven by the matching being done at the level that is first to provide good evidence for the correct response which will typically be the level that can start first (i.e., the orthographic level). Such will certainly be the case when a briefly presented prime provides support for a match at that level (in horse race terms, an orthographically similar prime would give the early starting orthographic matching process an additional boost). Hence, in general, the largest priming effects will be orthographic priming effects as that relationship will dominate processing.

When there is not an orthographic relationship but there is a phonological relationship between the prime and reference stimulus, however (i.e., Lupker et al., 2015a; the present experiment), the situation changes somewhat. Now the reference-target matching at the phonological level, but not the orthographic level, is given a boost. The result would be some early matches at the phonological level and, hence, any priming effect would essentially be attributable to phonology. Further, as Lupker et al. (2015b) demonstrated, in the absence of both an orthographic relationship and a phonological relationship, a strong conceptual relationship (i.e., translation equivalency) can even produce a small degree of priming (i.e., 8–12 ms). In that situation, the boost that lexical/conceptual processing was given was apparently sufficient to allow reference-target matching at that level to proceed quickly enough on some trials. As a result, matching at that level was able to have some impact on the overall process. In fact, the ability of the lexical/conceptual level to contribute in Lupker et al.'s experiments involving Kanji noncognate translation equivalents and English targets may have been further aided by the fact that those primes provided nonmatching information at the orthographic and phonological levels. Thus, the ability of those levels to quickly recognize a match between the reference stimulus and the target may have been hindered to some degree.

If this analysis is correct, it does seem likely that Kinoshita and Norris (2009) were more or less correct in saying "The (same-different) task appears to tap into the same representations that support word recognition but not to be influenced by the lexical retrieval processes" (p. 13). That is, it seems likely that matching at the word level would hardly ever produce any priming in this task, even when using identity primes (which would explain why lexicality does not impact the size of the priming effect). However, what is less clear is whether prelexical phonology from the prime plays any role in producing priming when orthographic priming is being investigated in the same-different task. That is, in most alphabetic languages, it is virtually impossible to create orthographically similar prime-target pairs that are not also phonologically similar. Could, therefore, some of the "orthographically-based" priming actually be attributable to there being a phonological relationship between the primes and reference/target stimuli and, hence, the phonological matching process also receiving an early boost?

There appear to have been two attempts to investigate this question in the literature. Besner, Coltheart, and Davelaar (1984) did so using a sequential same-different task (without a masked prime) in which the reference and target stimuli were to be classified as "same" only if they matched both in terms of letter identity and case. They showed that "different" responses for letter strings that were phonologically identical (HILE-hyle) were a nonsignificant 7 ms slower than for letter strings that mismatched at the same number of letter positions (e.g., HILE-hule). Kinoshita and Norris (2009), using the standard masked priming same-different task, contrasted the impact of pseudohomophone primes (skore priming SCORE) versus the impact of nonword primes matching their targets at the same number of letter positions as the pseudohomophone primes did (e.g., smore-SCORE) on "same" trials. The pseudohomophone prime condition was only a nonsignificant 2 ms faster, causing the authors to conclude "These results suggest that phonology plays no role in priming in the cross-case same-different task and that priming is purely orthographic" (p. 9).

Although both Besner et al.'s (1984) and Kinoshita and Norris's (2009) contrasts were purely phonological, in both cases their manipulation of phonology was fairly weak. Besner et al.'s two target types (hyle and hule) and Kinoshita and Norris's two prime types (skore and smore) differ in only one phoneme. Further, in both cases, numerically, the effect went in the direction that would be predicted by a phonologically based account. Therefore, it's not impossible that phonology may be responsible for some of the "orthographic" priming in alphabetic language same-different tasks, although presently available evidence does not imply that its impact is major. That is, it is notable that the size of the uncontaminated phonological effects reported here (15–20 ms) is substantially smaller than the potentially contaminated orthographic priming effects in the literature (e.g., 80+ ms, Norris & Kinoshita, 2008).

Are the Present Priming Effects Purely Phonological?

The same-different task is, of course, not the only task that appears to be susceptible to phonological priming as phonological priming effects have also emerged in the lexical decision (e.g., Ferrand & Grainger, 1992, 1994; Grainger & Ferrand, 1996) and naming tasks (e.g., Lukatela & Turvey, 1994). Nonetheless, given the basic differences in how people perform these tasks, it seems unlikely that phonological priming effects would have the same explanation in the various tasks. With respect to the present task (i.e., the same-different task), the account offered above is that when the phonological information from the prime matches the phonological information from the reference stimuli it aids in making a "same" decision while inhibiting a "different" decision. As noted, the matching process may have been a horse race (with the phonological process finishing first on a number of trials) or it may have been an information accumulation process (with the phonological match pushing the response process in the direction of a positive response). As suggested earlier, however, even if this analysis is generally correct, one could question whether the observed priming in the present experiment was entirely phonological.

More specifically, the Hiragana transcription primes are essentially pseudohomophones (e.g., in English, brane) and pseudohomophones do have the ability to activate the lexical/conceptual representations of their base word through a phonologically mediated process. Thus, the possibility exists that some of the priming in the present experiment was due to lexical/conceptual factors, factors that were shown to produce priming by Lupker et al. (2015b). The process by which lexical/conceptual priming occurs would be essentially the same as that hypothesized for phonological priming to occur. That is, a match between the lexical/conceptual code of the reference stimulus and the lexical/conceptual code activated by the prime could have produced a bias toward a positive response. Indeed, Bowers and Michita (1998) have shown that Hiragana transcriptions of high-frequency Kanji words (transcriptions that readers likely would have seen in text) produced the same long term priming effects that their Kanji words themselves produced, suggesting that those transcriptions activated all the same processing structures that the words themselves activated.[2]

As argued by Nakayama, Sears, Hino, and Lupker (2012, 2013), phonological priming effects, at least in translation priming tasks, do not interact with frequency whereas lexical/conceptual priming effects do interact with frequency. Thus, in an attempt to evaluate the nature of the apparently phonological effects in the present situation, one could ask whether the observed effects interact with frequency. Unfortunately, however, the present stimuli are so uniformly low in frequency ($M = 2.7$ occurrences per million, with a median split producing means for the high- and low-frequency groups of 2.9 and 2.4 occurrences per million, respectively) that they could not provide much of an answer to this question. Nevertheless, a post hoc analysis indicates there was virtually no difference between the two groups of stimuli in terms of priming effects on either "same" or "different" trials (both $F\text{s} < 1$).

As suggested by a reviewer, an alternative way of answering this question might be to use Hiragana primes that were not pseudohomophones but, instead, were one phoneme (or one mora) different from the reference stimuli. Those primes would not match the lexical/conceptual representation of the reference stimuli, leading to little, if any, lexical/conceptual priming, but should produce nearly as much phonological priming as the Hiragana transcriptions. Unfortunately, in the present situation, this type of manipulation would be unlikely to help answer the question. The present priming effects (13–19 ms) would likely be reduced if we used primes that matched the targets in one or two fewer phoneme/mora position(s) than the transcription primes do simply because they would be less phonologically similar to the reference stimuli than the transcription primes are. Would, then, a reduction in the size of the priming effect when using primes matching in $n - 1$ phoneme positions to, say, 10 ms, be attributable to the lesser phonological similarity or to eliminating lexical/conceptual priming? Given the sizes of the effects involved, it would seem to be virtually impossible to tease these possibilities apart. Hence, at present, there is no strong empirical evidence allowing us to say that the priming effects observed here were entirely free of lexical/conceptual influences.

One final point to note is that the present data provide some information about the potential role of visual information in this task. As mentioned, in alphabetic languages, any concerns about matching being done at the visual level can be easily addressed by presenting the reference stimulus and the target in different cases ("cross-case" matching), a manipulation that cannot be used in Japanese where there is no uppercase versus lowercase distinction. Nonetheless, what the present results indicate is that this issue is likely not a major concern in Japanese either. That is, there was very little difference between the priming effect for the group for which the reference stimulus and the target were identical and the priming effect for the group for which the reference stimulus and target were in different font types and sizes. If participants had been matching on the basis of visual information, one would have expected that the former group would have shown a somewhat smaller priming effect (i.e., less influence of phonology) than the latter. Still, a small difference (4 ms) in that direction was observed, meaning that it's not impossible that visual matching might have driven responding on a small proportion of the trials.

Conclusion

In summary, the main implication for the sequential presentation masked priming same-different task seems to be that phonological matching/priming is possible in a reader's L1. Therefore, when using primes that are both orthographically and phonologically related to the reference stimuli, one will need to exercise some caution in attributing any observed priming effects to orthographic similarity. Hence, like the sandwich priming paradigm, the same-different task does not provide an uncontaminated view of the nature of the orthographic code. However, no experimental paradigm is perfect and, the converging evidence that one can draw from using both paradigms (e.g., Davis & Lupker, in press; Lupker, Zhang, Perry, & Davis, 2015) offers promise for, as Grainger (2008) stated, ultimately "cracking the orthographic code" (p. 1).

[2] Although virtually all Japanese words are typically written in only one script, some Japanese text does include Hiragana transcriptions of Kanji words. As a result, Bowers and Michita (1998) were able to find some high-frequency Kanji words for use in their experiments whose Hiragana transcriptions had, at some point, likely been seen by Japanese readers. In contrast, because the Kanji words used in our experiment were quite low frequency (i.e., themselves occurring infrequently in Japanese text) most, if not all, of the transcriptions used here would never have been seen by Japanese readers. This fact is, of course, consistent with the idea that it would have been somewhat unlikely that the Hiragana transcriptions used in the present experiment would have activated the words' lexical/conceptual representations.

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(*Appendix follows*)

Appendix

Stimuli

Same Trials (Reference Stimulus, Transcription Prime, Unrelated Prime, Target)

暗示, あんじ, うみべ, 暗示; 異国, いこく, くちび, 異国; 恩師, おんし, じつぎ, 恩師; 仮説, かせつ, うらめ, 仮説; 活路, かつろ, したく, 活路; 貨幣, かへい, いちや, 貨幣; 仮面, かめん, いえで, 仮面; 記号, きごう, ますい, 記号; 期末, きまつ, ほへい, 期末; 儀礼, ぎれい, うわぎ, 儀礼; 毛皮, けがわ, ひとめ, 毛皮; 下校, げこう, やきん, 下校; 豪雨, ごうう, どれい, 豪雨; 個体, こたい, くかく, 個体; 湿度, しつど, みんわ, 湿度; 神父, しんぷ, ずつう, 神父; 祖先, そせん, ふぜい, 祖先; 知性, ちせい, しはつ, 知性; 窒素, ちっそ, こんや, 窒素; 転移, てんい, ふせん, 転移; 天使, てんし, ろうひ, 天使; 陶器, とうき, ふりん, 陶器; 花見, はなみ, のうふ, 花見; 美人, びじん, しせき, 美人; 補足, ほそく, じてん, 補足; 本屋, ほんや, すいろ, 本屋; 水着, みずぎ, ふうし, 水着; 名画, めいが, ゆだん, 名画; 屋台, やたい, ちこく, 屋台; 夜中, よなか, みほん, 夜中; 弱火, よわび, だいく, 弱火; 連鎖, れんさ, ふどう, 連鎖; 果汁, かじゅう, きょうち, 果汁; 芸者, げいしゃ, せしゅう, 芸者; 紅茶, こうちゃ, がんしょ, 紅茶; 受刑, じゅけい, とりょう, 受刑; 新書, しんしょ, きょうき, 新書; 清酒, せいしゅ, びりょく, 清酒; 茶色, ちゃいろ, がいしゃ, 茶色; 発車, はっしゃ, しょどう, 発車; 歌声, うたごえ, すいおん, 歌声; 解読, かいどく, えんぶん, 解読; 各論, かくろん, りんかく, 各論; 岩石, がんせき, らいひん, 岩石; 乾杯, かんぱい, どろぼう, 乾杯; 君臨, くんりん, ほうよう, 君臨; 刑罰, けいばつ, おうごん, 刑罰; 血縁, けつえん, みっこう, 血縁; 決裁, けっさい, もんぜん, 決裁; 幸運, こううん, えいやく, 幸運; 黒板, こくばん, はんそく, 黒板; 婚姻, こんいん, ぼくめつ, 婚姻; 最適, さいてき, べんかい, 最適; 参謀, さんぼう, べつわく, 参謀; 水平, すいへい, てんこう, 水平; 清潔, せいけつ, ぶったい, 清潔; 生成, せいせい, いしがき, 生成; 戦友, せんゆう, ていへん, 戦友; 送迎, そうげい, ふんしつ, 送迎; 損壊, そんかい, もくろく, 損壊; 定説, ていせつ, こくひん, 定説; 点灯, てんとう, れっせい, 点灯; 特典, とくてん, せきさい, 特典; 偽物, にせもの, へいみん, 偽物; 日没, にちぼつ, なんかん, 日没; 熱湯, ねっとう, ちくざい, 熱湯; 発散, はっさん, とうごく, 発散; 分校, ぶんこう, おおゆき, 分校; 砲弾, ほうだん, ひんけつ, 砲弾; 誘発, ゆうはつ, へんしん, 誘発; 零細, れいさい, あさがた, 零細; 論説, ろんせつ, ゆうれい, 論説; 炎症, えんしょう, ちゃくじつ, 炎症; 銃声, じゅうせい, しつりょう, 銃声; 商会, しょうかい, げんりゅう, 商会; 商船, しょうせん, へいじょう, 商船; 挿入, そうにゅう, ちゃくにん, 挿入; 動脈, どうみゃく, じょうぞう, 動脈; 放流, ほうりゅう, きゃっかん, 放流; 有償, ゆうしょう, しゅうめい, 有償

Different Trials (Reference Stimulus, Transcription Prime, Unrelated Prime, Target)

合図, あいず, かやく, 王子; 下限, かげん, くよう, 見事; 歌謡, かよう, ほんき, 横目; 感度, かんど, ふくぶ, 遺影; 気圧, きあつ, かがい, 風味; 紀行, きこう, あくむ, 日課; 起点, きてん, ほよう, 河原; 吟味, ぎんみ, ざいい, 自伝; 原画, げんが, たいま, 自戒; 国務, こくむ, さかて, 始動; 芝生, しばふ, さいく, 野心; 水死, すいし, みまい, 気質; 推理, すいり, よしん, 網羅; 静止, せいし, てさき, 硬貨; 聖地, せいち, ほどう, 田畑; 疎通, そつう, やさき, 連打; 谷間, たにま, すなお, 歩行; 貸与, たいよ, よぞら, 佳作; 地質, ちしつ, とそう, 日誌; 地層, ちそう, せいり, 発火; 点火, てんか, いせい, 下山; 粘土, ねんど, いやけ, 仮想; 避妊, ひにん, ごそう, 本家; 肥満, ひまん, たんご, 偽装; 美容, びよう, かふん, 水位; 頻度, ひんど, けしき, 舗装; 冬場, ふゆば, きはく, 察知; 分化, ぶんか, ごにん, 養父; 未婚, みこん, てんぷ, 掲示; 虫歯, むしば, えいじ, 宝庫; 模範, もはん, ぼうか, 市外; 油彩, ゆさい, うんが, 互換; 乳児, にゅうじ, じょれつ, 市中; 銃器, じゅうき, びみょう, 貯水; 処方, しょほう, きゅうゆ, 着地; 中古, ちゅうこ, しょくひ, 火力; 利潤, りじゅん, ぎしょう, 教義; 異名, いみょう, かいきょ, 獣医; 廃虚, はいきょ, りょうじ, 侮辱; 中佐, ちゅうさ, ぎょこう, 委縮; 足腰, あしこし, らんりつ, 送電; 円形, えんけい, しまぐに, 退団; 円滑, えんかつ, しっつい, 最短; 愛人, あいじん, こうがく, 欠航; 王様, おうさま, かっとう, 勤勉; 緊密, きんみつ, じっけい, 愛国; 合体, がったい, かいとう, 交番; 完走, かんそう, うらかた, 材質; 格闘, かくとう, えいえん, 旋回; 芸人, げいにん, せんさい, 強奪; 剣道, けんどう, がくだん, 降伏; 精密, せいみつ, なっとう, 壁面; 高熱, こうねつ, げんたい, 雑談; 体格, たいかく, ちんれつ, 当番; 参観, さんかん, こうぶつ, 誓約; 熱心, ねっしん, のうりつ, 全壊; 砂浜, すなはま, かんもん, 悪質; 生計, せいけい, しつげん, 関節; 雑音, ざつおん, いんめつ, 宅配; 浸水, しんすい, せっぱん, 養育; 淡水, たんすい, らくたん, 中庭; 電圧, でんあつ, とくめい, 誘惑; 電動, でんどう, ようせい, 平面; 当惑, とうわく, だいこん, 算数; 断面, だんめん, おやゆび, 悪口; 配線, はいせん, あんごう, 道徳; 腹痛, ふくつう, たかだい, 半日; 空想, くうそう, ないりく, 還暦; 返答, へんとう, まいぼつ, 国名; 栄光, えいこう, はぐるま, 洗練; 顔色, かおいろ, とうえい, 万能; 溶岩, ようがん, ぶつぞう, 本命; 集結, しゅうけつ, みゃくはく, 等級; 競泳, きょうえい, そうちゃく, 惨状; 新緑, しんりょく, そうきゅう, 重心; 動力, どうりょく, さいしゅう, 熟練; 愛着, あいちゃく, せっきょう, 直線; 専業, せんぎょう, きょうさく, 略奪; 失脚, しっきゃく, きょくげん, 大腸; 名曲, めいきょく, きゅうてい, 年中

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