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# Masked semantic priming effects from the prime's orthographic neighbours

Yuu Kusunose[a], Yasushi Hino[a] and Stephen J. Lupker[b]

[a]Faculty of Arts and Sciences, Waseda University, Tokyo, Japan; [b]Department of Psychology, The University of Western Ontario, London, Canada

**ABSTRACT**
The present research involved masked priming lexical decision experiments using, in the crucial condition, masked primes with an orthographic neighbour that was semantically related to the target. Regardless of the lexicality of the prime, a significant priming effect was observed when the relatedness proportion (RP, that is, the proportion of primes and targets that were directly related on the "word" trials) was 2/3 (Experiments 1 and 2). No effect emerged, however, when the RP was 0 (Experiment 3). These results indicate that lexical/semantic activation arises automatically for both the prime and its neighbours. This activated lexical/semantic information appears to be evaluated together with the lexical/semantic information activated by the target, creating a decision bias during the decision-making process, but only when that information often provides a clue as to the nature of the correct decision. Our results, therefore, also provide support for the retrospective account of masked semantic priming.

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Masked semantic priming effects; orthographic neighbours; relatedness proportion



First demonstrated by Meyer and Schvaneveldt (1971), it is now a well-established finding that the speed of responding to a target word in a lexical decision task is faster when that target is preceded by a semantically related prime (e.g. NURSE—DOCTOR) than when it is preceded by an unrelated prime (e.g. BUTTER—DOCTOR) (e.g. Lupker, 1984; Meyer & Schvaneveldt, 1971; Neely, 1977; Seidenberg, Waters, Sanders, & Langer, 1984). A number of accounts have been proposed to explain this "semantic priming effect" and, indeed, semantic priming effects likely have multiple sources (see e.g. Neely, 1991, for a review). One typical assumption is that some priming is a result of automatic semantic processing of the prime, particularly when the prime–target interval is short (e.g. Neely, 1977; Posner & Snyder, 1975). More specifically, the most common explanation of this sort is that when a prime (e.g. NURSE) is presented, it activates its corresponding lexical/semantic unit with that activation spreading automatically to related units, activating those units and producing facilitation when processing related targets (e.g. DOCTOR).

## Semantic activation of orthographic neighbours

If semantic priming is due to automatic semantic activation produced by prime processing when prime–target intervals are short (Neely, 1977), one might also expect to observe a priming effect based on any semantic relationships between orthographic neighbours of the prime and the target word. Such a prediction follows from the fact that there are a number of studies demonstrating that semantic activation arises not only for the word being read but also for its orthographic neighbours (e.g. Boot & Pecher, 2008; Bowers, Davis, & Hanley, 2005; Forster, 2006; Forster & Hector, 2002; Hino, Lupker, & Taylor, 2012; Mulatti, Cembrani, Peressotti, & Job, 2008; Pecher, De Rooji, & Zeelenberg, 2009; Pecher, Zeelenberg, & Wagenmakers, 2005; Rodd, 2004).[1] For example, Forster and Hector (2002) asked their participants to decide whether a presented stimulus is the name of an animal. In their task, not only did the negative trials involve a number of non-animals (e.g. BASKET), they also involved two types of nonword stimuli: nonwords

**CONTACT** Yuu Kusunose hino@waseda.jp

derived from animal names (i.e. TURPLE from TURTLE) and nonwords derived from non-animal names (i.e. CISHOP from BISHOP), both created by replacing a single letter in the base word. Participants' responses were slower for the TURPLE-type nonwords than for the CISHOP-type nonwords, suggesting that the TURPLE-type nonwords were activating animal information. This result has been referred to as the TURPLE effect.

Similar findings were also reported by Rodd (2004) using word stimuli. In Rodd's Experiment 1, the non-exemplar stimuli consisted of 29 experimental words (e.g. LEOTARD) with an animal neighbour (e.g. LEOPARD) and 29 control words (e.g. CELLAR) with a non-animal neighbour (e.g. COLLAR). When her participants were asked to decide whether the word being presented was the name of an animal, their responses were significantly slower for the experimental words than for the control words, providing further support for the idea that letter strings do activate semantic information appropriate to their orthographic neighbours.

Hino et al. (2012) reported additional evidence for this conclusion. In their relatedness judgment task, "unrelated" decisions were significantly slower for unrelated word pairs (e.g. MISSILE—POCKET) in which the first word was related to an orthographic neighbour of the second word (e.g. ROCKET) than for word pairs (e.g. SCHOOL—POCKET) in which the first word was not related to any orthographic neighbour of the second word. This result also suggests that semantic activation arises for orthographic neighbours of a word being read.

As one final example of this type of effect, using a semantic categorisation task with masked primes, Bell, Forster, and Drake (2015) reported that semantic categorisation responses were faster when an orthographic neighbour of the masked prime was from the same semantic category as the target than when the prime's neighbour and the target were from different categories. Similar results were obtained regardless of whether the prime was a word (in their Experiments 2 and 3) or a nonword (in their Experiment 1).

The fact that semantic activation of a word's neighbours can arise automatically at least suggests that it may be possible to observe semantic priming effects in lexical decision tasks whenever one of the prime's orthographic neighbours is semantically related to the target, at least when the prime–target stimulus-onset asynchronies (SOAs) are short. Consistent with this expectation, using a lexical decision task with a masked prime (in their Experiment 1), Bourassa and Besner (1998) reported that a nonword prime (e.g. deg) produced a small (7 ms) but significant priming effect when an orthographic neighbour of that nonword prime (e.g. dog) was related to the target (e.g. CAT), with the priming effect from the actual prime "dog" being 24 ms (see also Perea & Lupker, 2003).[2] In contrast, when the prime was unmasked (in their Experiment 2), there was a significant 18 ms priming effect for the "dog—CAT" pairs, but only a nonsignificant 2 ms effect for the "deg—CAT" pairs. These results support the conclusion that, when a visual stimulus is presented, semantic activation arises automatically for its orthographic neighbours early in processing, activation that can produce a semantic priming effect, although it also appears that that activation will decay quite quickly (see also Pecher et al., 2009, for a similar data pattern).

Most models of orthographic/lexical processing, in particular, those based on the Interactive-Activation framework (e.g. Davis, 2010; Grainger & Jacobs, 1996; McClelland & Rumelhart, 1981) can explain these phenomena by simply adopting the assumption that activation cascades from the lexical level to the semantic level. That is, these types of models assume that initially a word stimulus activates not only its lexical unit but also lexical units for its orthographic neighbours. The further assumption is that these partially activated lexical units then begin to activate their semantic information which then produces activation in the units of semantically related concepts. Ultimately, the activation of neighbours at the lexical (and, presumably, semantic) level dies off as the lexical unit for the presented word wins the lexical competition. However, evidence of the semantic activation of orthographic neighbours would emerge in an experimental task if the task is sufficiently sensitive to early processing.

## Form-first models

These cascading activation assumptions, however, have not been adopted by all models of word recognition. That is, there are some models that suggest that semantic activation arises only after the process of selecting a lexical unit has been completed (e.g. Bell et al., 2015; Forster, 2006; Forster & Hector, 2002; Mulatti et al., 2008). Forster and Hector (2002) termed this position the "form-first" view and, at least on the surface, this type of position would appear to be inconsistent with the data described above. That is, if semantic activation occurs only after the completion of the lexical-selection process (i.e. after a single lexical unit appropriate to the target has been selected), there would be no reason to expect that semantic activation would arise for the prime's neighbours.

Forster and colleagues (Bell et al., 2015; Forster, 2006; Forster & Hector, 2002), however, have (at least partially) addressed that problem by offering a number extensions to the form-first idea. One of those is the proposal of the Links Model, a model that can explain the TURPLE effect without abandoning the form-first view. The key assumption in this model is that lexical units are connected to semantic fields which are created as a result of lexical co-occurrences. These semantic fields are simply links (or clusters) among lexical units and, although the semantic fields may roughly correspond to taxonomic categories such as animals, they would not represent any detailed semantic information about the concepts (i.e. their activation would not represent the retrieval of meaning information concerning a concept). Most importantly, however, under certain circumstances (e.g. when a taxonomic category is used in a semantic categorisation task), the activated semantic fields can impact the lexical-selection process.

Specifically, as in other models, the standard assumption is made that, when a visual stimulus is presented, it activates lexical units that are similar in orthography (i.e. orthographic neighbours). The important model specific assumption is that, if the task provides a context, for example, if the task is a semantic categorisation task using the animal category, the lexical units that are linked to the "animal" semantic field would have a special status. Any units that are both orthographically similar to the presented stimulus and linked to the "animal" semantic field would be used in the lexical-selection process. That is, these lexical units would be selected and entered into a verification process, a process in which they are compared to the presented stimulus. Thus, a negative decision to "TURPLE" would be delayed because the animal neighbour, "TURTLE" would have to be checked and rejected first. In contrast, the decision to "CISHOP" would not be delayed because the non-animal neighbour, "BISHOP" would not be selected, due to the fact that it is not linked to the "animal" semantic field, and would, therefore, not need to be checked/rejected. According to the Links Model, therefore, the TURPLE effect is presumed to arise during the lexical-selection process as a result of pre-activating a semantic field.

A slightly different type of extension was offered by Bell et al. (2015). According to this account, a semantic categorisation task creates a special circumstance that does allow semantic representations for neighbours to be activated. Bell et al. provide two versions of this idea. In one, semantic representations for all members of the specified category are pre-activated. In the other, the threshold for activation of these representations is lowered. In both situations, the impact of presenting a nonword like "TURPLE" would be to cause the semantic information for TURTLE to be activated, hence delaying a negative decision. In contrast, because the semantic representation for "BISHOP" would not be affected by the requirement to respond positively to animal names, a negative decision for "CISHOP" would not be delayed.

In addition to being able to explain Forster and Hector's (2002) TURPLE effect, these types of accounts would also be able to explain the impact of a masked prime in Bell et al.'s (2015) masked priming semantic categorisation tasks. In a semantic categorisation task, the contextual information (i.e. the category name) would have pre-activated (or reduced the threshold of) semantic representations for category exemplars prior to the presentation of the stimuli. Thus, when a masked prime is presented, any neighbour of that prime that is a member of the category would have its semantic information activated, allowing it to produce a priming effect when the target belongs to the same category. As such, Bell et al.'s results (in their Experiments 1, 2, and 3) could be accounted for in terms of this type of model.

In addition, this type of model would appear to be able to explain Hino et al.'s (2012) report that negative decisions were slower for "MISSILE—POCKET" pairs than for "SCHOOL—POCKET" pairs in their relatedness judgement task. According to Bell et al. (2015), the first word could act like a semantic category is presumed to act in a categorisation task which would allow the semantic representation of "ROCKET" to be activated by "POCKET" if the initial word was "MISSILE" but not if it was "SCHOOL". As a result, negative decisions should be slower for the "MISSILE—POCKET" pairs than for the "SCHOOL—POCKET" pairs, as was observed.

Essentially, by assuming that relevant semantic representations can be activated whenever task-specific contextual information is provided, the form-first model does appear to be able to account for many of the previous results without giving up the assumption that processing is form-first in normal circumstances. Equally importantly, as suggested by Bell et al. (2015), an additional implication of these ideas is that the semantic activation of neighbours should not arise when no task-specific contextual information is provided beforehand. In order to examine this idea, Bell et al. examined the perception of masked words using a two-alternative forced-choice discrimination task. In this task, a word is presented for 50 ms and is immediately followed by a backward mask. A pair of words is then presented side by side and participants are asked to indicate which word is closer in meaning to the masked word. The data show that participants can select the alternative that was related to the masked word (e.g. listen—hear, hour) with above chance accuracy, indicating that some semantic processing of that word did take place. However, there was no evidence that participants had a greater than chance tendency to select a word related to an orthographic neighbour of the masked stimulus (e.g. loosen—hear, hour) regardless of whether that stimulus was a word (in their Experiment 4) or a nonword (in their Experiment 5). That is, as predicted, Bell et al. failed to detect any impact of the masked word's neighbour in their forced-choice discrimination tasks in contrast to the significant effects of the neighbours of masked primes in their semantic categorisation tasks. Based on these results, Bell et al. concluded that the effect due to the semantic activation of a word's neighbour is limited to the cases in which contextual information is available beforehand.

What seems a bit puzzling, however, is why an effect of the masked word's neighbour was not detected even when the masked word was presented following the alternatives (e.g. hear, hour—loosen) in their Experiment 6. Assuming that the initial lexical/semantic activation of a word (e.g. loosen) is guided by any available contextual information, it would seem that the just presented, contextually important words (e.g. hear and hour) should affect the processing of a subsequent word if that subsequent word had a neighbour that was related to one of those context words. That is, semantic activation for "listen" (or a lower threshold for "listen") should arise partially due to the presentation of the alternative "hear" and the semantic activation for "listen" should then occur when "loosen" is presented, inclining participants to select "hear" rather than "hour". Nonetheless, that result did not emerge. At least at present, therefore, it's unclear how much support the null effects in Bell et al.'s (2015) discrimination tasks provide for the form-first models.

Although Bell et al.'s (2015) proposals do appear to be able to explain results in tasks in which a context is presented, what they do not appear to be able to explain are findings like Bourassa and Besner's (1998) and Perea and Lupker's (2003) that there was a significant priming effect based on the semantic relationship between the prime's neighbour and the target when the masked primes were nonwords in lexical decision tasks (e.g. deg—CAT). In contrast to the semantic categorisation task, there is no task-specific contextual information available prior to the presentation of targets in lexical decision tasks. In an attempt to explain these types of results, Bell et al. (2015) suggested that nonwords can be easily misperceived as words when they are masked. Hence, it would be possible that "deg" was misperceived as "dog" on some of the trials which is what caused a semantic priming effect to be observed for the "deg—CAT" pairs. If so, the data from Bourassa and Besner and from Perea and Lupker may not necessarily be inconsistent with the form-first models.

## The present research

One question that Bell et al.'s (2015) account of neighbour priming effects raises is, what if the masked prime in a lexical decision experiment is a word? As Bell et al. argue, when the masked prime is a word (e.g. DATA), it should be considerably less likely that it would actually be misperceived as its orthographic neighbour (e.g. DATE) because the spelling pattern of the prime is represented in lexical memory. Therefore, it would appear that no extension of a form-first model would predict facilitation for a "DATA—COUPLE" pair relative to a "NOISE—COUPLE" pair if no additional context were available. According to the Interactive-Activation models, on the other hand, the masked prime would automatically activate all the lexical units similar to the spelling pattern of the prime (i.e. its own unit as well as the lexical units of its orthographic neighbours). Those activated lexical units would then automatically activate their associated semantic information. Thus, one would expect a priming effect due to the relatedness between the orthographic neighbour of the prime (e.g. DATE) and the target (e.g. COUPLE) even if the prime were a word (e.g. DATA). Assuming that there is lexical competition between the prime and its orthographic neighbours, the lexical activation of the orthographic neighbours will have a limited life span and, hence, the semantic activation of those neighbours would be somewhat difficult to detect. Nonetheless, one may very well observe a priming effect due to the semantic activation of the prime's neighbours if the task is sufficiently sensitive to effects arising early in processing. In the present research, therefore, we examined whether a masked prime produces a priming effect due to the relatedness between a prime's neighbour (using primes with only a single neighbour) and the target in a lexical decision task, using both word and nonword primes.

A second purpose of the present research was to gain a better understanding of the specific conditions under which masked semantic priming effects arise. Although there are numerous reports of masked semantic priming in lexical decision tasks in the literature, that literature is somewhat inconsistent, suggesting that the issue is less than straightforward, with priming effect sizes being modulated by factors like prime duration, task type and the type of word pairs used (e.g. Bueno & Frenck-Mestre, 2008; Finkbeiner, Forster, Nicol, & Nakamura, 2004; Perea & Gotor, 1997). For example, using associative pairs, Perea and Gotor (1997) failed to detect a semantic priming effect in their lexical decision task (Experiment 1) when the prime duration was 33 ms, although a significant effect was detected with longer prime durations (50 and 67 ms). Similarly, using associative and non-associative semantically similar pairs, Bueno and Frenck-Mestre (2008) also failed to observe a priming effect with short prime durations (28 and 43 ms durations) in their lexical decision task (Experiment 5), although significant effects were detected for both types of pairs when the prime duration was longer (71 and 199 ms durations in Experiments 6 and 7). In essence, regardless of the type of word pairs used, a priming effect was not obtained when the prime duration was shorter than 50 ms in these lexical decision experiments.

In contrast to the results from lexical decision experiments, results from experiments using the semantic categorisation task as the target task do tend to show priming effects even when the prime duration is shorter than 50 ms. For example, although Bueno and Frenck-Mestre (2008) reported that the priming effects for their associative pairs were limited to the longer prime duration conditions (71 and 199 ms) even in the semantic categorisation task (in Experiments 2, 3, and 4), a significant priming effect was observed in all the prime duration conditions (28, 43, 71, and 199 ms) for nonassociative semantically similar pairs (in Experiments 1, 3, and 4) in that same task.

Given that a semantic priming effect has been repeatedly observed in semantic categorisation tasks with masked primes, it would be difficult to claim that semantic activation does not arise for masked primes at least when an appropriate context is provided. Nonetheless, as noted above, there have been a number of experiments that have failed to produce a semantic priming effect in lexical decision tasks. Hence, there do appear to be some additional factors at play here.

One factor that might be relevant in a lexical decision task is the relatedness proportion (RP), that is, the percentage of word trials in which the prime and target are related. Bodner and Masson (2001, 2003) have demonstrated that both repetition and semantic priming effects do increase with an increased RP in their masked prime lexical decision tasks. Bodner and Masson explained their results in terms of a retrospective relatedness checking strategy (e.g. Balota & Lorch, 1986; Neely & Keefe, 1989; Ratcliff & McKoon, 1988), when the RP is high enough to make such a strategy beneficial. Specifically, in a typical priming experiment, a semantic relationship between a prime and a target will indicate with 100% certainty that the target is a word while the lack of a semantic relationship means that the target is at least slightly more likely to be a nonword. Evaluating the prime–target relationship in an attempt to take advantage of this situation, however, is effortful. Hence, an evaluation process of this sort will only be undertaken when it is beneficial on a large percentage of trials.

When the process is undertaken, what it does is to create a response bias, that is, a bias toward a "word" response is created when there is a semantic relationship between the prime and target and a bias toward a "nonword" response is created when there is no relationship. The result is a larger latency difference between related and unrelated trials (i.e. a larger priming effect) than when the RP is low (i.e. when a strategy of this sort would likely not be employed). Although it would seem like the prime must be identified for a strategy of that sort to operate, Bodner and Masson (2001, 2003) suggested that a strategy based on incomplete prime information can play a role in masked priming tasks and, as a result, repetition and semantic priming effect sizes in a lexical decision task can be modulated by the RP even when using masked primes.

If Bodner and Masson's (2001, 2003) argument about RP effects in masked priming experiments is correct and if there is automatic semantic activation of the prime's neighbours, it seems likely that semantic priming from neighbours in a masked prime lexical decision task would be more likely to arise when the RP is high. That is, if a high RP can induce participants to use activated semantic information during the decision-making process, it should not matter whether that information comes from the prime or from one of the prime's neighbours. Hence, one would be more likely to observe priming effects due to the prime's neighbours when the RP is higher. Therefore, in the present lexical decision experiments, we manipulated the RPs, expecting that a neighbour priming effect would be more likely to emerge in a task with a high RP.

In summary, in order to examine whether a semantic priming effect arises from a prime's neighbour, we manipulated the relatedness of a prime's neighbour and the target for unrelated word pairs. For each prime, the orthographic neighbour in question was the only word that could be formed by replacing a single character (e.g. Coltheart, Davelaar, Jonasson, & Besner, 1977) in the prime.[3] Our stimuli were all Japanese Katakana-written character strings. The lexicality of the primes was manipulated as a between-subject factor (in Experiments 1 and 3) because our word and nonword primes had the same orthographic neighbour and were paired with the same (word) targets. In the word prime condition, the primes were always Katakana words (e.g. テクニック (technique)—ハイキング (hiking)) whereas in the nonword prime condition, the primes were always Katakana-written nonwords (e.g. ピクネック—ハイキング (hiking)), with, as noted, both of those primes having the same orthographic neighbour (e.g. ピクニック (picnic)). In the crucial conditions (i.e. in the conditions in which the relatedness of the primes' neighbour to the targets was being manipulated), the primes and targets were, themselves, all unrelated. In order to manipulate the RP, related filler pairs (e.g. テント (tent)—キャンプ (camp)) were added to the stimulus set in order to create high RP conditions (in Experiments 1 and 2) while no related filler pairs were included in the stimulus set in Experiment 3 in order to produce a 0 RP situation.

## Experiment 1

### Method

#### Participants

Sixty-four undergraduate and graduate students from Waseda University participated in this experiment in exchange for a small amount of money (500 yen). Thirty-two students participated in the word prime condition and the remainder participated in the nonword prime condition. All were native Japanese speakers who had normal or corrected-to-normal vision.

#### Stimuli

Forty-six Japanese Katakana words with only a single orthographic neighbour were selected from National Language Research Institute (1993) as candidates for prime stimuli in the word prime condition in Experiment 1. For each of the 46 Katakana words, a different Katakana word that was not related to the Katakana word itself but was related to the orthographic neighbour of the Katakana word was selected as a target candidate (using a Japanese thesaurus—Shibata & Yamada, 2002), based on the first author's intuition. The selected target candidates consisted of 40 Katakana words with no orthographic neighbour and 6 Katakana words with a single orthographic neighbour.

In order to estimate the degree of relatedness between the prime candidate and the target candidate, between the prime candidate and the prime candidate's neighbour, and between the prime candidate's neighbour and the target candidate, we created two versions of a questionnaire. When the target candidate possessed an orthographic neighbour (for six targets), we also evaluated the degree of relatedness between the prime candidate and the target candidate's neighbour, between the prime candidate's neighbour and the target candidate's neighbour, and between the target candidate and its neighbour. As such, 156 Katakana word pairs were involved in the ratings that led to the selection of the experimental stimuli. In addition, to help anchor the scale on the high end and to allow us to select good filler pairs, 92 related Katakana word pairs (e.g. テント (tent)—キャンプ (camp)) were also selected and used in the relatedness ratings task. Therefore, 248 Katakana word pairs were created in total and randomly divided into 2 sets of 124 word pairs. Each set of word pairs was, then, randomly ordered and listed in a questionnaire along with a 7-point scale ranging from 1 (*Unrelated*) to 7 (*Related*). A different set of 62 undergraduate and graduate students from Waseda University was asked to rate the degree of relatedness of each Katakana word pair by circling the appropriate number on the scale. Specifically, these participants were instructed to rate the similarity of the meanings of the two words in each pair. They were also instructed to use the scale in a consistent manner for all the word pairs and to preview all the pairs before starting the ratings in order to get an idea of the range of the pairs. Thirty-one students rated each version of the questionnaire.

Mean ratings were computed for all the word pairs. Based on these data, we selected 32 Katakana word pairs for use in the word prime condition. We selected word pairs in which (1) the relatedness rating between the prime and its neighbour was less than 3.0, (2) the relatedness rating between the prime and the target was also less than 3.0, but (3) the relatedness rating between the prime's neighbour and the target was more than 4.0. As a result, the mean relatedness ratings were 1.83 (standard error of the mean, SEM = 0.08) between the prime and the prime's neighbour, 1.90 (SEM = 0.10) between the prime and the target, and 5.68 (SEM = 0.95) between the prime's neighbour and the target, as shown in Table 1. The 32 Katakana word pairs are listed along with the primes' neighbours in Appendix 1.[4]

Based on the 32 experimental word pairs, 2 stimulus sets were created. In each stimulus set, half of the word pairs were used as related neighbour pairs in which the prime's neighbour was related to the target. The prime and target were re-paired for the rest of the pairs to create the unrelated pairs. That is, a prime in a pair was paired with a target in a different pair, making sure that the prime and the target as well as the prime's neighbour and the target were both unrelated to each other. The word pairs used as related neighbour pairs in the first stimulus set were re-paired and used as the unrelated pairs in the second stimulus set, and vice versa.

Because our 32 word pairs (including the related neighbour and unrelated pairs) were all unrelated prime–target pairs, in order to achieve an RP of 2/3, we added 64 related filler word pairs to our stimulus sets. The 64 related filler pairs were selected from the 92 related pairs involved in the relatedness ratings. The mean ratings were all more than 4.0 for these pairs with an average of 5.52 (SEM = 0.06).

In order to create the nonword trials, we also added 96 Katakana word-nonword pairs to each of the 2 stimulus sets. In each of these pairs, a Katakana word prime was paired with Katakana nonword, which was created by replacing a single Katakana character from a real Katakana word. None of the Katakana words used to create the nonword targets were used in the experimental or related filler word pairs and none were related to the word prime paired with their nonword target. As a result, each stimulus set consisted of 192 pairs in total.

In order to create stimulus sets in the nonword prime condition, a nonword prime had to be created that was a neighbour of the orthographic neighbour of the word prime for each of the 32 word pairs. This goal was accomplished by replacing one character from the neighbour of the word

**Table 1.** Statistical characteristics of the prime, prime's neighbour, and target for the 32 pairs with Katakana word and nonword primes used in Experiments 1 and 3.

| Variable | Word prime | Nonword prime | Prime's neighbour | Target |
|---|---|---|---|---|
| Word length | 3.69 | 3.69 | 3.67 | 4.28 |
| | (0.11) | (0.11) | (0.11) | (0.16) |
| Number of morae | 3.53 | 3.53 | 3.53 | 3.91 |
| | (0.11) | (0.11) | (0.11) | (0.15) |
| Word frequency | 2528.56 | | 1830.06 | 846.75 |
| | (1107.06) | | (598.49) | (250.37) |
| Familiarity rating | 5.93 | | 6.25 | 6.12 |
| | (0.07) | | (0.04) | (0.11) |

| Variable | Prime—Prime's Neighbour | Prime—Target | Prime's Neighbour—Target |
|---|---|---|---|
| Relatedness rating | 1.83 | 1.90 | 5.68 |
| | (0.79) | (0.95) | (0.95) |

Notes: SEM is in parenthesis ( ). Word frequencies and familiarity ratings were taken from Amano and Kondo (2003a, 2003b) and, thus, the frequencies were counts per 287,792,797 words. The familiarity ratings were based on a 7-point scale ranging from 1 (Unfamiliar) to 7 (Familiar).

prime. For example, for the "テクニック (technique)—ハイキング (hiking)" pair, the prime's neighbour was "ピクニック (picnic)". Thus, the nonword "ピクネック" was created from the neighbour of the prime to be used as a nonword prime. Care was taken to make sure that there is no other orthographic neighbour for that nonword according to National Language Research Institute (1993).

These nonwords were, then, paired with the targets of the 32 word pairs to create the 32 nonword—word pairs (e.g. ピクネック—ハイキング). As with the 32 word pairs in the word prime condition, 2 stimulus sets were created, each of which consisted of 16 related neighbour pairs and 16 unrelated pairs. In addition, each stimulus set also involved the same 64 related filler pairs. As such, the RP was, once again, 2/3 in these stimulus sets.

In order to create nonword trials in the nonword prime condition, the 96 Katakana nonword targets used in the word prime condition were again used as nonword targets. Because the word targets involved 64 pairs with word primes (the fillers) and 32 pairs with nonword primes, a similar ratio was established for the nonword targets. To do so, from the 96 nonword targets, 64 were selected and, then, 32 of them were paired with Katakana word primes in the first stimulus set and with Katakana nonword primes in the second stimulus set, and vice versa for the other 32 nonword targets from the selected 64. The remaining 32 nonword targets from the 96 were paired with Katakana word primes and added to both stimulus sets. As such, each stimulus set involved 64 word prime—nonword target pairs and 32 nonword prime—nonword target pairs and, hence, each stimulus set consisted of 192 pairs in total. As in the word prime condition, none of the Katakana words and nonwords used in the nonword trials were used in the experimental or related filler pairs.

In addition, eight Katakana word pairs and eight Katakana word-nonword pairs that were not involved in the stimulus sets used in the word and nonword prime conditions were created and used as stimuli in the practice trials.

### Procedure

Stimuli were presented on a video monitor (Iiyama HM204DA) controlled by a MS-DOS-based program on an IBM-AT compatible PC, with millisecond timing functions described by Dlhopolsky (1988). Participants were asked to indicate the lexicality of targets (word or nonword) by pressing one of two buttons on a response box interfaced to the computer. "Word" responses were made with the participants' dominant hand. The viewing distance was approximately 50 cm.

As previously noted, Prime Lexicality was a between-subject factor. Thus, 32 participants were assigned to the word prime condition and the rest were assigned to the nonword prime condition.

Participants were tested individually. Each trial began with a 50 ms 400 Hz warning tone, after which 6 hash marks ("######") appeared at the centre of the video monitor for 1000 ms. The hash marks were, then, replaced by a prime which was presented for 33 ms and was then immediately replaced by the target.[5] The target remained on the video monitor until the participant made a response. The onsets of the prime and target were synchronised with the vertical retrace signals of the video monitor using the technique described by Dlhopolsky (1989). Participants were instructed to make a word-nonword discrimination response to the target stimulus, which appeared at the centre of the video monitor, as quickly and as accurately as possible by pressing either the "word" or "nonword" key on the response box. The specific nature of a trial sequence was not mentioned to the participants. Lexical decision latency from the onset of the target to the participant's response and whether the response was correct were automatically recorded by the PC. Sixteen practice trials were given prior to the 192 experimental trials in both the word and nonword prime conditions. During the practice trials, participants were provided with latency and accuracy feedback after each trial. No feedback was provided during the experimental trials. During the experimental trials, a brief rest was given after every 48 trials. The order of the experimental trials was randomised separately for each participant. The inter-trial interval was 2 s.

## Results

Because the target "チフス (typhus)" produced more than 40% errors in both the word and nonword prime conditions, trials involving that target were removed from the statistical analyses. Lexical decision latencies were classified as outliers if they were out of the range of 2.5 standard deviations (SDs) from the mean for each participant. With this procedure, 2.85% (173 data points) of the "word" trials were classified as outliers and, thus, were excluded from the statistical analyses. In addition, 4.69% (285 data points) of the "word" trials were errors and, hence, these trials were also excluded from the latency analyses. Mean response latencies from the correct trials and error rates were calculated across both subjects and items and submitted to two-way analyses of variance (ANOVAs). Neighbour Type (prime's neighbour related vs. prime's neighbour unrelated) was a within-subject factor and Prime Lexicality (word prime vs. nonword prime) was a between-subject factor in the subject ($F_1$) analyses. In the item ($F_2$) analyses, both Neighbour Type and Prime Lexicality were within-item factors. The mean response latencies and error rates from the subject analyses are presented in Table 2. The results of the filler and nonword trials are reported in Appendix 2.

In the analyses of the lexical decision latencies from the experimental trials, the main effect of Neighbour Type was significant in both the subject and item analyses, $F_1(1, 62) = 16.36$, mean squared error (MSE) = 339.93, $p < .001$; $F_2(1, 30) = 6.09$, MSE = 849.00, $p < .025$, reflecting the fact that responses were faster when the prime's neighbour was related to the target than when the prime's neighbour was unrelated to the target. Neither the main effect of Prime Lexicality, $F_1(1, 62) = 0.14$, MSE = 9184.06; $F_2(1, 30) = 1.55$, MSE = 592.33, nor the interaction between Neighbour Type and Prime Lexicality, $F_1(1, 62) = 0.18$, MSE = 339.93; $F_2(1, 30) = 0.11$, MSE = 943.90, was significant in either analysis. The lack of a significant interaction reflects the fact that the priming effect sizes were very similar in the word and nonword prime conditions.

In the analyses of error rates, the main effect of Neighbour Type was marginally significant in the item analysis, $F_2(1, 30) = 3.05$, MSE = 11.16, $p < .10$, although not in the subject analysis, $F_1(1, 62) = 1.08$, MSE = 13.41, reflecting the tendency for responses to be somewhat more accurate when the prime's neighbour was related to the target than when the prime's neighbour was unrelated to the target. No other effect was significant in either analysis, all $F$s < 1.[6]

**Table 2.** Mean lexical decision latencies in millisecond and error rates in percent for each condition in Experiment 1. The RP was 2/3 in this experiment.

| | Relatedness | | | | Priming effect | |
|---|---|---|---|---|---|---|
| | Related neighbour | | Unrelated control | | | |
| Prime type | RT | ER | RT | ER | RT | ER |
| Word prime | 551 (11.84) | 2.13 (0.71) | 563 (12.74) | 3.31 (0.78) | 12 | 1.18 |
| Nonword prime | 543 (12.03) | 2.34 (0.65) | 558 (12.16) | 2.50 (0.71) | 15 | 0.16 |

Note: SEM is in parenthesis ( ).

## *Discussion*

In Experiment 1, a priming effect due to the relatedness between the prime's neighbour and the target was observed in both word and nonword prime conditions. In addition, as can be seen in Table 2, the size of the priming effect was similar in the two conditions. As such, in contrast to what Bell et al.'s (2015) analysis would suggest, our results indicated that the semantic priming effect from the prime's neighbour to the target is unlikely to be due to a misperception of the masked primes. If the data in the previous literature using nonword primes (e.g. Bourassa & Besner, 1998; Perea & Lupker, 2003) were simply due to a misperception of masked primes, there would be no reason to expect a significant priming effect when the prime was a word. That is, when a masked prime is a word (e.g. DATA), instead of misperceiving the prime as its orthographic neighbour (e.g. DATE), assuming that the primes can be perceived at all, it would be much more likely to be perceived as the prime itself (e.g. DATA). If so, there would be no reason to expect that the "DATA—COUPLE" pairs would produce faster responses than the "NOISE—COUPLE" pairs. As such, our results are more consistent with the interactive view of semantic activation: when a masked stimulus is presented, it activates the semantic information of the stimulus itself (when it is a word) as well as that of any orthographic neighbours, which can affect decisions to the target at least when the RP is reasonably high (e.g. 2/3).

The significant priming effect from the word primes in Experiment 1 provides a clear challenge to Bell et al.'s (2015) accounts derived from the form-first assumption and, at the same time, that effect is quite consistent with the interactive view of semantic activation. Nonetheless, given the small size of the priming effect in the word prime condition in Experiments 1 (12 ms), we felt that a replication of the effect in that particular condition was desirable. In Experiment 2, therefore, we attempted to replicate the effect for word primes using a slightly expanded stimulus set. As in Experiment 1, because no contextual information is available in the lexical decision task, Bell et al.'s form-first account would predict no priming effect. In contrast, the interactive view of semantic activation would predict a significant priming effect, as we observed in the word prime condition of Experiment 1.

## Experiment 2

### Method

#### Participants

Twenty-eight undergraduate and graduate students from Waseda University participated in this experiment in exchange for a small amount of money (500 yen). All were native Japanese speakers who had normal or corrected-to-normal vision. None had participated in Experiment 1.

#### Stimuli

Including the 36 Katakana word primes used in Experiment 1, 70 Katakana words with only a single orthographic neighbour were selected from National Language Research Institute (1993) as candidates for prime stimuli in Experiment 2. For each of these 70 Katakana words, a different Katakana word that was not related to the word itself but was related to the single orthographic neighbour of the Katakana word was selected as a target candidate (using a Japanese thesaurus—Shibata & Yamada, 2002), based on the first author's intuition as in Experiment 1. The selected target candidates consisted of 55 Katakana words with no orthographic neighbour and 15 Katakana words with a single orthographic neighbour.

In order to estimate the degree of relatedness between the prime candidate and the target candidate, between the prime candidate and the prime candidate's neighbour, and between the prime candidate's neighbour and the target candidate, we created two versions of a questionnaire. When the target candidate possessed an orthographic neighbour, we also attempted to estimate the degree of relatedness between the prime candidate and the target candidate's neighbour, between the prime candidate's neighbour and the target candidate's neighbour, and between the target candidate and its neighbour. A total of 258 Katakana word pairs were involved in the ratings and they were randomly divided into two sets of 129 word pairs. Each set of word pairs was, then, randomly ordered and listed in a questionnaire along with a 7-point scale ranging from 1 (*Unrelated*) to 7 (*Related*). A different set of 63 students from Waseda University was asked to rate the degree of relatedness of each Katakana word pair by circling the appropriate number on the scale. Thirty-two students rated the first version of the questionnaire and the remainder rated the second version. The procedure of the rating task was the same as that in Experiment 1.

After collecting the ratings, mean ratings were computed for all the word pairs. Based on these data, we selected 46 Katakana word pairs using the same criteria as those used in Experiment 1. The 32 word pairs used in Experiment 1 were among the 46 word pairs. The mean relatedness ratings were 1.87 (SEM = 0.07) between the prime and the prime's neighbour, 1.83 (SEM = 0.08) between the prime and the target, and 5.70 (SEM = 0.08) between the prime's neighbour and the target, as shown in Table 3. The 46 Katakana word pairs are listed along with the primes' neighbours in Appendix 3.[7]

Based on these word pairs, two stimulus sets were created in the same manner as in Experiment 1. In each stimulus set, half of the word pairs were used as related neighbour pairs in which the prime's neighbour was related to the target. For

**Table 3.** Statistical characteristics of the prime, prime's neighbour, and target for the 46 Katakana word pairs used in Experiment 2.

| Variable | Prime | Prime's neighbour | Target |
|---|---|---|---|
| Word length | 3.80 (0.11) | 3.80 (0.11) | 4.35 (0.13) |
| Number of morae | 3.67 (0.11) | 3.67 (0.11) | 4.02 (0.11) |
| Word frequency | 1825.37 (783.34) | 2137.96 (483.04) | 1047.11 (222.09) |
| Familiarity rating | 5.59 (0.12) | 6.22 (0.04) | 6.17 (0.08) |
| **Variable** | **Prime—Prime's neighbour** | **Prime—Target** | **Prime's neighbour—Target** |
| Relatedness rating | 1.87 (0.07) | 1.83 (0.08) | 5.70 (0.08) |

Notes: SEM is in parenthesis ( ). Word frequencies and familiarity ratings were taken from Amano and Kondo (2003a, 2003b) and, thus, the frequencies were counts per 287,792,797 words. The familiarity ratings were based on a 7-point scale ranging from 1 (Unfamiliar) to 7 (Familiar).

the rest of the pairs, the prime and target were re-paired to create unrelated pairs. The word pairs used as related neighbour pairs in the first stimulus set were re-paired and used as unrelated pairs in the second stimulus set, and vice versa.

In addition, we also added 92 related filler word pairs to our stimulus sets in order to increase the RP to 2/3. The 92 related filler pairs used in the relatedness ratings in Experiment 1 were used as related filler pairs in Experiment 2 because the ratings were all more than 4.0, with the average being 5.43 (SEM = 0.05).

In order to create the nonword trials, we also added 138 Katakana word-nonword pairs to each of the 2 stimulus sets. In each of these pairs, a Katakana word prime was paired with a Katakana nonword, which was created by replacing a single Katakana character in a real Katakana word. None of the Katakana words used in creating the nonword trials were used in the experimental or related filler word pairs and none were related to the word prime paired with their nonword target. As a result, each stimulus set consisted of 276 pairs in total. In addition, the sixteen pairs used in the practice trials in Experiment 1 were also used for the practice trials in Experiment 2.

### Procedure

The procedures were identical to those in Experiment 1 except that the experiment consisted of 276 trials and, hence, a brief rest was given after every 69 trials.

### Results

As in Experiment 1, the target "チフス (typhus)" was error-prone, producing more than 50% errors in both the related neighbour and unrelated conditions. Hence, the trials involving that target were removed from the analyses. In the same manner as in Experiment 1, outliers were excluded from the statistical analyses. As a result, 2.35% (90 data points) of the "word" trials were excluded from the analyses. In addition, 5.66% (217 data points) of the "word" trials were errors and, thus, were excluded from the latency analyses. Mean response latencies from the correct trials and error rates were calculated across both subjects and items and submitted to a one-way ANOVAs. The mean lexical decision latencies and error rates from the subject analyses are presented in Table 4. The results of the filler and nonword trials are reported in Appendix 2.

**Table 4.** Mean lexical decision latencies in millisecond and error rates in percent for each condition in Experiment 2. The RP was 2/3 in this experiment.

| | Related neighbour | | Unrelated control | | Priming effect | |
|---|---|---|---|---|---|---|
| Prime type | RT | ER | RT | ER | RT | ER |
| Word Prime | 555 (10.73) | 4.50 (0.75) | 571 (11.43) | 3.25 (0.72) | 16 | − 1.25 |

Note: SEM is in parenthesis ( ).

In the analyses of lexical decision latencies, the main effect of Neighbour Type was significant in both analyses, $F_1(1, 27) = 14.89$, MSE = 242.46, $p < .01$; $F_2(1, 44) = 7.42$, MSE = 754.22, $p < .01$. In the analyses of error rates, the main effect of Neighbour Type was not significant in either analysis, $F_1(1, 27) = 1.18$, MSE = 18.51; $F_2(1, 44) = 2.30$, MSE = 15.16. As such, we successfully replicated the results of the word prime condition in Experiment 1.[8]

### Discussion

Consistent with the results from the word prime condition in Experiment 1, we observed a significant (16 ms) priming effect due to the relatedness between the word prime's neighbour and the target in Experiment 2. Together with the results from Experiment 1, therefore, these results clearly indicate that the relatedness between a prime's neighbour and the target can produce priming even when the primes are words. As such, our results suggest that semantic activation of the prime's neighbour arises even with no contextual information to potentially drive that activation, a conclusion that is quite consistent with the interactive view of semantic activation.

What was a little different about these experiments was that the RP was set to 2/3 in both cases (trials on which the target was related to a prime's neighbour (e.g. テクニック (technique)—ハイキング (hiking)) counting as unrelated trials). That is, we added related filler pairs (e.g. テント (tent)—キャンプ (camp)) to our stimulus sets to increase the RP to 2/3. Following Bodner and Masson's (2003) retrospective account of semantic priming, when the semantic information activated by the masked primes was related to the target in these experiments, it was not only a 100% valid cue for making a "word" decision but it was also a cue that was useful on at least 2/3 of the word trials. As such, it would be beneficial to the participants to invoke a retrospective relatedness checking strategy. If so, any relevant semantic activation of an orthographic neighbour that also arose automatically when the masked prime was presented would have presumably biased participants toward making a "word" decision to the target (while the lack of such information would likely bias participants toward making a "nonword" decision because none of the nonword trials involved a semantic relationship between the prime and target).

If this analysis of participants' behaviour in Experiments 1 and 2 is correct, the expectation is that there would be a smaller, or nonexistent, priming effect when the RP is smaller, in particular, if it was set to 0. That is, if we removed all the related filler pairs from our stimulus sets, all the remaining pairs would technically become unrelated pairs because, as noted, even if the prime's neighbour was related to the target in our related neighbour pairs, the prime itself was unrelated to the target. As such, any semantic activation produced by the masked primes (and/or their neighbours), although it would be a valid cue when making lexical decisions to the targets, it would not be a useful cue because it would occur infrequently and, likely, not be very potent. Thus, even if semantic activation arises from the masked prime as well as from the prime's neighbour, there would be no reason to expect much evidence of a priming effect due to the relatedness between the prime's neighbour and the target.

In contrast, if the priming effects observed in our experiments were based simply on automatic spreading activation from the prime's neighbour to the target, one would expect a priming effect due to the relatedness of prime's neighbour and the target even when the related filler pairs were removed from our stimulus sets. Therefore, in Experiment 3, we used the same experimental stimuli as in Experiment 1, however, we removed all the related filler pairs to see whether a priming effect due to the prime's neighbour would arise with an RP of 0.

## Experiment 3

### Method

#### Participants

Sixty undergraduate and graduate students from Waseda University participated in this experiment in exchange for a small amount of money (500 yen). Thirty students participated in the word prime condition and the remainder participated in the nonword prime condition. All were native Japanese speakers who had normal or corrected-to-normal vision. None had participated in either of the previous experiments.

#### Stimuli

The 32 word pairs used in the word prime condition of Experiment 1 were once again used in the word prime condition of Experiment 3. Based on these 32 word pairs, two stimulus sets were created in the same manner as in Experiment 1. In addition, 32 word—nonword pairs (selected from those used in Experiment 1) were also added to each of the two stimulus sets. As such, each stimulus set consisted of 64 pairs in total in the word prime condition. As previously noted, the 32 word pairs (including the related neighbour and unrelated control pairs) were all unrelated prime–target pairs and, hence, the RP was 0.

In the nonword prime condition, the 32 nonword—word pairs used in the nonword prime condition of Experiment 1 were used and 2 stimulus sets were created from these pairs in the same manner as in Experiment 1. In addition, 32 nonword—nonword pairs (selected from those used in the nonword prime condition of Experiment 1) were also added to each of the 2 stimulus sets. Thus, each stimulus set also consisted of 64 pairs in total. Because no directly related word pairs were added to the stimulus sets, the RP was also 0 in the nonword prime condition. In both the word and nonword prime conditions, the same sixteen pairs used in the practice trials of the previous experiments were again used as practice stimuli.

#### Procedure

The procedures were the same as those in the previous experiments except that there were only 64 experimental trials and, hence, a brief rest was given only once in the middle of the experimental trials.

### Results

As in the previous experiments, the target "チフス (typhus)" produced numerous errors (more than a 50% error rate) in all the conditions. Thus, the trials involving that target were removed from the statistical analyses. In addition, outliers were removed using the same procedure as used in the previous experiments. As a result, 3.23% (60 data points) of

**Table 5.** Mean lexical decision latencies in millisecond and error rates in percent for each condition in Experiment 3. The RP was 0 in this experiment.

| | Relatedness | | | | | |
|---|---|---|---|---|---|---|
| | Related neighbour | | Unrelated control | | Priming effect | |
| Prime type | RT | ER | RT | ER | RT | ER |
| Word prime | 560 (13.08) | 4.67 (0.98) | 560 (12.90) | 4.20 (1.02) | 0 | −0.47 |
| Nonword prime | 531 (8.89) | 2.27 (0.82) | 536 (8.65) | 3.57 (0.74) | 5 | 1.30 |

Note: SEM is in parenthesis ( ).

the "word" trials were excluded from the analyses. In addition, 3.98% (74 data points) of the "word" trials were errors and, thus, these trials were excluded from the latency analyses. Mean response latencies from the correct trials and error rates were calculated across both subjects and items and submitted to Neighbour Type by Prime Lexicality ANOVAs as in Experiment 1. The mean response latencies and error rates from the subject analyses are presented in Table 5. The results of the nonword trials are reported in Appendix 2.

In the analyses of lexical decision latencies, the main effect of Prime Lexicality was significant in the item analysis, $F_2(1, 30) = 36.94$, MSE = 632.98, $p < .001$, and marginally significant in the subject analysis, $F_1(1, 58) = 2.94$, MSE = 7066.34, $p < .10$; reflecting the tendency for lexical decision latencies to be longer with word primes than with nonword primes. No other effect was significant in either analysis, all $F$s < 1.

In the analyses of error rates, the main effect of Prime Lexicality was significant in the item analysis, $F_2(1, 30) = 4.42$, MSE = 16.47, $p < .05$, although not in the subject analysis, $F_1(1, 58) = 2.46$, MSE = 28.03, reflecting the tendency for error rates to be somewhat larger with word primes than with nonword primes. No other effect was significant in either analysis, all $F$s < 1.2.[9]

## Discussion

In contrast to the results of Experiments 1 and 2, the priming effect due to the relatedness between the prime's neighbour and the target was not significant in Experiment 3. As such, these results indicate that the semantic priming effects observed in Experiments 1 and 2 were not simply due to automatic spreading activation from the lexical/semantic unit of the prime's neighbour to the lexical/semantic unit of the target. Instead, consistent with the claims of Bodner and Masson (2003), although the semantic information from the prime's neighbour is automatically activated, it affects the decisions to the target only when it is a useful cue for making a lexical decision. When the RP was 2/3 in Experiments 1 and 2, some semantic information produced by the masked primes (including the semantic information due to the prime's neighbours) was related to the targets in 83.33% (5/6) of the "word" trials because the prime's neighbour was related to the target in the half of the unrelated prime—target trials (i.e. the experimental trials). Hence, the existence of a semantic relationship between the information activated by the prime and that of the target was a very useful cue that the target was a word while the lack of evidence of a semantic relationship between the prime and target was a good cue that the target was a nonword. Therefore, participants undertook a retrospective analysis of this information, leading to a small but significant priming effect.

In contrast, when the RP was 0 as in Experiment 3, even though the semantic information produced by the prime's neighbour was related to the target on the half of the "word" trials, the motivation to try to use that information would be noticeably weaker both because the information itself is likely weaker (coming from a neighbour of the prime rather than the prime itself) and it is available on only 50% of the "word" trials. As such, it is much less likely that the semantic information produced by the masked primes would have been used as a cue for making lexical decisions to the targets. As a result, no priming effect due to the use of such a strategy would be expected to emerge in Experiment 3, as was observed.

One other point to note is that there was a significant main effect of Prime Lexicality in Experiment 3 in both the latency and error analyses (although there was not a parallel effect in Experiment 1). This result indicates that word primes slowed down target processing in comparison to nonword primes at least when no semantic information produced by masked primes is used in responding to the targets. Because more lexical/semantic information would have been activated by word primes, it's possible that this effect was merely an attention effect, reflecting the time necessary to shift attention (i.e. disengage) from prime processing. If so, the lack of a parallel effect in Experiment 1 would underline our conclusion that processing is done slightly differently when the RP is large than when it is 0. Note, however, that because Prime Lexicality was a between-subject factor, it is also possible that the effect of Prime Lexicality in Experiment 3 was merely due to having slightly better readers in the nonword prime versus word prime condition.

In the previous literature, although Bodner and Masson (2001, 2003) have reasonably consistently reported that the semantic priming effect size was modulated by RP in their lexical decision tasks with 45 ms prime duration and we were able to get clear semantically based priming effects along with an RP modulation with a 33 ms prime duration, not everyone has obtained similar results. For example, there are some studies reporting a null direct semantic priming effect when the prime duration was shorter than 50 ms in lexical decision experiments (e.g. Bueno & Frenck-Mestre, 2008; Perea & Gotor, 1997). In addition, there are also some studies that failed to observe an effect of RP on the size of the semantic priming effect in masked prime lexical decision tasks (e.g. Grossi, 2006; Perea & Rosa, 2002).

It's not clear what the source of these inconsistencies is. Because it would seem like obtaining an RP effect would be more likely if the prime was more visible, one might wonder if the difference was due to our primes being more visible (in spite of their shorter exposure durations). However, because our primes themselves were not directly related to the targets in the neighbour prime pairs, if participants were able to identify our primes, it seems like it would have been more difficult to detect a priming effect, as in Bourassa and Besner's (1998) Experiment 2 (with the 300 ms primes). Note also that, because Bueno and Frenck-Mestre (2008) reported that a significant semantic priming effect can arise even with a 28 ms prime duration in a semantic categorisation task, it does seem clear that semantic activation can arise even with 33 ms primes. Subsequent prime processing may even depress the semantic activation as the activated lexical units compete with one another. Thus, one possibility is that it may actually be easier to observe a priming effect due to relatedness between the prime's neighbour and target with shorter prime durations. Consistent with this idea, note that both Bourassa and Besner and Perea and Lupker (2003) were successful at detecting a neighbour priming effect in their lexical decision tasks with 40 ms primes.

## General discussion

In order to examine whether a priming effect arises due to the semantic relatedness between a prime's neighbour and a target in lexical decision tasks with masked primes, we conducted three lexical decision experiments. When the prime—target RP was 2/3 in the "word" trials (in Experiments 1 and 2), a significant priming effect was observed not only when the primes were nonwords (in the nonword prime condition of Experiment 1) but also when the primes were words (in Experiment 2 and in the word prime condition of Experiment 1). Such was not the case when the RP was 0 (in Experiment 3).

### *The interactive-activation accounts*

Because we observed a significant priming effect when using word primes, it is unlikely that the priming effect observed here was simply due to a misperception of the masked primes as suggested by Bell et al. (2015). That is, if the effect were due to a misperception of the masked primes, there should have been little, if any, priming effect when the primes were words in Experiments 1 and 2 because the fact that the primes themselves were words would have substantially lowered the probability of them being misperceived as their neighbour (assuming that they were successfully perceived at all).

In addition, because we observed significant priming effects using the lexical decision task, there is no reason to imagine that these effects emerged only as a result of there being prior contextual information. In Bell et al.'s (2015) semantic categorisation tasks, a category name was given to the participants before the presentation of the stimuli and, hence, it is possible to argue that the processing of the masked prime was influenced by the category name. That is, the category name may have increased the activation of the exemplars belonging to the category prior to the trial (or lowered their thresholds), allowing those exemplars to play a role in the priming process when one of the prime's orthographic neighbours was an exemplar. In our lexical decision tasks, however, no contextual information was given to our participants before the presentation of the masked primes. Therefore, according to Bell et al.'s analysis, there should have been no priming effect due to the relatedness between the prime's neighbour and the target in our experiments. Nonetheless, priming effects emerged in Experiments 1 and 2.

The results in Experiments 1 and 2 are consistent with models assuming automatic semantic activation not only for the masked prime but also for its orthographic neighbours. That is, these results are consistent with the idea that early semantic activation is derived from the pattern of orthographic information activated by the masked prime. That orthographic information is initially unresolved which leads to a diffuse pattern of lexical and semantic activation and, hence, semantic information from orthographic neighbours would become available in addition to semantic information from the prime itself. As such, our results are consistent with the interactive-activation view of semantic activation, in which interactive activation is assumed to arise between orthographic/lexical and semantic representations (e.g. Balota, Ferraro, & Connor, 1991; Boot & Pecher, 2008; Bourassa & Besner, 1998; Bowers et al., 2005; Hino & Lupker, 1996; Hino, Lupker, & Pexman, 2002; Hino et al., 2012; Pecher et al., 2005; Rodd, 2004).

Based on just the results of Experiments 1 and 2, one might be tempted to suggest that the effect of the prime's neighbour observed in those experiments was due to automatic spreading activation. That is, the semantic activation that arises not only for the prime but also for the prime's neighbour spreads to neighbouring concepts in memory and, hence, the activation of the target's concept would inevitably be facilitated when it is related to the prime's neighbour. Similarly, it would be possible to explain these results in terms of models assuming an attractor network in which word meanings are represented by sets of semantic features and the amount of priming is determined by the relative degree of shared semantic information activated by the prime and target (e.g. Masson, 1991). When the neighbour of a prime is related to the target, the network state (determined initially by the prime's neighbour as well as the prime itself) will be more similar to the network state appropriate to the target than when a prime and its neighbours are completely unrelated to the target. Therefore, in the former situation, there will be more rapid settling into the attractor basin of the target, producing a facilitory priming effect. As will be returned to below, however, accounts based on either attractor networks or automatic spreading activation would not be consistent with the fact that priming was only obtained when the RP was high.

### *The form-first account*

Just above, we have argued that the significant priming effect due to the semantic relatedness between the prime's neighbour and the target in the word prime condition (in Experiments 1 and 2) was inconsistent with form-first models because the effect cannot be explained in terms of the misperception of the masked prime. In an effort to save this type of model, however, one could argue that prime processing was affected by the context provided by the target in these experiments (i.e. it was affected by a post hoc rather than a prior context).

An example of how this might work can be found in the experiments of Pecher et al. (2009). Using a sentence verification task, Pecher et al. reported that "false" decisions were slower and less accurate when a subject noun (e.g. pear) had an orthographic neighbour (e.g. bear) having a property in the sentence (e.g. A pear can growl.) than when a subject noun had no orthographic neighbour having a property in the sentence (e.g. A pear can make a web.). In their task, the subject noun was presented 50 ms earlier than the rest of the sentence (i.e. the property in the sentence). Therefore, no contextual information was available before the presentation of the subject noun. Nonetheless, Bell et al. (2015) suggested that semantic activation could arise based on processing the property in the sentence if that property is available before the processing of the subject noun is completed. If so, "bear" should be involved in the processing required for the subject noun "pear" when the sentence was "A pear can growl" (i.e. it is activated by "can growl") but not when the sentence was "A pear can make a web". As a result, a negative decision would be slower for the former sentence than for the latter, as was observed.

Similarly, one may suggest that the processing of the masked prime could be affected by the target in our experiments. Specifically, when the target is presented, semantic activation from the target would affect ongoing processing of the masked prime. Thus, semantic activation of the prime's neighbour could be produced whenever the prime's neighbour was related to the target, which may facilitate the lexical/semantic activation of the target. Essentially, if the assumption were adopted that context can follow, as well as proceed, prime processing, the results from Experiments 1 and 2 (as well as those of Bourassa and Besner (1998) and Perea and Lupker (2003)) could be made consistent with the form-first model (although this is not the explanation that Bell et al. (2015) proposed for Bourassa and Besner's and Perea and Lupker's results).

### *Retrospective account of the semantic priming effect*

As noted, the results in Experiments 1 and 2 could be accounted for in terms of the interactive-activation models' assumption of automatic spreading activation, in terms of the interactive models assuming an attractor network, or, potentially, in terms of the form-first model if the appropriate assumptions were made (i.e. delayed context affects prime processing). Note, however, that all of these accounts would be based on the idea that the priming effect arises automatically. As such, none of them would be consistent with our results in Experiment 3. In that experiment, the prime—target RP was 0 and we failed to observe a priming effect regardless of whether the primes were words or nonwords. As none of the accounts discussed above would make a distinction between processing with a high versus low RP, none of them would predict that there would be an effect in Experiments 1 and 2 but not in Experiment 3.

Given the fact that the impact of the prime's neighbour changed as a function of the RP, our results are quite consistent with a strategy-based account involving retrospective processing (e.g. Balota & Lorch, 1986; De Wit & Kinoshita, 2015; Neely & Keefe, 1989; Ratcliff & McKoon, 1988). Following Bodner and Masson's (2001, 2003) assumption that the retrospective relatedness checking strategy can operate even based on incomplete prime information in masked priming tasks, the basic explanation of our results would be as follows. When the RP is high, the decision-making process uses the results of a relatedness evaluation process based on information produced by the prime and target. The results of this relatedness evaluation then create a decision bias. When the prime's neighbour is related to the target, a positive bias would be created and, hence, "word" decisions would be facilitated in a lexical decision task. When no relationship is detected, a negative bias would be created, delaying responding on unrelated "word" trials. This process would only be engaged, however, when it was to the participant's advantage to do so. If the RP was quite low, little would be gained by invoking this added processing. Essentially, then, the present effects, particularly the effect of the prime's neighbour would follow if one makes the assumption that priming is essentially due to the use of a retrospective relatedness checking strategy when it is particularly beneficial to do so, along with the assumption that there is automatic lexical/semantic activation of orthographic neighbours that can be used to create a decision bias.

This analysis implies, of course, that there was no priming due to spreading activation in these experiments. That idea is consistent with the argument recently put forward by De Wit and Kinoshita (2015). De Wit and Kinoshita examined the effect of RP in a lexical decision task with a 240 ms prime–target SOA and observed that the semantic priming effect size was modulated by RP unlike in a semantic categorisation task (De Wit & Kinoshita, 2014). More specifically through a latency distribution analysis, they found that, in the lexical decision task, there was a larger priming effect in the high RP condition and that difference was mainly due to the effect increasing in the slower tail of the latency distribution. Because the relatedness between the prime and target can only be evaluated after the target has been presented, de Wit and Kinoshita suggested that the larger priming effect in the slower tail of the latency distribution reflected the greater use of a retrospective relatedness checking strategy in the high RP condition. They further suggested that such a strategy could potentially explain all the semantic priming effects they observed in their lexical decision task, including those observed at short SOAs. Our results appear to point toward a similar conclusion with respect to the priming effects we observed in the present experiments.

### *Lexical decision versus semantic categorisation*

In Bell et al.'s (2015) semantic categorisation tasks, no directly related prime—target pairs were involved in their stimulus sets. As such, the prime—target RP in their semantic categorisation tasks was similar to that in our Experiment 3. Nonetheless, whereas we failed to observe a priming effect in our lexical decision tasks, Bell et al. reported a significant priming effect in their semantic categorisation tasks. Although their prime duration (50 ms SOA) was slightly longer than that in our experiments (33 ms SOA), given the fact that we observed a significant effect with a 33 ms SOA when the RP was 2/3 (in Experiment 1 and 2), it is unlikely that the lack of a priming effect in our Experiment 3 was due simply to our shorter prime duration.

This contrast between Bell et al.'s (2015) results and ours is consistent with the fact that, as previously discussed, although masked semantic priming effects have typically been reported in semantic categorisation tasks, priming effects have been more inconsistent in lexical decision tasks (e.g. Bueno & Frenck-Mestre, 2008; Finkbeiner et al., 2004; Perea & Gotor, 1997). The obvious question is, why do the priming patterns differ in the two tasks when masked primes are used? The answer may be contained in an analysis of what is involved in making the two different decisions.

Following Bell et al.'s (2015) suggestions, it seems likely that, when performing a semantic categorisation task, processing becomes tuned to the semantic activation of a critical set of features, the ones that define the category. These features would, of course, also be the ones shared by categorically related primes and targets. Finkbeiner et al. (2004), for example, have suggested that participants in a semantic categorisation task are able to focus on a small number of senses/features when making decisions about a specific category. Consistent with this idea, Rodd (2004) reported that while words having an animal neighbour (e.g. LEOTARD, having the animal neighbour LEOPARD) produced a processing disadvantage in the negative trials of an "animal" decision task, the effect disappeared when the same items were used in the negative trials of a "plant" decision task. These results indicate that the semantic features that were relevant to animal decisions became irrelevant in making plant decisions (e.g. see also Hino, Pexman, & Lupker, 2006; Quinn & Kinoshita, 2008, for similar arguments). Essentially, priming effects in the semantic categorisation task would be tuned to the activation of this type of information, making the task maximally sensitive to the overlap in categorically relevant semantic features shared by the prime and target (and any activated neighbours) even when the prime is masked (see De Wit & Kinoshita, 2014, for a similar explanation).

In contrast, in the lexical decision task, there would be no specific set of features that one could focus on and, hence, whatever semantic information was active could potentially influence responding. If the activated semantic information provides enough of a clue to make lexical decisions to the targets, a priming effect may emerge, as in Experiments 1 and 2. On the other hand, when the activated semantic information does not provide a good clue for making lexical decisions, no priming effect would be observed, as in Experiment 3. Essentially, then, the argument becomes that the main reason why there are different results in the two tasks is because the tasks are sufficiently different that the priming has different sources in the two tasks, neither of which is spreading activation. Essentially, the difference in some ways reflects the difference in the nature of representations used in these tasks (as in Norris & Kinoshita's, 2008, account).

As such, everything considered, our results would seem to cause problems for the interactive-activation models based on automatic spreading activation, for the interactive models with attractor networks and for any form-first model that assumes automatic activation of lexical/semantic units unless those models could additionally assume that there is a retrospective relatedness checking strategy that operates when making lexical decisions (and at least at present, it is not clear whether these models could accommodate such a strategy). Future research will provide an opportunity to evaluate what processing strategies might be available under masked priming conditions and how those strategies, particularly retrospective strategies, might be integrated into models of the word recognition process.

## Notes

1. Recently, Marelli, Amenta, and Crepaldi (2015) reported that lexical decision latencies were faster for words with meanings similar to those of their "orthographic relatives" than for words with meanings different from those of their "orthographic relatives". Marelli et al.'s definition of "orthographic relatives" is words starting with the same spelling pattern as the word in question (e.g. "whisky", "whiskey", "whisker", and "whiskered" are "orthographic relatives" of the word "whisk"). Although orthographic relatives are not orthographic neighbours in the standard sense and, therefore, the question Marielle et al. were investigating is not quite the same as the question investigated by these other researchers, Marelli et al.'s results are consistent with the idea that semantic activation arises for words that are spelled similarly to the word being read.
2. Although Bourassa and Besner (1998) reported only a 7 ms priming effect for pairs with nonword primes (e.g., deg—CAT), Perea and Lupker (2003) reported 10–15 ms priming effects using the same task when the "related" nonword primes were created by transposing the internal letters of a word related to the target (e.g., jugde—COURT).
3. Orthographic neighbours were generated using "sakuin.dat" in National Language Research Institute

(1993), which is a computer-based dictionary with 36,780 word entries.

4. In the 32 Katakana word pairs, there were 4 targets that had an orthographic neighbour. Using the relatedness rating data, we assured that none of the target's neighbours was related to the prime, the prime's neighbour or the target. All the relatedness ratings were less than 3.0, with the mean ratings being 1.66 between the prime and the target's neighbour, 2.01 between the target and the target's neighbour and 1.90 between the prime's neighbour and the target's neighbour.
5. The prime duration used by Bourassa and Besner (1998) and Perea and Lupker (2003) was 40 ms and the primes were followed by a 40 ms mask stimulus. Because Bourassa and Besner reported that the nonword neighbour priming effect was modulated by the prime duration but not by the prime-target SOA, we decided to use a prime duration close to 40 ms in our experiments. Specifically, using a video monitor with a 60 Hz vertical retrace rate, we chose to use a 33 ms prime duration because it was the closest possible duration to 40 ms obtainable with our monitor.
6. We also analysed the data from all three experiments using linear mixed-effects (LME) modelling in *R* (Baayen, Davidson, & Bates, 2008). Across Experiments 1, 2, and 3, we first fitted a model that included random intercepts for subjects and items. We also attempted to fit a maximal model including by-subject and by-item random slopes following Barr, Levy, Scheepers, and Tily (2013). With respect to lexical decision latency analyses, the results for the two models were essentially the same in all the experiments. With respect to the error analyses, the maximal model failed to converge in Experiments 1 and 3. Thus, we only report the results using the model with random intercepts for subjects and items.

   In Experiment 1, the LME model was fitted to log-transformed lexical decision latencies and errors with Prime Lexicality and Neighbour Type as fixed factors. The only significant effect was Neighbour Type in the analysis of lexical decision latencies, $t = 4.00$, $p = .000$.
7. In the 46 Katakana word pairs, there were 5 targets that had an orthographic neighbour. Using the relatedness rating data, we made certain that none of the target's neighbours was related to the prime, the prime's neighbour or the target. All the relatedness ratings were less than 3.0, with the mean ratings being 1.76 between the prime and the target's neighbour, 1.87 between the target and the target's neighbour and 1.92 between the prime's neighbour and the target's neighbour.
8. In Experiment 2, a LME model was fitted to log-transformed lexical decision latencies and errors with Neighbour Type as a fixed factor. The effect of Neighbour Type was significant in the analysis of lexical decision latencies, $t = 3.07$, $p = .002$, but not in the analysis of errors.
9. As in Experiment 1, a LME model was fitted to log-transformed lexical decision latencies and errors with Prime Lexicality and Neighbour Type as fixed factors. Although no significant effect was detected in the analysis of lexical decision latencies, the effect of Prime Lexicality was marginally significant in the analysis of errors, $z = 1.67$, $p = .094$.

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## Appendix 1. Thirty-two prime–target pairs (and the prime's neighbour) used in Experiments 1 and 3 along with their English translations

| Word prime | | Nonword prime | Target | | Prime's neighbour | |
|---|---|---|---|---|---|---|
| Katakana word | English translation | Katakana nonword | Katakana word | English translation | Katakana word | English translation |
| エッグ | egg | バニグ | ショルダー | shoulder | バッグ | bag |
| エラー | error | カラヌ | ホワイト | white | カラー | color |
| エロス | Eros | ノキス | ドリンク | drink | エキス | extract |
| ゲリラ | guerrilla | ゴヌラ | チンパンジー | chimpanzee | ゴリラ | gorilla |
| ココア | cocoa, chocolate | スコタ | イーブン | even | スコア | score |
| コブラ | cobra | ケレラ | チフス | typhus | コレラ | cholera |
| サービス | service | シーカス | ライオン | lion | サーカス | circus |
| ショール | shawl | ニョート | セカンド | second | ショート | short, shortstop |
| スクープ | scoop | ノクール | カルチャー | culture | スクール | school |
| スコープ | scope | ウコップ | シャベル | shovel | スコップ | scoop, shovel |
| セリフ | lines, what to say | セニフ | アウト | out | セーフ | safe |
| ソーダ | soda | ソルノ | ケチャップ | ketchup | ソース | sauce |
| ダメージ | damage | イノージ | キャラクター | character | イメージ | image |
| チョップ | chop | リョッキ | カーディガン | cardigan | チョッキ | vest |
| テクニック | technique | ピクネック | ハイキング | hiking | ピクニック | picnic |
| データ | data | デニト | カップル | couple | デート | date |
| トローチ | troche | ブノーチ | ペンダント | pendant | ブローチ | brooch |
| ドリーム | dream | クケーム | シチュー | stew | クリーム | cream |
| ナイター | night game | ラニター | タバコ | tobacco | ライター | lighter |
| ニュース | news | ジューヌ | ラムネ | lemon soda | ジュース | juice |
| ノイズ | noise | クリズ | パズル | puzzle | クイズ | quiz |
| ハードル | hurdle | ハンノル | ブレーキ | brake | ハンドル | steering wheel |
| ヒヤリング | hearing | イヤイング | ネックレス | necklace | イヤリング | earrings |
| プリンス | prince | クリント | レジュメ | resume, vita | プリント | print |
| ヘビー | heavy | ラビー | サファイア | sapphire | ルビー | ruby |
| ペーパー | paper | スニパー | デパート | department store | スーパー | grocery store |
| ミッション | mission | クッチョン | カーペット | carpet | クッション | cushion |
| メイド | maid | ゲイド | ツアー | tour | ガイド | guide |
| メジャー | major | レニャー | ドライブ | drive | レジャー | leisure |
| レーダー | radar | リーザー | キャプテン | captain | リーダー | leader |
| ワイフ | wife | ナリフ | フォーク | fork | ナイフ | knife |
| ワンマン | one man | ハンタン | ギョーザ | dumpling | ワンタン | won-ton |

## Appendix 2. Results of the filler and nonword trials in Experiments 1, 2, and 3

*Experiment 1*

In the word prime condition, the mean response latencies and error rates from the subject analyses were 556 ms (SEM = 11.31) and 5.72% (SEM = 0.68) for the 64 related filler trials and 627 ms (SEM = 17.75) and 3.81% (SEM = 0.68) for the 96 nonword trials, respectively. In the nonword prime condition, the mean lexical decision latency and error rate from the subject analyses were 564 ms (SEM = 11.57) and 4.75% (SEM = 0.62) for the 64 related filler trials. In this condition, 64 nonword targets were paired with both word primes and nonword primes (across subject groups). The mean lexical decision latencies were comparable when they were paired with word primes (660 ms, SEM = 15.98) versus when they were paired with nonword primes (654 ms, SEM = 16.19), $F_1(1, 31) = 1.30$, MSE = 344.20; $F_2(1, 63) = 1.01$, MSE = 1508.63. The mean error rates were also comparable when they were paired with word primes (4.41%, SEM = 0.71) versus nonword primes (4.03%, SEM = 0.89), $F_1(1, 31) = 0.13$, MSE = 17.09; $F_2(1, 63) = 0.57$, MSE = 21.82. For the 32 word prime—nonword target pairs that were presented to all subjects, the mean lexical decision latency and error rate from the subject analyses were 639 ms (SEM = 14.95) and 2.78% (SEM = 0.55), respectively.

*Experiment 2*

The mean lexical decision latencies and error rates from the subject analyses were 577 ms (SEM = 10.01) and 6.18% (SEM = 0.74) for the 92 related filler pairs and 632 ms (SEM = 13.75) and 3.29% (SEM = 0.48) for the 138 nonword pairs, respectively.

*Experiment 3*

In the word prime condition, the mean lexical decision latency and error rate from the subject analyses were 641 ms (SEM = 22.47) and 4.57% (SEM = 0.94) for the 32 word—nonword pairs. In the nonword prime condition, the mean lexical decision latency and error rate from the subject analyses were 628 ms (SEM = 14.22) and 5.57% (SEM = 1.51) for the 32 nonword—nonword pairs.

## Appendix 3. Forty-six prime–target pairs (and the prime's neighbour) used in experiment 2 along with their english translations

| Prime | | Target | | Prime's neighbour | |
|---|---|---|---|---|---|
| Katakana | English translation | Katakana | English translation | Katakana | English translation |
| インナー | inner, underware | バッター | batter | ランナー | runner |
| ウエット | wet | ダイエット | diet | ウエスト | waist |
| エッグ | egg | ショルダー | shoulder | バッグ | bag |
| エッジ | edge | ワッペン | patch | バッジ | badge |
| エラー | error | ホワイト | white | カラー | color |
| エロス | Eros | ドリンク | drink | エキス | extract |
| クロッキー | snapshot | ボクシング | boxing | グロッキー | groggy, exhausted |
| グリース | grease | イエロー | yellow | グリーン | green |
| ゲリラ | guerrilla | チンパンジー | chimpanzee | ゴリラ | gorilla |
| ココア | cocoa, chocolate | イーブン | even | スコア | score |
| コテージ | cottage | ミュージカル | musical | ステージ | stage |
| コブラ | cobra | チフス | typhus | コレラ | cholera |
| コンソール | console | ピアノ | piano | コンクール | contest, competition |
| コンバート | convert | バイオリン | violin | コンサート | concert |
| サービス | service | ライオン | lion | サーカス | circus |
| ショール | shawl | セカンド | second | ショート | short, shortstop |
| ジャンク | junk | マガジン | magazine | ジャンプ | jump |
| スクープ | scoop | カルチャー | culture | スクール | school |
| スコープ | scope | シャベル | shovel | スコップ | scoop, shovel |
| セリフ | lines, what to say | アウト | out | セーフ | safe |
| ソーダ | soda | ケチャップ | ketchup | ソース | sauce |
| ターニング | turning | コーヒー | coffee | モーニング | morning |
| ダメージ | damage | キャラクター | character | イメージ | image |
| チョップ | chop | カーディガン | cardigan | チョッキ | vest |
| テクニック | technique | ハイキング | hiking | ピクニック | picnic |
| データ | data | カップル | couple | デート | date |
| トローチ | troche | ペンダント | pendant | ブローチ | brooch |
| ドリーム | dream | シチュー | stew | クリーム | cream |
| ナイター | night game | タバコ | tobacco | ライター | lighter |
| ニュース | news | ラムネ | lemon soda | ジュース | juice |
| ノイズ | noise | パズル | puzzle | クイズ | quiz |
| ハードル | hurdle | ブレーキ | brake | ハンドル | steering wheel |
| ヒヤリング | hearing | ネックレス | necklace | イヤリング | earrings |
| プリンス | prince | レジュメ | resume, vita | プリント | print |
| ヘビー | heavy | サファイア | sapphire | ルビー | ruby |
| ペーパー | paper | デパート | department store | スーパー | grocery store |
| ミッション | mission | カーペット | carpet | クッション | cushion |
| メイド | maid | ツアー | tour | ガイド | guide |
| メジャー | major | ドライブ | drive | レジャー | leisure |
| モデム | modem | ファッション | fashion | モデル | model |
| ランキング | ranking | ジョギング | jogging | ランニング | running |
| レーダー | radar | キャプテン | captain | リーダー | leader |
| レタス | lettuce | カーテン | curtain | レース | lace |
| レンジ | range | コンタクト | contact lens | レンズ | lens |
| ワイフ | wife | フォーク | fork | ナイフ | knife |
| ワンマン | one man | ギョーザ | dumpling | ワンタン | won-ton |