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The Role of Orthography in the Semantic Activation of Neighbors

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There is now considerable evidence that a letter string can activate semantic information appropriate to its orthographic neighbors (e.g., Forster & Hector's, 2002, TURPLE effect). This phenomenon is the focus of the present research. Using Japanese words, we examined whether semantic activation of neighbors is driven directly by orthographic similarity alone or whether there is also a role for phonological similarity. In Experiment 1, using a relatedness judgment task in which a Kanji word–Katakana word pair was presented on each trial, an inhibitory effect was observed when the initial Kanji word was related to an orthographic and phonological neighbor of the Katakana word target but not when the initial Kanji word was related to a phonological but not orthographic neighbor of the Katakana word target. This result suggests that phonology plays little, if any, role in the activation of neighbors' semantics when reading familiar words. In Experiment 2, the targets were transcribed into Hiragana, a script they are typically not written in, requiring readers to engage in phonological coding. In that experiment, inhibitory effects were observed in both conditions. This result indicates that phonologically mediated semantic activation of neighbors will emerge when phonological processing is necessary in order to understand a written word (e.g., when that word is transcribed into an unfamiliar script).

Keywords: orthographic neighbors, phonological neighbors, relatedness judgment task

One of the main goals of reading research is to understand how readers are able to retrieve the appropriate meaning of the word being read. In theory, there would be two possible routes for retrieving the appropriate meaning of a visually presented word. One route would involve the activation of an orthographic (and/or lexical) representation with the corresponding semantic representation being activated directly from that representation. This route can be referred to as the "direct" route. Alternatively, it is also possible that, when a word is read, a phonological representation (derived from either the orthographic representation or from a lexical representation) is activated that then activates the word's semantic representation, in much the same way that meaning is retrieved during listening. This route can be referred to as the "phonologically mediated" route.

Which of these positions is correct has been an ongoing debate in the reading literature. Some researchers have suggested that the phonologically mediated route is the fundamental route for retrieving the meaning of a word based on the fact that there is considerable evidence indicating automatic activation of phonology early in the processing of a visually presented word (e.g., Grainger & Ferrand, 1994; Perfetti, Bell, & Delaney, 1988; Ziegler, Van Orden, & Jacobs, 1997). Van Orden (1987), for example, reported that, in his semantic categorization task (e.g., Is it the name of a flower?), more false positive errors were observed for homophone foils (e.g., ROWS) whose homophonic mate was a category exemplar (e.g., ROSE) than for spelling-control foils (e.g., ROBS), which he took as evidence that semantic activation is mediated by phonology. Further evidence supporting Van Orden's claim comes from the nature of his false positive errors. If a direct route were being used, false positive errors should be minimal when the homophone foils (e.g., ROWS) are high in frequency because high-frequency words should rapidly activate their meanings, meanings that are not consistent with the semantic category in question (i.e., flower). Such was not the case, however. Although false positive errors were independent of foil frequency, those errors were modulated by the frequency of the homophonic category exemplar (i.e., ROSE). That is, the false positive errors were higher when the category exemplars were lower in frequency.

Van Orden (1987) explained his findings by proposing that a spelling check can be carried out after semantic representations have been activated through phonology. When the homophonic exemplar is high in frequency, the spelling information for the exemplar would become available rapidly once its phonological information had been activated by the foil. Hence, the spelling check would quickly detect a mismatch, decreasing the likeli-

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hood of a false positive error. When the homophonic exemplar is low in frequency, however, the correct spelling information for the exemplar would be somewhat less available. As a result, the spelling check would become less accurate and, hence, false positive errors would increase. Based on his results and this analysis, Van Orden suggested that the meaning of a visually presented word is always retrieved via phonology with, if necessary, a spelling check being carried out involving the spelling information of the activated candidates and the visual stimulus to make sure that the correct semantic information has been activated.

Lesch and Pollatsek (1993) also reported data consistent with Van Orden's (1987) position. Assuming that semantic activation is always mediated by phonology, similar priming effects would be expected from an associate (e.g., BEECH) of a target (e.g., NUT) and from a homophone of that associate (e.g., BEACH) when a short prime exposure is used (i.e., an exposure too short to allow for a spelling check). However, due to the fact that a spelling check would be carried out on the prime if enough time is available to do so, the expectation is that the priming effect from the homophone of the associate (but not the priming effect from the associate itself) should disappear if the prime exposure is sufficiently long. Indeed, this pattern of results is exactly what was reported by Lesch and Pollatsek, supporting Van Orden's position.

In contrast, however, other researchers have suggested that, although phonological activation may arise early in the processing of a visually presented word, semantic activation is typically not mediated by phonology. Instead, according to these researchers, the direct route plays the main role in activating semantics except in somewhat rare situations when the direct route is actually slower than the phonologically mediated route (e.g., Fleming, 1993; Jared & Seidenberg, 1991; Taft & van Graan, 1998).

Jared and Seidenberg (1991), for example, attempted to replicate Van Orden and colleagues' (Van Orden, 1987; Van Orden, Johnston, & Hale, 1988) results using two types of categories in their semantic categorization tasks: broad categories and narrow categories. When the categories used are narrow, as they were in Van Orden and colleagues' experiments, Jared and Seidenberg argued that their participants would adopt a strategy in which they would generate essentially all the category exemplars when a category name is given. These candidates would be retained in short-term memory as phonological codes with responding being based on whether the presented stimulus generates a match for one of the phonological codes. In this situation, false positive errors would tend to occur for homophone foils (i.e., words with homophonic mates that are category exemplars) because their phonological codes do match codes stored in memory, although, of course, some of these potential errors can be caught by a spelling check. The other types of categories used were broad ones (living things and objects). These categories should not allow participants to generate a complete set of exemplars, causing responding to be based more on the normal retrieval of meaning information.

When narrow categories were used, Jared and Seidenberg (1991) successfully replicated Van Orden and colleagues' (Van Orden, 1987; Van Orden et al., 1988) results. When broad categories were used, however, the results observed by Van Orden and colleagues were not replicated. Specifically, when the homophone foils were high-frequency words, the false positive errors were comparable for the homophone foils and the spelling controls (i.e., there was no homophone effect), a result more in line with the idea that the direct route was being used to retrieve word meanings. Based on these results, Jared and Seidenberg suggested that, although both routes can be used to activate meanings, the direct route plays the essential role in retrieving the meaning of a word when the orthographic form is familiar. The phonologically mediated route would only come into play when processing words with less familiar orthographic forms (i.e., novel words and, possibly, low-frequency words) because the direct route would be less efficient and, hence, less reliable for those stimuli.

Taft and van Graan (1998) also questioned the phonological mediation view of semantic activation based on data from their semantic categorization tasks. Assuming that semantic activation is always mediated by phonology, the expectation is that the speed of semantic activation should be modulated by the difficulty of phonological coding. Such did not appear to be the case, however. When the effect of spelling-to-sound regularity was examined in a semantic categorization task, no regularity effect emerged in spite of the fact that a significant regularity effect was observed using the same items in a standard naming task. Based on these results, Taft and van Graan concluded that the direct route plays the main role in retrieving the meaning of a visually presented word, consistent with the conclusions offered by Jared and Seidenberg (1991).

Semantic Activation of Orthographic Neighbors

The question of how semantics are activated from a written word is the general focus of the present research with the specific focus being on the phenomenon that meaning retrieval is not limited to just the word being read but also occurs for what are referred to as the word's orthographic neighbors (Coltheart, Davelaar, Jonasson, & Besner, 1977). Forster and Hector (2002), for example, 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 (e.g., TURPLE) created from animal names (i.e., TURTLE) and nonwords (e.g., CISHOP) created from non-animal names (i.e., BISHOP), both created by replacing a single letter. 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 reported by Rodd (2004) using word stimuli. In Rodd's Experiment 1, the nonexemplar stimuli consisted of 29 experimental words (e.g., LEOTARD) with an animal neighbor (e.g., LEOPARD) and 29 control words (e.g., CELLAR) with a non-animal neighbor (e.g., COLLAR). The task was to decide whether the word was a name of an animal. The semantic categorization responses were significantly slower for the experimental words than for the control words (see also Boot & Pecher, 2008; Bowers, Davis, & Hanley, 2005; Forster, 2006; Mulatti, Cembrani, Peressotti, & Job, 2008; Pecher, De Rooij, & Zeelenberg, 2009; Pecher, Zeelenberg, &

Wagenmakers, 2005), providing further support for the idea that letter strings do activate semantic information appropriate to their orthographic neighbors.

Further evidence for this conclusion comes from the masked priming literature. Using a lexical decision task (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 neighbor of the nonword prime (e.g., dog) was related to the target (e.g., CAT), with the priming effect from the prime "dog" being 24 ms (see also Perea & Lupker, 2003). 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 all lead to the conclusion that, when a visual stimulus is presented, semantic activation arises automatically for its orthographic neighbors early in processing, although it does appear that it 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 (IA) framework (e.g., Davis, 1999, 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 neighbors. One could further assume that these partially activated lexical units then begin to activate their semantic information through the direct route to semantics. Ultimately, the activation of neighbors 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 neighbors would emerge in an experimental task if the task is sensitive to early processing.

Although this type of account is based on the idea that semantic activation is accomplished by a direct route, it would not necessarily be inconsistent with the idea that semantic activation and, hence semantic activation of neighbors, is phonologically mediated. That is, in English, because orthographic neighbors are often phonologically similar (i.e., phonological neighbors), one could argue that the activation of semantics for orthographic neighbors arose from processing along a phonologically mediated route (e.g., something resembling the nonlexical route in Coltheart, Rastle, Perry, Langdon, & Ziegler's, 2001, dual-route cascaded model). In order to rule out such a phonological explanation, it would be necessary to create an independent manipulation of the orthographic and phonological relationships between the target and its neighbors, which, in alphabetic languages like English, is rather difficult to do. Such is not the case in Japanese due to the more complicated nature of Japanese orthography.

Orthographic and Phonological Neighbors of Japanese Words

More specifically, Japanese words are written in one of three scripts: Hiragana, Katakana, or Kanji. Hiragana and Katakana (referred to as Kana scripts) are phonetic scripts in that each of the characters represents a mora (a rhythmic unit with a constant duration, most of which correspond to a syllable, consisting of either a single vowel or a combination of a consonant and a vowel). In contrast, Kanji is a logographic script involving characters imported from China. Thus, as with Chinese characters, many would argue that Kanji characters directly activate meaning, and, essentially, Kanji characters can be considered to be morphemes. Also worth noting is that, according to Tamaoka, Kirsner, Yanase, Miyaoka, and Kawakami (2002), more than 60% of Kanji characters possess multiple pronunciations (i.e., Kun-reading and On-reading pronunciations), making it difficult for Kanji-written words to activate semantics through a phonologically mediated route (but see Hino, Miyamura, & Lupker, 2011, for an evaluation of the similarity of the orthographic-phonological relationships for words written in Kana vs. Kanji).

Although any Japanese words can be transcribed into Hiragana or Katakana, most Japanese words are typically written in only a single script. Specifically, in Japanese sentences, nouns, adverbs, and verb and adjective stems are typically written in Kanji, but grammatical elements such as auxiliary verbs and particles are typically written in Hiragana. In addition, a number of special types of nouns (e.g., foreign loan words, animal names, scientific terms) are typically written in Katakana.

Further, in contrast to English where research with words printed in upper versus lowercase indicates that the two types of letters activate abstract orthographic representations, such is unlikely to be true for a Japanese word printed in different scripts. Hino, Lupker, Ogawa, and Sears (2003), for example, examined masked cross-script repetition priming and word frequency effects for Japanese words in lexical decision and naming tasks. They reported that (1) although normal word frequency effects were observed for words printed in their familiar script, the frequency effect virtually disappeared when the words were transcribed into an unfamiliar script in both tasks and that (2) the cross-script repetition priming effect size was determined by the degree to which phonological representations play a role in producing responses in each task. Based on these results, Hino et al. concluded that orthographic representations are not abstract but script-dependent for Japanese words. In contrast, the same phonological representation does appear to be activated by a Japanese word regardless of the script it is printed in.

These characteristics of Japanese make it possible to find word pairs that are phonological but not orthographic neighbors as well as word pairs that are both orthographic and phonological neighbors. For example, a Katakana word "ダーク(dark)," consists of three morae, /da.R.ku/. By changing the second mora to /i/, a word, /da.i.ku/, is created, which is normally printed in Kanji "大工 (carpenter)." As such, "ダーク" and "大工" are phonological neighbors. However, because the two words are printed in different scripts, they are orthographically dissimilar and, thus, they are not orthographic neighbors. In contrast, the Katakana word "サイズ(size)" consists of three morae, /sa.i.zu/. When the first mora is changed to /ku/, a word, /ku.i.zu/, is created, which is also a Katakana word "クイズ(quiz)." Thus, "サイズ" and "クイズ" are phonological neighbors as well as being orthographic neighbors. Using Japanese words, therefore, it is possible to manipulate orthographic and phonological similarity in a reasonably independent fashion and, hence, to evaluate whether semantic activation arises for orthographic neighbors or phonological neighbors when a target word is read.[1]

In the present experiments, we employed a relatedness judgment task in which two words are presented sequentially and participants are asked to decide whether the two words are semantically related to one another. We manipulated the relatedness between the initially presented word and a neighbor of the word presented second (the "target") on unrelated trials (i.e., trials in which the two words were not themselves semantically related). To use an English example, negative responses would be expected for both "MISSILE–POCKET" and "SCHOOL–POCKET" pairs. However, if semantic activation arises automatically for target neighbors (e.g., ROCKET) when reading the target POCKET, a negative response would be delayed whenever one of those neighbors is related to the initial word. Hence, there should be an inhibitory effect for the "MISSILE–POCKET" pairs relative to the "SCHOOL–POCKET" pairs.

The benefit of using Japanese stimuli is that it is possible to manipulate the type of target neighbor that is related to the initial word. In Experiment 1, the initial word was always presented in Kanji, and the target was always presented in Katakana. In the orthographic/phonological neighbor condition, the initial word was related to either the highest or the second highest frequency orthographic and phonological neighbor of the target. As shown in Table 1, the pair "質問 (question)–サイズ (size, /sa.i.zu/)" was a pair in the orthographic/phonological neighbor condition due to the fact that the Katakana word "クイズ (quiz, /ku.i.zu/)" is a frequent orthographic and phonological neighbor of "サイズ (size, /sa.i.zu/)," and, of course, "クイズ (quiz, /ku.i.zu/)" is related to the initial word, "質問 (question)." In the phonological neighbor condition, the initial Kanji word was related to either the highest or the second highest frequency phonological (but not orthographic) neighbor of the Katakana word target. As shown in Table 1, "道具 (tool)–ダーク (dark, /da.R.ku/)" was a pair in this condition due to the fact that the Kanji word "大工 (carpenter, /da.i.ku/)" is a phonological but not orthographic neighbor of "ダーク (dark, /da.R.ku/)," and is related to the initial word "道具 (tool)." Relatedness judgment performance in these conditions was compared with those in their respective control conditions in which the initial Kanji word was not related to either the Katakana word target or any of the neighbors of the target (e.g., "体育 (gymnastics)–サイズ (size)" and "行事 (event)–ダーク (dark)," respectively).

In this task, if semantic activation arises for the critical target neighbor, negative responses in the critical conditions would be slower than those in their respective control conditions. Therefore, if a direct route is primarily used for semantic activation of the target and, hence, the semantic activation arises only for orthographic neighbors, an inhibitory effect due to the relatedness between the initial word and the critical target neighbor is expected only in the orthographic/phonological neighbor condition. In contrast, if semantic activation for the target is driven only by phonology, only phonological neighbors would be activated, and, therefore, an inhibitory effect would be expected not only in the orthographic/phonological neighbor condition but also in the phonological neighbor condition with the effect sizes being similar in the two conditions. Finally, if semantic activation of neighbors arises through both routes, the expectation is that the semantic activation of the critical target neighbor should be greater in the orthographic/phonological neighbor condition than in the phonological neighbor condition, although inhibitory effects should arise in both conditions.

Processing Familiar Katakana Words and Their Unfamiliar Hiragana Transcriptions

As noted, because both Katakana and Hiragana are phonetic scripts, it is possible to write any Japanese word in either of those two scripts. As also noted, in Experiment 1, the target words were all presented in Katakana; however, what is important to realize is that they were words that are always written in Katakana, and, hence, they have familiar orthographic forms. Therefore, although Katakana is a shallow orthography, it would not be unexpected that processing these words would involve a direct route to semantics (e.g., Besner & Hildebrandt, 1987; Hino et al., 2003). Assuming that orthographic representations are script dependent for Japanese words (e.g., Hino et al., 2003), however, such should not be the case if the words are transcribed into an unfamiliar script (i.e., Hiragana script forms of the words that are normally written in Katakana). Under that circumstance, a direct route, if it existed, would be inefficient because the orthographic–semantic mappings for these unfamiliar forms have not been learned. As a result, a phonologically mediated route would presumably have to be used to activate semantics.

This hypothesis was examined in Experiment 2. As also shown in Table 1, the targets in this experiment were the Hiragana transcriptions of the Katakana words used in Experiment 1. If this hypothesis is correct, when a word is transcribed in this fashion, semantic activation must now be driven by phonology rather than in the fashion described in the IA-type models discussed earlier. As a result, semantic activation would now arise only for phonological neighbors. If so, we should observe similar-size inhibitory effects due to the relatedness between the initial word and the critical target neighbor in the orthographic/phonological neighbor and the phonological neighbor conditions.

[1] When we describe morae using the Roman alphabet, we use the format from Tamaoka and Makioka (2004). In addition, we also use a period to denote a moraic boundary (e.g., /da.R.ku/ for "ダーク (dark)"). Japanese morae are rhythmic units of a constant duration consisting of either a single vowel, /V/, a combination of a consonant and a vowel, /CV/, or three types of special sounds: a nasal, /N/, a geminate, /Q/, or a long vowel, /R/. The geminate /Q/ represents the duration of a single mora in which one pauses with one's mouth in the shape of a following consonant. The /R/ is not a sign for a retroflex. Instead, because /R/ is a sign for a long vowel, it indicates that the previous vowel should be prolonged with the duration twice as long as a single mora. The mora plays an important role in Japanese orthography because each Kana character (Hiragana and Katakana) generally corresponds to a single mora. In addition, because Japanese is a mora-timed language, the mora also plays a central role in speech segmentation (e.g., Otake, Hatano, Cutler, & Mehler, 1993) as well as in reading (e.g., Verdonschot et al., 2011). When selecting phonological neighbors of Japanese words in the present research, therefore, we considered the mora to be the basic phonological unit. Hence, phonological neighbors were defined as words having identical morae except one (e.g., サイズ (size, /sa.i.zu/) and クイズ (quiz, /ku.i.zu/); ダーク (dark, /da.R.ku/) and 大工 (carpenter, /da.i.ku/)).

Table 1
Examples of Experimental and Control Pairs in the Orthographic/Phonological Neighbor (Ortho/Phono Neighbor) and Phonological Neighbor (Phono Neighbor) Conditions in Experiments 1 and 2

Neighbor type	Relatedness to neighbor	Initial word	Target	Critical neighbor
Ortho/phono neighbor	Experimental (related)	質問（question) /si.tu.mo.N/	サイズ[さいず] (size) /sa.i.zu/	クイズ（quiz) /ku.i.zu/
	Control (unrelated)	体育（gymnastics) /ta.i.i.ku/	サイズ[さいず] (size) /sa.i.zu/	
Phono neighbor	Experimental (related)	道具（tool) /do.u.gu/	ダーク[だあく] (dark) /da.R.ku/	大工（carpenter) /da.i.ku/
	Control (unrelated)	行事（event) /gjo.u.zi/	ダーク[だあく] (dark) /da.R.ku/	

Note. All the targets are Katakana words in Experiment 1. Hiragana transcriptions of these Katakana words, which were used as targets in Experiment 2, are shown in brackets.

Experiment 1

Method

Participants. Forty-four undergraduate and graduate students from Waseda University participated in this experiment. They were paid a small amount of money (500 yen) in exchange for their participation. All were native Japanese speakers who had normal or corrected-to-normal vision.

Stimuli. Fifty-two Katakana words were selected from the National Language Research Institute (1970).[2] These words were all three or four characters in length, and their frequency counts were all less than 55 per 940,533. For the 52 Katakana words, phonological neighbors were generated by replacing a single mora from the pronunciations of these words using the National Language Research Institute (1993). Because phonological neighbors are any words sharing all but one mora with the original word, phonological neighbors involved not only Katakana words but also Kanji words and words written in a combination of Kanji and Hiragana (e.g., "タイヤ (tire), /ta.i.ya/" and "態度 (attitude), /ta.i.do/" are both phonological neighbors of the Katakana word "タイル (tile), /ta.i.ru/".[3]

Orthographic neighbors of these words were also generated by replacing a single character from these Katakana words using the National Language Research Institute (1993). Because orthographic neighbors are words sharing characters with the original word, all the orthographic neighbors of the 52 Katakana words were also Katakana words (e.g., "クイズ (quiz), /ku.i.zu/" is an orthographic neighbor of a Katakana word "サイズ (size), /sa.i.zu/"). Because each Katakana character corresponds to a single mora, the orthographic neighbors were also phonological neighbors of the original Katakana words.

The 52 Katakana words were, then, divided into two groups of 26 words. In one group, each Katakana word was paired with a phonological (but not orthographic) neighbor that had either the highest or the second highest frequency count ("タイル (tile, /ta.i.ru/)"–"態度 (attitude, /ta.i.do/)"). In the other group, each Katakana word was paired with either the highest or the second highest frequency orthographic and phonological neighbor (e.g., "サイズ (size, /sa.i.zu/)"–"クイズ (quiz, /ku.i.zu/)").

For each of the 52 word pairs consisting of a Katakana word target and its neighbor (orthographic and phonological neighbor in 26 pairs and phonological but not orthographic neighbor in the other 26 pairs), we selected three two-character Kanji words that are semantically related to the critical neighbor of the target but unrelated to the target itself (e.g., "質問 (question)" for the "サイズ (size)–クイズ (quiz)" pair). In addition, we also selected two two-character Kanji words that are unrelated to both the target and its neighbor (e.g., "体育 (gymnastics)" for the "サイズ (size)–クイズ (quiz)" pair). Each of these five two-character Kanji words were, then, paired with the Katakana word target and with its critical neighbor, creating 10 word pairs from each of the 52 target–neighbor pairs, in which three pairs were related (e.g., "質問 (question)–クイズ (quiz)") and the other seven pairs were unrelated (e.g., "質問 (question)–サイズ (size)," "体育 (gymnastics)–"サイズ (size)," and "体育 (gymnastics)–クイズ (quiz)").

Based on the 520 word pairs, two versions of a questionnaire were created for collecting subjective ratings, each of which consisted of 260 word pairs, of which 78 were related pairs, and 182 were unrelated pairs. The 260 word pairs were randomly ordered in the questionnaire. Each word pair was accompanied by a 7-point scale ranging from 1 (*unrelated*) to 7 (*related*). A new set of 60 participants was asked to rate the semantic relatedness of each word pair by circling the appropriate number on the scale. Thirty participants were assigned to each version of the questionnaire.

After collecting the relatedness ratings, the average rating was computed for each of the 520 word pairs. Based on the rating data and frequency counts of the Kanji words, 22 Katakana word target–orthographic/phonological neighbor pairs (in the orthographic/phonological neighbor condition) and 22 Katakana word target–phonological neighbor pairs (in the phonological neighbor condition) were selected for use in this experiment (e.g., "サイズ (size)–クイズ (quiz)" was a pair in the orthographic/phonological neighbor condition, and "タイル (tile)–態度 (attitude)" was a pair in the phonological neighbor condition).

[2] One may argue that frequency counts in the National Language Research Institute (1970) norms do not reflect the present use of words because the data were collected in 1960s. Note, however, that Amano and Kondo (2003) reported that the frequency counts in their 2003 norms were strongly correlated with those in National Language Research Institute norms ($r = .56$). In addition, Hino and Lupker (1998) and Hino et al. (2003) reported a significant word frequency effect in both lexical decision and naming tasks by manipulating word frequency using National Language Research Institute norms. As such, the frequency counts in the National Language Research Institute norms appear to be still valid for manipulating/controlling word frequencies of Japanese words.

[3] Phonological and orthographic neighbors were generated using a computer-based dictionary with 36,780 word entries (*sakuin.dat* in National Language Research Institute, 1993).

For each of the 44 target–neighbor pairs, two Kanji words were also selected to create experimental and control pairs as illustrated in Table 1. One of the Kanji words was related to the critical neighbor of the target but was unrelated to the target itself, and the other Kanji word was unrelated to both the target and its critical neighbor (e.g., "質問 (question)" and "体育 (gymnastics)" were selected for the "サイズ (size)–クイズ (quiz)" pair in the orthographic/phonological neighbor condition, and "姿勢 (posture)" and "台風 (typhoon)" were selected for the "タイル (tile)–態度 (attitude)" pair in the phonological neighbor condition). For the Kanji word that was related to the neighbor of the target, the mean relatedness rating to the critical target neighbor was more than 4.00 (5.75 on average), whereas the mean relatedness rating to the target was less than 4.00 (1.65 on average). In contrast, for the Kanji word that was unrelated to both the target and its critical neighbor, the mean relatedness ratings were less than 4.00 both to the target (1.63 on average) and to the critical target neighbor (1.59 on average).

As shown in Table 2, word length, $F(1, 42) = 0.40$, $MSE = 0.23$, the number of morae, $F(1, 42) = 1.83$, $MSE = 0.20$, orthographic neighborhood size, $F(1, 42) = 0.67$, $MSE = 12.23$, phonological neighborhood size, $F(1, 42) = 1.79$, $MSE = 375.70$, word frequency, $F(1, 42) = 0.00$, $MSE = 97.43$, and experiential familiarity ratings, $F(1, 42) = 0.06$, $MSE = 0.21$, for the Katakana word targets were comparable in the orthographic/phonological neighbor and the phonological neighbor conditions. Mean word frequency of the critical target neighbor was also comparable in the two conditions, $F(1, 42) = 1.86$, $MSE = 2{,}860.71$. The word frequencies of the Kanji words that were related to the critical target neighbor, $F(1, 42) = 0.03$, $MSE = 5{,}241.13$, and those of the unrelated Kanji words, $F(1, 42) = 0.00$, $MSE = 4{,}617.04$, were also comparable in the two conditions.

In addition, for the Kanji words that were related to the critical target neighbor, the mean relatedness ratings to the target were comparable in the orthographic/phonological neighbor condition (1.74) and the phonological neighbor condition (1.57), $F(1, 42) = 1.55$, $MSE = 0.20$. The mean ratings from the Kanji words to the critical target neighbor were also comparable in the two conditions (5.65 vs. 5.84), $F(1, 42) = 1.15$, $MSE = 0.36$. Similarly, for the Kanji words that were unrelated to both the target and its critical neighbor, neither the relatedness ratings to the target (1.63 vs. 1.63), $F(1, 42) = 0.00$, $MSE = 0.22$, nor the ratings to the critical target neighbor (1.47 vs. 1.72), $F(1, 42) = 3.20$, $MSE = 0.21$, $p > .08$, were significantly different in the two conditions.[4]

Based on the 44 Katakana word targets (22 targets in the orthographic/phonological neighbor condition and 22 targets in the phonological neighbor condition), experimental pairs were created by pairing a target with the Kanji word that was related only to the critical target neighbor (e.g., "質問 (question)–サイズ (size)" in the orthographic/phonological neighbor condition and "姿勢 (posture)–タイル (tile)" in the phonological neighbor condition). In addition, 44 control pairs were also created by pairing each Katakana word target with the Kanji word that was unrelated to both the target and its critical neighbor (e.g., "体育 (gymnastics)–サイズ (size)" in the orthographic/phonological neighbor condition and "台風 (typhoon)–タイル (tile)" in the phonological neighbor condition). The experimental and control pairs along with their critical target neighbors are listed in the Appendix.

Using the experimental and control pairs, two stimulus sets were created. The 44 Katakana word targets were used only once in each of the two stimulus sets. When a Katakana word target appeared in an experimental pair in the first stimulus set (e.g., "質問 (question)–サイズ (size)" and "姿勢 (posture)–タイル (tile)"), it appeared in a control pair in the second stimulus set (e.g., 体育 (gymnastics)–サイズ (size)" and "台風 (typhoon)–タイル (tile)"), and vice versa. Therefore, each stimulus set involved 11 experimental and 11 control pairs in the orthographic/phonological neighbor condition and 11 experimental and 11 control pairs in the phonological neighbor condition.

In addition to these pairs, a set of 44 related filler pairs were added to the two stimulus sets (e.g., "果物 (fruit)–メロン (melon)" and "野菜 (vegetable)–サラダ (salad)"). The related filler pairs consisted of a Katakana word target and its related Kanji word. In the filler pairs, the Kanji words were all two characters in length, and the mean word frequency was 31.19. The Katakana word targets in these pairs were all 3–4 characters in length, with an average of 3.25. The mean word frequency of these Katakana words was 12.61. Although we did not measure the relatedness of these filler pairs, we selected the filler pairs only if three judges (including the first author) agreed that the Kanji word and the Katakana word are related in meaning. Each of the two stimulus sets, therefore, consisted of 88 Kanji word–Katakana word pairs in total. Half of the participants received each stimulus set.

We also selected an additional set of eight related and eight unrelated Kanji word–Katakana word pairs for use in the practice trials. None of the words used in the practice trials were used in the experimental trials.

Procedure. A pair of Kanji and Katakana words was sequentially presented at the center of the video monitor (Iiyama, HM204DA). Participants were asked to decide whether the two words were related and to respond by pressing either a "Yes (Related)" or a "No (Unrelated)" key on the response box connected to an IBM-AT compatible PC. The "Yes" response was always made with the participant's dominant hand.

Participants were also instructed that their responses should be made as quickly and as accurately as possible. Sixteen practice trials were given prior to the 88 experimental trials. After each of the practice trials, participants were informed about their response latency and whether their response was correct. No feedback was given during the experimental trials. The order of stimulus presentation for the experimental trials was randomized for each participant.

On each trial, a fixation point was first presented at the center of the video monitor following a 50-ms, 400-Hz beep signal. One second after the onset of the fixation point, a Kanji word was presented for 1,000 ms just above the fixation point. At the offset of the Kanji word, a blank fixation screen was presented for 400 ms and was followed by a Katakana word target just above the fixation

[4] For the initial Kanji words that were related to the critical target neighbors, the mean numbers of morae were 3.59 in the orthographic/phonological neighbor condition and 3.45 in the phonological neighbor condition, $F(1, 42) = 0.80$, $MSE = 0.26$. For the initial Kanji words that were unrelated to the critical target neighbors, the mean number of morae was 3.45 in the orthographic/phonological neighbor condition and 3.64 in the phonological neighbor condition, $F(1, 42) = 1.22$, $MSE = 0.30$. As such, the numbers of morae for the initial Kanji words were also comparable across the two neighbor conditions.

Table 2
Stimulus Characteristics of the Katakana Word Targets (Targets), Critical Target Neighbors (Neighbors), and the Initial Kanji Words in the Experimental and Control Pairs in the Orthographic/Phonological Neighbor (Ortho/Phono Neighbor) and the Phonological Neighbor (Phono Neighbor) Conditions

	Targets						Neighbors
Condition	Length	Morae	Ortho-N	Phono-N	Freq	Fam	Freq
Ortho/phono neighbor	3.36	3.36	4.77	13.77	11.82	6.14	57.95
Phono neighbor	3.27	3.18	3.91	21.59	11.68	6.11	79.95

	Experimental initial Kanji words (related to the critical neighbor)			Control initial Kanji words (unrelated to the critical neighbor)		
	Freq	Rel. to target	Rel. to neighbor	Freq	Rel. to target	Rel. to neighbor
Ortho/phono neighbor	59.41	1.74	5.65	61.64	1.63	1.47
Phono neighbor	63.00	1.57	5.84	62.73	1.63	1.72

Note. For "Targets" and "Neighbors," Length, Morae, Ortho-N, Phono-N, Freq, and Fam stand for mean word length, mean number of morae, mean number of orthographic neighbors, mean number of phonological neighbors, mean word frequency, and mean experiential familiarity rating, respectively. For the "Experimental and Control initial Kanji words," Rel. to target and Rel. to neighbor stand for mean relatedness rating to the target and mean relatedness rating to the critical target neighbor, respectively. In the two neighbor conditions, the number of morae was identical for each target and its critical neighbor. Orthographic neighborhood sizes and phonological neighborhood sizes were counted using the National Language Research Institute (1993). Word frequency counts are from the National Language Research Institute (1970). Experiential familiarity ratings are from Amano and Kondo's (2003) database.

point. Presentation of the target was terminated by the participant's response. The PC recorded the response latency from the onset of the target to the participant's key press and whether the response was correct on each trial. The inter-trial interval was 2 s.

Results

Response latencies were classified as outliers if they were out of the range of 2.5 *SD*s from the mean for each participant. With this procedure, 2.38% (46 data points) of the negative (experimental and control) trials were classified as outliers and were excluded from the statistical analyses. In addition, 4.24% (82 data points) of the negative trials were errors, and, hence, these trials were also excluded from the latency analysis. Mean response latencies and error rates for the negative trials were calculated across both subjects and items and were submitted to two-way analyses of variance (ANOVAs). Neighbor Type (the orthographic/phonological neighbor vs. the phonological neighbor) and Relatedness-to-Neighbor (related to the critical target neighbor vs. unrelated) were within-subject factors in the subject analysis. In the item analysis, whereas Neighbor Type was a between-item factor, Relatedness-to-Neighbor was a within-item factor because the same target was used in the experimental and control pairs across the two stimulus sets. The mean response latencies and error rates from the subject analyses are presented in Table 3.

In the analyses of response latencies, the main effect of Neighbor Type was marginal in the subject analysis, $F_1(1, 43) = 3.04$, $MSE = 2{,}342.03$, $p < .09$, $\eta_p^2 = .07$, and was nonsignificant in the item analysis, $F_2(1, 42) = 1.90$, $MSE = 2{,}056.39$, $\eta_p^2 = .04$. The main effect of Relatedness-to-Neighbor was also marginal only in the subject analysis, $F_1(1, 43) = 3.10$, $MSE = 941.52$, $p < .09$, $\eta_p^2 = .07$; $F_2(1, 42) = 2.78$, $MSE = 1{,}051.71$, $\eta_p^2 = .06$. More importantly, the interaction between Neighbor Type and Relatedness-to-Neighbor was significant in both the subject and item analyses, $F_1(1, 43) = 12.08$, $MSE = 866.84$, $p < .01$, $\eta_p^2 = .22$; $F_2(1, 42) = 4.75$, $MSE = 1{,}051.71$, $p < .05$, $\eta_p^2 = .10$.

Table 3
Mean Response Latencies (RTs) in Milliseconds and Error Rates (ERs) in Percentages in Each Condition of the Negative Trials in Experiment 2: The Relatedness Judgment Task With Familiar Katakana Word Targets

	Neighbor type			
	Orthographic/phonological neighbor		Phonological neighbor	
Relatedness to neighbor	RT (ms)	ER (%)	RT (ms)	ER (%)
Experimental (related)	635 (19.42)	4.59 (1.23)	607 (22.04)	2.82 (0.87)
Control (unrelated)	612 (18.65)	2.41 (0.71)	614 (21.13)	5.89 (1.25)
Effect	−23	−2.18	+7	+3.07

Note. Standard errors of the means are in parentheses.

Pairwise comparisons further revealed that the 23-ms inhibitory effect of the relatedness to the critical target neighbor in the orthographic/phonological neighbor condition was significant in both analyses, $F_1(1, 43) = 14.63$, $MSE = 835.41$, $p < .001$, $\eta_p^2 = .25$; $F_2(1, 21) = 7.08$, $MSE = 1{,}099.31$, $p < .025$, $\eta_p^2 = .25$. The 7-ms facilitory effect in the phonological neighbor condition was not significant in either analysis, $F_1(1, 43) = 1.20$, $MSE = 972.95$, $\eta_p^2 = .03$; $F_2(1, 21) = 0.14$, $MSE = 1{,}004.10$, $\eta_p^2 = .01$.

In the analysis of error rates, neither the main effect of Neighbor Type, $F_1(1, 43) = 1.18$, $MSE = 27.16$, $\eta_p^2 = .03$; $F_2(1, 42) = 0.22$, $MSE = 90.82$, $\eta_p^2 = .01$, nor the main effect of Relatedness-to-Neighbor, $F_1(1, 43) = 0.23$, $MSE = 37.72$, $\eta_p^2 = .01$; $F_2(1, 42) = 0.06$, $MSE = 38.78$, $\eta_p^2 = .00$, was significant in either analysis. The interaction between Neighbor Type and Relatedness-to-Neighbor, however, was significant in both analyses, $F_1(1, 43) = 8.81$, $MSE = 34.41$, $p < .01$, $\eta_p^2 = .17$; $F_2(1, 42) = 4.36$, $MSE = 38.78$, $p < .05$, $\eta_p^2 = .09$.

Pairwise comparisons further revealed that the 2.18% inhibitory effect of the relatedness to the critical target neighbor in the orthographic/phonological neighbor condition was marginal in the subject analysis, $F_1(1, 43) = 3.17$, $MSE = 33.01$, $p < .09$, $\eta_p^2 = .07$, but was nonsignificant in the item analysis, $F_2(1, 21) = 1.34$, $MSE = 49.37$, $\eta_p^2 = .06$. In contrast, the 3.07% facilitory effect in the phonological neighbor condition was significant in the subject analysis, $F_1(1, 43) = 5.29$, $MSE = 39.13$, $p < .05$, $\eta_p^2 = .11$, and was marginal in the item analysis, $F_2(1, 21) = 3.73$, $MSE = 28.19$, $p < .07$, $\eta_p^2 = .15$.

In the positive filler trials, the mean response latency was 576 ms ($SEM = 16.05$). The mean error rate for these trials was 7.39% ($SEM = 0.82$).

Discussion

Presumably due to the relatedness between the initial Kanji word and the critical target neighbor, relatedness judgments were 23 ms slower and 2.18% less accurate for the experimental pairs than for the control pairs in the orthographic/phonological neighbor condition. In the phonological neighbor condition, however, the pattern was quite different. Responses were 7 ms faster and 3.07% more accurate when the initial Kanji word was related to the critical target neighbor, with the effect in the error data reaching statistical significance.

Although the relatedness ratings for all the experimental and control pairs (the negative trials) were less than 4.00, some pairs did produce a number of errors. In particular, the experimental and control pairs involving the target word "ガイド (guide)" produced error rates of 29% and 55%, respectively ("組織 (organization)–ガイド (guide)" and "空港 (airport)–ガイド (guide)") in the phonological neighbor condition. In the orthographic/phonological neighbor condition, the experimental pair involving "アパート (apartment)" ("商店 (store)–アパート (apartment)") produced a 35% error rate, although the corresponding control pair ("危険 (danger)–アパート (apartment)") produced no errors. When these four pairs were removed from the analysis, the mean error rates for the experimental and control pairs were 3.23% and 2.61% in the orthographic/phonological neighbor condition and were 1.82% and 3.70% in the phonological neighbor condition. As a result, the interaction between Neighbor Type and Relatedness-to-Neighbor became nonsignificant in the analyses of error rates, $F_1(1, 43) = 2.94$, $MSE = 23.36$, $p > .09$, $\eta_p^2 = .06$; $F_2(1, 40) = 2.22$, $MSE = 19.97$, $p > .10$, $\eta_p^2 = .05$.[5]

The main point made by these data is that it appears that semantic activation did not arise for phonological neighbors of a target word, producing interference. Therefore, it appears that semantic activation of neighbors was driven by orthographic information, consistent with a direct route account.[6]

Experiment 2

As noted, although the targets used in Experiment 1 were all written in Katakana—an orthographically shallow script—they were all familiar orthographic forms. The results of Experiment 1 indicate that, in spite of the shallowness of the orthography, there was no evidence of semantic activation of phonological neighbors. The only neighbors that were semantically activated were orthographic neighbors, indicating that those results can be explained within an IA-type model with the assumption of cascading activation from the orthographic/lexical level to the semantic level.

In Experiment 2, the targets were no longer orthographically familiar. Specifically, the same word pairs were used as in Experiment 1; however, the targets were transcribed into Hiragana, a script that they rarely, if ever, appear in (none of them were listed in National Language Research Institute's, 1970, word frequency norms, nor were any contained in Amano & Kondo's, 2003, familiarity rating database). Under this circumstance, it would appear that a phonologically mediated route to the target's semantics must be used. The expectation, therefore, is that phonological

[5] In the analyses of response latencies, the results were unchanged when the experimental and control pairs involving the target words, "ガイド (guide)" and アパート (apartment)" were removed. That is, the mean response latencies for the experimental and control pairs were 632 ms and 612 ms in the orthographic/phonological neighbor condition and were 605 ms and 614 ms in the phonological neighbor condition, respectively. Hence, the interaction between Neighbor Type and Relatedness-to-Neighbor was significant in both analyses, $F_1(1, 43) = 9.07$, $MSE = 1{,}039.55$, $p < .01$, $\eta_p^2 = .17$; $F_2(1, 40) = 5.52$, $MSE = 935.97$, $p < .025$, $\eta_p^2 = .12$.

[6] Because homophonic words are sometimes discriminated by having different accent types in Japanese (e.g., "橋 (bridge, /ha.si/ with type 2 accent)" and "箸 (chopsticks, /ha.si/ with Type 1 accent)"), one may argue that the phonologically mediated route would be less efficient when a target and the critical target neighbor possessed different accent types. When we compared the accent types in each target–critical neighbor pair in our stimuli using Amano and Kondo's (2003) accent type database, six pairs (out of 22 pairs) in the orthographic/phonological neighbor condition and nine pairs (out of 22 pairs) in the phonological neighbor condition consisted of words with different accent types. In addition, one could also argue that the relatedness between the initial Kanji word and the critical target neighbor would be somewhat more difficult to detect when the critical neighbor was not a noun. Although all the critical neighbors were nouns in the orthographic/phonological neighbor condition, six critical neighbors (out of 22) were verbs and adjectives in the phonological neighbor condition. As such, one could argue that the lack of the inhibitory effect in the phonological neighbor condition could have been due to a lack of control over these factors. As described in Experiment 2, however, we observed equivalent inhibitory effects in the two neighbor conditions using the same stimulus set as used in Experiment 1, the only difference being that the targets were transcribed from Katakana into Hiragana, a change that does not, of course, affect either accent type or part of speech. As such, the results of Experiment 2 clearly suggest that the lack of an inhibitory effect in the phonological neighbor condition in Experiment 1 cannot be attributed to either accent type or part of speech differences between the stimuli in our two conditions.

neighbors will be activated, producing an inhibition effect when the target has a phonological neighbor that is related to the initial stimulus (i.e., there will be an inhibition effect in both conditions).

Method

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

Stimuli. The stimulus sets used in this experiment were the same as those in Experiment 1; however, all the Katakana word targets were transcribed into Hiragana as shown in brackets in Table 1. Thus, the pair "質問 (question)–サイズ (size)" in the orthographic/phonological neighbor condition was presented as "質問 (question)–さいず (size)" in Experiment 2. Similarly, the pair "姿勢 (posture)–タイル (tile)" in the phonological neighbor condition was presented as "姿勢 (posture)–たいる (tile)." All the Hiragana transcription targets are shown in brackets in the Appendix.

Procedure. The procedure in this experiment was the same as that in Experiment 1, with the exception that the targets were all presented in Hiragana.[7]

Results

Response latencies were classified as outliers if they were out of the range of 2.5 *SD*s from the mean for each participant. With this procedure, 3.56% (69 data points) of the negative (experimental and control) trials were classified as outliers and excluded from the statistical analyses. In addition, 4.39% (85 data points) of the negative trials were errors and, hence, were excluded from the latency analysis. As in Experiment 1, mean response latencies and error rates for the critical word targets were calculated across subjects and items and submitted to Neighbor Type by Relatedness-to-Neighbor ANOVAs. The mean response latencies and error rates from the subject analyses are presented in Table 4.

In the analyses of response latencies, the main effect of Neighbor Type was significant both in the subject and item analyses, $F_1(1, 43) = 13.36$, $MSE = 2{,}358.23$, $p < .01$, $\eta_p^2 = .24$; $F_2(1, 42) = 4.52$, $MSE = 3{,}959.77$, $p < .05$, $\eta_p^2 = .10$. The main effect of Relatedness-to-Neighbor was also significant in both analyses, $F_1(1, 43) = 23.18$, $MSE = 2{,}627.34$, $p < .001$, $\eta_p^2 = .35$; $F_2(1, 42) = 14.09$, $MSE = 2{,}647.59$, $p < .01$, $\eta_p^2 = .25$. Unlike in Experiment 1, there was no hint of an interaction between Neighbor Type and Relatedness-to-Neighbor in either analysis, $F_1(1, 43) = 0.04$, $MSE = 1{,}853.86$, $\eta_p^2 = .00$; $F_2(1, 42) = 0.00$, $MSE = 2{,}647.59$, $\eta_p^2 = .00$, due to the fact that very similar inhibitory effects were observed in the orthographic/phonological neighbor and the phonological neighbor conditions.

In the analysis of error rates, the main effect of Neighbor Type was not significant in either analysis, $F_1(1, 43) = 0.00$, $MSE = 37.18$, $\eta_p^2 = .00$; $F_2(1, 42) = 0.02$, $MSE = 70.87$, $\eta_p^2 = .00$. The main effect of Relatedness-to-Neighbor was significant only in the subject analysis, $F_1(1, 43) = 6.32$, $MSE = 38.91$, $p < .025$, $\eta_p^2 = .13$; $F_2(1, 42) = 1.94$, $MSE = 56.41$, $\eta_p^2 = .04$. There was, however, a significant interaction between Neighbor Type and Relatedness-to-Neighbor in both analyses, $F_1(1, 43) = 12.55$, $MSE = 30.14$, $p < .01$, $\eta_p^2 = .23$; $F_2(1, 42) = 4.18$, $MSE = 56.41$, $p < .05$, $\eta_p^2 = .09$.

Pairwise comparisons further revealed that the 5.29% inhibitory effect of the relatedness to the critical target neighbor in the orthographic/phonological neighbor condition was significant in both analyses, $F_1(1, 43) = 14.00$, $MSE = 44.06$, $p < .01$, $\eta_p^2 = .25$; $F_2(1, 21) = 7.88$, $MSE = 42.23$, $p < .025$, $\eta_p^2 = .27$. In contrast, the 0.57% facilitory effect in the phonological neighbor condition was not significant in either analysis, $F_1(1, 43) = 0.28$, $MSE = 24.99$, $\eta_p^2 = .01$; $F_2(1, 21) = 0.17$, $MSE = 70.59$, $\eta_p^2 = .01$. Therefore, although the inhibitory effects due to the relatedness to the critical target neighbor were virtually identical in the two neighbor type conditions in the latency analyses, there was a slightly larger effect in the orthographic/phonological neighbor condition in the error rate analyses.

For the positive filler trials, the mean response latency was 607 ms ($SEM = 12.52$). The mean error rate for these trials was 6.61% ($SEM = 0.75$).

Discussion

Due to the fact that the Katakana word targets used in Experiment 1 were transcribed into Hiragana in Experiment 2, the response latencies were somewhat longer in Experiment 2 than in Experiment 1. That is, mean response latencies in the negative (experimental and control) trials in Experiments 1 and 2 were 617 ms and 707 ms, respectively, reflecting the fact that the Hiragana transcription targets in Experiment 2 were less familiar than the Katakana word targets in Experiment 1. More importantly, an inhibitory effect due to the relatedness between the initial Kanji word and the critical target neighbor was now observed not only in the orthographic/phonological neighbor condition but also in the phonological neighbor condition.

The existence of an inhibitory effect in the phonological neighbor condition in Experiment 2, therefore, clearly indicates that phonological neighbors must not have been semantically activated in Experiment 1, consistent with the argument that the semantic activation in that experiment was accomplished via a direct access route. Equally importantly, given the significant inhibitory effects in the two neighbor conditions in Experiment 2, it appears that, when unfamiliar Hiragana transcriptions of words normally written in Katakana are used, semantic activation does arise through a phonologically mediated route, leading to the semantic activation of phonological neighbors.

The inhibition effects in the two neighbor conditions in the latency data were virtually identical in Experiment 2. Note, however, that the inhibitory effect in the error data in Experiment 2 was larger in the orthographic/phonological neighbor condition. Based on these results, one may be tempted to think that the semantic activation of neighbors was driven by both orthography and phonology in Experiment 2. Due to the actual nature of the stimuli used, however, this idea could not be correct. When a Katakana word is transcribed into Hiragana, any orthographic neighbor of that Katakana word is not an orthographic neighbor of the Hiragana transcription. For example, as previously noted, "クイズ (quiz)" is an orthographic neighbor of the Katakana

[7] Although the Hiragana-written targets were unfamiliar in Experiment 2, we used the same instruction as those in Experiment 1 because Japanese readers generally recognize unfamiliar Kana-written stimuli as words even when they are transcribed from other scripts (e.g., Hino et al., 2003).

Table 4
Mean Response Latencies (RTs) in Milliseconds and Error Rates (ERs) in Percentages in Each Condition of the Negative Trials in Experiment 3: The Relatedness Judgment Task With Unfamiliar Hiragana Transcription Targets

Relatedness to neighbor	Neighbor type			
	Orthographic/phonological neighbor		Phonological neighbor	
	RT (ms)	ER (%)	RT (ms)	ER (%)
Experimental (related)	738 (21.39)	6.59 (1.40)	713 (18.57)	3.61 (1.00)
Control (unrelated)	702 (16.97)	1.30 (0.50)	674 (17.23)	4.18 (0.88)
Effect	−36	−5.29	−39	+0.57

Note. Standard errors of the means are in parentheses.

word "サイズ (size)." When "サイズ" is transcribed into Hiragana ("さいず"), however, the Katakana word "クイズ" is not an orthographic neighbor of the Hiragana transcription because no characters are shared in the two words (i.e., "さいず" and "クイズ"). As a result, the Hiragana targets in the "orthographic/phonological neighbor" condition in Experiment 2 actually are not orthographic neighbors of the Katakana word that is related to the initial Kanji word. Therefore, they cannot cause inhibition as a result of semantic activation of that neighbor through a direct route.

As in Experiment 1, word pairs involving the target words, "がいど (guide)" and "あぱあと(apartment)" produced more than 30% error rates in Experiment 2. The error rates were 59% and 9% for the "組織 (organization)–がいど (guide)" and "空港 (airport)–がいど (guide)" pairs in the phonological neighbor condition and were 35% and 0% for the "商店 (store)–あぱあと (apartment)" and "危険 (danger)–あぱあと (apartment)" pairs in the orthographic/phonological neighbor condition. We, thus, re-analyzed the data with those four pairs being removed. In the analyses of error rates, mean error rates for the experimental and control pairs were 5.36% and 1.32% in the orthographic/phonological neighbor condition and were 3.39% and 2.16% in the phonological neighbor condition. As a result, the interaction between Neighbor Type and Relatedness-to-Neighbor became nonsignificant in both analyses, $F_1(1, 43) = 3.91$, $MSE = 22.33$, $p > .05$, $\eta_p^2 = .08$; $F_2(1, 40) = 2.52$, $MSE = 16.45$, $p > .10$, $\eta_p^2 = .06$. As such, the different sizes of the inhibitory effects on error rates in the two neighbor conditions appear to be, to a large degree, due to the inclusion of these particular pairs.[8]

Note also that the results of Experiment 2 provide a manipulation check with respect to Experiment 1. That is, although we attempted to control the relatedness between the initial Kanji word and the critical target neighbor in a similar manner in the two neighbor conditions in Experiment 1 by collecting relatedness ratings, one could argue that the results of Experiment 1 were due to the initial Kanji words and the critical target neighbors for the word pairs used in the phonological neighbor condition being slightly less strongly related than the pairs in the orthographic/phonological neighbor condition. In addition, as described in Footnote 6, we were not able to fully control two seemingly unimportant factors concerning the neighbors (accent type and part of speech) across our two conditions. A significant inhibitory effect not only in the orthographic/phonological neighbor condition but also in the phonological neighbor condition in Experiment 2 alleviates any concerns arising from these issues.

General Discussion

The specific issue examined in the present research is the process by which words activate the semantic information of their neighbors. There are a number of studies reporting the evidence of semantic activation of neighbors using alphabetic languages (e.g., Boot & Pecher, 2008; Bourassa & Besner, 1998; Forster, 2006; Forster & Hector, 2002; Mulatti et al., 2008; Pecher et al., 2009, 2005; Rodd, 2004). Using stimuli in alphabetic languages, however, it is hard to determine whether the semantic activation of neighbors arises directly from orthography or is mediated by phonology because orthographically similar stimuli tend to be phonologically similar as well. In order to address this particular issue, Experiments 1 and 2 involved relatedness judgment tasks using Japanese stimuli. Because Japanese words are written in three different scripts, it is possible to find word pairs in which the two words are dissimilar in orthography but similar in phonology (e.g., "ダーク (dark, /da.R.ku/)"–"大工 (carpenter, /da.i.ku/)") as well as word pairs in which the two words are similar in both orthography and phonology (e.g., "サイズ (size, /sa.i.zu/)"–"クイズ (quiz, /ku.i.zu/)"). If only orthographic neighbors are activated when a word is read, presenting the word "size (サイズ)" as

[8] When the four pairs involving the target words—"がいど (guide)" and "あぱあと(apartment)"—were removed, mean response latencies for the experimental and control pairs were 733 ms and 703 ms in the orthographic/phonological neighbor condition and were 710 ms and 674 ms in the phonological neighbor condition. In the analyses of response latencies, the main effect of Relatedness-to-Neighbor was significant in both analyses, $F_1(1, 43) = 17.99$, $MSE = 2{,}741.47$, $p < .001$, $\eta_p^2 = .30$; $F_2(1, 40) = 12.10$, $MSE = 2{,}243.03$, $p < .01$, $\eta_p^2 = .23$. The main effect of Neighbor Type was significant in the subject analysis, $F_1(1, 43) = 11.75$, $MSE = 2{,}441.67$, $p < .01$, $\eta_p^2 = .22$, and was marginally significant in the item analysis, $F_2(1, 40) = 3.57$, $MSE = 3{,}738.76$, $p < .07$, $\eta_p^2 = .08$. The interaction between Neighbor Type and Relatedness-to-Neighbor was not significant in either analysis, $F_1(1, 43) = 0.19$, $MSE = 2{,}054.03$, $\eta_p^2 = .00$; $F_2(1, 40) = 0.12$, $MSE = 2{,}243.03$, $\eta_p^2 = .00$. As such, the results from the latency analyses were essentially unchanged with these pairs removed.

a target, would lead to the semantic activation of its orthographic neighbor "quiz (クイズ)," which would interfere with saying that "size" is unrelated to "question (質問) ." In contrast, the word "dark (ダーク)" as a target would not produce semantic activation of its phonological neighbor, "carpenter (大工)" leading to no interference with the ability to say that "dark" is unrelated to "tool (道具) ." If the semantic activation of neighbors is mediated by phonology, however, there will be interference in both situations because "size (サイズ,/sa.i.zu/)" is phonologically similar to "quiz (クイズ,/ku.i.zu/)" and "dark (ダーク,/da.R.ku/)" is phonologically similar to "carpenter (大工, ,/da.i.ku/)" in Japanese.

In the relatedness judgment task in Experiment 1, the initially presented word was always a two-character Kanji word, and it was followed by a Katakana word target, that is, a word that is always written in Katakana. Although inhibition was observed in the orthographic/phonological neighbor condition, there was no hint of inhibition in the phonological neighbor condition, indicating that the only neighbors that were activated when reading the target were orthographic neighbors. As such, these results were most consistent with what can be called the orthographic dominance view of semantic activation (e.g., Fleming, 1993; Jared & Seidenberg, 1991; Taft & van Graan, 1998), that is, that under most circumstances, the activation of semantics is driven by orthographic/lexical processing.

Note that the orthographic dominance view does not deny the possibility that semantic activation can be phonologically mediated. Specifically, phonological mediation of semantic activation may occur when the direct route is inefficient. Based on this idea, the expectation was that we would observe a different pattern of results in our relatedness judgment task if the Katakana word targets were transcribed into Hiragana, a script they never appear in.

Consistent with that expectation, an inhibitory effect was observed in the two neighbor conditions in Experiment 2: a 36-ms inhibitory effect in the orthographic/phonological neighbor condition and a 39-ms inhibitory effect in the phonological neighbor condition. These results clearly indicated that the semantic activation of neighbors was being mediated by phonology when the targets were presented in the unfamiliar script forms.

In general, our results are, therefore, quite consistent with the orthographic dominance view (e.g., Fleming, 1993; Jared & Seidenberg, 1991; Taft & van Graan, 1998). For words with familiar orthographic forms (i.e., Katakana words), the semantic activation of neighbors was mediated by orthographic similarity between the target and its neighbors, and, hence, the effect due to the semantic activation of a neighbor was observed for an orthographic neighbor but not for a phonological neighbor. When these words were presented in orthographically unfamiliar forms (i.e., Hiragana transcriptions of Katakana words), however, the semantic activation of a neighbor was mediated by phonological similarity between the target and its neighbors. As a result, an inhibition effect was observed in the phonological neighbor condition in addition to the orthographic/phonological neighbor condition.

Based on the results from Experiments 1 and 2, therefore, our conclusions are not dissimilar from those of Jared and Seidenberg (1991). Along these lines, what should be noted is that the frequencies of our Katakana word targets in Experiments 1 were not high (all were less than 55 per 940,533, with an average of 11.75). As such, these Katakana word targets were not what would be regarded as highly orthographically familiar (i.e., high-frequency words). In addition, because Katakana is a shallow orthography, Katakana words possess quite regular/consistent orthographic-to-phonological relationships, meaning that a phonologically mediated route might be thought to be reasonably efficient for these words (e.g., Kimura, 1984; Saito, 1981). Nonetheless, there was no sign of semantic activation for phonological neighbors in Experiment 1. Hence, our results suggest that the use of the phonologically mediated route is even more limited than what has been suggested by Jared and Seidenberg's data. That is, our data suggest that use of the phonologically mediated route may be limited to the cases in which phonology must be used to activate semantics because there has been little, if any, opportunity for learning orthographic-to-semantic mappings (e.g., Hiragana transcriptions of words that are not normally printed in Hiragana).

Note also that the argument is not that readers strategically switch between the two means of semantic activation depending on the stimulus type (i.e., the orthographic familiarity of the stimuli). Given that semantic activation of neighbors arises early in processing, it certainly appears that it must be arising in an automatic fashion. Therefore, the idea would be that the direct route and the phonologically mediated route would be available for most stimuli, but the speed of processing would be different for the two routes. The direct route would generally be fast-acting in comparison to the phonologically mediated route. Thus, if the stimuli are sufficiently familiar, they will be processed quickly on the direct route. In contrast, if the stimuli are orthographically unfamiliar, the direct route would be quite inefficient; thus, the phonologically mediated route would provide access to semantics.

What also needs to be noted is that some authors have reported data suggesting that semantics are activated by phonology when reading in Japanese. Using a semantic categorization task, as in Van Orden (1987), but with Kanji word stimuli, Wydell, Patterson, and Humphreys (1993) and Sakuma, Sasanuma, Tatsumi, and Masaki (1998) have shown an increased level of false positive errors with homophone foils. At the same time, however, both Wydell et al. and Sakuma et al. also observed more false positive errors for orthographically similar foils than for orthographically dissimilar foils. Thus, these data appear to suggest that both the direct and phonologically mediated routes are available when reading Japanese Kanji words. Because the results of our Experiment 1 revealed no sign of the use of a phonologically mediated route when reading Katakana words, the obvious implication would be that the phonologically mediated route is used for Kanji words but not for Kana words. Given that the orthographic–phonological relationships are more complicated for Kanji words than for Kana words, however, it is unclear why a phonologically mediated route would be available only for Kanji words.

Indeed, results inconsistent with such a suggestion have been reported more recently by Chen, Yamauchi, Tamaoka, and Vaid (2007). Those authors reported that a masked homophone priming effect was observed in their lexical decision tasks when the masked primes were presented in Hiragana but not in Kanji (see also Shen & Forster, 1999, for the lack of a masked homophone priming effect in a lexical decision task using Chinese stimuli), whereas a masked semantic priming effect was observed when the masked primes were presented in Kanji but not in Hiragana. In contrast to Wydell et al. (1993) and Sakuma et al. (1998), therefore, Chen et al.'s data support the idea that phonological activation is quite slow to arise when reading Kanji words, and, hence, semantic activation would have to be driven by orthography for

Kanji words. At least at present, therefore, there is little evidence that a phonologically mediated route is used for Kanji words.

Another point to note about this argument is that although Wydell et al. (1993) and Sakuma et al. (1998) examined homophone interference effects using a semantic categorization task, we examined the effect due to semantic activation of neighbors in a relatedness judgment task. Because semantic activation of neighbors is assumed to arise early in processing and to decay very quickly (e.g., Bourassa & Besner, 1998; Pecher et al., 2009), the effect observed in our task should more closely reflect the early components of processing. In contrast, by examining the homophone interference effect in a semantic categorization task, Wydell et al.'s and Sakuma et al.'s results would likely be sensitive to both early and late components of processing. Nonetheless, more empirical research would be needed in order to resolve these apparently conflicting ideas.

Can the Form-First Model Account for the Present Results?

The basic assumption made in the present discussion is that the effects reported in our experiments arose as a result of the activation of semantic information concerning the critical target neighbor. Following an interactive view (e.g., Boot & Pecher, 2008; Bowers et al., 2005; Pecher et al., 2009, 2005), we assumed activation cascades between the orthographic/lexical (or, in Experiment 2, the phonological) and semantic levels with semantic activation arising for words whenever their orthographic (or phonological) representations are at least partially activated.

Some researchers, however, have suggested that orthographic/lexical processing is modular in the sense that semantic activation arises only after a lexical representation has been selected (the *form first hypothesis*; e.g., Forster, 2006; Forster & Hector, 2002; Mulatti et al., 2008). If so, semantic activation would be expected to only arise for a word selected during lexical processing and not for any orthographic neighbors of the presented stimulus. Therefore, advocates of this position would need to explain effects of the sort reported here in terms of some aspect of orthographic/lexical processing.

In fact, Forster and colleagues (Forster, 2006; Forster & Hector, 2002) have proposed such an explanation, referred to as the *Links model*. In this model, lexical units are assumed to be connected to semantic fields that are created as a result of lexical co-occurrence. 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). Nonetheless, due to the existence of these semantic fields, when a taxonomic category is used in a semantic categorization task, the fields would impact selection of an appropriate lexical unit. That is, when a visual stimulus is presented, it activates lexical entries (candidates) that are similar in orthography. If the task is a semantic categorization task using the animal category, only lexical candidates that are linked to the animal semantic field would be initially selected for verification against the input stimulus with those selected lexical candidates being compared with the input stimulus in a frequency-ordered manner. As such, a negative decision to "TURPLE" is delayed because the animal neighbor, "TURTLE," has to be checked first, whereas the decision to "CISHOP" is not delayed because the non-animal neighbor, "BISHOP," is eliminated from consideration before the verification process. The question, therefore, is whether it would be possible to account for our results in terms of this type of form-first framework.

According to the Links model, the verification process would be constrained by a semantic field only if a taxonomic category is used in a semantic task. In addition, a semantic field is assumed to be created by clustering lexical units together as a result of lexical co-occurrence (i.e., through associative links). Thus, as shown by Forster (2006), semantic fields would exist for narrower, taxonomic categories (e.g., animals) but not for broader categories (e.g., physical objects).

In a relatedness judgment task, however, it is unclear what the relevant semantic field/associative cluster would involve. It seems unlikely that it could correspond to a narrow taxonomic category shared by the initial stimulus and the related neighbor and, as noted, broader categories do not appear to invoke this type of response strategy. Further, a new field would need to be fairly rapidly created on each new trial based on the nature of the initial stimulus. As such, it is unclear whether it would be possible to use the Links model to account for the inhibitory effects in our Experiments 1 and 2—effects that were due to the relatedness between the initial Kanji word and the critical target neighbor. In order to account for our results in terms of the Links model, it would be necessary for this model to be expanded in some way in order to describe how the nature of the verification process could be influenced by the relatedness between the initial word and the critical target neighbor in a relatedness judgment task.

Conclusions

The present research was an investigation of the role of orthography and phonology in activating semantic information, particularly, semantic information about the neighbors of a presented word. In order to try to tease apart the roles of orthography and phonology in this process, we conducted two relatedness judgment tasks using Japanese words. In Experiment 1, using a relatedness judgment task in which the words in a Kanji word–Katakana word pair were sequentially presented on each trial, an inhibitory effect was observed when the initial Kanji word was related to an orthographic neighbor of the Katakana word target but not when the initial word was related to a phonological neighbor of the target. When the targets were transcribed into the unfamiliar Hiragana script in Experiment 2, however, inhibitory effects were observed for phonological neighbors of the target. Assuming cascaded activation between the lower (i.e., orthographic, lexical and phonological) levels and the semantic level, our results were most consistent with the orthographic dominance view of semantic activation (e.g., Fleming, 1993; Jared & Seidenberg, 1991; Taft & van Graan, 1998). That is, the semantic activation appears to be primarily driven by orthography for orthographically familiar targets. Phonologically mediated activation emerges only when the direct route becomes inefficient by severely reducing the orthographic familiarity of the targets (i.e., in the present situation, by transcribing the targets into an unfamiliar script).

References

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

Besner, D., & Hildebrandt, N. (1987). Orthographic and phonological codes in the oral reading of Japanese kana. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 335–343. doi: 10.1037/0278-7393.13.2.335

Boot, I., & Pecher, D. (2008). Word recognition is affected by the meaning of orthographic neighbours: Evidence from semantic decision tasks. *Language and Cognitive Processes, 23,* 375–393. doi:10.1080/01690960701527317

Bourassa, D. C., & Besner, D. (1998). When do nonwords activate semantics? Implications for models of visual word recognition. *Memory & Cognition, 26,* 61–74. doi:10.3758/BF03211370

Bowers, J. S., Davis, C. J., & Hanley, D. (2005). Automatic semantic activation of embedded words: Is there a "hat" in "that"? *Journal of Memory and Language, 52,* 131–143. doi:10.1016/j.jml.2004.09.003

Chen, H.-C., Yamauchi, T., Tamaoka, K., & Vaid, J. (2007). Homophonic and semantic priming of Japanese kanji words: A time course study. *Psychonomic Bulletin & Review, 14,* 64–69. doi:10.3758/BF03194029

Coltheart, M., Davelaar, E., Jonasson, J. T., & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and performance VI* (pp. 535–555). New York, NY: Academic Press.

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

Davis, C. J. (1999). *The self-organising lexical acquisition and recognition (SOLAR) model of visual word recognition* (Unpublished doctoral dissertation). University of New South Wales, Sydney, Australia.

Davis, C. J. (2010). The spatial coding model of visual word identification. *Psychological Review, 117,* 713–758. doi:10.1037/a0019738

Fleming, K. K. (1993). Phonologically mediated priming in spoken and printed word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 272–284. doi:10.1037/0278-7393.19.2.272

Forster, K. I. (2006). Early activation of category information in visual word recognition. *The Mental Lexicon, 1,* 35–58. doi:10.1075/ml.1.1.05for

Forster, K. I., & Hector, J. (2002). Cascaded versus noncascaded models of lexical and semantic processing: The *turple* effect. *Memory & Cognition, 30,* 1106–1117. doi:10.3758/BF03194328

Grainger, J., & Ferrand, L. (1994). Phonology and orthography in visual word recognition: Effects of masked homophone primes. *Journal of Memory and Language, 33,* 218–233. doi:10.1006/jmla.1994.1011

Grainger, J., & Jacobs, A. M. (1996). Orthographic processing in visual word recognition: A multiple read-out model. *Psychological Review, 103,* 518–565. doi:10.1037/0033-295X.103.3.518

Hino, Y., & Lupker, S. J. (1998). The effects of word frequency for Japanese Kana and Kanji words in naming and lexical decision: Can the dual-route model save the lexical-selection account? *Journal of Experimental Psychology: Human Perception and Performance, 24,* 1431–1453. doi:10.1037/0096-1523.24.5.1431

Hino, Y., Lupker, S. J., Ogawa, T., & Sears, C. R. (2003). Masked repetition priming and word frequency effects across different types of Japanese scripts: An examination of the lexical activation account. *Journal of Memory and Language, 48,* 33–66. doi:10.1016/S0749-596X(02)00500-4

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

Jared, D., & Seidenberg, M. S. (1991). Does word identification proceed from spelling to sound to meaning? *Journal of Experimental Psychology: General, 120,* 358–394. doi:10.1037/0096-3445.120.4.358

Kimura, Y. (1984). Concurrent vocal interference: Its effects on Kana and Kanji. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 36*(A), 117–131. doi:10.1080/14640748408401506

Lesch, M. F., & Pollatsek, A. (1993). Automatic access of semantic information by phonological codes in visual word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 285–294. doi:10.1037/0278-7393.19.2.285

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review, 88,* 375–407. doi:10.1037/0033-295X.88.5.375

Mulatti, C., Cembrani, V., Peressotti, F., & Job, R. (2008). The *turple* effect is modulated by base word frequency: Implications for models of lexical and semantic access. *Psychonomic Bulletin & Review, 15,* 1078–1082. doi:10.3758/PBR.15.6.1078

National Language Research Institute. (1970). *Denshi-keisanki niyoru shinbun no goichousa* [Studies on the vocabulary of modern newspapers (Vol. 1): General descriptions and vocabulary frequency tables]. Tokyo, Japan: Shuei Shuppan.

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

Otake, T., Hatano, G., Cutler, A., & Mehler, J. (1993). Mora or syllable? Speech segmentation in Japanese. *Journal of Memory and Language, 32,* 258–278. doi:10.1006/jmla.1993.1014

Pecher, D., De Rooji, J., & Zeelenberg, R. (2009). Does a pear growl? Interference from semantic properties of orthographic neighbors. *Memory & Cognition, 37,* 541–546. doi:10.3758/MC.37.5.541

Pecher, D., Zeelenberg, R., & Wagenmakers, E. (2005). Enemies and friends in the neighborhood: Orthographic similarity effects in semantic categorization. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 121–128. doi:10.1037/0278-7393.31.1.121

Perea, M., & Lupker, S. J. (2003). Does jugde activate COURT? Transposed-letter similarity effects in masked associative priming? *Memory & Cognition, 31,* 829–841. doi:10.3758/BF03196438

Perfetti, C. A., Bell, L. C., & Delaney, S. M. (1988). Automatic (prelexical) phonetic activation in silent reading: Evidence from backward masking. *Journal of Memory and Language, 27,* 59–70. doi:10.1016/0749-596X(88)90048-4

Rodd, J. M. (2004). When do leotards get their spots? Semantic activation of lexical neighbors in visual word recognition. *Psychonomic Bulletin & Review, 11,* 434–439.

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

Sakuma, N., Sasanuma, S., Tatsumi, I. F., & Masaki, S. (1998). Orthography and phonology in reading Japanese Kanji words: Evidence from the semantic decision task with homophones. *Memory & Cognition, 26,* 75–87. doi:10.3758/BF03211371

Shen, D., & Forster, K. I. (1999). Masked phonological priming in reading Chinese words depends on the task. *Language and Cognitive Processes, 14,* 429–459. doi:10.1080/016909699386149

Taft, M., & van Graan, F. (1998). Lack of phonological mediation in a semantic categorization task. *Journal of Memory and Language, 38,* 203–224. doi:10.1006/jmla.1997.2538

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

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

Van Orden, G. C. (1987). A ROWS is a ROSE: Spelling, sound, and reading. *Memory & Cognition, 15,* 181–198. doi:10.3758/BF03197716

Van Orden, G. C., Johnston, J. C., & Hale, B. L. (1988). Word identification in reading proceeds from spelling to sound to meaning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 371–386. doi:10.1037/0278-7393.14.3.371

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

Wydell, T. N., Patterson, K. E., & Humphreys, G. W. (1993). Phonologically mediated access to meaning for Kanji: Is a rows still a rose in

Japanese Kanji? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 491–514. doi:10.1037/0278-7393.19.3.491
Ziegler, J. C., Van Orden, G. C., & Jacobs, A. M. (1997). Phonology can help or hurt the perception of print. *Journal of Experimental Psychology: Human Perception and Performance, 23,* 845–860. doi:10.1037/0096-1523.23.3.845

Appendix

Experimental and Control Word Pairs Used in Experiments 1 and 2 Along With the Critical Target Neighbors

Orthographic/phonological neighbor condition			
Paired Kanji word		Katakana word target	
Experimental	Control	Target	Critical neighbor
気分 (temper)	在庫 (stock)	ヌード [ぬうど] (nude)	ムード (mood)
革命 (revolution)	担当 (being in charge)	トランス [とらんす] (trance)	フランス (France)
運送 (transportation)	医学 (medical science)	ブラック [ぶらっく] (black)	トラック (truck)
地方 (countryside)	保険 (insurance)	ボーカル [ぼおかる] (vocal)	ローカル (local)
質問 (question)	体育 (gymnastics)	サイズ [さいず] (size)	クイズ (quiz)
測量 (measurement)	要領 (gist)	ベンチ [べんち] (bench)	センチ (centimeter)
区画 (compartment)	主張 (assertion)	オーナー [おおなあ] (owner)	コーナー (corner)
試合 (game, match)	発行 (publication)	リース [りいす] (lease)	リーグ (league)
全力 (full efforts)	劇団 (theatrical group)	コスト [こすと] (cost)	ベスト (best)
色彩 (color, hue)	遺族 (victim's family)	カバー [かばあ] (cover)	カラー (color)
自動 (automatic)	土地 (land)	モニター [もにたあ] (monitor)	モーター (motor)
通路 (lane)	幻想 (illusion)	コーチ [こおち] (coach)	コース (course)
説明 (explanation)	場合 (case)	ガード [があど] (guard)	ガイド (guide)
観客 (audience)	再生 (regeneration)	スタンプ [すたんぷ] (stamp)	スタンド (stand)
形式 (format)	想像 (imagination)	パイプ [ぱいぷ] (pipe)	タイプ (type)
舞台 (stage)	沿岸 (coast)	コンビ [こんび] (combination)	コント (skit)
講演 (lecture)	予防 (prevention)	オール [おおる] (all)	ホール (hall)
施設 (institution)	要求 (demand)	セーター [せえたあ] (sweater)	センター (center)
商店 (store)	危険 (danger)	アパート [あぱあと] (apartment)	デパート (department store)
重量 (weight)	洋画 (foreign movies)	グラス [ぐらす] (glass)	グラム (gram)
主題 (subject, theme)	未満 (under something)	テープ [てえぷ] (tape)	テーマ (theme)
公園 (park)	清掃 (cleaning)	データ [でえた] (data)	デート (date)

(*Appendix continues*)

Appendix (*continued*)

Phonological neighbor condition			
Paired Kanji word		Katakana word target	
Experimental	Control	Target	Critical neighbor
発言 (remark)	材料 (material)	レベル [れべる] (level)	述べる (state)
周辺 (periphery)	精密 (preciseness)	チック [ちっく] (tic)	近く (neighborhood)
人種 (race)	音質 (acoustic quality)	キャベツ [きゃべつ] (cabbage)	差別 (discrimination)
改善 (improvement)	連合 (union)	シューズ [しゅうず] (shoes)	修理 (repair)
住宅 (house)	記録 (record)	ピンチ [ぴんち] (pinch)	団地 (residential complex)
道具 (tool)	行事 (event)	ダーク [だあく] (dark)	大工 (carpenter)
警察 (police)	表明 (manifestation)	タイム [たいむ] (time)	逮捕 (arrest)
姿勢 (posture, attitude)	台風 (typhoon)	タイル [たいる] (tile)	態度 (attitude)
範囲 (range)	絶賛 (accolade)	チーズ [ちいず] (cheese)	地域 (area)
創業 (initiation)	捜索 (search)	カーテン [かあてん] (curtain)	開店 (opening)
組織 (organization)	空港 (airport)	ガイド [がいど] (guide)	制度 (institution)
不動 (immovability)	持参 (bringing)	アンテナ [あんてな] (antenna)	安定 (stability)
苦情 (complaint)	所得 (income)	ピンク [ぴんく] (pink)	文句 (complaint)
家庭 (home)	選手 (player)	ホルモン [ほるもん] (hormone)	訪問 (visit)
価格 (price)	素人 (amateur)	スープ [すうぷ] (soup)	数字 (digit)
湿度 (humidity)	見本 (sample)	ローン [ろおん] (loan)	気温 (temperature)
還元 (reduction)	靴下 (sock)	ベース [べえす] (base)	返す (return)
非行 (delinquency)	製菓 (confectionery production)	ワルツ [わるつ] (waltz)	悪い (bad, wrong)
大量 (great amount)	中継 (relay)	オート [おおと] (auto)	多い (large)
職業 (employment)	作品 (creation, output)	シート [しいと] (sheet)	仕事 (job)
役員 (officer)	行進 (march)	カーブ [かあぶ] (curve)	幹部 (executive officers)
笑顔 (a smiley face)	神秘 (mystery)	タクシー [たくしい] (taxi)	楽しい (pleasant)

Note. English translation of each word is in parentheses. Hiragana transcription of each Katakana word target used in Experiment 2 is in brackets.

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