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Is There Phonologically Based Priming in the Same−Different Task? Evidence From Japanese−English Bilinguals

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Norris and colleagues (Kinoshita & Norris, 2009; Norris & Kinoshita, 2008; Norris, Kinoshita, & van Casteren, 2010) have suggested that priming effects in the masked prime same−different task are based solely on prelexical orthographic codes. This suggestion was evaluated by examining phonological priming in that task using Japanese−English bilinguals. Targets and reference words were English words with the primes written in Katakana script, a syllabic script that is orthographically quite different from the Roman letter script used in writing English. Phonological priming was observed both when the primes were Japanese cognate translation equivalents of the English target/reference words (Experiment 1) and when the primes were phonologically similar Katakana nonwords (Experiment 2), with the former effects being substantially larger than the noncognate translation priming effects reported by Lupker, Perea, and Nakayama (2015). These results indicate that the same−different task is influenced by phonological information. One implication is that, due to the fact that phonology and orthography are inevitably confounded in Roman letter languages, previously reported priming effects in those languages may have been at least partly due to phonological, rather than orthographic, similarity. The potential extent of this problem, the nature of the matching process in the same−different task, and the implications for using this task as a means of investigating the orthographic code in reading are discussed.

Keywords: orthographic code, phonological priming, same−different task, cognate translation equivalents

To read a word successfully (i.e., to understand its meaning), readers must be able to ascertain not only the identities of the word's letters but also their order. Failing to do so leads to confusion between similarly spelled words like *pail* and *hail* as well as confusion between anagrams like *carve* and *crave*. In an attempt to model the process of going from a word on the page to that word's meaning, the typical assumption made is that an abstract representation (i.e., the "orthographic code") of the word being read is created (abstract in the sense that no distinction is made between upper- and lower-case versions of the letters). This representation, which codes both letter identities and letter order, is then used to access higher level (e.g., lexical, semantic) information (Grainger, 2008; Kinoshita & Kaplan, 2008; McConkie & Zola, 1979; Norris & Kinoshita, 2008; see Dehaene, Cohen, Sigman, & Vinckier, 2005; Grainger, Rey, & Dufau, 2008, for neural accounts of this process).

One basic challenge that arises within this conceptualization is understanding the nature of the orthographic code. A number of theories have been proposed, generally falling into one of two camps. One type of theory assumes that the orthographic code is composed of letter units that are inherently noisy with respect to the positions of the letters (e.g., Gómez, Ratcliff, & Perea, 2008, the overlap model; Davis, 2010, the spatial coding model; Adelman, 2011, the letters in time and retinotopic space model; Norris & Kinoshita, 2012; Norris, Kinoshita, & van Casteren, 2010, the Bayesian Reader model). Thus, although it is possible to read anagrams like *carve* correctly, it is also possible to mistake them for their anagram mate (i.e., *crave*), a result quite consistent with the available data (Chambers, 1979; O'Connor & Forster, 1981; Perea & Lupker, 2003a, 2003b, 2004; see also Johnson, Perea, & Rayner, 2007, for evidence during sentence reading). A second type of theory assumes that the orthographic code consists of bigram units representing the ordered sequences of each letter pair in the word (Dehaene et al., 2005; Grainger & van Heuven, 2003; Grainger, Granier, Farioli, Van Assche, & van Heuven, 2006; Whitney, 2001). For example, when reading *carve*, representational units for *ca*, *cr*, *cv*, *ce*, *ar*, *av*, *ae*, *re*, *re*, and *ve* are activated, and activating those units would also activate, to some degree, the lexical

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representation for *crave* because most of those units are the same units involved in reading *crave*.

The most commonly used technique for trying to distinguish between various models has been the masked prime lexical-decision task (Forster & Davis, 1984). Unfortunately, many of the models make similar predictions in a number of situations, making it difficult to draw clear conclusions about the nature of the orthographic code based on any particular set of data from that task. As a result, researchers have begun using alternative experimental paradigms for this purpose (e.g., Kinoshita & Norris, 2009; Lupker & Davis, 2009; Lupker, Zhang, Perry, & Davis, 2015; Norris & Kinoshita, 2008; Norris et al., 2010).

The task that is the focus of the present research is the cross-case masked prime same−different task (Kinoshita & Norris, 2009; Norris & Kinoshita, 2008; Norris et al., 2010). In this task, as shown in Figure 1, a reference stimulus in lower case is initially presented above a forward mask consisting of a row of hash marks for approximately 1 s. The forward mask is followed by a brief (e.g., 50 ms) presentation of a prime stimulus, replacing the forward mask, and then by a second visible target stimulus in upper case, replacing the prime. Hence, the target serves as a backward mask for the prime. The task is to decide whether the reference and target stimuli are the same or different, ignoring the difference in case. The standard result is that responses on "same" trials are significantly faster when the target and the prime are orthographically similar than when they are not.

For "different" trials (i.e., when the reference and the target are different), there are two ways to set up the related trials. That is, related primes can be related to the targets or they can be related to the reference stimuli. If the related primes on "different" trials are related to the targets (and, hence, not to the reference stimuli), whenever the reference and the prime on a trial are related, the correct response must be "same." In such a situation, the reference−prime relationship could be used to predict the response. In contrast, when the related primes on "different" trials are related to the reference stimuli, the reference−prime relationship does not predict the nature of the response. This latter situation is referred to as the "zero-contingency" scenario, and it was the scenario used in the present experiments. When a zero-contingency scenario is used, there is an inhibition effect on "different" trials when the prime is orthographically similar to the reference stimulus (Kinoshita & Norris, 2010; Perea, Moret-Tatay, & Carreiras, 2011).

Based on previous results using the masked prime same−different task, Norris and colleagues (Norris & Kinoshita, 2008; Kinoshita & Norris, 2009, 2010) have repeatedly argued that reference−target matching in that task is done solely at the abstract orthographic level. The implications of this argument are that priming effects in the task are essentially due to the orthographic similarity of

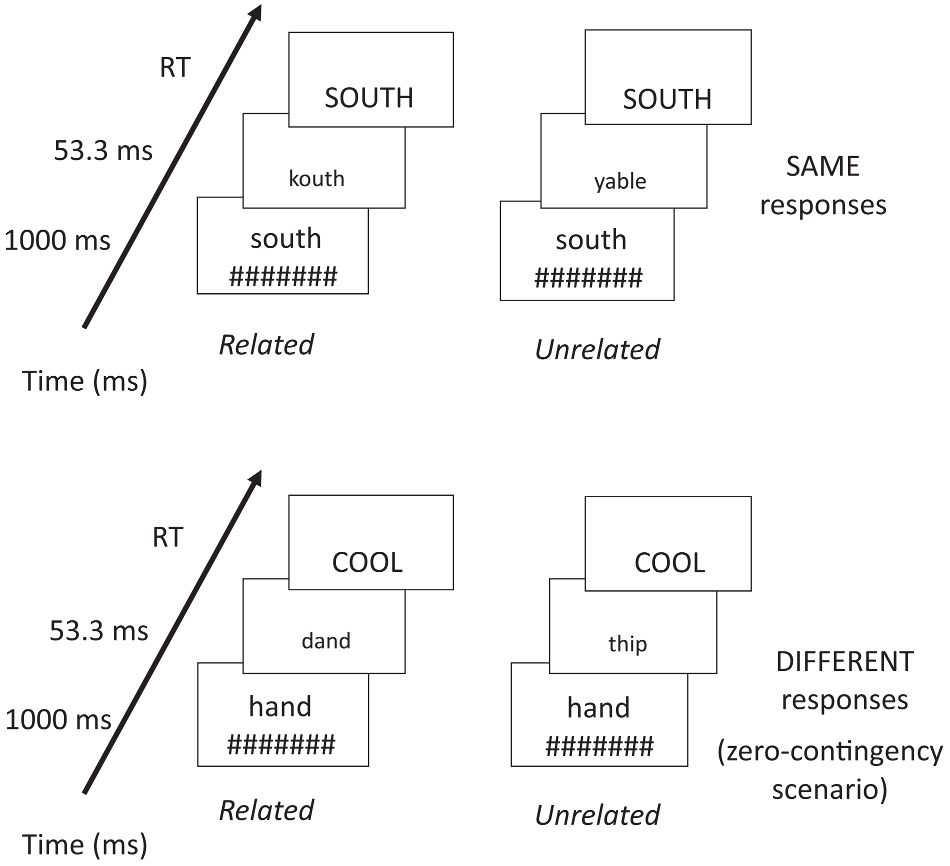

Figure 1. Standard display sequence in a masked prime same−different task in which a zero-contingency scenario was used to create related "different" trials. RT = reaction time.

the reference's and prime's orthographic codes, and, therefore, that the task may be an ideal one for investigating the nature of the orthographic code in reading. For example, they have claimed: "The same−different task is based on a comparison of the target and reference strings at a purely orthographic level" (Duñabeitia, Kinoshita, Carreiras, & Norris, 2011, p. 525), "the same−different task holds considerable promise as a tool for examining the nature of prelexical orthographic representations. The task appears to tap into the same representations that support word recognition but not to be influenced by the lexical retrieval processes" (Kinoshita & Norris, 2009, p. 13), and "This evolving prelexical orthographic representation is both input to the lexical access process and the representation used in the same−different task" (Kinoshita & Norris, 2009, p. 14).

The empirical bases of these claims is that: (a) the size of the priming effect appears to be independent of the lexical status of the reference/target as well as the frequency of the reference/target if it is a word (e.g., Kinoshita & Norris, 2009; Norris & Kinoshita, 2008) and (b) morphological relationships between the prime and the reference/target (e.g., walker−WALK) do not produce priming beyond that due to orthographic similarity (e.g., brothel−BROTH) (Duñabeitia et al., 2011; Kinoshita, Norris, & Siegelman, 2012). A further component of their argument, and the one that we investigated here, is that phonological priming effects do not appear to emerge in this task.

Norris and colleagues' core claim—that matching in the task is done at the abstract orthographic level only—is not without challenges. Chambers and Forster (1975), for example, proposed that reference and target stimuli are actually matched at three levels—letter, letter cluster, and word levels, based on their data from a simultaneous matching task (i.e., the reference and target stimuli were presented simultaneously). Their basic idea is that codes at all three levels are established for each letter string and matching processes are carried out at all three levels simultaneously. Whichever level yields a "same" response most rapidly is the level that drives the decision.

The main source of support for Chambers and Forster's (1975) claim was that high-frequency words were matched more rapidly than low-frequency words, which were matched more rapidly than legal nonwords, which were matched more rapidly than illegal nonwords. Their argument is simply that matching would be expected to be faster to the extent that a target and reference stimulus can take advantage of more levels. Therefore, high-frequency words, which can take advantage of all three levels and do so quite efficiently at the word level, should produce the shortest latencies, whereas illegal nonwords, which can only be matched at the letter level, should produce the longest latencies.

As noted above, Norris and Kinoshita (2008) did not find differential priming as a function of lexicality and/or frequency when using sequential reference−target presentations. Nor did they find, in contrast to Chambers and Forster (1975), any overall effects of lexicality and/or frequency. However, their data did trend in that direction, as noted by Kelly, van Heuven, Pitchford, and Ledgeway (2013), who reported clear evidence of Chambers and Forster's pattern in their four experiments using the sequential same−different task. As such, Kelly et al. proposed that matching is often done on the basis of lexical, rather than orthographic, codes when words are used as reference and target stimuli. What such a proposal would not explain, however, is that, if words can be matched at either the orthographic or lexical level whereas nonwords can only be matched at the orthographic level, why are the priming effects for word and nonword trials typically identical in size, as Norris and Kinoshita (2008) have reported. Therefore, as argued by Angiolillo-Bent and Rips (1982) and Marmurek (1989), lexicality and/or frequency effects in the same−different task may be better explained in terms of non-matching processes such as ease of encoding.

There is, however, more recent evidence that, for words, matching does take place at a level higher than the orthographic level (Lupker, Perea, & Nakayama, 2015). Lupker et al. used a translation priming manipulation in their sequential same−different task. Specifically, Japanese−English bilinguals were presented with an English reference word followed by a masked Japanese (Kanji script) prime that could be either a noncognate translation equivalent of, or unrelated to, the reference stimulus. On same trials (i.e., when the target matched the reference), a small (approximately 10 ms) facilitation effect was observed. On different trials, a zero-contingency manipulation was used (see Figure 1). On those trials, a small inhibition effect was observed from translation primes, presumably due to the prime biasing participants toward a "same" response, hence, slowing responding when the target did not match the reference stimulus. Because Roman and Kanji scripts have no orthographic similarity, these effects cannot be orthographically based and, because the translation equivalents were all noncognates, these effects cannot be phonologically based. Therefore, they are most likely based on relationships that exist at either the lexical or semantic level, implying that matching does occur at these higher levels.

As mentioned, however, the priming effects Lupker et al. (2015) observed were small (8–12 ms). The obvious implication is that matching at the lexical or semantic level played only a minor role in Lupker et al.'s experiments despite the strong lexical/semantic relationships that exist between translation equivalents. Indeed, as Norris and colleagues have reported, orthographically based priming effects are typically 5–10 times larger (e.g., ranging from 50−100 ms) than Lupker et al.'s effects. Hence, Lupker et al.'s data are not inconsistent with the idea that orthographic codes play virtually the entire role in this task, the only exception being those few instances in which there is a very strong conceptual relationship between the prime and target.

The purpose of the present research was to further examine the idea that the masked prime same−different task is virtually entirely orthographically based, but, this time, by asking whether there are phonological contributions to the matching/priming process. Specifically, by asking whether the same−different task shows phonological priming effects, the goal was to determine whether the matching task and the priming effects observed are ever based on phonological codes.

Given the strong relationship between orthography and phonology in languages using the Roman alphabet, disentangling the impacts of phonology and orthography is quite difficult. Indeed, in almost all the reported experiments that appear to demonstrate orthographic priming effects, there is considerable phonological similarity between the primes and the reference/target stimuli because those experiments were conducted in Roman alphabet languages. Therefore, if phonological priming were to be demonstrated in the same−different task, one could argue that most of the priming effects in masked prime same−different experiments currently in the literature may have been, at least in part, phonological effects. The further implication would be that this task would be a less than ideal task for investigating the nature of the orthographic code per se.

At present, there is little evidence with respect to the question of whether the same−different task is affected by phonology. One attempt to evaluate this issue was reported by Besner, Coltheart, and Davelaar (1984). Those researchers used a sequential same−different task (without a masked prime) in which the reference and target stimulus were to be classified as "same" only if they matched both in terms of letter identity and case. The important comparison involved the response latencies for "NO" (different) responses for letter strings that were phonologically identical (HILE−hyle) versus letter strings that mismatched at the same number of letter positions (e.g., HILE−hule). The 7-ms difference between these conditions (HILE−hyle trials were slower) was not significant.

A second look at this issue comes from Kinoshita and Norris (2009). Those researchers, using a masked prime same−different task, compared latencies for trials involving pseudohomophone primes (skore−SCORE) with latencies for trials involving nonword primes matching their targets at the same number of letter positions as the pseudohomophone primes did (e.g., smore−SCORE). No difference was observed, 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).

Both Besner et al. (1984) and Kinoshita and Norris (2009) were successful at unconfounding phonology and orthography in their experiments. What needs to be noted, however, is that, in both cases, their manipulations of phonology were fairly weak. The two types of targets in Besner et al. (hyle and hule) and the two types of primes in Kinoshita and Norris (skore and smore) differ in only one phoneme. Therefore, it seems likely that, if phonology does matter in the same−different task, evidence for such an effect would be difficult to observe with those particular manipulations. In fact, given the nature of Roman alphabet languages, it may not be possible to design a manipulation strong enough to disentangle the effects of phonology and orthography in those types of language. Fortunately, such is not the case when one is examining cross-script priming with Japanese−English bilinguals.

As reported by Nakayama, Sears, Hino, and Lupker (2012), primes presented in Japanese Katakana script prime phonologically related English targets in a lexical-decision task (e.g., サイド /sa.i.do/, *side*−GUIDE produces faster latencies than コール /ko.R.ru/, *call*–GUIDE; see also Ando, Jared, Nakayama, & Hino, 2014, for a demonstration of similar effects using Kanji primes). As Nakayama et al. also reported, Katakana-written cognate primes (i.e., translation equivalents that are phonologically, but not orthographically, similar to one another, e.g., ガイド/ga.i.do/ *guide*−GUIDE vs. コール /ko.R.ru/, *call*−GUIDE) do as well. Importantly, as Nakayama, Sears, Hino, and Lupker (2013) reported, Katakana-written cognate primes produce significantly larger priming effects than Kanji-written noncognate primes (the "cognate priming advantage") for Japanese−English bilinguals (see also Nakayama, Verdonschot, Sears, & Lupker, 2014). Cognate priming advantages have been observed in a number of languages (Duñabeitia, Perea, & Carreiras, 2010; Gollan, Forster, & Frost, 1997; Voga & Grainger, 2007) and, at least for different script bilinguals (i.e., bilinguals whose two languages do not have any orthographic similarity), the clear implication is that the advantage is due to the phonological similarity of the prime and target. Therefore, these two sources of phonological effects provide a good means of evaluating any impact of phonology in the masked prime same−different task.

More specifically, in both experiments, the same set of English reference words and targets were used. In Experiment 1, they were primed by either unrelated words or Japanese cognate translation equivalents. Priming effects in Experiment 1 that are noticeably larger than the 8–12 ms effects produced by the Japanese noncognate primes in Lupker et al. (2015) would provide evidence that phonological codes are used in the same−different task, at least when relevant phonological information is provided by a masked prime. In Experiment 2, the related primes were phonologically similar Japanese (Katakana) nonwords. Significant priming effects in Experiment 2 would provide further, more direct, evidence for a phonological contribution to priming in the masked prime same−different task.

A further manipulation in these experiments involved the frequency of the targets. As shown by Nakayama et al. (2012, 2013, see also Ando et al., 2014) phonological priming effects in cross-script priming tasks are unaffected by target frequency unless target processing is very rapid (i.e., when the latency floor is being approached). Therefore, one might expect that, if any priming effects observed in Experiments 1 and 2 are indeed based on phonology, no interaction with frequency will be observed.

Note that, in both of these experiments, the Japanese primes were written in Katakana. Because syllabic Katakana is a shallower script than logographic Kanji, the nature of the orthography−phonology relationships for words written in Katakana would be more similar to the relationships found in Roman alphabet languages than would the relationships be for words written in Kanji. Further, due to the straightforward relationship between orthography and phonology, phonological information from a masked Katakana prime would likely be available more rapidly than from a masked Kanji prime (Okano, Grainger, & Holcomb, 2013). Although as Ando et al. (2014) have demonstrated, it is possible to get phonological priming effects for Kanji primes and English targets in lexical decision tasks, the effects are weaker than when Katakana primes are used (Nakayama et al., 2012, 2013, 2014).[1]

Experiment 1: Priming With Cognate Translation Equivalents

Method

Participants. Thirty-six proficient Japanese–English bilinguals from Waseda University (Tokyo, Japan) participated in this experiment. Their mean age was 21.6 years and their age of first exposure to English was 9.8 years (*SD* = 3.5). All participants had TOEIC scores higher than 700, with their mean score being 834 (range: 700–990; test score range: 10–990).

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[1] An additional reason why Katakana was used for the primes in these experiments is that virtually all Japanese−English cognates are normally written in Katakana. Therefore, selecting a stimulus set for the cognate priming manipulation in Experiment 1 would have been almost impossible if Kanji prime words had been used.

Materials. Detailed lexical characteristics of the stimuli used in Experiment 1 are reported in Table 1. Critical stimuli for the "same" trials consisted of 120 Japanese−English cognate translation equivalents, most of which (88%) were taken from Nakayama et al. (2012). Half of the targets were low-frequency English words (M = 4.6 letters long), with their mean frequency being 17.0 occurrences per million (see Brysbaert & New, 2009, for subtitle frequency). The other half were high-frequency English words (M = 4.6 letters long), with their mean frequency being 239.3 occurrences per million. For the "same" trials, these targets were always used as the reference stimuli as well.

Each target was primed by either a Japanese Katakana cognate translation equivalent (e.g., "south−サウス /sa.u.su/, *south*−SOUTH") or an unrelated Katakana word that also had a cognate translation equivalent (e.g., "south−カーブ /ka.R.bu/, curve−SOUTH").[2] That is, the unrelated primes were a different set of Katakana cognate words, the vast majority of which (98%) were also taken from Nakayama et al. (2012). The unrelated Katakana primes were orthographically, phonologically, and semantically unrelated to their English targets/references. The unrelated primes were 3.7 characters in length and were generally low-frequency words (M = 7.2 occurrences per million; Amano & Kondo, 2000). The Katakana translation equivalent (i.e., related) primes were also 3.7 characters in length and their written word frequency was on average 9.4 occurrences per million.

For the "different" trials, as noted, we employed the zero-contingency scenario, as was done in a number of previous experiments using the same−different task (Kinoshita & Norris, 2010; Perea et al., 2011). Targets in the "different" trials were another set of 120 English words. Lexical characteristics of the targets were matched to those for the targets used in the "same" trials. Thus, half of the targets were low-frequency English words (M = 18.7) and the other half were high-frequency English words (M = 241.5). The mean word lengths of low- and high-frequency targets were both 4.6. These English targets also had Japanese cognate translation equivalents, although those Japanese words were not presented in the experiment. The nonpresented Japanese cognate words had similar mean word frequencies and word lengths as the cognate translation equivalents in the "same" trials.

The related condition on "different" trials was created by using a new set of 120 Japanese−English cognate translation equivalents. As noted, we adopted a zero-contingency scenario and thus English words were used as reference stimuli and their Japanese translation equivalents were used as critical primes (e.g., reference = "hand" and prime = "ハンド" /ha.N.do/, *hand*, with the target being COOL). Here again, half of the reference words were low-frequency English words (M = 18.6) and the other half were high-frequency English words (M = 230.8). The two sets of English reference words were matched on their average word length (M = 4.6 in the two conditions). The reference word always contained the same number of letters as the target word. The Japanese cognate translation primes were not related to their target words in any respect.

The unrelated condition was created by using an additional set of 120 Japanese cognate words as primes. These primes were not orthographically, phonologically, or semantically similar to their reference words or their target words. The four types of primes had equivalent mean word frequencies and word lengths as those used in the "same" trials.

Thus, there were a total of 240 trials with 120 word triplets requiring "same" responses and 120 word triplets requiring "different" responses. Within each condition, half of the stimuli involved low-frequency English stimuli and the other half involved high-frequency English stimuli. Two counterbalanced lists were created so that, within the frequency and response conditions, each target word was in the related condition in one list and in the unrelated condition in the other.

Procedure. Participants were tested individually in a silent room. The presentation of stimuli and measuring of response latencies was controlled by DMDX software (Forster & Forster, 2003) installed on a desktop PC with a CRT monitor. The sequence of each trial was as follows (see Figure 2): the English reference word was presented in lower case for 1,000 ms above a forward mask "#######". The reference stimulus was then removed and the mask was replaced by the Japanese prime word, which remained on the screen for 53.3 ms. (A 53.3-ms prime duration was selected [for both experiments], because a goal in Experiment 1 was to compare our cognate priming results with the noncognate priming results in Experiment 5 in Lupker et al. [2015], in which a 53.3-ms prime duration had been used. Note also that a 53.3-ms prime duration has been used in much of the literature using the masked prime same−different task [e.g., Norris & Kinoshita, 2008].) The upper-case English target then appeared in the same position as the prime and remained on the screen until the participant responded.

Participants were asked to decide whether the reference and the target were the same word. Participants were told to respond using the "same" button or the "different" button as quickly as possible, trying to make as few errors as possible. The trials were presented in a different random order for each participant. Prior to the experimental session, participants received 20 practice trials. The practice stimuli were chosen according to the same criteria used in the experimental design and contained triplets not found in the experimental lists.

Results

Correct response latencies faster than 200 ms or slower than 800 ms were removed as outliers (1.0% and 1.3% of the "same" and "different" trial data, respectively). The remainder of the correct responses and the error rates were analyzed using 2 (Target Frequency [high vs. low) × 2 (Prime Type [related vs. unrelated]) analyses of variance separately for the "same" and "different" trial conditions. In the subject analyses, target frequency and prime type were within-subject factors, and, in the item analyses, target frequency was a between-item factor and prime type was a within-item factor. Mean response latencies and error rates for each condition in Experiment 1 are reported in Table 2.

"Same" trials. Responses to high-frequency targets (440 ms) were 3 ms faster than to low-frequency targets (443 ms), however, this small difference was not significant, $F_s(1, 35) = 1.96$, $p > .15$;

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[2] As has been done in previous studies testing Japanese−English translation equivalents (e.g., Nakayama et al., 2012; Nakayama et al., 2014), the phonologically similar Japanese and English words were those that had a small sound difference as noted by Japanese−English bilinguals, rather than being selected by counting the number of shared phonemes in the two words. Our approach seems more appropriate given that the phonological properties of the two languages are relatively different (Japanese has a mora or CV-based phonology, which does not allow consonant cluster sounds, and English has a phoneme based phonology, etc.).

Table 1
Stimulus Characteristics of English Reference and Target Stimuli for "Same" and "Different" Trials Used in Experiments 1 and 2, and the Characteristics of the Japanese Cognate Translation Primes and Unrelated Cognate Primes Used in Experiment 2

	High-frequency targets				Low-frequency targets			
Stimuli	Example	Freq.	Len.	*N*	Example	Freq.	Len.	*N*
"Same" trials								
Reference	south	239.3	4.6	6.3	lease	17.0	4.6	6.1
Cognate primes	サウス /sa.u.su/, *south*	9.1	3.4	—	リース /ri.R.su/, *lease*	9.7	3.4	—
Unrelated primes	カーブ /ka.R.bu/, *curve*	7.3	3.4	—	ナイン /na.i.N/, *nine*	7.2	3.4	—
Target	SOUTH	239.3	4.6	6.3	LEASE	17.0	4.6	6.1
"Different" trials								
Reference	hand	230.8	4.6	6.2	pitch	18.6	4.6	6.3
Cognate primes	ハンド /ha.N.do/, *hand*	9.9	3.4	—	ピッチ /pi.Q.cji/, *pitch*	9.5	3.3	—
Unrelated primes	グレー /gu.re.R/, *gray*	7.6	3.4	—	クルー /ku.ru.R/, *crew*	7.1	3.3	—
Target	COOL	241.5	4.6	6.1	SHEET	18.7	4.6	6.0

Note. For English targets in the "different" trials, the mean word frequencies and word lengths of Japanese cognate translation equivalents (not presented in the experiments) were 10.1 and 3.3 for low-frequency targets and 9.1 and 3.4 for high-frequency targets, respectively. Freq. = word frequency; Len. = length; *N* = orthographic neighborhood size.

$F_i(1, 118) = 1.56, p > .15$. Error rates also did not differ significantly for high- versus low-frequency targets (5.9% vs. 6.6%) (both *F*s < 1). The main effect of prime type was highly significant, $F_s(1, 35) = 148.55, p < .001$, mean square error (*MSE*) $= 322.7$; $F_i(1, 118) = 165.09, p < .001, MSE = 553.5$. Participants responded to targets 37 ms faster when Japanese primes were cognate translation equivalents of their reference words (and targets) than when the primes were unrelated to their reference words (423 ms vs. 460 ms). Participants also made significantly fewer errors in the translation condition than in the unrelated condition (2.7% vs. 9.8%), $F_s(1, 35) = 36.08$ $p <$

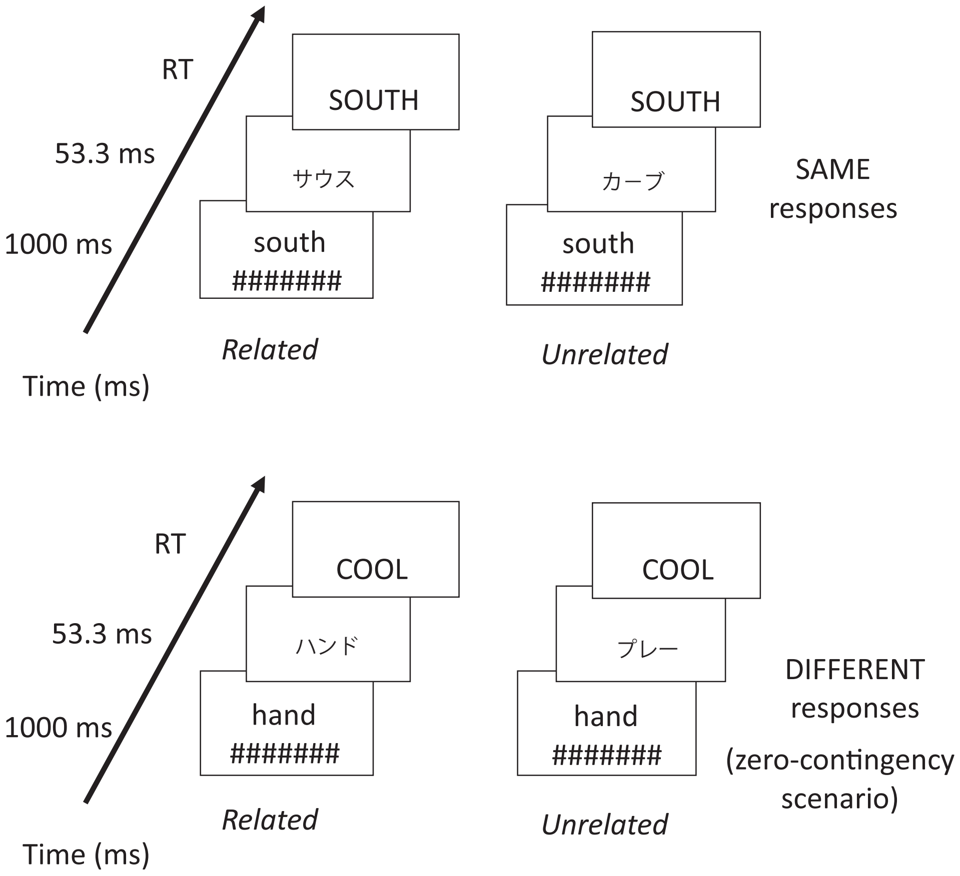

Figure 2. Display sequence in Experiment 1 in which a zero-contingency scenario was used to create related "different" trials. RT = reaction time.

Table 2
Response Latencies in Milliseconds (and Error Rates) for "Same" and "Different" Responses to Low- and High-Frequency English Targets as a Function of Prime Relatedness in Experiment 1: Japanese Cognate Translation Primes

Relationship	Low-frequency targets	High-frequency targets
"Same" trials		
Related	424 (3.1%)	422 (2.3%)
Unrelated	462 (10.1%)	457 (9.4%)
Priming effect	+38 (+7.0%)	+35 (+7.1%)
"Different" trials		
Related	475 (4.5%)	468 (3.8%)
Unrelated	449 (1.9%)	448 (2.0%)
Priming effect	−26 (−2.6%)	−20 (−1.8%)

.001, *MSE* = 50.1; $F_i(1, 118) = 99.26$, $p < .001$, *MSE* = 30.3. There was no Target Frequency × Prime Type interaction (both *F*s < 1). That is, priming effects were identical for low-frequency (38 ms and 7.0% effects) and high-frequency reference/target words (35 ms and 7.1% effects).

"Different" trials. Response latencies were again slightly faster for high- than for low-frequency targets (458 ms vs. 462 ms), however, this 4-ms difference was only marginally significant, $F_s(1, 35) = 3.34$, $p = .08$, *MSE* = 183.1; $F_i(1, 118) = 2.29$, $p > .10$. Target frequency also did not affect the error rates (*F*s < 1). There was again a significant main effect of prime type, $F_s(1, 35) = 64.71$, $p < .001$, *MSE* = 294.3; $F_i(1, 118) = 73.25$, $p < .001$, *MSE* = 483.9. Participants responded to targets 23 ms slower when the primes were Japanese cognate translation equivalents of the reference words. Participants also made significantly more errors in the translation condition than in the unrelated condition (4.2% vs. 2.0%), $F_s(1, 35) = 9.49$, $p < .01$, *MSE* = 18.7; $F_i(1, 118) = 15.96$, $p < .001$, *MSE* = 18.6. There was no Target Frequency × Prime Type interaction, $F_s(1, 35) = 1.31$, $p > .20$; $F_i < 1$, for response latencies, and both *F*s < 1, for errors.

Post hoc comparison between the cognate priming effects in Experiment 1 and Lupker et al.'s (2015; see Experiment 5) effects for noncognate translation equivalents. To examine the potential cognate priming advantage in the present circumstances, we statistically compared the cognate priming effects observed in Experiment 1 with the noncognate priming effects observed previously in Lupker et al. (2015). For the noncognate priming effects, the data in their Experiment 5 were used for the comparator because the same prime duration (53.3 ms) was used in that experiment as in the present experiment.[3] In the analyses, Cognate Status (cognate vs. noncognate) was a between-subject/item factor, and Prime Type (translation vs. unrelated) was a within-subject/item factor.

For the cognate priming effect (the present experiment), we used the data from the high-frequency targets (Lupker et al., 2015, did not manipulate target frequency and their target frequencies were, on average, approximately 110 occurrences per million). Although the present results clearly showed that target frequency does not modulate the size of priming effects in same−different tasks, if target frequency mattered even slightly, the difference between experiments would work against finding a significant Cognate Status × Prime Type interaction (i.e., a cognate priming advantage). We previously reported that there are larger translation priming effects for *low-* than for *high*-frequency targets in the lexical-decision task (e.g., Nakayama et al., 2012, 2013) and the average frequency was slightly lower for the stimuli in Lupker et al.'s Experiment 5 than for the high-frequency targets in the present experiment.

We should also note that the bilinguals in Lupker et al.'s (2015) Experiment 5 were slightly lower in English proficiency (mean TOEIC score, 815) than those in the present experiment (mean TOEIC score, 834). This proficiency difference would also appear to work against finding a significant interaction, because *lower* L2 proficiency is associated with significantly *larger* priming in a lexical-decision task (e.g., Nakayama et al., 2012, 2013).

"Same" trials. The main effect of Cognate Status was significant, $F_s(1, 72) = 8.17$, $p < .01$, *MSE* = 4,676.6; $F_i(1, 118) = 86.92$, $p < .001$, *MSE* = 660.2. The main effect of Prime Type was also significant, $F_s(1, 72) = 83.77$, $p < .001$, *MSE* = 227.7; $F_i(1, 118) = 80.43$, $p < .001$, *MSE* = 402.5. Critically, there was a significant Cognate Status × Prime Type interaction, $F_s(1, 72) = 25.71$, $p < .001$, *MSE* = 227.7; $F_i(1, 118) = 25.84$, $p < .001$, *MSE* = 402.5. The cognate priming effect (35 ms) was significantly larger than the noncognate priming effect (10 ms).

"Different" trials. The main effect of Cognate Status was significant, $F_s(1, 72) = 7.80$, $p < .01$, *MSE* = 5,367.6; $F_i(1, 118) = 95.00$, $p < .001$, *MSE* = 690.7. The main effect of Prime Type was also significant, $F_s(1, 72) = 38.57$, $p < .001$, *MSE* = 212.4; $F_i(1, 118) = 30.09$, $p < .001$, *MSE* = 485.2. More importantly, there was a significant Cognate Status × Prime Type interaction, $F_s(1, 72) = 5.23$, $p < .05$, *MSE* = 212.4; $F_i(1, 118) = 6.08$, $p < .05$, *MSE* = 485.2. The cognate priming effect (20 ms), this time inhibitory, was significantly larger than the noncognate priming effect (9 ms).[4]

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[3] Prior to the post hoc analyses, data from Lupker et al.'s (2015) Experiment 5 went through the same data treatment applied in the present experiments. The pattern of priming effects did not change, with a 10-ms facilitation effect for "same" trials (*ps* < .001) and a 9-ms inhibition effect for "different" trials (*ps* ≤ .05).

[4] As in Nakayama et al.'s (2013) experiments, cognate priming in the present Experiment 1 involved Katakana primes while noncognate priming in Lupker et al.'s (2015) Experiment 5 involved Kanji primes. As Nakayama et al. explained, use of different scripts in the two situations is necessitated by the nature of written Japanese. As noted in footnote 1, virtually all English cognates are written in Katakana. In contrast, virtually all noncognates are written in Kanji. Due to the fact that different script primes were used in the two situations, an argument could, of course, be made that this difference may have mattered. Specifically, as will be discussed further in the main text, the argument would be that the larger priming effects in the present Experiment 1 were due to the Katakana primes being more similar to their targets at the lexical/semantic level than the Kanji primes used in Lupker et al.'s Experiment 5, rather than being due to the phonological similarity of the primes and reference stimuli in the present Experiment 1. Given the small contribution to priming by lexical/semantic factors even when, as in Lupker et al.'s experiments, the translation equivalents are quite similar in meaning, such an argument would be difficult to substantiate. Equally importantly, as Nakayama et al. noted, prior masked priming research in Japanese has indicated that Kanji primes are no less effective at producing lexical/semantic priming than Katakana primes when familiar Kanji words are used (Nakamura, Dehaene, Jobert, Le Bihan, & Kouider, 2005; Nakamura, Dehaene, Jobert, Le Bihan, & Kouider, 2007). Nakayama et al.'s analysis of this issue can be found in their article on pages 954, 960, and 961.

Discussion

The pattern in Experiment 1 is clear. The priming effects from the cognate translation equivalent primes, on both the “same” and “different” trials, were highly significant. Because the primes and reference stimuli were similar phonologically and semantically but not orthographically, these effects cannot be attributed to similarities in orthographic codes. Further, the effects in Experiment 1 (35 ms and 20 ms) were significantly larger than the noncognate priming effects (10 ms and 9 ms) observed by Lupker et al. (2015). As Nakayama et al. (2013) and Nakayama et al. (2014) have argued, cognate priming advantages, at least for different-script bilinguals for whom translation equivalents are completely different orthographically, are most likely phonologically based priming effects (also see Voga & Grainger, 2007). Thus, the results of Experiment 1 provide good evidence that at least some portion of the priming effect in the masked prime same−different task is phonologically based.

Experiment 2: Priming With Phonologically Similar Nonwords

As noted, Lupker et al. (2015) have demonstrated that noncognate translation equivalent primes produce small but significant priming effects for Japanese−English bilinguals in the masked prime same−different task (8–12 ms). Therefore, the most reasonable interpretation of the substantially larger priming effects for cognate translation equivalents is that they are phonological effects. One could, however, argue that the larger effects for cognates may have been lexically/semantically (i.e., conceptually) based because the translation equivalents used in Experiment 1 may have been much more closely related than the translation equivalents used by Lupker et al. That is, the Japanese cognate words used in Experiment 1 are loan words from English. Therefore, one could argue that the concepts represented by the cognate translation equivalents are virtually identical. In contrast, noncognate translation equivalents are original Japanese words (or loan words from Chinese) that may represent meanings that are somewhat different from those possessed by their (e.g., English) translation equivalents. Therefore, a smaller, conceptually based translation priming effect might be expected for noncognate translation equivalents than for cognate translation equivalents (see Finkbeiner, Forster, Nicol, & Nakamura, 2004).

For a couple of reasons, however, it would be difficult to sustain an argument that the larger cognate priming effects were due to differential degrees of conceptual similarities for cognates and noncognates. First, Japanese−English cognate translation equivalents do not necessarily share more conceptual senses than noncognate translation equivalents, as shown by Nakayama et al. (2013) and, second, as shown by Allen and Conklin (2014), Japanese−English cognate translation equivalents are rated no more conceptually similar to each other than Japanese−English noncognate translation equivalents are. Instead, as noted just above, cognate priming advantages in lexical-decision tasks (e.g., Duñabeitia et al., 2010; Gollan et al., 1997; Nakayama et al., 2013; Nakayama et al., 2014; Voga & Grainger, 2007), at least for different script bilinguals (i.e., bilinguals whose two languages do not have any orthographic similarity), appear to be due to the phonological similarity between the prime and target. Therefore, the cognate priming advantage in Experiment 1 is most likely to have been a phonological effect due to similarities in the phonological codes. If this argument is correct, it should be possible to obtain phonological priming effects in the absence of any semantic/lexical relationships. To examine this issue, in Experiment 2, we used the same reference stimuli and targets. The primes, however, were Katakana nonwords that were phonologically similar to the English reference/target stimuli.

Method

Participants. Thirty-six proficient Japanese–English bilinguals from Waseda University (Tokyo, Japan) participated in this experiment. None had participated in Experiment 1. Their mean age was 22.1 years and their age of first exposure to English was 10.1 years (*SD* = 2.7). All participants had TOEIC scores higher than 700, with their mean score being 831 (range: 710–980; test score range: 10–990).

Materials. The same set of 240 English reference words and targets used in Experiment 1 was used in Experiment 2. The critical manipulation made was to the Japanese primes. Japanese primes were Katakana nonword primes created by changing one phoneme of the Japanese translation equivalents and unrelated words used in the Experiment 1. For instance, for the triplet used in the related condition of the “same” trials in Experiment 1, “south−サウス /sa.u.su/, *south*−SOUTH,” the Japanese word prime was replaced by a phonologically similar nonword “サオス /sa.o.su/.” Similarly, for the triplets in the unrelated condition, “south−カーブ /ka.R.bu/, curve−SOUTH”), the prime was replaced by “カエブ” /ka.e.bu/. The same treatments were made to triplets for the “different” trials. Across “same” and “different” trials, half of the nonword primes were created by replacing vowels (e.g., p*u*.re.R.su → p*e*.re.R.su) and the other half were created by replacing consonants (e.g., *t*o.ra.bu.ru → *n*o.ra.bu.ru). Note that, in the Japanese language, replacement of one phoneme always results in a change of one Katakana character whether the replaced phoneme is a vowel or a consonant (e.g., for the examples used above, プレース → ペレース [consonant change] and トラブル →ノラブル [vowel change]). The phoneme replacement was made equally frequently to initial character, middle character, and final character positions. Lastly, the replacement was done in a pairwise manner; primes in the related and unrelated conditions received the same treatment in terms of the type of phoneme replacement (vowels vs. consonants) and the position of the replacement within a word (initial, middle, and final).

In Experiment 2, there were a total of 240 trials with 120 word triplets requiring “same” responses and 120 word triplets requiring “different” responses. The only difference from Experiment 1 was that the Japanese primes were phonologically similar Katakana nonwords. Counterbalancing lists were created identically to those in Experiment 1.

Procedure. The procedure was identical to that in Experiment 1. A schematic of the trial sequences in Experiment 2 is contained in Figure 3.

Results

Correct response latencies faster than 200 ms or slower than 800 ms were removed as outliers (0.5% and 1.0% of the “same” and “different” trial data, respectively). The remainder of the correct

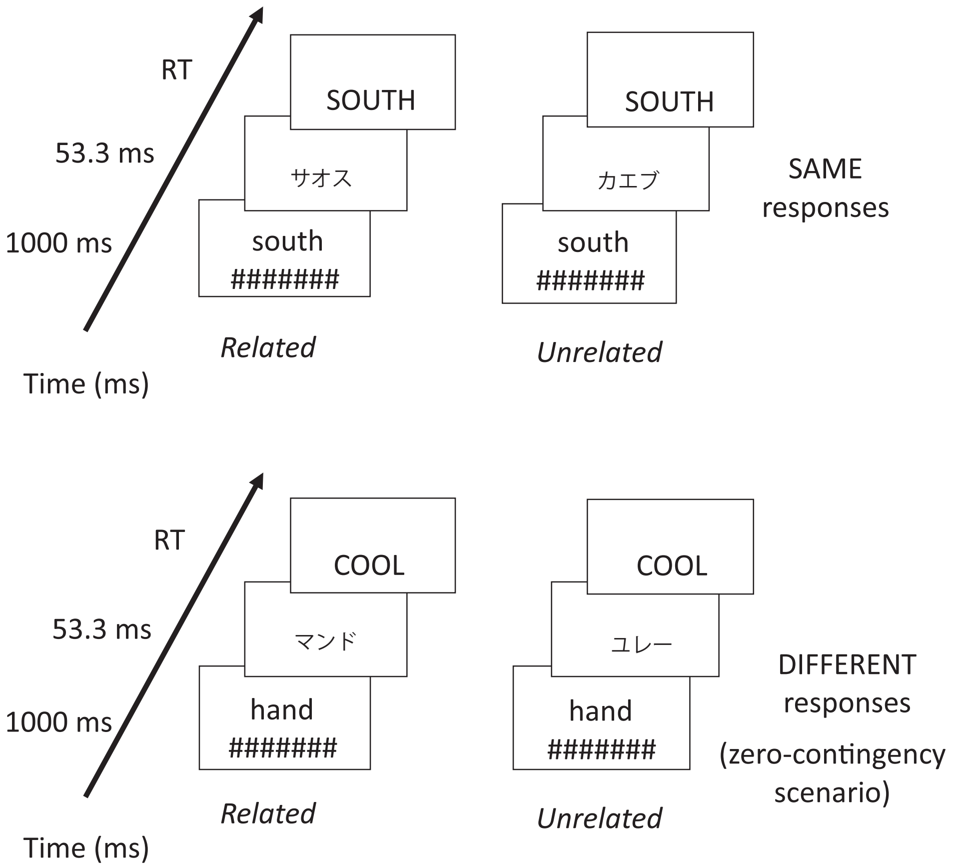

Figure 3. Display sequence in Experiment 2 in which a zero-contingency scenario was used to create related "different" trials. RT = reaction time.

responses and the error rates were analyzed in the same way as in Experiment 1. Mean response latencies and error rates for each condition in Experiment 2 are reported in Table 3.

"Same" trials. Responses to high-frequency targets (425 ms) were slightly faster than to low-frequency targets (431 ms). This 6-ms frequency effect was, unlike the parallel (3-ms) effect in Experiment 1, significant in the subject analysis, $F_s(1, 35) = 9.07$, $p < .01$, $MSE = 140.7$, although not in the item analysis, $F_i(1, 118) = 1.03$, $p > .30$. The main effect of Prime Type was highly significant, $F_s(1, 35) = 122.93$, $p < .001$, $MSE = 198.6$; $F_i(1, 118) = 67.87$, $p < .001$, $MSE = 661.5$. Participants responded to targets on average 26 ms faster when those (English) targets were preceded by phonologically similar Japanese nonwords than by unrelated Japanese nonwords. There was no hint of an interaction (both Fs < 1) because the facilitation effects were identical in size for low- and high-frequency targets (i.e., 26-ms effects).

Error rates did not significantly differ for high- and low-frequency targets (4.7% vs. 5.1%) (Fs < 1). Mirroring the latency data, participants made significantly fewer errors in the related condition than in the unrelated condition, $F_s(1, 35) = 24.27$ $p < .001$, $MSE = 15.1$; $F_i(1, 118) = 21.12$, $p < .001$, $MSE = 29.0$. There was no Prime Type × Target Frequency interaction, $F_s(1, 35) = 2.11$, $p > .15$; $F_i(1, 118) = 1.96$, $p > .15$.

"Different" trials. Again, responses to high-frequency targets were slightly faster than to low-frequency targets (447 ms vs. 453 ms). The 6-ms frequency effect was significant in the subject analysis, $F_s(1, 35) = 5.80$, $p < .05$, $MSE = 221.4$, and was marginally significant in the item analysis, $F_i(1, 118) = 3.65$, $p = .06$, $MSE = 509.1$. More importantly, there was a significant Prime Type effect, with responses being significantly slower when Japanese nonword primes were phonologically similar to their English reference words, $F_s(1, 35) = 68.04$, $p < .001$, $MSE = 184.2$; $F_i(1, 118) = 21.64$, $p < .001$, $MSE = 980.3$. This inhibitory priming

Table 3
Response Latencies in Milliseconds (and Error Rates) for "Same" and "Different" Responses to Low- and High-Frequency English Targets as a Function of Prime Relatedness in Experiment 2: Japanese Nonword Phonological Primes

Trials	Low-frequency targets	High-frequency targets
"Same"		
Related	418 (3.6%)	412 (3.0%)
Unrelated	444 (5.8%)	438 (7.1%)
Priming effect	+26 (+2.2%)	+26 (+4.1%)
"Different"		
Related	462 (2.8%)	456 (4.4%)
Unrelated	443 (2.7%)	438 (2.0%)
Priming effect	−19 (−0.1%)	−18 (−2.4%)

effect was virtually identical for high- and low-frequency targets (−19 ms and −18 ms effects, respectively), as indicated by the lack of Prime Type × Target Frequency interaction (*F*s < 1).

Error rates did not differ for high- and low-frequency targets (3.2% vs. 2.8%) (*F*s < 1). Error rates were higher when Japanese nonword primes were phonologically similar to their English reference words than when they were not, although the Prime Type effect (3.6% vs. 2.4%) was only marginally significant in the subject analysis, $F_s(1, 35) = 3.80$, $p = .06$, $MSE = 13.7$; $F_i(1, 118) = 5.30$, $p < .01$, $MSE = 16.4$. There was a significant Prime Type × Target Frequency interaction, $F_s(1, 35) = 4.00$, $p = .05$, $MSE = 11.1$; $F_i(1, 118) = 4.51$, $p < .05$, $MSE = 16.4$. A significant effect was observed for high-frequency targets (−2.4% effect), $t_s(35) = 2.50$, $p < .05$, $SEM = .93$; $t_i(118) = 3.04$, $p < .01$, $SEM = .76$, but not for low-frequency targets (−0.1% effect) (*t*s < 1.0).

Discussion

The critical experimental question in Experiment 2 was whether one would observe a phonologically based priming effect using Japanese (Katakana) nonword primes and English words as references and targets in a same−different task. The answer is clearly positive, with significant (and sizable) priming effects emerging on both "same" and "different" trials.

The obvious implication of these results, coupled with those of Experiment 1, is that phonological codes are involved in the same−different task. That is, the task involves more than simply evaluating/matching the reference and the target's orthographic codes. Presumably, the matching process also involves the phonological level and, as a result, the phonology provided by the prime and its relationship to the phonology of the reference stimulus can provide evidence either for or against a reference−target match. As a result, on related "same" trials (i.e., when the prime and reference stimulus/target are phonologically similar), positive latencies are faster than on unrelated trials, whereas on related "different" trials (i.e., when the prime is phonologically similar to the reference stimulus but not to the target), negative latencies are slower than on unrelated trials.

What is also important to emphasize is that the existence of priming on "different" trials in both experiments does indicate that, as argued by Norris and colleagues (Kinoshita & Norris, 2009, 2010; Norris & Kinoshita, 2008; Norris et al., 2010), priming in the same−different task is not due to the prime activating the target. That is, when one uses a zero-contingency design on "different" trials, the prime is not related to the target. Instead, the prime is related to the reference stimulus. Therefore, if priming were due to an interaction between the prime and the target, no priming effect would be expected. The further implication is that the effect must be a result of the interaction between the prime and the reference stimulus. That is, in line with Norris and colleagues' argument, the priming effects on both "same" and "different" trials are most likely due a partial match between the code supplied by reference stimulus and the code supplied by the prime, codes that, as shown in the present experiments, apparently are, at least some of the time, phonological in nature.

There appear to be two additional aspects of the data from Experiment 2 that deserve mention. First, the priming effects were, as in Experiment 1 and in Nakayama et al. (2013) and Nakayama et al. (2014), independent of target frequency, being identical in size for high- and low-frequency targets on "same" as well as "different" trials. This pattern is supportive of the idea that the priming is due to phonological codes that are prelexical rather than lexical in nature.

Second, although it is not straightforward to compare across experiments that were not initially designed for such a comparison, there is an interesting relationship between the priming effects for cognate primes in Experiment 1 (which are presumably due to both the phonological similarity and the lexical/semantic similarity of translation equivalents) and the sum of (a) the effects observed by Lupker et al. (2015) for noncognate translation equivalent primes and (b) the effects reported in Experiment 2 for phonologically similar primes. More specifically, in Experiment 1, the cognate priming effects were 37 ms on "same" trials and 23 ms on "different" trials. The noncognate priming effects reported by Lupker et al. were approximately 10 ms on both "same" and "different" trials. The phonological priming effects reported in Experiment 2 were 27 ms on "same" trials and 19 ms on "different" trials. These essentially additive patterns are also consistent with the idea that the phonological priming observed here is independent of higher level (e.g., lexical/semantic) information and, therefore, independent of any priming that may be due to activation of those higher level representations. That is, these patterns also support the idea that the phonological priming in the same−different task is a prelexical, rather than a lexical, phenomenon.

General Discussion

Norris and colleagues (Norris & Kinoshita, 2008; Kinoshita & Norris, 2009, 2010) have proposed that reference−target matching in the cross-case same−different task is done at the abstract orthographic level and that priming effects in the task are essentially due to the orthographic similarity of the reference's and prime's orthographic codes. If this proposal is correct, an implication would be that the task would be an extremely useful one for investigating the nature of orthographic coding. As those researchers put it: "The same−different task is based on a comparison of the target and reference strings at a purely orthographic level" (Duñabeitia et al., 2011, p. 525) and "the same−different task holds considerable promise as a tool for examining the nature of prelexical orthographic representations. The task appears to tap into the same representations that support word recognition but not to be influenced by the lexical retrieval processes" (Kinoshita & Norris, 2009, p. 13). Recent results from Lupker et al. (2015), which demonstrated a lexical/semantic contribution to priming effects in this task, indicate that this claim is a bit too strong. That is, those results demonstrate that the same−different task is influenced by codes other than prelexical orthographic codes. However, the effects reported by Lupker et al. were small and, possibly, they may only be evident when the strength of the lexical/semantic relationship is maximal (e.g., when using a translation priming manipulation).

The goal of the present research was to examine the possibility that a different factor—phonological similarity—also plays a role in this task. In Roman-letter languages, letter strings with similar orthographies inevitably have similar phonologies. Therefore, many of the orthographically based effects in the same−different task literature could, in theory, have a phonological component. As noted, a couple of results have suggested that phonology may not play a role in the same−different task (Besner et al., 1984; Kinoshita & Norris, 2009).

Both of those experiments involved a contrast between two types of nonwords: (a) pseudohomophones (e.g., skore) and (b) letter strings mismatching the homophone mate (e.g., SCORE) at the same number of letter positions that the pseudohomophones do (i.e., smore). Although no significant differences were observed between the two nonword conditions in those experiments, the phonological manipulations were quite weak because the pseudohomophones and their control nonwords differed in only one phoneme.

In the present experiments, the manipulation of phonological similarity was much stronger. In both experiments, participants were Japanese−English bilinguals who were doing a same−different task with English reference and target words. In Experiment 1, primes were Japanese cognates of English reference words. A significant priming effect was observed on both "same" and "different" trials. These effects could, in theory, be due to phonological similarity or lexical/semantic similarity because the primes and reference words were cognate translation equivalents. However, the significant contrast between the 30+ ms cognate priming in effects in Experiment 1 and the 10-ms noncognate priming effects in Lupker et al.'s (2015) Experiment 5 suggests that the main source of the priming in Experiment 1 was phonological rather than lexical/semantic.

In Experiment 2, primes were Katakana nonwords phonologically similar to their reference words. Again, a significant priming effect was observed on both "same" and "different" trials. These effects are clearly due to phonological similarity because the Katakana nonwords and the English reference words are not similar on any other dimension.

Regardless of whether one takes issue with the conclusion that the priming effects in Experiment 1 were at least somewhat phonological and argues instead that they were lexical/semantic, the main implication from the two experiments is that priming effects in the masked prime same−different task are not inevitably based on orthographic similarity. Therefore, at least a slightly altered conceptualization of the matching process and how it is primed is needed.

What we take to be the most reasonable conceptualization is one that aligns with Chambers and Forster's (1975) original proposal. That is, the reference and target stimuli are actually being matched at a number of levels simultaneously, minimally, at the prelexical orthographic, the prelexical phonological, and the word level. The final output could be thought of either as coming from a first-past-the-post process (at least for "same" responses) or as being a weighted average of outputs from all levels. What also may be true is that the lower the level, the more likely it is to provide an output (or to provide the largest contribution to the weighted average) because lower level processing on the target would presumably finish prior to higher level processing. As such, it would seem reasonable that the prelexical orthographic level typically would tend to dominate the process.

Consistent with Norris and colleagues' (Kinoshita & Norris, 2009, 2010; Norris & Kinoshita, 2008; Norris et al., 2010) claims, what the prime does is to feed information into this system, apparently to all levels, supporting either a "same" or a "different" judgment (i.e., depending on the identity of the reference stimulus). Because orthographic information from the prime would be available earlier than other types of information, the impact of (i.e., priming due to) orthographic similarity may be the most potent and, hence, the easiest to observe. Indeed, lexical/semantic priming, in particular, may only emerge in rare situations (e.g., for translation equivalents) and, even then, would be fairly small in size. In fact, if lexical/semantic information did play a major role in this task, nonwords should not normally show the same size priming effects as words do (e.g., Norris & Kinoshita, 2008) because nonwords do not have lexical or semantic representations. The more central question deriving from the present research, however, is: What can one now say about the same−different task given the clear demonstration that phonological similarity impacts processing in that task?

Phonological effects are pervasive in the word recognition literature (e.g., homophone effects: Ferrand & Grainger, 2003; Pexman, Lupker, & Jared, 2001; Pexman, Lupker, & Reggin, 2002; Rubenstein, Lewis, & Rubenstein, 1971; phonological feedback effects: Stone, Vanhoy, & Van Orden, 1997; Ziegler, Van Orden, & Jacobs, 1997; masked phonological priming effects: Ferrand & Grainger, 1992, 1994; Grainger & Ferrand, 1996) and arguments have been made that phonology plays a primary role in low-level reading processes (Frost, 1998). Therefore, it would seem possible that prelexical phonology could be available early enough in processing to play almost as important a role in same−different judgments as prelexical orthographic information. If so, that would certainly call into question Norris and colleagues' (Norris & Kinoshita, 2008; Kinoshita & Norris, 2009, 2010) conclusions on the potential of the same−different task to provide clear information about the nature of orthographic coding.

What would also be called into question is the strength of support provided by Kinoshita and Kaplan's (2008) and Kinoshita and Norris's (2009) results for the conclusion that letter matching and, hence, priming in the cross-case letter-matching task, is mainly based on abstract orthographic codes. The relevant task is one in which participants had to indicate whether two sequentially presented letters matched while disregarding the case of those letters. What those researchers reported was that priming in the letter-match task was independent of the case of the prime and target (i.e., when the reference stimulus was "a," the prime "a" primed the target "A" as well as the prime "A" did) as well as being independent of the visual similarity of the prime and target (i.e., when the reference stimulus was "a," the prime "a" primed the target "A" as well as the prime "c" primed the target "C" when the reference stimulus was "c"). The central point being made here is that were the decisions/priming effects in that task based on either phonological codes or abstract orthographic codes, the same patterns of results would be expected. Although it is not clear at present which of these possibilities is correct, the idea that the sequential letter-matching task is based on phonological codes is not without precedence in the literature. Commenting specifically on the letter-matching task, Proctor (1981) stated: "All sequential matches are apparently based on name codes" (p. 302).

Nonetheless, what the present data do not do is to explicitly speak to the issue of the balance between orthographic and phonological effects in the same−different task or to any factors that might affect that balance. That is, although the data unambiguously show that phonological similarity can produce priming in the masked prime same−different task, they do not indicate the potential pervasiveness of phonological effects, particularly in experiments involving Roman alphabet stimuli. It is possible, although seemingly unlikely, that phonological priming may play a very large role in such tasks. It is also possible that it plays virtually no role, with its effects only manifesting themselves in special circumstances. For example, they may only arise when there is no orthographic similarity between the prime and reference and, hence, no possibility for orthographic priming, such as when the prime and reference are written in different scripts. In those types of circumstances, any similarity between the prime's and reference's phonological codes (i.e., on related trials) may cause rapid matching at the phonological level, allowing that level to dominate processing. Or, the truth may be somewhere in between, with phonology and orthography contributing more or less equally in the same−different task. At present, all we can say with certainty is that, until these issues are resolved, conclusions drawn about the nature of orthographic coding based on data from the masked prime same−different task will have to be regarded cautiously.

An Alternative Conceptualization of Priming in Same−Different Matching

One thing to note about the phonological priming effects in Experiments 1 and 2 is that they were independent of target frequency. A similar pattern has been observed a number of times previously when using Japanese−English bilinguals in English lexical-decision tasks with Japanese primes (Nakayama et al., 2012, 2013). In the same−different task, the interpretation of this pattern offered above is that the prelexical phonological codes from the prime match the prelexical phonological codes of the reference stimulus, which provides evidence for a "same" decision. Therefore, the reason these effects are independent of word frequency is because the task itself is divorced from any lexical processing. The fact that nonword targets show as much priming as word targets in the same−different task whereas nonwords show virtually no priming from formally similar primes in lexical decision tasks supports the idea that the sources of the priming effects differ in the two tasks, with lexical/semantic representations normally playing little role in producing priming in the same−different task. Hence, the phonological priming effects in that task would most likely be localized at the prelexical level.

In contrast, a common interpretation of phonological priming effects in lexical decision is that, although they are also due to prelexical representations, their impact is on lexical (i.e., higher level) representations. That is, prelexical phonological representations that are activated by prime processing activate the lexical representations of similarly pronounced words, allowing those representations to be accessed faster once target processing begins.

There appears, therefore, to be a clear difference between the lexical-decision and same−different tasks in terms of how phonology would be presumed to impact processing. On the other hand, based on a suggestion of Kinoshita and Norris (2010), there would seem to be a way to reconceptualize the same−different task that would allow for a stronger parallel to be drawn between it and the lexical-decision task. In particular, this reconceptualization would then allow for an account of processing in the same−different task that is based on a single matching process (as in lexical decision) rather than being based on matching processes taking place at several levels simultaneously, as proposed by Chambers and Forster (1975).

What Kinoshita and Norris (2010) suggested is that "The same−different task is like lexical decision with only a single word in the lexicon—the reference" (p. 195). The idea is that, on each trial in a same−different task, whether the reference is a word or a nonword, a representation of that reference is established in order to serve task performance. Input from the target would then alter the activation level of that representation. A "same" response in a same−different task would be analogous to a "word" response in a lexical-decision task in that it would occur once the representation of the reference had been activated above a certain threshold after target presentation. Similarly, a "different" response would be analogous to a "nonword" response in that it would occur once a sufficient level of evidence had been accumulated indicating that the target was not the reference word (e.g., the activation level of the representation had reached some lower threshold).

To make the parallel between tasks complete, one would merely need to argue that the activation level of this task-based representation is affected by orthographic and phonological (and possibly lexical/semantic, as in Lupker et al.'s [2015] experiments) information from the prime. Specifically, the impact of a related prime would be to preactivate the reference's representation (the single item in the lexicon) whereas the impact of an unrelated prime would be to decrease the activation of that representation. Because there is no reason to assume that these representations would necessarily reflect frequency or lexicality information (having been created on the fly), one would expect similar orthographic and phonological priming effects for nonword and word reference stimuli, and, in addition, for words, those effects would be independent of word frequency, as is typically observed (e.g., Norris & Kinoshita, 2008).

Further, in line with the results typically reported (e.g., Norris & Kinoshita, 2008; Perea et al., 2011), one would not expect priming in the same−different task on "different" trials whenever a zero-contingency manipulation was not used. That is, when related primes were related to their targets (e.g., reference—judge, prime—canal, target—CANAL vs. reference—judge, prime—thumb, target—CANAL) rather than to their reference stimuli, no priming would be expected because "related" (i.e., canal) and "unrelated" (i.e., thumb) primes would have the same impact of the activation level of the representation for the reference stimulus (i.e., judge). Therefore, if one were to adopt this type of account, the claim would be that, although the phonological information from primes that produces priming is prelexical, the matching processing itself is not based on prelexical representations. It is based on higher level representations just as it is in the lexical-decision task.

This analysis would appear to be reasonably consistent with Norris and colleagues' core principle that priming is task dependent, being based on an accumulation of evidence for a particular decision, and, as noted, it allows one to maintain a more unitary conceptualization of how priming itself works. However, it is somewhat different from the proposal discussed above, based on Chambers and Forster's (1975) analysis, in which the matching process is assumed to involve a number of different codes and to take place at multiple levels simultaneously. At present, the extant data do not, unfortunately, appear to provide any obvious way of distinguishing between these two ideas, leaving their resolution as an issue for future research.

Conclusion

The main goal of the present research was to determine whether one would observe phonological priming in the same−different task when one uses a strong phonological similarity manipulation. The answer is clearly yes as sizable phonological priming effects were observed in both experiments. Coupled with the fact that it is also possible to obtain priming based on lexical/semantic information, one is led to conclude that the masked prime same−different task may not be providing as clear a view of the nature of the orthographic code, in the words of Kinoshita and Norris (2009), the "evolving prelexical orthographic representation [that] is . . . input to the lexical access process" (p. 14), as originally hoped. Nonetheless, as researchers, psychologists have had to get used to the fact that our tools are not perfect and that the only way to build firm conclusions about any proposition is through converging evidence from multiple experimental paradigms. The masked prime same−different task seemingly does have a reasonably strong orthographic basis. Therefore, together with other similar experimental paradigms (e.g., Lupker & Davis, 2009, the sandwich priming paradigm), it should, nonetheless, be a very useful tool in helping us gain a more complete picture of the nature of the orthographic coding process.

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Appendix

Stimuli in the Present Experiments

English reference words, Japanese cognate primes, unrelated word primes, phonologically similar Japanese nonword primes, unrelated nonword primes, and English target words used in the present experiments.

"Same trials" low- frequency targets: bat, バット, スコア, バッテ, スコイ, BAT; belt, ベルト, マーク, ベロト, マエク, BELT; boots, ブーツ, コピー, ブイツ, コパー, BOOTS; brand, ブランド, ピストル, ルランド, ギストル, BRAND; dry, ドライ, リスク, デライ, ロスク, DRY; cheese, チーズ, カメラ, チール, カメタ, CHEESE; panel, パネル, ロック, ラネル, ゾック, PANEL; eagle, イーグル, リゾート, イーヌル, リゴート, EAGLE; guide, ガイド, コール, ガエド, コアル, GUIDE; gum, ガム, キー, ガモ, キア, GUM; lease, リース, ナイン, リオス, ナエン, LEASE; lighter, ライター, バラード, ラウター, バロード, LIGHTER; map, マップ, ボタン, マッピ, ボタエ, MAP; medal, メダル, モード, ケダル, ゴード, MEDAL; nude, ヌード, ホラー, ヌエド, ホルー, NUDE; peach, ピーチ, ナイフ, ピージ, ナイク, PEACH; pin, ピン, カー, ヒン, ガー, PIN; poster, ポスター, タレント, ポクター, タネント, POSTER; radar, レーダー, コマンド, レードー, コムンド, RADAR; bubble, バブル, カット, バブク, カッソ, BUBBLE; spy, スパイ, ルック, スパウ, ルッケ, SPY; sensor, センサー, デジタル, センバー, デジナル, SENSOR; shower, シャワー, フライト, シャラー, フダイト, SHOWER; skirt, スカート, タイトル, ソカート, テイトル, SKIRT; spoon, スプーン, セミナー, サプーン, ソミナー, SPOON; steak, ステーキ, トランク, セテーキ, タランク, STEAK; tank, タンク, トレー, カンク, ノレー, TANK; tent, テント, プラス, トント, ペラス, TENT; melody, メロディー, ハリケーン, メロディア, ハリケーオ, MELODY; wax, ワックス, ユーモア, ハックス, ブーモア, WAX; bird, バード, テニス, タード, レニス, BIRD; boom, ブーム, エラー, ブーモ, エラウ, BOOM; bowl, ボウル, タブー, ボウレ, タブオ, BOWL; release, リリース, ジャンプ, リリーム, ジャンス, RELEASE; cable, ケーブル, ドクター, クーブル, デクター, CABLE; coin, コイン, リレー, コウン, リラー, COIN; cue, キュー, パック, キュイ, バッコ, CUE; fork, フォーク, アナログ, フォーツ, アナロヌ, FORK; guitar, ギター, シード, ギトー, シエド, GUITAR; gym, ジム, ビザ, ジヌ, ビガ, GYM; lens, レンズ, ビーチ, ネンズ, ミーチ, LENS; maker, メーカー, ストレス, レーカー, フトレス, MAKER; mask, マスク, ミール, マサク, ミオル, MASK; trumpet, トランペット, プロデュース, トリンペット, プレデュース, TRUMPET; cookie, クッキー, メソッド, クッチー, メトッド, COOKIE; peak, ピーク, ヨット, ペーク, ユット, PEAK; pipe, パイプ, シネマ, パウプ,

(*Appendix continues*)

シノマ, PIPE; racket, ラケット, アレンジ, ラヘット, アケンジ, RACKET; rat, ラット, コラム, ラッポ, コラフ, RAT; rocket, ロケット, チャイム, ロケッゾ, チャイプ, ROCKET; salad, サラダ, シャツ, サラザ, シャヌ, SALAD; shock, ショック, リサーチ, ショッフ, リサーシ, SHOCK; skate, スケート, ウイルス, スネート, ウイムス, SKATE; soup, スープ, ベンチ, クープ, ネンチ, SOUP; rush, ラッシュ, ガソリン, リッシュ, ゴソリン, RUSH; stamp, スタンプ, シューズ, スタンパ, シューゼ, STAMP; milk, ミルク, ランチ, リルク, サンチ, MILK; tile, タイル, マッチ, タウル, マオチ, TILE; veil, ベール, ルアー, ゼール, クアー, VEIL; zero, ゼロ, ミニ, ゼコ, ミジ, ZERO.

“Same” trials high- frequency targets: area, エリア, ネール, エリウ, ネーラ, AREA; bank, バンク, ドーム, バウク, ドイム, BANK; best, ベスト, ニーズ, ベセト, ニオズ, BEST; boat, ボート, シンク, ベート, スンク, BOAT; single, シングル, アシスト, シングム, アシスコ, SINGLE; couple, カップル, リタイア, カップロ, リタイエ, COUPLE; cover, カバー, ジャズ, タバー, ビャズ, COVER; dress, ドレス, シェア, ゾレス, ミェア, DRESS; rich, リッチ, マイク, リエチ, マウク, RICH; hair, ヘア, バー, ヘウ, バオ, HAIR; hit, ヒット, ハーフ, ヒッタ, ハーヘ, HIT; hope, ホープ, ヒント, ホアプ, ヒオト, HOPE; list, リスト, ポップ, リスコ, ポッス, LIST; double, ダブル, シェフ, ガブル, キェフ, DOUBLE; note, ノート, バレエ, ノアト, バルエ, NOTE; part, パート, グラフ, パーロ, グラヌ, PART; play, プレー, キット, ムレー, リット, PLAY; power, パワー, エース, ペワー, ウース, POWER; record, レコード, オレンジ, レソード, オゲンジ, RECORD; drink, ドリンク, マイナー, ドヒンク, マイパー, DRINK; short, ショート, ベランダ, ヒョート, レランダ, SHORT; girl, ガール, ネット, ガウル, ネオト, GIRL; south, サウス, カーブ, サオス, カエブ, SOUTH; spot, スポット, チェーン, ツポット, キェーン, SPOT; time, タイム, チキン, タイミ, チキオ, TIME; test, テスト, ワゴン, ヘスト, ラゴン, TEST; enjoy, エンジョイ, ヨーロッパ, オンジョイ, ヤーロッパ, ENJOY; trouble, トラブル, ハンガー, ノラブル, サンガー, TROUBLE; earth, アース, ルビー, アエス, ルブー, EARTH; world, ワールド, コンテナ, ワールゾ, コンテワ, WORLD; count, カウント, ハードル, タウント, ダードル, COUNT; bed, ベッド, ボイス, ベッポ, ボイク, BED; black, ブラック, エリート, ブラッツ, エリーソ, BLACK; care, ケア, ヨガ, ケオ, ヨゲ, CARE; cost, コスト, バナナ, ノスト, サナナ, COST; course, コース, ノズル, コイス, ノゾル, COURSE; dance, ダンス, ページ, ダンソ, ペーザ, DANCE; film, フィルム, ライバル, フィルヌ, ライバク, FILM; ground, グラウンド, ディベート, グラエンド, ディビート, GROUND; heart, ハート, シェル, ハーロ, シェス, HEART; home, ホーム, ペット, ソーム, テット, HOME; line, ライン, ゲーム, ヤイン, ベーム, LINE; mind, マインド, ク

(*Appendix continues*)

レヨン, マエンド, クリヨン, MIND; night, ナイト, シーン, ナイテ, シーオ, NIGHT; number, ナンバー, プラント, ノンバー, ペラント, NUMBER; place, プレース, リベラル, ペレース, ロベラル, PLACE; cup, カップ, ランク, カッツ, ランヌ, CUP; race, レース, ホルン, レーソ, ホルア, RACE; tree, ツリー, プラン, ルリー, スラン, TREE; lucky, ラッキー, ブロック, ラッビー, ブモック, LUCKY; chief, チーフ, タッチ, チアフ, タウチ, CHIEF; sound, サウンド, アイデア, サウンデ, アイデイ, SOUND; stop, ストップ, ユーザー, スボップ, ユーガー, STOP; camp, キャンプ, オーバー, キョンプ, ウーバー, CAMP; table, テーブル, エンジン, テーズル, エンギン, TABLE; town, タウン, ベビー, タエン, ベバー, TOWN; support, サポート, オープン, サソート, オークン, SUPPORT; type, タイプ, アート, タエプ, アイト, TYPE; word, ワード, リアル, パード, キアル, WORD; young, ヤング, ケージ, ヤンブ, ケーギ, YOUNG.

“Different” trials low-frequency targets: adult, アダルト, レビュー, アガルト, レジュー, MINUS; bacon, ベーコン, アンテナ, ベーケン, アントナ, FERRY; bike, バイク, テープ, ザイク, セープ, DATA; chip, チップ, ベース, チッグ, ベーク, TONE; corn, コーン, シニア, コーエ, シニオ, PACE; culture, カルチャー, ギャンブル, カルチャオ, ギャンブリ, GORILLA; drama, ドラマ, レバー, ドナマ, レガー, PUNCH; fan, ファン, ビーム, ファイ, ビーメ, MIX; hobby, ホビー, マイル, ホボー, マアル, BLEND; host, ホスト, コーチ, ホソト, コエチ, TRAP; locker, ロッカー, ファクス, ロッター, ファズス, APPEAL; mail, メール, ピアノ, メーリ, ピアヌ, WIDE; merit, メリット, アクセス, メリッコ, アクセフ, BRAKE; mouse, マウス, ゾーン, マエス, ゾアン, DRILL; parade, パレード, キッチン, ペレード, クッチン, HELMET; pen, ペン, ハウ, ペウ, ハオ, BAY; pink, ピンク, ハーブ, ニンク, ターブ, BELL; print, プリント, ファウル, プリウト, ファオル, ROUGH; quiz, クイズ, ドール, クイブ, ドース, SALE; rap, ラップ, ローン, ガップ, ヨーン, EVE; rope, ロープ, カジノ, ロアプ, カゼノ, DESK; ski, スキー, ルート, シキー, ラート, DAM; socks, ソックス, ローカル, ソッフス, ローラル, FENCE; spell, スペル, アウト, ソペル, エウト, COLOR; summit, サミット, レジャー, ソミット, ルジャー, CANCEL; thrill, スリル, ワット, プリル, タット, STUDIO; towel, タオル, アーチ, タオヌ, アーヒ, SLIDE; trend, トレンド, ジュース, トルンド, ジュアス, ALBUM; vision, ビジョン, スケール, ビギョン, スネール, TOILET; wire, ワイヤー, シーズン, ワエヤー, シウズン, GOAL; apple, アップル, スケッチ, アッズル, スセッチ, FREAK; barrel, バレル, コート, バレフ, コーヨ, DESIGN; butter, バター, シルク, バラー, シヌク, TIMING; concert, コンサート, フォーラム, コンサーソ, フォーラク, BALANCE; couch, カウチ, プレス, ラウチ, クレス, EVENT; deck, デッキ, ムード, ダッキ, マード, RATE; drug, ド

(*Appendix continues*)

ラッグ, ステレオ, ドロッグ, スタレオ, LANE; guest, ゲスト, バッジ, メスト, ガッジ, VIDEO; holiday, ホリデー, ボックス, コリデー, モックス, EPISODE; jet, ジェット, ボーカル, ジェッコ, ボーカム, WIG; maid, メイド, バッグ, ネイド, ガッグ, GOLF; memo, メモ, ノー, ミモ, ナー, SLUM; mound, マウンド, トンネル, ミウンド, テンネル, VALVE; oil, オイル, バンド, エイル, ビンド, SKY; patch, パッチ, シフト, パッシ, シフコ, IMAGE; pie, パイ, オン, パウ, オオ, INK; pitch, ピッチ, クルー, ギッチ, ムルー, SHEET; pro, プロ, メガ, プリ, メゴ, JAM; rail, レール, バック, レーロ, バッケ, SOLO; rental, レンタル, キャリア, レンナル, キャミア, BALLET; sand, サンド, オペラ, サエド, オポラ, POSE; soap, ソープ, ニット, ソーグ, ニッロ, RICE; sofa, ソファ, トリオ, コファ, ソリオ, TEXT; staff, スタッフ, ワースト, ステッフ, ワオスト, PRIDE; switch, スイッチ, エッセー, ソイッチ, アッセー, MORALE; ton, トン, ペア, トア, ペオ, GAP; tower, タワー, リフト, タカー, リムト, SHARP; tube, チューブ, ビジネス, チュービ, ビジネセ, PILL; wing, ウィング, スピード, ウィンル, スピーボ, TAXI; yard, ヤード, ブラシ, ダード, グラシ, TOUR.

"Different" trials high-frequency targets: air, エア, セル, エウ, セレ, MAN; body, ボディー, スタント, ボディア, スタンテ, PARK; boss, ボス, パパ, ボソ, パプ, TEAM; card, カード, リズム, カーダ, リズモ, LOVE; change, チェンジ, ユニット, チェンゾ, ユニッテ, ATTACK; class, クラス, ラジオ, クマス, ラギオ, FIGHT; club, クラブ, ルーツ, クラグ, ルーヌ, RING; date, デート, マニア, デオト, マネア, KICK; fair, フェア, ギャグ, フェオ, ギャゴ, SLOW; floor, フロア, ネック, ルロア, メック, DREAM; food, フード, バケツ, クード, ダケツ, DARK; front, フロント, スポーツ, フコント, ストーツ, MAJOR; glass, グラス, エコー, グレス, エクー, HUMAN; hard, ハード, ラベル, ハーゾ, ラベツ, BEER; house, ハウス, ヘビー, ハエス, ヘバー, GREEN; king, キング, ポスト, ヒング, ドスト, WORK; light, ライト, カフェ, ライテ, カファ, MONEY; normal, ノーマル, ペッパー, ノーハル, ペッター, OFFICE; head, ヘッド, ケーキ, ケッド, ネーキ, LIFE; party, パーティー, メッセージ, ラーティー, ヘッセージ, SENSE; point, ポイント, スプレー, ポウント, スペレー, KNOCK; room, ルーム, ラスト, ルーモ, ラステ, SAVE; sign, サイン, ミセス, ソイン, マセス, BLUE; special, スペシャル, サーキット, スケシャル, サーリット, COUNTRY; start, スタート, カーテン, フタート, ナーテン, PAPER; store, ストア, メイン, サトア, ムイン, CATCH; talk, トーク, ゲリラ, トープ, ゲリザ, STAR; truck, トラック, メモリー, トサック, メコリー, MAGIC; turn, ターン, トマト, サーン, ホマト, LADY; white, ホワイト, ラウンジ, ホタイト, ラルンジ, UNDER; beat, ビート, マクロ, ビエト, マキロ, LONG; book, ブック, ソフト, ブオク, ソヘト, LAND;

(*Appendix continues*)

brother, ブラザー, キャメル, ムラザー, チャメル, MACHINE; chance, チャンス, ミネラル, チャンル, ミネラク, ACTION; check, チェック, ファンド, チェップ, ファンゴ, HAPPY; clear, クリア, ゲート, クルア, ゲオト, BRAIN; corner, コーナー, ブライド, コーナウ, ブライダ, LITTLE; door, ドア, エゴ, ダア, ウゴ, PAIN; family, ファミリー, プログラム, ファヒリー, プトグラム, REPORT; follow, フォロー, サーカス, フォゴー, サーラス, CHOICE; free, フリー, スーツ, クリー, ムーツ, BALL; full, フル, タフ, フレ, タヒ, KISS; hand, ハンド, グレー, マンド, ユレー, COOL; news, ニュース, ノウハウ, ニューセ, ノウハオ, WINE; off, オフ, ハム, オヌ, ハフ, BIG; lead, リード, ブレス, リーデ, ブレソ, CITY; living, リビング, フラット, リニング, フヤット, SCHOOL; kill, キル, ゲイ, ケル, ゴイ, SAFE; order, オーダー, スペース, オードー, スピース, SHOOT; pass, パス, ピザ, ポス, パザ, SONG; police, ポリス, ワープ, ポリク, ワーグ, DINNER; show, ショー, ボトル, ピョー, ゾトル, MAMA; smart, スマート, ホルモン, スミート, ホラモン, DRIVE; smile, スマイル, プロセス, スモイル, プルセス, BOARD; step, ステップ, デビュー, セテップ, ダビュー, GIFT; story, ストーリー, リサイクル, ツトーリー, キサイクル, HOTEL; top, トップ, コード, トッズ, コーゴ, SET; try, トライ, ルール, ソライ, グール, GAS; watch, ウォッチ, マフィア, ウェッチ, ムフィア, LEVEL; wife, ワイフ, スリム, ワエフ, スルム, ROAD.

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