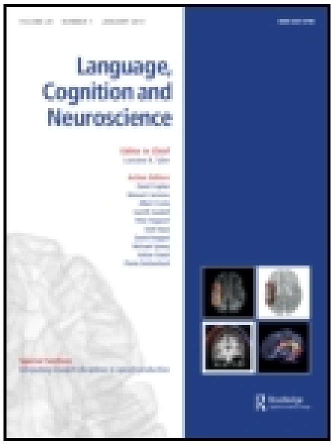

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Non-cognate translation priming effects in the same-different task: evidence for the impact of “higher level” information

Stephen J. Lupker[a], Manuel Perea[b] & Mariko Nakayama[c]

[a] Department of Psychology, University of Western Ontario, London, ON N6A 5C2, Canada

[b] Departamento de Metodología, Facultad de Psicología, Universitat de València, Av. Blasco Ibáñez, 21, Valencia 46010, Spain

[c] Faculty of Letters, Arts and Sciences, Waseda University, 1-24-1 Toyama Shinjuku-ku, Tokyo 162-8644, Japan

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Non-cognate translation priming effects in the same–different task: evidence for the impact of "higher level" information

Stephen J. Lupker[a]*, Manuel Perea[b] and Mariko Nakayama[c]

[a]*Department of Psychology, University of Western Ontario, London, ON N6A 5C2, Canada;* [b]*Departamento de Metodología, Facultad de Psicología, Universitat de València, Av. Blasco Ibáñez, 21, Valencia 46010, Spain;* [c]*Faculty of Letters, Arts and Sciences, Waseda University, 1-24-1 Toyama Shinjuku-ku, Tokyo 162-8644, Japan*

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Norris and colleagues have proposed that priming effects observed in the masked prime same–different task are based solely on pre-lexical orthographic information. This proposal was evaluated by examining translation priming effects from non-cognate translation equivalents using both Spanish–English and Japanese–English bilinguals in the same–different task. Although no priming was observed for Spanish–English bilinguals, who also produced very little translation priming in a lexical decision task, significant priming was observed for Japanese–English bilinguals. These results indicate that, although most of the priming in the same–different task has an orthographic basis, other types of priming effects can emerge. Therefore, while the masked prime same–different task provides a good way of investigating the nature of orthographic coding, it, like the sandwich priming technique, can also be influenced by higher level information.

Keywords: orthographic code; masked priming; same–different task; non-cognate translation equivalents; lexical decision task

In order to successfully model the reading process, it will be necessary to understand the component process referred to as "orthographic coding" (Davis, 2010; Grainger, 2008; Grainger & van Heuven, 2003; Whitney, 2001). Orthographic coding is the process of constructing an abstract representation of the letter string being read which then serves as the code allowing access to higher level (e.g., lexical) information. Successful reading requires that this code accurately specify both the identities of the letters in any word being read as well as the relative positions of those letters. That is, if identity information is not successfully coded, readers may confuse words like *late* and *lame*, whereas, if position information is not successfully coded, readers may confuse anagrams like *calm* and *clam*.

Although both identity and position must be coded accurately for successful reading, recent research has also made it clear that the coding system for position is somewhat imprecise. That is, readers do confuse anagrams created by transposing letters (e.g., *jugde*) with their base words (i.e., *judge*) to a greater degree than letter strings involving replacement of the transposed letters (e.g., *jupte*; Chambers, 1979; O'Connor & Forster, 1981; Perea & Lupker, 2003a, 2003b, 2004) as well as confusing transposed-letter anagram words like *trial* and *trail* (Andrews, 1996). At the same time, however, as shown by the now famous "Cambridge e-mail", readers have little trouble reading when the letter strings they are reading contain sets of transposed letters (e.g., "eervy letetr by iesltf" can be easily interpreted as "every letter by itself"; see Rayner, White, Johnson, & Liversedge, 2006, for additional evidence from experiments in which eye movements were monitored during sentence reading).

Observations such as these have led to the rejection of the idea that orthographic coding involves a "slot-coding" or "position-specific" mechanism, an assumption made in the original versions of many of the basic word recognition models (e.g., the dual-route cascaded model, Coltheart, Rastle, Perry, Ziegler, & Langdon, 2001; the multiple read-out model, Grainger & Jacobs, 1996; the interactive-activation model, Rumelhart & McClelland, 1982). This assumption is simply that the positions of the letters are established very early in processing, well before the identities of the letters are known. In response to the rejection of the slot-coding assumption, two types of orthographic coding mechanisms have emerged. One approach assumes that letter positions are coded in a fashion that, although precise enough to normally allow successful reading, is, nonetheless, noisy (e.g., Gomez, Perea, & Ratcliff's, 2008, Overlap model; Davis's, 2010, SOLAR model; Adelman's, 2011, Letters in Time and Retinotopic Space model). Alternatively, there are now a number of orthographic coding schemes postulating a set of representations between the letter and word levels, representations coding the bigrams in the word being read (Dehaene, Cohen, Sigman, & Vinckier, 2005; Grainger, Granier, Farioli, van Assche, & van Heuven, 2006;

*Corresponding author. Email: lupker@uwo.ca

Grainger & van Heuven, 2003; Whitney, 2001). For example, when the word *judge* is read, activated letter-level representations activate representations for bigrams *ju*, *jd*, *jg*, *ud*, etc., representing the ordering of letter pairs in the word. These types of models are referred to as "open bigram" models.

There have now been a number of attempts to adjudicate between these families of models (e.g., Lupker & Davis, 2008; Lupker, Zhang, Perry, & Davis, 2015; Whitney, Bertrand, & Grainger, 2012). Most have involved the masked priming paradigm (Forster & Davis, 1984) along with the lexical decision task with the question being, does the pattern of priming effects observed more closely mirror the predictions of the noisy representation models or open bigram models? The basic assumption is that, to the extent that primes and targets share orthographic codes, more priming will be observed, with the different models predicting different patterns in the reported experiments. Although this assumption is a reasonable rule of thumb, unfortunately, as Lupker and Davis (2009) noted, priming effects in the conventional masked prime lexical decision task are affected by factors other than the similarity of the prime's and target's orthographic codes. In particular, masked primes activate lexical representations of any words orthographically similar to themselves which then makes those words strong competitors during target processing. As a result, target processing can be slowed to a greater or a lesser extent for different prime types as a function of the nature of the prime's similarity to words other than the target. Therefore, priming effects in the masked prime lexical decision task may often not document the degree of similarity between the prime's and target's orthographic codes.

One potential way to avoid this problem is to use the sandwich priming technique developed by Lupker and Davis (2009). In this technique, the target is always briefly presented (e.g., for 33 ms) just prior to the prime of interest. A lexical decision is then made to the target (e.g., trial sequences are of the form TABLE – nable – TABLE). As Lupker and Davis argue, the initial presentation of the target activates the target's lexical representation while inhibiting most competing lexical representations. Hence, the prime will not activate those same competitors to any noticeable degree, allowing target processing to complete with little, if any, competition. Therefore, the priming effects should closely represent the orthographic similarity of the prime's and target's orthographic codes.

Although the sandwich priming technique seems well-suited for answering questions about the nature of the orthographic code, what needs to be kept in mind is that the participant's task itself is lexical decision. Therefore, the results are open to priming effects of other sorts (e.g., phonological, morphological, semantic). A second potential way of avoiding the lexical competition problem involves using the masked prime same–different task (Kinoshita & Norris, 2009; Norris & Kinoshita, 2008; Norris, Kinoshita, & van Casteren, 2010), a task that, these authors have argued, appears to be unaffected not only by lexical factors but also by any other factors above the pre-lexical orthographic level. Specifically, in this task, an initial reference stimulus is presented for approximately 1 s, followed by a masked prime and then a target. The task is to decide whether the reference stimulus and the target are the same or different. The main result is that if the prime and target are orthographically similar to one another, there is priming on "same" trials (i.e., responses are faster to "table – nable – TABLE" type triplets than to "table – wotan – TABLE" type triplets), although not on "different" trials (i.e., responses to "field – nable – TABLE" type triplets are not faster than to "field – wotan – TABLE" type triplets).

A number of findings do suggest that this task is performed on the basis of only orthographic codes. One finding is that the priming effects tend to be equivalent for high-frequency word, low-frequency word and non-word targets (e.g., Kinoshita & Norris, 2009; Norris & Kinoshita, 2008). Frequency is presumed to be a factor affecting the nature of lexical representations and, further, non-words targets, of course, would not actually have lexical representations. A second finding is that morphological factors seem to play no role in the priming effects. For example, using Spanish stimuli, priming was equivalent for orthographically related pairs regards of whether they are also morphologically related (e.g., in English, walker-WALK), pseudo-related (e.g., corner-CORN) or morphologically unrelated (brothel-BROTH; Duñabeitia, Kinoshita, Carreiras, & Norris, 2011, see also Kinoshita, Norris, & Siegelman, 2012, for an investigation of this issue in Hebrew). A third finding is that the role of phonology, at least lexical phonology, appears to be limited as pseudohomophone primes (e.g., skore-SCORE) are no more effective than primes with slightly different phonology (e.g., smore-SCORE).

At present, we know of only one comparison of the sandwich priming, lexical decision task and the masked prime same–different task (Lupker et al., 2015). In those experiments, three different types of orthographically related primes were used (that were not related to their targets either semantically or morphologically). The two tasks produced not only quite similar patterns of orthographic priming effects but also quite similar amounts of priming (in ms), suggesting that, in general, both paradigms provide reasonable ways of evaluating the nature of the orthographic code.

The goal of the present research was to extend the examination of the claim that priming in the masked prime same–different task is based solely on pre-lexical orthographic representations. As noted, it is clear that the sandwich priming paradigm is not pure in that any lexical decision-making will be affected by factors like semantic and morphological relationships between the prime and target (when those relationships exist) was well as target factors like frequency. Such should not be the case for the masked prime same–different task and the bulk of the literature is supportive of that claim.

Needless to say, there is, nonetheless, at least some evidence in the literature that the masked prime same–different task is affected by factors beyond the nature of the prime's and target's orthographic codes. Perea, Abu Mallouh, García-Orza, and Carreiras (2011), for example, found a morphological effect in this task in Arabic. In particular, they found that the advantage for a transposed-letter priming condition in comparison to a replacement-letter priming condition only arose when the order of the (morphological) root letters was kept intact and not when two root letters had been transposed. This difference was not due to any potential peculiarities of the prime–target stimuli because a replication of the experiment with intermediate adult learners of Arabic (who did not know most of the words) revealed a transposed-letter priming effect regardless of the order of the root letters. Perea et al. concluded that "the masked priming same–different task may be sensitive to factors above the level of letter representations" (p. 916; note, however, that Kinoshita et al., 2012, argued that these results reflected a confound with position-dependent allography; see Yakup, Abliz, Sereno, & Perea, 2014, for empirical evidence for a role of position-dependent allography in Arabic script).

Likewise, Kelly, van Heuven, Pitchford, and Ledgeway (2013) have recently noted that priming for non-word targets does not always work the same way as for word targets, suggesting that the sources of the priming in the two cases might be different. In particular, Kelly et al. have argued that the extant data do not rule out the possibility that, in the case of non-word referents and targets, participants might be using pre-lexical representations, whereas, in the case of word referents and targets, they could be using lexical representations (i.e., that representations beyond the orthographic level are playing a role in this task, at least for the word targets). Consistent with this type of argument, Kelly et al. noted that responses to word targets are inevitably faster in this task than responses to non-word targets, suggesting that the process is unlikely to be completely identical in the two situations.

In an effort to continue the investigation of the nature of the code used in the masked prime same–different task, we sought out a prime–target relationship that, while not being orthographically based, appears to be as extensive as possible at levels above the orthographic level. The relationship we selected was the relationship between non-cognate translation equivalents. The motivation for this selection is as follows. A standard assumption in the bilingual literature has been that establishing a lexical relationship between translation equivalents is the first step in learning the vocabulary of a second language (e.g., Kroll & Stewart, 1994). Hence, the relationship between translation equivalents would seem to be represented at the lexical level. The relationship between the pairs would also, of course, be represented at the semantic level, potentially allowing priming from either of two sources. More recently, the argument has been advanced that translation equivalents actually only share a relationship at the semantic level (e.g., Brysbaert & Duyck, 2010, although see Kroll, van Hell, Tokowicz, & Green, 2010). Even if that is true, however, the semantic relationship they have would be as strong a semantic relationship as it would be possible to create, especially when considering that the word pairs we used all represent simple familiar concepts (e.g., espejo-MIRROR) that share virtually all their senses. Crucially, non-cognate translation equivalents are clearly not related at the pre-lexical orthographic level. Hence, if priming in the masked prime same–different task is based solely on orthographic relationships, non-cognate translations equivalents should produce no priming in that task. The present experiments were conducted to test this prediction.

In the first two experiments, we investigated non-cognate translation priming with Spanish (L1) primes and English (L2) targets, using a lexical decision task in Experiment 1 and a masked prime same–different task in Experiment 2. Also contained in the first two experiments was an identity priming manipulation involving English (L2) words. This manipulation was included mainly as a manipulation check, given the fact that although L1–L2 non-cognate priming has often been reported in the literature (e.g., de Groot & Nas, 1991; Duñabeitia, Perea, & Carreiras, 2010; Duyck & Warlop, 2009; Gollan, Forster, & Frost, 1997; Jiang, 1999; Jiang & Forster, 2001; Kim & Davis, 2003; Voga & Grainger, 2007; Williams, 1994), it has sometimes been difficult to detect with same-script bilinguals (e.g., Davis et al., 2010; Sánchez-Casas & García-Albea, 2005). The expectation, however, is that our stimuli should produce translation, as well as identity, priming in Experiment 1 due to the assumed lexical and semantic relationship between the word pairs (see Duñabeitia et al., 2010). In the masked prime same–different task in Experiment 2, we would, again, expect to observe identity priming because identity primes should prime at the orthographic level. On the other hand, there should not be translation priming in Experiment 2 according to Norris and Kinoshita (2008) because the translation primes and targets are not related at the pre-lexical orthographic level.

Experiments 3, 4 and 5 are parallels to Experiments 1 and 2, except using Japanese–English translation pairs with Japanese–English, rather than Spanish–English, bilinguals. Cross-language priming effects for Japanese–English bilinguals tend to be among the most robust in the bilingual literature (e.g., Nakayama, Sears, Hino, & Lupker, 2012, 2013; Nakayama, Verdonschot, Sears, & Lupker, 2014). Therefore, a demonstration that there was no translation priming for those individuals in a masked prime same–different task would provide very strong evidence that the priming in that task is based only on orthographic codes rather than higher level (e.g., lexical, semantic) codes.

Experiment 1 (masked prime lexical decision task, Spanish–English bilinguals)

Method

Participants

Twenty undergraduate students from the department of English Philology at the University of Valencia participated voluntarily in this experiment (15 female and 5 male). The majority of their courses were taught in English and all students reported that they use English on a daily basis. The average age of the students was 21.3 years. All were native speakers of Spanish and their age of exposure to English varied between 3 and 13 years (M = 7.80, SD = 2.97).

Materials

For the translation priming manipulation, we selected a total of 100 Spanish prime-English target pairs. The English targets were chosen according to the following criteria: they had a single translation in Spanish and they were not cognates with a Spanish word. Their length ranged between 3 and 10 letters (M = 5.1). The number of letters in the prime and target words was either the same or differed by one letter. The frequency of the English targets varied between 1.8 and 866.04 per million (M = 107.56; subtitle frequency in the Brysbaert & New, 2009, count), their number of orthographic neighbours (Coltheart's N – Coltheart, Davelaar, Jonasson, & Besner, 1977) ranged from 0 to 23 (M = 4.85) and the mean concreteness of the English words was 5.64 (range 3.05–6.70 on a 1–7 scale; Coltheart, 1981). The Spanish primes ranged from 3 to 9 letters in length (M = 5.26), their written subtitle frequency ranged from 0.10 to 1445.31 per million (M = 107.50), their number of orthographic neighbours ranged from 0 to 25 (M = 4.47) and their concreteness indices ranged from 2.48 to 6.77 (M = 5.39) based on the EsPal Spanish Database (Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013). These Spanish–English translation pairs and their respective unrelated primes are listed in Appendix 1. To create the unrelated prime condition, we selected a Spanish word of the same length and approximately the same word frequency to replace each related Spanish prime word. We created two counterbalanced lists so that each target word was in the related condition in one list and in the unrelated condition in the other. Thus, there were 50 word pairs in the related condition and 50 word pairs in the unrelated condition in each list. An additional set of 100 orthographically legal non-words in English was also created using Wuggy (Keuleers & Brysbaert, 2010). These non-words were preceded by a Spanish prime word of the same length (plus/minus one) as the target English non-word.

For the identity priming manipulation, we selected a new set of 30 English words. The length of these words ranged from 3 to 11 letters (M = 5.63), the mean subtitle frequency was 359.37 per million (range: 26–895) and the concreteness index varied between 2.46 and 6.24 (M = 3.90). These English–English identity pairs and their unrelated primes are listed in Appendix 1. Fifteen pairs of words were used in the identity condition (where the prime and the target were the same English word) and the remaining 15 target words were preceded by an English unrelated prime word, matched in length and frequency to the target word. Thirty non-word English stimuli were also created using Wuggy. Fifteen of those non-words were preceded by exactly the same non-word, whereas the remaining 15 non-word targets were preceded by unrelated non-words of the same length. Two lists were created to rotate the related/unrelated primes for both the word and non-word targets.

Procedure

The experimental session was conducted in a quiet room in groups of 3–10 participants. All participants gave written informed consent before taking part in the experimental session. The software used for the presentation of stimuli and measuring of response latencies was DMDX (Forster & Forster, 2003). Each trial started with the presentation of a row of hash marks (######) in the centre of the screen for 500 ms. The number of hash marks used on each trial was equal to the maximum length of the prime or target on the trial. After 500 ms, the mask was immediately replaced by the Spanish prime in lower case, which remained on the computer screen for 50 ms (i.e., 3 screen refreshes). The prime was immediately followed by the target in uppercase, which remained on the screen until the participant responded or 2 s had elapsed. Primes, targets and the forward mask were all presented in Courier New 14-pt. Participants were asked to press the "yes" button if the uppercase stimulus was an English word and the "no" button if the uppercase stimulus was not a word. They were asked to respond as fast as possible, trying to make as few mistakes as possible. The trials were presented in a different random order for each participant. When the experiment was complete, they were asked whether they had recognised all the English words. All of them answered affirmatively.

Results and discussion

Incorrect responses (2.1% and 0.8% for the word data in the translation and identity manipulations, respectively) and lexical decision latencies less than 250 ms or greater than 1500 ms (0.5% and 0.5% for the word data in the translation and identity manipulations, respectively) were excluded from the latency analyses. The data were analysed using linear mixed models with the R packages *lme4* (Bates, Maechler, Bolker, & Walker, 2014) and *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2014). For the translation priming manipulation, Prime Type (translation, unrelated) was a fixed effect factor. The random effects were the by-subjects and by-items slopes, and the by-subjects and by-items intercepts (i.e., the maximal model). In the analysis of response latencies, inverted response latencies (–1000/RT) were used as the dependent variable so that the distribution of the RTs would be closer to a Gaussian distribution. For the error rates, we employed generalised linear models with the same design using a binomial distribution. The analyses for the identity priming manipulation were parallel to those in the translation priming manipulation, with prime type (identity, unrelated) being a fixed effect factor in that analysis.

Translation priming

Lexical decision times were, on average, 12 ms faster when the target words were preceded by a translation prime than when preceded by an unrelated prime (608 vs. 620 ms, respectively), $t = 2.50$, $p = .0146$. The error data did not reveal any difference between the translation and unrelated conditions (2.1% and 2.1%, respectively), $z < 1$.

Identity priming

Lexical decision times were, on average, 33 ms faster when the target words were preceded by an identity prime than when preceded by an unrelated prime (578 ms vs. 611 ms, respectively), $t = 3.60$, $p = .001$. Error rates were very low (0.3% and 1.3% in the identity and control conditions, respectively), and the difference was not significant, $z = 1.25$, $p = .21$ – this value of z was obtained in a model with only random slopes for subjects and items because the maximal model failed to obtain converge.

The results are straightforward. In the lexical decision task, there was a small but significant masked L1→L2 translation priming effect with non-cognate translation equivalent pairs, thus replicating earlier research with fluent L2 readers (e.g., de Groot & Nas, 1991; Duñabeitia et al., 2010; Duyck & Warlop, 2009; Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Kim & Davis, 2003; Voga & Grainger, 2007; Williams, 1994). In addition, there was an identity priming effect in the participants' L2. These stimuli are, therefore, sufficient for examining the question of whether it is possible to observe translation priming effects in the masked prime same–different task. Because masked translation priming effects may be more difficult to detect in the same–different task than in lexical decision (as noted, Kinoshita & Norris (2009), would predict a null effect of masked translation priming in the same–different task), we felt that it would be necessary to increase the experimental power in Experiment 2. Therefore, the sample size was (nearly) twice as large as in Experiment 1.

Experiment 2 (masked prime same–different task, Spanish–English bilinguals)

Method

Participants

The participants were 38 native Spanish speakers (25 female and 13 male). All were students of C1-English (i.e., Advanced Level) in one of two Language Centres (The British Council or Centre d'Idiomes) in Valencia. Their mean age was 24 years and they reported that they used English on a daily basis. Their age of exposure to English varied between 4 and 10 years ($M = 7.60$, SD = 2.15).

Materials

The same 100 direct translations of English targets presented in Experiment 1 were used to create the "same" trials in the translation manipulation. For the "different" trials, the related condition was created by using 50 primes that were direct translations of the reference stimulus: e.g., "girl – niña – CASH" ("niña" being the Spanish word for "girl"). In the unrelated condition of the "different" trials, the primes were another 50 Spanish words, matched in length and frequency to the translation prime but not having any relationship to the reference stimulus or the target: e.g.. "girl – cola – CASH" ("cola" being the Spanish word for "tale"). Note that in the related conditions for both the "same" and "different" trials, the prime is related to the reference stimulus in order to create a "zero-contingency" scenario, that is, a scenario in which the relation between the reference stimulus and the prime is not predictive of a "same" response. As noted by Kinoshita and Norris (2010) and Perea, Moret-Tatay, and Carreiras (2011), the use of a zero-contingency sequence on different trials, rather than the alternative sequence in which the related prime is related to the target (e.g., "girl – efectivo – CASH", where "efectivo" is the Spanish word for "cash") can affect the pattern of results on "different" trials but not on "same" trials.

For the identity priming manipulation, the 30 word targets (and their corresponding primes) from the identity priming manipulation in Experiment 1 were used to create the "same" trials. For the "different" trials, we selected an additional set of 30 English word targets. The length of these words ranged from 3 to 11 letters ($M = 5.64$) and the subtitle frequency ranged from 1.76 to 2691.39 per million ($M = 242.90$). To serve as reference stimuli on "different" trials, we also selected a set of 30 English words of the same length (and similar frequency) as the targets. Finally, we also selected 30 English words, one for each target word, to serve as unrelated primes on the "different" trials.

All 60 word targets were presented to each participant. The related condition of the "same" trials involved 15 triplets of the same word, e.g. "day – day – DAY". In the unrelated condition, the primes were the selected unrelated word prime for that target from Experiment 1 (e.g., "leg – bag – LEG"). On the "different" trials, the related condition involved 15 triplets in which the reference stimulus was the same as the prime (e.g., "mother – mother – TISSUE"). Finally, in the unrelated condition of the "different" trials, the prime word was unrelated to both the reference stimulus and the target (e.g., "earth – sharp – GUEST").

There were, therefore, 260 experimental trials (200 involving the translation priming materials and 60 involving the identity priming materials). These trials were preceded by 16 practice trials. The practice stimuli were chosen according to the same criteria as used in the same–different translation task design and contained triplets not found in the experimental lists.

Procedure

Participants were tested in a silent room, in groups of up to four people. The software/hardware was the same as in Experiment 1. The sequence of each trial was as follows: the reference stimulus was presented in lowercase for 1000 ms above a forward mask consisting of the same number of hash marks as the target's length. Then, the reference stimulus was removed and the mask was replaced by the prime word in lowercase, which remained on the screen for 50 ms. The uppercase target word then replaced the prime and remained on the screen until the participant responded or until 2 s had elapsed. Participants were asked to decide whether the reference and the target were the same word. As in Experiment 1, there was no mention of the prime in the instructions. Participants were asked 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.

Results and discussion

Error responses (3.5% and 2.8% in the translation and identity manipulations, respectively) and response times less than 250 ms or greater than 1000 ms (1.3% and 2.0% in the translation and identity manipulations, respectively) were excluded from the latency analyses. The statistical analyses paralleled those in Experiment 1.

Translation priming

For "same" trials, there was no sign of a translation priming effect in the latencies, $t < 1$. The means were 557 ms in the translation condition and 556 ms in the unrelated condition. The error data did not show an effect of translation priming either, $z = 1.13$, $p = .26$. The means were 3.2% and 3.9% in the translation and unrelated conditions, respectively.

For "different" trials, there was no sign of a translation priming effect in either the latency or the error data, $t < 1$ and $z < 1$, respectively. The means were 587 ms (2.3%) in the translation condition and 585 ms (1.8%) in the unrelated condition.

Identity priming

For "same" trials, the analyses of the latency data revealed a 45-ms advantage for targets preceded by an identity prime in comparison to targets preceded by an unrelated prime (524 vs. 559 ms, respectively), $t = 5.11$, $p < .001$. The mean error rates were 2.1% and 3.5% for the identity and unrelated conditions, respectively. This difference was not significant, $z < 1$.

For "different" trials, the analysis of the latency data revealed slower response times for targets preceded by an identity prime in comparison to targets preceded by an unrelated prime (601 vs. 580 ms), $t = -3.64$, $p = .0008$. The parallel difference did not arise in the error data (2.3% vs. 2.1% in the identity vs. unrelated conditions, respectively), $z < 1$.

As expected, there was a sizeable masked identity priming effect with there being an advantage in the identity compared to the unrelated condition on "same" trials. Because this experiment involved a zero-contingency design (i.e., the prime matched the reference stimuli but not the target on different trials), there was also a disadvantage in the identity condition on "different" trials (e.g., see Perea et al., 2011, for the same pattern of data with identity primes). That is, in a zero-contingency scenario, the related primes, because they match the reference stimulus, provide evidence for a "same" response. The result is not only a speed-up of responses on "same" trials, it is also a slowdown of responses on "different" trials. This pattern would be entirely consistent with the task analysis provided by Norris and Kinoshita (2008).

The main empirical point, however, is that, unlike in the lexical decision task (Experiment 1), there was no hint of a masked translation priming effect on either "same" or "different" trials. This result is also quite consistent with the account proposed by Norris and Kinoshita (2008).

Experiment 3 (masked prime lexical decision task, Japanese–English bilinguals)

The results of Experiments 1 and 2, in particular, the lack of a translation priming effect in Experiment 2, provide support for Norris and Kinoshita's (2008) claim that performance in the masked prime same–different task is based entirely on orthographic codes. However, before accepting that claim, we made another attempt to find a translation priming effect in that task.

The size of the translation priming effect in the lexical decision task of Experiment 1 was fairly small (12 ms). A non-cognate priming effect of this size is not, however, uncommon when same-script bilinguals are tested (e.g., Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009, Experiment 1, 100 ms stimulus onset asynchrony (SOA) condition: 19 ms effect; de Groot and Nas, 1991, Experiment 4, lower case prime and upper case target condition: 22 ms effect) and, in fact, there are several reports in the literature of an inability to find priming in similar situations (Davis et al., 2010; Sánchez-Casas & García-Albea, 2005). Therefore, looked at from an entirely empirical perspective, one can certainly argue that any priming effect that might have emerged in the same–different task would have been of a fairly small size and potentially difficult to detect. One could also make the argument that because their two languages have the same script, Spanish–English bilinguals would not have been the bilinguals most likely to show a significant priming effect in such a task.

In contrast, different-script bilinguals tend to show much more robust non-cognate translation priming effects in lexical decision (Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Kim & Davis, 2003; Nakayama et al., 2013; Voga & Grainger, 2007). For example, Nakayama et al. (2013, Experiment 1) reported a 71 ms priming effect for low-frequency English (L2) words and a 46 ms priming effect for high-frequency English words when primed by Japanese (L1) Kanji primes, effects that the authors attributed to the semantic relationship between the primes and targets. What was done in the present Experiment 3, therefore, was to select a set of Japanese–English non-cognate translation equivalents that would be expected to produce a large priming effect in lexical decision for Japanese–English bilinguals. The primes were written in Kanji as in Nakayama et al.'s experiment. The expectation is that we would obtain a significantly larger translation priming effect than that in the present Experiment 1. That result would allow us to create a much stronger test of Norris and Kinoshita's (2008) claim by examining whether those prime–target pairs would produce priming when used as the "same" pairs in a same–different task.[1]

Method

Participants

Thirty-six proficient Japanese–English bilinguals (28 female and 8 male) from Waseda University (Tokyo, Japan) participated in this experiment. Their mean age was 22 years and their age of exposure to English varied between 6 and 13 years (M = 10.22, SD = 3.06). All of the participants had TOEIC scores higher than 805 with their mean score being 871 (range = 805–990; test score range: 10–990). While comparable scores are not available for the bilinguals participating in Experiments 1 and 2, these scores suggest that the Japanese–English bilinguals were at least as proficient in English as the Spanish–English bilinguals were.

Stimuli

The critical stimuli were 60 L1–L2 non-cognate translation equivalents (e.g., 屋根 – ROOF). English targets were on average 4.7 letters in length (range: 4–6). The written word frequencies of the English targets ranged from 2.8 to 642 per million (M = 115.0; subtitle frequency in Brysbaert & New, 2009), their number of orthographic neighbours ranged from 0 to 20 (M = 5.8, Coltheart's N), and their mean concreteness rating was 3.6 (range 1.3–4.9 on a 1–5 scale (Brysbaert, Warriner, & Kuperman, 2014). Japanese translation primes were always two-character Kanji words. Their written word frequencies ranged from 0.9 to 348 per million (M = 68.0, Amano & Kondo, 2000) with their average number of strokes being 19.6 (range: 9–32). Their mean imageability ratings ranged from 4.0 to 6.8 (M = 5.0) and their orthographic familiarity ratings ranged from 5.5 to 6.7 (M = 6.2), both on a 1–7 scale (Amano & Kondo, 2000). Sixty Japanese control primes, that were phonologically and conceptually unrelated to their English targets, were also selected (e.g., 児童 – ROOF). The unrelated primes were also two-character Kanji words and were matched to the translation primes on their mean word frequency (M = 59.0, range 1.3–230), number of strokes (M = 18.6, range 6–33), imageability ratings (M = 5.0, range 4.0–6.5) and orthographic familiarity ratings (M = 6.2, range 5.5–6.7). These Japanese–English translation pairs and their respective unrelated primes are listed in Appendix 2. Two counterbalanced lists were created so that each target word was in the related condition in one list and in the unrelated condition in the other. Thus, there were 30 word pairs in the related condition and 30 word pairs in the unrelated condition in each list.

An additional set of 60 orthographically legal non-words in English were selected from the English lexicon project database (Balota et al., 2007) for the lexical decision task. English non-word targets were on average 4.7 letters in length (range: 4–6) and had an average of 5.9 orthographic neighbours (range: 0–22). Primes preceding the English non-words were two-character Japanese Kanji words. The Japanese primes preceding English non-words were matched to those preceding English word targets on their mean word frequency (M = 67.0, range 5.2–218), number of strokes (M = 19.0, range 8–33), imageability ratings (M = 5.0, range 4.3–6.2) and orthographic familiarity ratings (M = 6.2, range 5.9–6.7). There was only one presentation list for non-word targets, and their data were not subject to statistical analyses.

Apparatus and procedure

Each participant was tested individually in a quiet room. The experimental task was a masked prime lexical decision task. As was the case in the preceding experiments, the stimuli were presented using the DMDX software package (Forster & Forster, 2003). Primes, targets and the forward mask were all presented in size 14 font with the primes and mask being presented in MS Gothic and the targets (as well as the reference stimuli in Experiments 4 and 5) being presented in Arial. Otherwise, the procedure was identical to that in Experiment 1, except that the prime duration was 60 ms in Experiment 3. Participants completed 16 practice trials to familiarise themselves with the task prior to the collection of data. None of the items in the practice trials were used in the experimental trials. The trials were presented in a different random order for each participant.

Results and discussion

Correct response latencies that were faster than 300 ms or slower than 1500 ms were removed from the analysis (0.26% of the data). The remainder of the data was analysed identically to that in Experiment 1 using linear mixed models (i.e., with maximal models).

As expected, there was a significant L1–L2 noncognate translation priming effect, t = 7.09, p < .0001. English targets primed by Japanese translation equivalents were responded to significantly faster (623 ms) than when the same targets were primed by unrelated Japanese words (668 ms). A significant translation priming effect was also observed for errors (6.9% vs. 11.9%, for the translation vs. unrelated conditions, respectively), z = 3.55, p = .0004.

The existence of a 45 ms translation priming effect in Experiment 3 indicates that our Japanese primes are very effective primes for their English translation equivalents. Therefore, these stimuli should provide a strong test of Norris and Kinoshita's (2008) claim that priming in the masked prime same–different task is based solely on orthographic codes. Experiment 4 involved the same primes and targets in that task.

Experiment 4 (masked prime same–different, Japanese–English bilinguals)

Method

Participants

Forty-two proficient Japanese–English bilinguals (28 female and 14 male) from Waseda University participated in Experiment 4. None had participated in Experiment 3. All of the participants had TOEIC scores higher than 800 with their mean score being 868 (range = 800–970). Their mean age was 21 years and their age of exposure to English varied between 2 and 13 years (M = 9.6, SD = 3.56).

Materials

The 60 English targets used in Experiment 3 were used to create the "same" trials in Experiment 4. For the "different" trials, a new set of 60 English targets was selected. The targets in the "different" trials were matched to those in the "same" trials in their mean lexical characteristics. Their word lengths ranged from 4 to 6 (M = 4.7), their subtitle word frequencies ranged from 1.9 to 1947 (M = 107.0), their number of orthographic neighbours ranged from 0 to 17 (M = 5.7) and their imageability ratings ranged from 1.5 to 5.0 (M = 3.7). To serve as reference stimuli on "different" trials, 60 English words that were orthographically, phonologically and conceptually unrelated to their targets were also selected. The reference stimuli had a mean word length of 4.7 (range 4–6), subtitle frequency of 123.0 (range 6.8–1295), Coltheart's N of 5.9 (range 0–19) and imageability rating of 3.6 (range 1.4–5). None of the targets or reference stimuli were used in the "same" trials.

For the "different" trials, the related condition was created by using Japanese primes that were direct translations of their reference stimuli (e.g. "swan –白鳥– JUNK" with"白鳥" being the Japanese word for "swan"). The translation primes were always two-character Kanji words. The lexical characteristics of the translation primes were matched to those in the "same" trials. The word frequencies of the translation primes ranged from 1.0 to 375 (M = 69.0), their number of strokes ranged from 8 to 33 (M = 19.3), their imageability ratings ranged from 4.0 to 6.6 (M = 5.0) and their orthographic familiarity ratings ranged from 5.2 to 6.7 (M = 6.2). For the unrelated condition, another 60 two-character Kanji Japanese words were selected that matched the related primes/reference stimuli in their mean written word frequency (M = 67.0, range 1.2–421), number of strokes (M = 19.0, range 4–30), imageability ratings (M = 5.0, range 4.1–6.2) and orthographic familiarity ratings (M = 6.2, range 5.6–6.6). Unrelated primes did not have any relationship to their reference stimuli or targets (e.g., "swan –香水– JUNK" with "香水" being the Japanese word for "perfume"). As was the case in Experiment 2, the related translation primes were related to (i.e., translations of) the reference stimuli rather than the targets to create a zero-contingency scenario.

Within each counterbalancing list, half of the primes were Japanese translations of the reference stimulus, and the other half were unrelated primes with the pairing of the reference–prime relationship being alternated across the two lists. Thus, there were four types of reference–prime–target triplets: (1) roof-屋根 (*roof*)-ROOF, (2) roof-児童 (*pupil*)-ROOF, (3) swan-白鳥 (*swan*)-JUNK, and (4) swan-香水(*perfume*) -JUNK. There were 30 triplets within each condition.

Procedure

Participants were tested individually in a silent room. The trial sequence was identical to that in Experiment 2, except that primes were presented for 60 ms in Experiment 4. Participants received 20 practice items to familiarise themselves with the task prior to the experimental session. Again, none of the items in the practice trials were used in the experimental trials and the trials were presented in a different random order for each participant.

Results and discussion

Correct response latencies that were faster than 200 ms or slower than 1000 ms were removed as outliers (0.46% and 0.16% of the "same" and "different" trial data, respectively). Response latencies and errors were analysed similarly to Experiment 2, again, using the maximal linear mixed models.

"*Same*" *trials*

When Japanese primes were translation equivalents of English words, "same" responses were significantly faster (440 ms) than when the primes were unrelated to the English words (449 ms), $t = 2.15$, $p = .039$. Although there was a parallel difference in the error rate data (3.4% vs. 5.5%, for the translation vs. unrelated conditions, respectively), this difference was not significant $z = 1.47$, $p = .14$.

"*Different*" *trials*

When Japanese primes were translation equivalents of the reference words, "different" responses were significantly slower (474 ms) than when the primes were unrelated to the reference stimuli (465 ms), $t = -2.87$, $p = .006$. The inhibition effect was not significant for errors (3.3% vs. 2.1%), $z < 1$.

The results of Experiment 4 are quite straightforward. Although there was no orthographic relationship between the primes and targets, there was a small (9 ms) but significant (translation) priming effect on "same" trials. Responding on "same" trials was faster when the Kanji primes were translations of their targets. As there was no orthographic similarity between these primes and targets, this result is not consistent with the claim that priming in the same–different task is based solely on the orthographic evidence provided by the prime (Norris & Kinoshita, 2008), more specifically, the extent to which the pre-lexical orthographic code from the prime matches that of the target.

Also of note is the fact that there was a significant (negative) translation priming effect on "different" trials. Related "different" trials were created to reflect a zero-contingency situation. That is, the related prime was a translation equivalent of the reference stimulus rather than the target. The effect observed here is also consistent with what one typically observes in a within-language masked priming same–different task (e.g., Perea et al., 2011, Experiment 3, also see Kinoshita & Norris, 2010), an effect that was also observed in our identity condition in Experiment 2. Taken together, the present findings on both "same" and "different" trials clearly demonstrate the existence of priming effects from non-cognate translation equivalents, supporting the conclusion that priming in this task involves more than interactions at the level of the orthographic code.

Experiment 5 (masked prime same–different, Japanese–English bilinguals, reduced SOA)

The priming effects observed in Experiment 4 are novel, representing the first time that a priming effect has been observed in the masked prime same–different task that cannot be localised at the level of pre-lexical orthographic representations. Experiment 5 was a follow-up experiment intended to expand this finding while simultaneously addressing an additional issue.

The results of Experiment 4 were different from those in Experiment 2 in which no translation priming was observed with Spanish–English bilinguals. A straightforward explanation of this difference is that translation priming effects with non-cognates are often weak or non-existent for same-script bilinguals (e.g., Davis et al., 2010; de Groot & Nas, 1991; Sánchez-Casas & García-Albea, 2005; Schoonbaert et al., 2009). Therefore, it would be unlikely that Spanish–English bilinguals would show a significant translation priming effect in a same–different task, a task in which one would expect a smaller translation priming effect than the effect found in lexical decision (as documented by the comparison between the present Experiments 3 and 4). The reason for the low levels of translation priming for same-script bilinguals in lexical decision tasks is unclear. For example, it could stem from the fact that the prime is not treated as an L1 word but rather as an L2 non-word since the task is an L2 task. It could reflect the idea that same-script bilinguals do not have separate orthographic lexicons for their two languages and, therefore, locating the correct lexical entry, based on a briefly presented prime is more difficult than for different-script bilinguals. There are, certainly, other possible processing explanations as well.

What is also a possibility, of course, is that the difference was due to the fact that the primes in Experiment 4 were presented for a slightly longer time (60 ms) than the primes in Experiment 2 (50 ms). Experiment 5 was an attempt to evaluate this idea. Experiment 5 was identical to Experiment 4 except for the fact that the prime duration was reduced to 53 ms, which is the same prime duration employed by Norris and Kinoshita (2008) in their masked prime same–different experiments.

One additional advantage of Experiment 5 is that, if a priming effect emerges, it produces clear evidence that the results in Experiment 4 were not Type I errors. Currently, there is considerable discussion in the literature about the (lack of) replicability of a number of results (e.g., Pashler & Wagenmakers, 2012; Peng, 2011; Stanley & Spence, 2014). Replicating the priming effects observed in Experiment 4 would help to alleviate those types of concerns in the present situation.[2]

Method

Participants

Thirty-eight proficient Japanese–English bilinguals (22 female and 16 male) from Waseda University participated in Experiment 5. All had TOEIC scores higher than 710 with their mean score being 815 (range = 710–990). Their mean age was 22 years and their age of exposure to English was between 4 and 13 years (M = 10.4 years, SD = 2.55). One of these individuals had participated in Experiment 4.

Materials

These were identical to those in Experiment 4.

Procedure

These were identical to those in Experiment 4, except that the prime duration was 53 ms.

Results and discussion

Outlier removal, conducted identically to that in Experiment 4, resulted in the exclusion of 0.22% and 0.79% of the data for the "same" trials and "different" trials, respectively. Data were analysed in the same way as in Experiment 4.

"*Same*" trials

As in Experiment 4, there was a significant priming effect. Responses were (significantly) 12 ms faster when Japanese primes were translation equivalents of English words (469 ms) than when they were unrelated Japanese words (481 ms), t = 3.29, p = .001. There was no significant effect for error rates (2.6% vs. 3.6%), $z < 1$.

"*Different*" trials

There was, again, a significant inhibitory priming effect; responses were 8 ms slower when Japanese primes were translation equivalents of the reference stimuli than when they were unrelated Japanese words (499 ms vs. 491 ms), $t = -2.53$, p = .0144. There was no effect for error rates, (2.9% vs. 2.5%), $z < 1$ – similar to Experiment 1, this value of z was obtained with an intercepts only model because the maximal model failed to converge.

Even with a shorter prime duration, L1 translation primes again facilitated "same" responses and inhibited "different" responses. These results provide additional support for the claim that priming in the same–different task is not based solely on pre-lexical orthographic representations.

General discussion

In recent years, considerable research effort has been directed towards understanding the nature of the orthographic code, that is, the mental representation that allows successful lexical access when reading words. While the masked prime lexical decision task has the potential to inform us on this issue, priming effects in that task are affected by lexical competition processes, processes that have little to do with the nature of the orthographic code.

Two techniques that have the potential to avoid the lexical competition problem, the sandwich priming lexical decision task (Lupker & Davis, 2009) and the masked prime same–different task (Norris & Kinoshita, 2008) have recently been proposed. The sandwich priming task involves inserting a brief presentation of the target stimulus into the normal masked priming lexical decision sequence. The goal is to kill off activation of competitors, making the priming effects that are observed more reflective of the similarity of the prime's and target's orthographic codes. Because the response task is lexical decision, however, the results are affected by factors that affect lexical decision-making, for example, semantic relationships between primes and targets. The masked prime same–different task involves asking participants to decide whether a clearly presented reference stimulus is the same stimulus as a clearly presented target stimulus after a masked prime has been briefly presented just prior to that target. The claim is that this task is carried out solely based on the orthography of the reference stimulus and the target and, therefore, the priming effect that is observed on "same" trials is a reflection of the orthographic similarity of the prime and the target/reference stimulus. The fact that other factors like morphological and, potentially, phonological relationships between the prime and target/reference stimulus do not appear to affect task performance supports the claim that this experimental paradigm may be a very good way to evaluate the nature of the orthographic code.

The goal of the present experiments was to evaluate this claim by determining whether one would observe a translation priming effect in the masked prime same–different task when the translation equivalents were non-cognates. The fact that the related prime–target pairs were non-cognates means that although there would be a lexical as well as a semantic relationship between primes and targets there would not be an orthographic (or phonological) relationship. Thus, if this claim is correct, there should be no priming in the present experiments with the masked prime same–different task.

The first attempt to evaluate the claim involved Spanish–English bilinguals. Using primes and targets that produced a 12 ms translation priming effect in a lexical decision task, a nonsignificant −1 ms priming effect was observed on "same" trials in the masked prime same–different task. This result is consistent with the claim that priming in the masked prime same–different task is, indeed, based only on the nature of the orthographic codes, as Spanish–English non-cognate translation equivalents have completely dissimilar orthographic codes.

The second attempt to evaluate this claim involved Japanese–English bilinguals whose test scores indicated that they were very proficient in English. The motivation behind using Japanese–English bilinguals was that different-script bilinguals tend to show much larger translation priming effects in lexical decision tasks than same-script bilinguals and, therefore, the potential to observe a small effect in the masked prime same–different task, if one exists, would be higher than with same-script, Spanish–English bilinguals. Indeed, the translation priming effect for the Japanese–English bilinguals in the lexical decision task, 45 ms, was much larger than that for the Spanish–English bilinguals. Most importantly, in Experiment 4, Japanese–English bilinguals produced a significant 9 ms translation priming effect in the masked prime same–different task on both "same" trials (i.e., facilitation) and "different" trials (i.e., interference). Parallel effects (12 ms and 8 ms, respectively) were observed in Experiment 5 when the prime duration was reduced to 53 ms. These results are clearly not supportive of the claim that the task is based entirely on orthographic codes with the observed priming effect being a reflection only of the orthographic similarity of the prime and target/reference stimulus at the pre-lexical level. Instead, it appears that priming resulted from the translation prime activating lexical and/or semantic structures relevant to the target/reference stimulus. On "same" trials, that activation leads to facilitated responding, whereas on "different" trials, it leads to inhibited responding.

The present results do not, of course, challenge the argument that priming in the masked prime same–different task is *mainly* based on orthographic information. Indeed, priming effects from orthographically related primes are usually much larger than the 8–12 ms effects observed in Experiments 4 and 5 and, as the results of Experiment 2 showed, when translation priming is fairly ineffective (only a 12 ms effect in lexical decision), there is no evidence of a translation priming effect in the masked prime same–different task. Nonetheless, the results of Experiments 4 and 5 clearly do indicate that pre-lexical orthography is not the entire story in the masked prime same–different task, at least with different-script (e.g., Japanese–English) bilinguals. That is, consistent with the claims made by Kelly et al. (2013), it does appear that, at least for word targets, the story also requires that one assume that information beyond the orthographic level is activated and, more importantly, used in the same–different task.

Overall, then, how does the story change? Note first that what the results of Experiments 4 and 5 do not do is to challenge Norris and colleagues' general conceptualisation of how the priming arises in the same–different task (Kinoshita & Norris, 2009, 2010; Norris & Kinoshita, 2008; Norris et al., 2010). That is, Norris and Kinoshita (2008) originally argued that the priming effects in the masked prime same–different task are not due to primes pre-activating target representations, leading to facilitated target processing. Rather, the priming effects are due to the interaction of the information provided by the prime with information relevant to the reference stimulus. Essentially, the reference stimulus is set up as a single entry in a task-relevant lexicon. If the target information matches that information, a positive ("same") response is evoked, and if the target information does not match that information, a negative ("different") response is evoked. Essentially, what the prime does it to change the likelihood of a "same" response on a given trial. If a prime supports the information relevant to the reference stimulus, it increases the likelihood that the answer would be the "same". If a prime does not support the information relevant to the reference stimulus, it increases the likelihood that the answer would be "different". Thus, when the correct response is indeed a positive one, relevant primes facilitate responses relative to unrelated primes, whereas when the correct decision is a negative one, relevant primes interfere with responses relative to unrelated primes (under the zero-contingency scenario).

This analysis, provided by Norris and colleagues' account, is quite consistent with the results of Experiments 4 and 5. Therefore, the only aspect of the story that the results of Experiments 4 and 5 alter is that they require that one acknowledge that evidence from the prime supporting the reference stimulus can come from either the lexical (Kelly et al., 2013) or semantic levels (as those are the levels at which non-cognate translation equivalents share representations). In other words, in contrast to the claims of Norris and colleagues (Kinoshita & Norris, 2009, 2010; Norris & Kinoshita, 2008; Norris et al., 2010), performance in this task is not based solely on pre-lexical orthographic information.

Note also that this general conceptualisation of priming espoused by Norris and colleagues for the same–different task, that it is the relationship between the prime and the reference stimulus that is relevant rather than the relationship between the prime and the target, is not a standard one in the priming literature. In almost every other priming situation beginning with the original semantic priming research (Meyer & Schvaneveldt, 1971; Neely, 1977), the explanation of priming effects has incorporated an "activation" component. Prime processing activates processing structures of the target by either automatic or strategic means. In the present situation, one could advance a similar argument to explain the priming on "same" trials. That is, that priming could be due to the translation prime activating the target. However, a similar explanation could not be used to explain the negative translation priming effect on "different" trials ("swan –白鳥–JUNK", with "白鳥" being the Japanese word for "swan", being slower than "swan –香水– JUNK", with "香水" being the Japanese word for "perfume") because the prime and target are completely unrelated in both conditions. In contrast, this negative priming effect is quite consistent with Norris and colleagues' conceptualisation of priming in the masked prime same–different task. Therefore, the negative priming effect on different trials in Experiments 4 and 5 is not only consistent with Norris and colleagues' conceptualisation of priming, it is also inconsistent with the more common account of priming effects.

Returning again to the central motivation for this research, regardless of how the priming effects in Experiments 4 and 5 can be explained, it is their existence that is most central to that motivation. Our goal was to determine whether the nature of priming effects in the masked prime same-different task was ever based on representations above the orthographic level. If the answer were "no", we would further conclude that this task would provide an uncontaminated measure of orthographic similarity, meaning that the task would provide an uncontaminated means of investigating the nature of the orthographic code. The existence of non-cognate translation priming indicates that the answer is "yes". Effects due to the activation of information at levels above orthography do exist in the task, just as they do in the sandwich priming task. However, the fact that translation equivalent primes, primes that are related to their targets/reference stimuli at both the lexical and semantic levels, only produce a few milliseconds of priming indicates that the impact of those factors is clearly limited. Therefore, this task, together with the sandwich priming task, should still be considered a good pair of tools for examining the orthographic coding process.

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Notes

1. Note that no identity priming manipulation was included in Experiments 3–5. This manipulation had been included in Experiments 1 and 2 as a manipulation check because translation priming effects in lexical decision are often quite weak for same-script bilinguals. Due to the fact that translation priming effects are extremely robust for proficient Japanese–English bilinguals in lexical decision, we had no a-priori concern that our translation pairs would fail to produce a priming effect in Experiment 3.
2. The authors would like to thank Sachiko Kinoshita, in her role as reviewer, for offering this suggestion.

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Appendix 1. Materials in Experiments 1 and 2

Spanish–English translation pairs:

Spanish translation primes, unrelated primes and English target words used in Experiments 1 and 2

rey, dar, KING; barco, letra, BOAT; espejo, arroyo, MIRROR; camión, vulgar, TRUCK; mesa, copa, TABLE; árbol, extra, TREE; azul, cuba, BLUE; alegre, orilla, HAPPY; peligro, caballo, DANGER; teclado, lámpara, KEYBOARD; leche, gesto, MILK; agua, obra, WATER; puente, código, BRIDGE; hierba, sueldo, GRASS; miércoles, velocidad, WEDNESDAY; sol, mes, SUN; pato, cuna, DUCK; edificio, francesa, BUILDING; silla, rumbo, CHAIR; casa, modo, HOUSE; ducha, cesto, SHOWER; amigo, oeste, FRIEND; seco, misa, DRY; cartero, bufanda, POSTMAN; ladrón, perdiz, THIEF; domingo, batalla, SUNDAY; arena, ideal, SAND; abogado, entorno, LAWYER; vaca, tubo, COW; desayuno, pirámide, BREAKFAST; oveja, ancho, SHEEP; lengua, puerto, TONGUE; naranja, racismo, ORANGE; terremoto, primitiva, EARTHQUAKE; nieve, dueño, SNOW; marido, cadena, HUSBAND; carne, miedo, MEAT; negro, lista, BLACK; año, ese, YEAR; reloj, debut, CLOCK; mañana, cuerpo, MORNING; conejo, demora, RABBIT; nariz, turno, NOSE; oído, arco, EAR; oro, mes, GOLD; cara, cine, FACE; mujer, norte, WOMAN; bombero, cantina, FIREMAN; hermano, muestra, BROTHER; verano, física, SUMMER; piedra, muerto, STONE; oso, gen, BEAR; libro, santa, BOOK; lobo, boda, WOLF; cocina, minuto, KITCHEN; dinero, semana, MONEY; playa, trato, BEACH; reina, corte, QUEEN; feo, ida, UGLY; iglesia, primero, CHURCH; miel, caos, HONEY; rana, nulo, FROG; periódico, constante, NEWSPAPER; mano, base, HAND; frío, tren, COLD; débil, limón, WEAK; falda, poste, SKIRT; cama, lago, BED; vuelo, bolsa, FLIGHT; cielo , radio, HEAVEN; avión, feliz, PLANE; plato, flora, DISH; beso, paja, KISS; piel, raíz, SKIN; lápiz, furor, PENCIL; campo, gente, FIELD; martes, cumbre, TUESDAY; asesino, esquema, KILLER; nube, pozo, CLOUD; tierra, pueblo, EARTH; loco, cita, CRAZY; camisa, severo, SHIRT; blanco, prensa, WHITE; rosa, café, PINK; plata, curso, SILVER; noche, largo, NIGHT; caja, ruso, BOX; odio, alba, HATE; muro, hoja, WALL; paraguas, doctoral, UMBRELLA; burro, delta, DONKEY; niño, pasa, CHILD; payaso, dopaje, CLOWN; maíz, fiel, CORN; ventana, tercero, WINDOW; cartera, serrano, WALLET; viernes, maestro, FRIDAY; luna, peso, MOON; jefe, isla, BOSS; pelo, capa, HAIR

English-English identity pairs:

Identity primes, unrelated primes and English target words used in Experiments 1 and 2

thing, guest, THING; play, dumb, PLAY; world, first, WORLD; level, fresh, LEVEL; little, carrot, LITTLE; someone, earring, SOMEONE; change, garlic, CHANGE; believe, hamster, BELIEVE; under, arrow, UNDER; without, liberty, WITHOUT; card, cell, CARD; development, information, DEVELOPMENT; power, truth, POWER; name, wing, NAME; god, may, GOD; business, trousers, BUSINESS; reason, moment, REASON; down, mail, DOWN; several, clothes, SEVERAL; government, downstairs, GOVERNMENT; remember, swimming, REMEMBER; large, cheap, LARGE; open, cash, OPEN; free, root, FREE; enough, beside, ENOUGH; day, hat, DAY; pretty, famous, PRETTY; drive, shell, DRIVE; high, busy, HIGH; phone, nurse, PHONE

Appendix 2. Materials in Experiment 3–5

Japanese-English translation pairs:

Japanese translation primes, unrelated primes and English target words used in Experiments 3–5

運命, 正確, FATE; 規則, 回数, RULE; 天使, 生理, ANGEL; 役割, 公開, ROLE; 希望, 利用, HOPE; 計画, 作品, PLAN; 旅行, 野菜, TRIP; 地獄, 農民, HELL; 犯罪, 引退, CRIME; 危険, 仲間, DANGER; 原因, 一般, CAUSE; 証拠, 支配, PROOF; 感覚, 憲法, SENSE; 価値, 期間, VALUE; 結果, 自然, RESULT; 屋根, 児童, ROOF; 子供, 手紙, CHILD; 銀行, 友人, BANK; 農場, 騒音, FARM; 試験, 切手, TEST; 指輪, 逮捕, RING; 都市, 預金, CITY; 商店, 報告, STORE; 金属, 論文, METAL; 血液, 台風, BLOOD; 医師, 地震, DOCTOR; 音楽, 結婚, MUSIC; 電車, 男子, TRAIN; 動物, 野球, ANIMAL; 爆弾, 患者, BOMB; 習慣, 進学, HABIT; 英雄, 記入, HERO; 割合, 制作, RATE; 恐怖, 家賃, FEAR; 過去, 理解, PAST; 種類, 効果, TYPE; 名前, 空気, NAME; 損失, 皇族, LOSS; 悪魔, 録画, DEVIL; 手品, 煮物, MAGIC; 技術, 開始, SKILL; 平和, 基本, PEACE; 努力, 歴史, EFFORT; 物語, 給与, STORY; 記憶, 移動, MEMORY; 地球, 警察, EARTH; 細胞, 展望, CELL; 牛乳, 太陽, MILK; 軍隊, 高齢, ARMY; 公園, 現金, PARK; 砂糖, 時計, SUGAR; 磁石, 舞台, MAGNET; 部屋, 天気, ROOM; 奴隷, 落語, SLAVE; 電話, 豆腐, PHONE; 食事, 道路, MEAL; 職員, 輸出, STAFF; 座席, 自殺, SEAT; 女性, 深夜, WOMAN; 家族, 言葉, FAMILY