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The Processing Advantage and Disadvantage for Homophones in Lexical Decision Tasks

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Studies using the lexical decision task with English stimuli have demonstrated that homophones are responded to more slowly than nonhomophonic controls. In contrast, several studies using Chinese stimuli have shown that homophones are responded to more rapidly than nonhomophonic controls. In an attempt to better understand the impact of homophony, we investigated homophone effects for Japanese kanji words in a lexical decision task. The results indicated that, whereas a processing disadvantage emerged for homophones when they have only a single homophonic mate (as in the English experiments), a processing advantage occurred for homophones when they have multiple homophonic mates (as in the Chinese experiments). On the basis of these results, we discuss the nature of the processes that may be responsible for producing the processing advantages and disadvantages for homophones.

Keywords: homophone disadvantage, homophone advantage, the number of homophonic mates, lexical decision task

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A number of studies of skilled adult readers of English have provided evidence that these individuals automatically and rapidly activate the phonological representations of words they read (e.g., Ashby, Sanders, & Kingston, 2009; Lesch & Pollatsek, 1993; Perfetti, Bell, & Delaney, 1988). Our general goal in the present research was to understand the consequences of this early activation of phonology on subsequent lexical processing. Experiments involving homophones have been particularly fruitful in attempting to address this issue.

Homophones are words that have the same phonology but different spellings and meanings (e.g., MAID and MADE). One line of research has used homophones to investigate the role of phonology in the activation of word meanings (e.g., Jared, Levy, & Rayner, 1999; Jared & Seidenberg, 1991; Newman, Jared, & Haigh, 2011; Van Orden, 1987; Van Orden, Johnston, & Hale, 1988). This research has sought to determine whether both meanings of a homophone pair are activated when only one member is read (e.g., whether the "servant" meaning is activated when MADE is presented). Another line of research, and the one that is of relevance here, has used homophones in the lexical decision task to explore orthographic-phonological processing dynamics (e.g., Chen, Vaid, & Wu, 2009; Edwards, Pexman, & Hudson, 2004; Kerswell, Siakaluk, Pexman, Sears, & Owen, 2007; Pexman & Lupker, 1999; Pexman, Lupker, & Jared, 2001; Pexman, Lupker, & Reggin, 2002; Rubenstein, Lewis, & Rubenstein, 1971; Ziegler, Tan, Perry, & Montant, 2000). This research capitalizes on the fact that homophones have two spellings that are associated with a single pronunciation. A review of that research is presented below. Most of this research has examined skilled adult readers of English, although a few studies have examined Chinese readers. As will be discussed, the available evidence indicates that homophone effects in the two languages differ in direction. In the current research, we extended this line of investigation to readers of Japanese kanji in an effort to understand the variables that influence homophone effects across languages and, more broadly, to provide insight into the nature of orthographic-phonological processing.

A Processing Disadvantage for Homophones in English Studies

Rubenstein et al. (1971) were the first to compare lexical decision performance for homophones and nonhomophones. Rubenstein et al. reported a processing disadvantage (compared to nonhomophones) for low-frequency homophones whose homophonic mate was a high-frequency word (low–high homophones). No effect of homophony was observed for high-frequency homophones whose homophonic mate was a low-frequency word (high–low homophones). On the basis of these results, Rubenstein et al. suggested that printed stimuli automatically activate their corresponding phonological representations, which in turn activate lexical candidates. Hence, multiple candidates would be activated when reading a homophone. Rubenstein et al. further suggested that a frequency-ordered search process would then be carried out on these candidates in order to select the correct lexical representation. This search process would take longer for the low–high homophones than for the low-frequency nonhomophonic controls because the representation for the high-frequency homophone

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would need to be examined (and rejected) before a response to the low-frequency homophone could be made, producing a processing disadvantage for the low–high homophones.

More recent research by Pexman et al. (2001), however, although replicating the homophone disadvantage, suggests that this effect is not due to a frequency-ordered lexical search process. If the homophone disadvantage were due to a frequency-ordered search, a homophone disadvantage would be expected not only for low–high homophones but also for high-frequency homophones if they had homophonic mates whose frequencies were higher than those of the homophones themselves (high–higher homophones). In their lexical decision task with pseudo-word foils, however, Pexman et al. reported that lexical decision responses were comparable for high–higher homophones and high-frequency nonhomophonic controls. Pexman et al. (2001) also examined homophone effects in lexical decision experiments with pseudo-homophone foils. Pseudo-homophones are pseudo-words that sound like real words (e.g., BRANE). In this situation, a homophone disadvantage was observed not only for high–higher homophones but even for high–low homophones. These results are quite inconsistent with Rubenstein et al.'s (1971) account.

In order to explain their results, Pexman and colleagues (Edwards et al., 2004; Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002) proposed a feedback account in which there is interactive activation between the orthographic and phonological levels (see also Grainger, Muneaux, Farioli, & Ziegler, 2005; Stone, Vanhoy, & Van Orden, 1997; Ziegler, Montant, & Jacobs, 1997). In this account, phonological activation arises automatically when a printed word is presented. The activation at the phonological level then feeds back to the orthographic/lexical level. When a homophone is presented, orthographic/lexical representations are activated not only for the presented homophone but also for its homophonic mate due to feedback from the phonological level. Thus, a competition is created at the orthographic/lexical level, making the orthographic/lexical processing required for making a lexical decision more difficult, potentially producing a homophone effect.

This type of account would predict that the processing disadvantage would be greatest for the low–high homophones, because the competition should be stronger when the homophonic mate is a high-frequency word. Furthermore, the competition problem should become larger when pseudo-homophone foils are used in the lexical decision task. That is, due to feedback from the phonological level, orthographic/lexical representations would often be activated by these nonwords. As a result, more extensive orthographic/lexical processing would be required for successful lexical decision making. For example, a higher activation threshold may be set (for examples of how this idea could be implemented, see Balota & Chumbley, 1984; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989). As a result, making lexical decisions would take longer, and, hence, there would be more opportunity for the phonological feedback to create measureable competition when a homophone is being read. Thus, any homophone disadvantage would be enhanced in the task with pseudo-homophone foils, meaning that a homophone disadvantage can emerge not only for the low–high homophones but also for high–higher homophones (e.g., Pexman et al., 2001) and even for high–low homophones (e.g., Pexman & Lupker, 1999; Pexman et al., 2001).

Homophone Effects in Logographically Scripted Languages

Homophone effects in lexical decision tasks in alphabetic languages such as English, therefore, appear to support the claims that (a) automatic phonological activation arises early in processing and (b) there is feedback activation from phonological representations to orthographic representations that can lead to orthographic/lexical competition. An interesting question is whether there are also homophone effects in nonalphabetic languages, for example, logographically scripted languages like Chinese or Japanese kanji. According to the orthographic depth hypothesis (e.g., Frost, 2005; Frost, Katz, & Bentin, 1987), phonological activation does not typically arise when reading words in deep orthographies like Chinese or Japanese kanji. Consistent with this position, Chen, Yamauchi, Tamaoka, and Vaid (2007) reported that a homophone priming effect was not observed in their lexical decision task in both 85-ms and 150-ms prime duration conditions when the primes were presented in kanji, although a significant effect was observed when the same primes were transcribed into hiragana. Similarly, Shen and Forster (1999) reported the lack of a masked homophone priming effect in their lexical decision task using Chinese stimuli. Therefore, one might expect that these languages would not show homophone effects in a lexical decision task. The available data, however, indicate that such is not the case.

Chinese

In contrast to the homophone disadvantage reported in lexical decision tasks in English, a processing advantage for homophones has tended to be shown in studies using Chinese stimuli (e.g., Chen et al., 2009; Ziegler et al., 2000). Ziegler et al. (2000), for example, found that in both lexical decision and naming tasks, response latencies were faster for Chinese characters with homophonic mates than for characters with no homophonic mate. Ziegler et al. suggested that their homophone advantages were due to greater phonological familiarity for homophones than for nonhomophones in Chinese. That is, there is typically a large difference in phonological familiarity between homophones and nonhomophones in Chinese (in contrast to languages like English), because, in Chinese, homophones often have numerous homophonic mates. According to Tan and Perfetti (1998), on average, a given pronunciation in Chinese can be generated by 11 different characters. In contrast, most English homophones possess only a single mate. Indeed, there are only a few English homophone triples, such as PAIR, PARE, and PEAR. Having a large number of homophonic mates, as is the case in Chinese, therefore, means that the phonological familiarity of a homophone would increase considerably, potentially aiding its processing.

Ziegler et al. (2000) also suggested that feedback from phonology to orthography is more likely to produce competition for the presented homophone in English than in Chinese because homophonic mates in English are typically more similar visually than Chinese homophonic mates, which may lead to enhanced competition at the orthographic/lexical level. Indeed, support for this idea comes from Ferrand and Grainger (2003) using French stimuli. Ferrand and Grainger examined the effects of homophony as a function of the orthographic similarity between the homophone and its higher frequency orthographic neighbor. In their lexical

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decision tasks, the processing disadvantage was greater for homophones when the higher frequency homophonic mate was also an orthographic neighbor than when the homophonic mate was not an orthographic neighbor. In addition, in an unpublished English lexical decision experiment by Haigh and Jared (2004; as cited in Haigh & Jared, 2007), a significant 58-ms inhibitory homophone effect was reported for homophones with similarly spelled mates (e.g., FEET–FEAT) but only a nonsignificant 20-ms inhibitory effect was reported for homophones with dissimilarly spelled mates (e.g., RAYS–RAISE). Therefore, in Chinese compared to English, there is potentially an enhanced benefit of phonological familiarity and less likelihood that the benefit will be canceled by orthographic/lexical competition.

An additional issue noted by Chen et al. (2009) is that one impact of feedback from phonology to orthography in Chinese (assuming that phonology can be activated rapidly enough to produce feedback) would be to increase the global orthographic/lexical activation to such a heightened level that a rapid response could be made in a lexical decision task (much like the Σ criterion works in Grainger and Jacobs's, 1996, multiple read-out model [MROM]). To the extent that these factors do matter, the nature of processing homophones in English and Chinese would differ in a way that could lead to lexical decisions to Chinese homophones being faster than those to nonhomophonic controls.

One important point to be noted here is simply that homophony does impact lexical decision making even for Chinese stimuli. These results indicate that automatic phonological activation arises not only when reading alphabetic languages (e.g., English and French) but also when reading logographically scripted languages (e.g., Chinese). However, the important additional observation is that the homophone effect in Chinese is in the opposite direction to that in English and French, which suggests that there are differences across languages either in the extent to which homophones activate phonological representations or in the impact of that activation on subsequent processing. In the present research we sought to understand whether the different patterns of homophone effects for logographically scripted and alphabetic languages can be explained in terms of the different nature of homophones in these languages (e.g., their number and/or degree of orthographic similarity). The logographic script that we used was Japanese kanji.

Japanese Kanji

The Japanese writing system consists of a logographic kanji script and two types of phonetic kana scripts (hiragana and katakana). Kanji characters are imported from China and, hence, as with Chinese characters, kanji characters are considered to be morphemes. In contrast, each kana character corresponds to a mora, a rhythmic unit of a constant duration consisting of either a single vowel or a combination of a consonant and a vowel. Thus, any kanji word can be transcribed into either hiragana or katakana based on its pronunciation. In Japanese text, however, any particular word is typically printed in only a single script.

Like Chinese words, many Japanese kanji words do have a large number of homophonic mates, and because kanji characters, like Chinese characters, are logographic (rather than alphabetic) characters, homophonic mates typically have quite different orthographic forms. For example, 目(eye) and 芽(sprout) are homophones, having the same pronunciation, /me/.[1] Thus, just like the processing advantage observed in the Chinese studies, a homophone advantage might be expected for kanji words. In contrast to this expectation, however, Tamaoka (2007) reported a significant homophone disadvantage in his lexical decision and naming tasks with kanji words.

Why might homophone effects differ in direction in Chinese and Japanese kanji? One potentially important difference between Japanese kanji and Chinese characters is that whereas Chinese characters possess only a single pronunciation, most Japanese kanji characters have multiple possible pronunciations (e.g., Verdonschot, La Heij, Paolieri, Zhang, & Schiller, 2011; Verdonschot, La Heij, & Schiller, 2010). In particular, most Japanese kanji characters possess both the so-called kun-reading and on-reading pronunciations. Kun readings are of Japanese origin and were assigned to kanji characters based on their meanings. On the other hand, on readings are of Chinese origin and were imported from China together with the characters. As a result, the nature of orthographic-phonological relationships is more complicated for Japanese kanji characters than for Chinese characters. Thus, it is possible that the patterns of homophone effects were different in Japanese (i.e., Tamaoka, 2007) and the two Chinese studies (Chen et al., 2009; Ziegler et al., 2000) because of differences in the nature of orthographic-phonological relationships for Chinese and Japanese kanji stimuli.

However, another possibility is that there was a confound in Tamaoka's (2007) stimuli. As is described below, Tamaoka's (2007) homophones and nonhomophones were not well matched in terms of familiarity ratings; hence, it is possible that the effect observed with these stimuli may actually be a familiarity effect rather than a homophone effect. If the nature of homophone effects is determined by aspects of the script that are shared by kanji and Chinese, we would expect to observe a processing advantage for homophones in kanji, paralleling those in Chinese, when familiarity is carefully controlled.

The Present Research

One of our purposes in the present research was, therefore, to reexamine the impact of homophony in a logographically scripted language (i.e., Japanese kanji) in lexical decision in order to better understand the relationship between the patterns of homophone effects and script type. Second, given the different patterns of homophone effects across languages, an additional goal was to gain a better understanding of the factors that may be responsible for the different homophone effects across languages.

Experiment 1 was an attempt to replicate Tamaoka's (2007) results using his stimuli: two-character kanji words and nonwords. After demonstrating that his inhibitory homophone effect could be replicated, we investigated in Experiment 2 whether the inhibition effect could be replicated with a new set of two-character kanji words in which familiarity ratings were matched between homophones and nonhomophones. In that experiment and in subsequent

[1] When we describe morae using the Roman alphabet for Japanese words, we use the format from Tamaoka and Makioka (2004). In addition, we use a period to denote a moraic boundary (e.g., /hi.na.N/ for 避難([evacuation]).

experiments we also examined the impact of orthographic similarity and the number of homophonic mates on the homophone effect in Japanese kanji. We now turn to a discussion of the rationale for examining each of these variables.

Orthographic Similarity for Homophonic Mates

As noted above, Ziegler et al. (2000) suggested that one reason that homophone effects are inhibitory in English but facilitatory in Chinese is that homophonic mates tend to be more similar visually in English than in Chinese. One can hypothesize that competition at the orthographic/lexical level arises only (or is more intense) for similarly spelled words (e.g., Davis & Lupker, 2006), which would mean that phonological feedback would typically not produce much competition for Chinese homophonic characters. In the present experiments we examined this idea using two-character Japanese kanji words. One advantage of using kanji words is that although there are a number of homophones that share a kanji character (e.g., 避難 [evacuation] and 非難 [criticism] have the pronunciation /hi.na.N/ and share the second character 非難), there are also many homophones that, as in Chinese, are completely different visually (e.g., 仮定 [assumption] and 課程 [course] have the same pronunciation, /ka.te.i/). Thus, we were better able to examine the role of orthographic similarity on the homophone effect using kanji words. Because the size of the inhibitory homophone effect is influenced by orthographic similarity in English, we might expect that lexical decision latencies should be longer for kanji homophones whose mates share a character than for kanji homophones whose mates do not share a character.[2]

Number of Homophonic Mates

Chen et al. (2009) reported that Chinese characters that have many homophonic mates produced faster lexical decisions than those with fewer homophonic mates, although only when the characters were low in frequency. They did not, however, include a control group of characters that were not homophones, and so it is unclear whether characters with few mates simply produced less facilitation or actually produced inhibition. Japanese kanji words are again ideal for examining this question because the range in the number of homophonic mates among kanji words is large. That is, as in Chinese, there are a number of kanji words with multiple homophonic mates, and there are also kanji words with only a single homophonic mate, as is typical in English. In fact, when counting the number of homophones using Amano and Kondo's (2003b) word frequency database (considering only single- and two-character kanji words), the average numbers of homophones were 9.04 for the 4,887 single-character kanji words and 5.76 for the 85,590 two-character kanji words. In addition, for the type of stimuli used here (two-character kanji words), 28.21% were nonhomophones, 17.53% were homophones with a single mate, and 54.26% were homophones with multiple mates.[3]

In Experiment 2 we conducted a post hoc examination of the impact of the number of homophonic mates on lexical decision performance, and in Experiments 3 and 4 the effect of the number of homophonic mates was directly investigated. In Experiment 3, we examined the homophone effect for homophones having only a single homophonic mate. If the processing disadvantage for homophones in the previous English studies was due to the fact that English homophones typically have only a single homophonic mate, we should be able to observe a processing disadvantage for the homophonic kanji words in Experiment 3. Experiment 4 involved a reexamination of the contrasts created in Experiments 2 and 3 in a within-subject situation. If the processing advantage for homophones in the previous Chinese studies was due to the use of homophones with multiple homophonic mates (consistent with our post hoc analyses in Experiment 2), we expect to observe a processing advantage for homophonic kanji words when they have multiple homophonic mates and a processing disadvantage for homophones with only a single homophonic mate (as in Experiment 3) in the same experiment.

Special Considerations in Stimulus Selection

Because we used two-character kanji compound words in all of our lexical decision experiments, it was necessary to equate our word groups not only on word-level factors such as frequency but also on factors relating to the individual characters. In addition to matching mean summed character frequencies (taken from Amano and Kondo's 2003b character frequency database) across word groups, as is described below, we attempted to equate the degree of transparency between the constituent kanji characters and the compound words by collecting relatedness ratings. In addition, because it has been reported that lexical decision performance for compound words is affected by morphological connectivity for the constituents of compound words (e.g., Kuperman, Schreuder, Bertram, & Baayen, 2009; Taft, 2003, 2004), we computed the numbers (family size) and summed frequencies (family frequency) of the compounds that share the left and right constituent character with the target compound using Amano and Kondo's (2003b) word frequency database (e.g., the left constituent family of 容姿 [appearance] involves 容器 [container] and 容易 [easy] and the right constituent family involves 勇姿 [brave figure] and 後姿 [back shot]). Furthermore, we also computed the degree of forward and backward predictability given one constituent kanji character in the two-character kanji compounds. That is, the forward (from left to right) predictability was computed by dividing the frequency count of the kanji compound by the left constituent family frequency. The backward (from right to left) predictability was computed by dividing the frequency count of the kanji compound by the right constituent family frequency. These values are expected to reflect how likely it is that the right (left) character will be used in combination with the left (right) character in the two-character kanji compounds. These variables were equated to the extent possible across word groups in our experiments.

[2] When a word often appears in text in different scripts (e.g., 眼鏡, メガネ and めがね [glasses], /me.ga.ne/), Amano and Kondo's (2003b) database counts as homophonic mates the alternative (kana) script versions of the kanji-written word. Because most Japanese words are written in only a single script, however, such words are exceptional. For our (kanji) stimuli, even when frequency counts were available for one of the kana script forms, they were much lower than the frequency for the kanji forms. As such, for the (kanji) words we did use, virtually all of their homophonic mates are other kanji words.

[3] For the 4,887 single-character kanji words, 1.82% of these words were nonhomophones, 5.69% were homophones with a single homophonic mate, and 92.49% were homophones with multiple homophonic mates.

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In addition, as noted by Taft (2003, 2004), lexical decision performance for polymorphemic words depends on the nature of the nonwords. In particular, when nonwords are nonsense strings, participants would be able to make a word response if they detect a morpheme in the presented stimulus. In contrast, when nonwords consist of incorrect combinations of real morphemes, detecting a morpheme would not provide a clue to making a lexical decision. In this situation, participants would need to determine whether the morphemes are combined correctly to form a word before making a lexical decision; hence, task performance would be more sensitive to whole-word-level variables, including homophony at the whole-word level. Therefore, in our experiments, we used two-character kanji nonwords that were created by arbitrarily pairing two real kanji characters. In order to equate the number of morae between our word and nonword stimuli, however, we used kanji characters with a single (either on- or kun-reading) pronunciation based on Kindaichi, Kindaichi, Kenbou, Shibata, and Yamada (1974) to create these nonwords. Because only a single pronunciation is possible for each of these characters, there is only a single possible pronunciation for a nonword created by combining these characters. Hence, it was possible to count the number of morae for these nonwords.

In summary, four lexical decision experiments are reported using two-character Japanese kanji stimuli. The experiments examined whether homophone effects in lexical decision are influenced by (a) the script type, (b) the orthographic similarity of the homophones and their homophonic mates, and (c) the number of homophonic mates. The goal was to account for differences in homophone effects across languages to gain a better understanding of orthographic-phonological processing dynamics.

Experiment 1 (Tamaoka, 2007, Replication)

Method

Participants. Twenty-six undergraduate and graduate students from Waseda University participated in Experiment 1. 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. The experimental stimuli were the two-character kanji stimuli used in Tamaoka's (2007) lexical decision task. That is, his 27 homophones and 27 nonhomophones were used along with his 54 nonwords. Tamaoka used three types of nonwords: pseudo-homophones that were homophonic to a single Japanese word, pseudo-homophones that were homophonic to many Japanese words, and control nonwords with random kanji combinations. In addition, 8 two-character kanji words and 8 two-character kanji nonwords that were not among the 108 experimental stimuli were used as practice stimuli.

Procedure. Participants were tested individually in a normally lit room. Stimuli were presented on a video monitor (Iiyama, HM204DA) driven by an IBM AT-compatible computer. Participants were seated in front of the video monitor at a distance of about 50 cm. They were asked to decide whether or not a kanji character string that appeared at the center of the video monitor was a word and to press either the *Word* or the *Nonword* key on a response box interfaced to the computer. They were also told that their responses should be made as quickly and as accurately as possible. The "Word" response was always made using the participant's dominant hand. Sixteen practice trials were given prior to the 108 experimental trials. The order of stimulus presentation for the experimental trials was randomized for each participant.

Each trial was initiated with a 50-ms, 400 Hz warning tone, after which a fixation point appeared at the center of the video monitor. One second later, a stimulus was presented directly above the fixation point. The fixation point and the stimulus were presented in white on a black background. The participant's response terminated the presentation of the stimulus. The response latencies from the onset of the stimulus to the participant's keypress and whether the response was correct were automatically recorded by the computer. The intertrial interval was 2 s.

Results

Lexical decision latencies were classified as outliers if they were out of the range of 2.5 standard deviations (*SD*s) from the mean for each participant. With this procedure, 0.93% (13 data points) of the "Word" trials were classified as outliers and, thus, excluded from the statistical analyses. Further, 6.13% (86 data points) of the "Word" trials were errors, so that these trials were also excluded from the latency analyses. Mean lexical decision latencies for the correct "Word" trials and error rates were calculated across both subjects and items and submitted to one-way analyses of variance (ANOVAs). As noted, Tamaoka's (2007) stimuli involved three types of nonwords: pseudo-homophones with a single homophonic mate, pseudo-homophones with multiple homophonic mates, and control nonwords with random kanji combinations, allowing him to evaluate pseudo-homophone effects in kanji. Paralleling his analyses, one-way ANOVAs by both subjects and items on the nonword data were calculated here. Using the same procedure as for the "Word" trials, 3.85% (54 data points) of the "Nonword" trials were classified as outliers and excluded from the statistical analyses. There were also 7.26% error trials (102 data points), which were also excluded from the latency analysis.

In the analyses of lexical decision latencies for word stimuli, the mean lexical decision latencies for the homophones and nonhomophones were 549 ms and 517 ms, respectively. As such, consistent with Tamaoka's (2007) results, lexical decision latencies were 32 ms slower for the homophones than for the nonhomophones, $F_1(1, 25) = 70.54$, $MSE = 185.86$, $p < .001$, $\eta_p^2 = .74$; $F_2(1, 52) = 5.04$, $MSE = 2{,}819.31$, $p < .05$, $\eta_p^2 = .09$. In the analyses of error rates for word stimuli, the mean error rates for the homophones and nonhomophones were 7.19% and 4.65%, respectively. The 2.54% higher error rate for the homophones was significant only in the subject analysis, $F_1(1, 25) = 5.22$, $MSE = 16.05$, $p < .05$, $\eta_p^2 = .17$; $F_2(1, 52) = 1.35$, $MSE = 59.64$.

In the nonword data, mean lexical decision latencies and error rates were 619 ms and 6.42% for the pseudo-homophones with a single homophonic mate, 608 ms and 6.73% for the pseudo-homophones with multiple homophonic mates, and 641 ms and 9.27% for the control nonwords, respectively. In the latency analyses, the main effect of nonword type was significant only in the subject analysis, $F_1(2, 50) = 11.96$, $MSE = 638.58$, $p < .001$, $\eta_p^2 = .32$; $F_2(2, 51) = 1.98$, $MSE = 2360.53$. Surprisingly, and in contrast to the standard result in English, both the pseudo-homophones with a single homophonic mate, $F_1(1, 25) = 11.33$, $MSE = 574.16$, $p < .01$, $\eta_p^2 = .31$, and the pseudo-homophones with multiple homophonic mates, $F_1(1, 25) = 23.29$, $MSE = 633.40$, $p < .001$, $\eta_p^2 = .48$, were responded to somewhat faster than the control nonwords, with lexical decision latencies being comparable for the two types of pseudo-homophones, $F_1(1, 25) = 2.35$, $MSE = 708.18$. In the analyses of error rates, the main effect of nonword type was not significant in either analysis, $F_1(2, 50) = 1.54$, $MSE = 41.13$; $F_2(2, 51) = 0.48$, $MSE = 89.33$.

Discussion

In his Experiment 1, Tamaoka (2007) reported a significant 36-ms homophone disadvantage in a lexical decision task. Using the same stimuli, we observed a 32-ms homophone disadvantage in the present experiment. As such, our results were essentially the same as those reported by Tamaoka. By closely checking his stimuli, however, one finds that his homophones were somewhat less familiar than his control words (5.27 vs. 5.52), $F(1, 52) = 3.27$, $MSE = 0.26$, $p < .08$, according to Amano and Kondo's (2003a) familiarity rating database. In order to remove the variance due to the difference in familiarity ratings, we conducted an analysis of covariance (ANCOVA) using the familiarity ratings as the covariate. Because our inhibitory homophone effect was significant in the item analysis of lexical decision latencies but not in the item analysis of error rates, we conducted the ANCOVA only for the item means of lexical decision latencies. In contrast to the significant homophone effect in the item ANOVA, the homophone effect was not significant in the ANCOVA when the familiarity ratings were used as the covariate, $F_2(1, 51) = 1.83$, $MSE = 1{,}666.97$. As such, the results of the ANCOVA suggest that the inhibitory homophone effect in Tamaoka's study may have been due to the difference in familiarity between his homophones and nonhomophones.

Another aspect of our results to note is that there was a tendency for the pseudo-homophones to be responded to somewhat faster than the control nonwords. In contrast to the present results, Tamaoka (2007) failed to detect such an effect using the same stimuli. Similar to our results, however, in his lexical decision task, the mean lexical decision latencies for the two types of pseudo-homophones were numerically less than those for the control nonwords (mean lexical decision latencies for the pseudo-homophones with a single homophonic mate, the pseudo-homophones with multiple homophonic mates, and the control nonwords were 852 ms, 834 ms, and 873 ms, respectively). Nonetheless, because (a) the effect was detected only in the subject analysis in our experiment and (b) Tamaoka failed to detect a significant effect using the same stimuli, at least at present, there is some doubt as to whether this is a real effect. What our data as well as Tamaoka's do suggest, however, is that, in contrast to English pseudo-homophones, when nonwords are created by combining two real kanji characters, homophony does not make these nonwords more wordlike, in the sense that it prolongs negative lexical decision latencies.

Experiment 2

The ANCOVA results indicate that it is quite possible that Tamaoka's (2007) inhibitory homophone effect was actually a familiarity effect. Therefore, in Experiment 2, we attempted to determine whether there is an inhibitory homophone effect when reading kanji words using a set of two-character kanji homophones and nonhomophones that were matched on familiarity ratings.

In addition, in order to determine whether the nature of the homophone effect is modulated by orthographic similarity among homophones as suggested by Ziegler et al. (2000), we created two groups of homophones. One group of homophones contained words with a higher frequency orthographically similar homophonic mate. The other group of homophones contained words with a higher frequency homophonic mate, but all their homophonic mates were orthographically dissimilar to the target homophone. Lexical decision performance for the two types of homophones was compared to that for a group of nonhomophonic controls.

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. Fifty-four kanji words were initially selected from Amano and Kondo's (2003b) word frequency database. These words were all two-character kanji words with three or four morae. Their frequency counts were all less than 10,000 per 287,792,787 (34.75 per million). All these words were homophones, and each possessed a higher frequency homophonic mate. Half of the homophones (orthographically similar) possessed a higher frequency homophonic mate that shared a kanji character (e.g., for 避難 [evacuation], /hi.na.N/, 非難 [criticism] is a higher frequency homophonic mate). The mean frequency of these 27 homophones was 908.41 (3.16 per million). The mean frequencies of their highest and lowest frequency homophonic mates were 11,382.41 (39.55 per million) and 5,707.59 (19.83 per million), respectively. For the rest of the homophones (orthographically dissimilar), none of the homophonic mates shared a kanji character (e.g., for 容姿 [appearance], /yo.u.si/, 要旨 [summary] is a higher frequency homophonic mate). Mean frequency of these 27 homophones was 908.82 (3.16 per million). The mean frequencies of their highest and lowest frequency homophonic mates were 14,024.67 (48.73 per million) and 2,754.56 (9.57 per million), respectively. The accent type was the same for the homophone and its higher frequency homophonic mate for all the homophones according to Amano and Kondo's (2003a) accent type database.[4] In addition to the two types of homophones, 27 nonhomophones were selected from the same word frequency database. Similar to the homo-

[4] According to Kindaichi et al. (1974), there are $N + 1$ types of accent for Japanese words with N morae. For three-mora words, for example, there are four different types of accent. In Type 1, the accent is on the first mora and the pitch drops down in the second and third. Thus, the pitch on the three morae changes from high to low to low (the HLL-type accent). In Type 2, the accent is on the second mora and, hence, the pitch rises from the first mora to the second and, then, drops down in the third (the LHL-type accent). In Types 3 and 0 accents, the pitch rises from the first mora to the second and third (the LHH-type accents). When a word is followed by a postposition, the postposition is pronounced in a low pitch for words with Type 3 accent (LHH-L), whereas the postposition is pronounced in a high pitch for words with Type 0 accent (LHH-H).

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phones, the nonhomophones were also two-character kanji words with three or four morae, and their frequency counts were less than 10,000 (34.75 per million). The mean frequency of the 27 nonhomophones was 903.96 (3.14 per million).

Word length and the number of morae were exactly matched across the three word groups. In addition, as shown in Table 1, word frequency, familiarity ratings, summed character frequency, and orthographic neighborhood size were equated across the three word groups (Fs $\leq$ 1).[5]

Because our word stimuli were all compound words, we attempted to equate the degree of transparency of the constituent kanji characters and the compound words across the three word groups. For this purpose, we collected relatedness ratings between the constituent characters and the compound words. Using 215 two-character kanji compound words including the 81 words used in Experiment 2, we created two questionnaires (the 215 words also included words used in Experiments 3 and 4). In the first, each of the 215 kanji words was paired with its left constituent kanji character and randomly ordered and listed in the questionnaire. In the second, each word was paired with its right constituent character and randomly listed in the questionnaire. Each kanji word–kanji character pair was accompanied by a 7-point scale ranging from 1 (*Unrelated*) to 7 (*Related*). Fifty-five participants who did not take part in Experiment 2 were asked to rate the relatedness of these pairs by circling the appropriate number on the scale. Twenty-eight participants provided ratings for the first questionnaire, and the rest provided ratings for the second questionnaire. Mean ratings between the compound and the left constituent were comparable across the three word groups, $F(2, 78) = 0.13$, $MSE = 0.73$. Similarly, the ratings between the compound and the right constituent character were also comparable across the three word groups, $F(2, 78) = 0.04$, $MSE = 1.18$.

Second, in order to equate morphological connectivity for the constituents of compound words across word groups, we computed family size and family frequency of the left (right) constituent character with the target compound using Amano and Kondo's (2003b) word frequency database. The family sizes of the left constituents were comparable across the three word groups, $F(2, 78) = 0.38$, $MSE = 526.90$. Similarly, the family sizes of the right constituents were also comparable across the three word groups, $F(2, 78) = 0.27$, $MSE = 412.57$. The family frequencies of the left constituents, $F(2, 78) = 1.13$, $MSE = 16{,}295{,}534{,}451.35$, and the family frequencies of the right constituents, $F(2, 78) = 0.27$, $MSE = 10{,}160{,}883{,}391.37$, were comparable across the three word groups.

In addition, we computed the forward and backward predictabilities by dividing the frequency count of the kanji compound by the left (right) constituent family frequency. The forward predictabilities, $F(2, 78) = 1.16$, $MSE = 0.03$, and the backward predictabilities, $F(2, 78) = 1.23$, $MSE = 0.05$, were comparable across the three word groups.

Note also that the mean numbers of orthographically similar homophonic mates were 2.44 for the 27 homophones with orthographically similar homophonic mates and 0.00 for the 27 homophones with orthographically dissimilar homophonic mates, $F(1, 52) = 47.31$, $MSE = 1.71$, $p < .001$. The mean numbers of higher frequency homophonic mates were, however, comparable for the two types of homophones, $F(1, 52) = 0.12$, $MSE = 0.64$.

In addition, in order to measure the degree of orthographic-phonological consistency for our kanji words, we computed Hino, Miyamura, and Lupker's (2011) consistency index values for those words using Amano and Kondo's (2003b) frequency database. To calculate these indices, one classifies orthographic neighbors as either friends or enemies depending on whether the shared character is pronounced the same or different, with the index indicating the proportion of neighbors classified as friends. When pronunciations of shared kanji characters are compared across orthographic neighbors, there are some cases in which the constituent kanji character is pronounced slightly differently not because the same character is assigned different types of pronunciation (e.g., on-reading vs. kun-reading pronunciation such as 食品 [food], /sjo.ku-hi.N/ vs. 手品 [magic], /te-zi.na/) but because a phonemic alternation occurs at the morphemic boundary (e.g., 食品 [food], /sjo.ku-hi.N/ vs. 新品 [something new], /si.N-pi.N/). When an orthographic neighbor with a phonemic alternation was classified as a phonological enemy, the mean consistency index values for the homophones with orthographically similar mates, the homophones with orthographically dissimilar mates, and the nonhomophones were .88, .89, and .80, respectively, $F(2, 78) = 1.68$, $MSE = 0.04$. When a neighbor with a phonemic alternation was classified as a phonological friend, the index values were .89, .90, and .85, respectively, $F(2, 78) = 0.55$, $MSE = 0.04$. As such, the orthographic-phonological consistencies appear to be comparable across the three word groups. The three groups of kanji words are listed in Appendix A.

In addition to the 81 kanji words, 81 kanji nonwords were created by arbitrarily pairing two kanji characters, each with a single pronunciation. According to Amano and Kondo's (2003b) word frequency database, 29 of these nonwords were pseudohomophones. The number of morae was equated for the 81 kanji words and the 81 kanji nonwords. The 81 nonwords are listed in Appendix D. Furthermore, 8 two-character kanji words and 8 two-character kanji nonwords that were not among the 162 experimental stimuli were used as practice stimuli.

Procedure. The procedure was identical to that in Experiment 1. Sixteen practice trials were given prior to the 162 experimental trials for each participant.

Results

Lexical decision 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, 1.80% (64 data points) of the "Word" trials were classified as outliers and excluded from the statistical analyses. Further, 12.09% (431 data points) of the "Word" trials were errors, and, hence, these trials were also excluded from the latency

[5] Word frequency counts were taken from Amano and Kondo's (2003b) frequency database with 360,850 word entries. Experiential familiarity ratings were taken from Amano and Kondo's (2003a) database with 88,569 word entries. Summed character frequencies were computed based on character frequencies taken from Amano and Kondo's (2003b) database with 6,847 character entries. The word frequencies and character frequencies were based on texts printed in the *Asahi* newspaper over 14 years (from 1985 to 1998). Finally, orthographic neighborhood sizes were determined by using National Language Research Institute (1993), which involves 36,780 word entries.

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Table 1
Stimulus Characteristics of the Three Groups of Kanji Words Used in Experiment 2

	Word group		
Variable	Homophones with dissimilar mates	Homophones with similar mates	Nonhomophones
Morae	3.48	3.48	3.48
Freq	908.82	908.41	903.96
Fam	5.04	5.10	5.09
CF	496,554.44	525,006.22	493,751.85
N	47.33	56.56	53.81
NoOSH	0.00	2.44	0.00
NoHFH	1.52	1.44	0.00
Rel to left	4.87	4.94	4.99
Rel to right	5.06	5.11	5.14
Left FS	21.04	26.48	24.11
Right FS	26.30	29.96	29.70
Left FF	54,926.78	106,314.67	88,463.04
Right FF	85,767.19	103,372.96	85,908.93
Forward P	0.041	0.058	0.110
Backward P	0.132	0.080	0.041

Note. Morae, Freq, Fam, CF, N, NoOSH, and NoHFH stand for mean number of morae, mean word frequency, mean familiarity rating, mean summed character frequency, mean orthographic neighborhood size, mean number of orthographically similar homophones, and mean number of higher frequency homophones, respectively. Rel to left (right) stands for mean relatedness rating between the left (right) constituent character and the kanji compound. Left (Right) FS and Left (Right) FF stand for mean family size and mean family frequency of the left (right) constituent, respectively. Forward (Backward) P stands for the forward (backward) predictability computed by dividing the frequency of the compound by the left (right) constituent family frequency.

analyses. Mean response latencies and error rates for the "Word" trials were calculated across both subjects and items and submitted to one-way ANOVAs. Word type (homophones with orthographically similar homophonic mates, homophones with orthographically dissimilar homophonic mates, and nonhomophones) was a within-subject factor in the subject analysis but a between-item factor in the item analysis. The mean lexical decision latencies and error rates from the subject analyses are presented in Table 2.

In the analyses of lexical decision latencies, the main effect of word type was significant in both analyses, $F_1(2, 86) = 21.56$, $MSE = 741.16$, $p < .001$, $\eta_p^2 = .33$; $F_2(2, 78) = 3.76$, $MSE = 2{,}756.74$, $p < .05$, $\eta_p^2 = .09$. Pairwise comparisons revealed that the 34-ms difference between homophones with orthographically similar homophonic mates and nonhomophones was significant in both analyses, $F_1(1, 43) = 24.93$, $MSE = 1{,}040.90$, $p < .001$, $\eta_p^2 = .37$; $F_2(1, 52) = 5.27$, $MSE = 3{,}171.86$, $p < .05$, $\eta_p^2 = .09$. The 31-ms difference between homophones with orthographically dissimilar mates and nonhomophones was also significant in both analyses, $F_1(1, 43) = 27.20$, $MSE = 801.90$, $p < .001$, $\eta_p^2 = .39$; $F_2(1, 52) = 5.38$, $MSE = 2{,}650.92$, $p < .025$, $\eta_p^2 = .09$. The 3-ms difference between the two types of homophones was not significant in either analysis (Fs < 1).

In the analyses of error rates, the main effect of word type was significant in the subject analysis, $F_1(2, 86) = 24.71$, $MSE = 27.60$, $p < .001$, $\eta_p^2 = .37$, although not in the item analysis, $F_2(2, 78) = 1.87$, $MSE = 233.07$. Pairwise comparisons revealed that the 6.39% difference between homophones with orthographically dissimilar mates and nonhomophones was significant only in the subject analysis, $F_1(1, 43) = 39.36$, $MSE = 22.80$, $p < .001$, $\eta_p^2 = .48$; $F_2(1, 52) = 2.21$, $MSE = 271.36$. The 0.79% difference between homophones with orthographically similar mates and nonhomophones was not significant in either analysis (Fs < 1). The 7.18% difference between the two types of homophones was significant only in the subject analysis, $F_1(1, 43) = 31.37$, $MSE = 36.17$, $p < .001$, $\eta_p^2 = .42$; $F_2(1, 52) = 2.45$, $MSE = 287.29$.

Table 2
Mean Lexical Decision Latencies (RT) in Milliseconds and Error Rates (ER) in Percent for the Three Types of Kanji Words in Experiment 2

			Homophone effect	
Condition	RT	ER	RT	ER
Homophones with dissimilar mates	577 (15.84)	15.91 (1.01)	31	−6.39
Homophones with similar mates	574 (16.00)	8.73 (0.93)	34	0.79
Nonhomophones	608 (20.39)	9.52 (1.07)		

Note. Standard error of the mean is in parentheses. Mean lexical decision latency and error rate for the 81 nonwords were 618 ms ($SEM = 20.92$) and 6.52% ($SEM = 0.64$), respectively.

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Discussion

Experiment 2 produced two interesting findings. One was that there was a processing advantage for kanji homophones compared to nonhomophonic controls. As such, in contrast to Tamaoka's (2007) results, our results were consistent with those from the Chinese studies (e.g., Chen et al., 2009; Ziegler et al., 2000).[6] Therefore, our results indicate that phonological activation does arise automatically when reading Japanese kanji words, as when reading Chinese words, and that the impact of homophony is the same in the two scripts.

When comparing the nature of the word stimuli in our experiment with those in most English studies, one may wonder whether the direction of a homophone effect may depend on the morphological structure of the written forms of the words in the language. Our word stimuli were all two-character kanji compound words. In contrast, most of English studies have used monomorphemic words (e.g., Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002; Rubenstein et al., 1971). Note, however, that both Ziegler et al. (2000) and Chen et al. (2009) used single-character stimuli; hence, their word stimuli were all monomorphemic and thus similar to those used in most English studies. In addition, Edwards et al. (2004) reported an inhibitory homophone effect for polymorphemic English words (e.g., WEIGHTED/WAITED) as well as for monomorphemic English words (e.g., FEAT/FEET). Based on these data, it is unlikely that differences in morphological structure are responsible for producing the different patterns of homophone effects in English versus Chinese and Japanese kanji.

The second interesting finding concerns the potential impact of orthographic similarity on the size of the homophone effect. One question addressed in Experiment 2 was whether the homophones with higher frequency orthographically similar mates would be more difficult to process than homophones with higher frequency, orthographically dissimilar mates due to enhanced orthographic/lexical competition (e.g., Ferrand & Grainger, 2003; Haigh & Jared, 2004, as cited in Haigh & Jared, 2007). The latency data provide no evidence of such an effect. In fact, in the error data, the homophones with orthographically similar mates seemed to be easier to process. This result is exactly the opposite of what would be expected if orthographic/lexical competition/inhibition was exaggerated by orthographic similarity.

In order to examine the error data more fully, we investigated whether the difference in error rates between our two types of homophones may have been driven by a small number of items. Indeed, two homophones with orthographically dissimilar mates produced more than 50% error rates (府政 [prefectural administration] and 結石 [calculus]). Therefore, we reanalyzed the data with these items removed. The significant main effect of word type in the analysis of error rates disappeared, $F_1(2, 86) = 2.54$, $MSE = 29.95$, $p > .05$; $F_2(2, 76) = 0.33$, $MSE = 131.16$, although the results from the analyses of lexical decision latencies were unchanged. Therefore, although it is unclear what it was about these items that produced such a high error rate, the fact that the effect was being driven by these two items suggests that, in general, orthographic similarity among homophones is not an important factor in determining the size of the homophone effect for kanji words.

Although our results did not follow the same pattern reported by Ferrand and Grainger (2003) and Haigh and Jared (2004; as cited in Haigh & Jared, 2007), it should be noted that our manipulation of orthographic similarity was somewhat different from those in English and French studies. In particular, our orthographically similar homophones share only 50% of their characters with their homophonic mates (i.e., a single character was shared for two-character kanji homophones). On the other hand, in Ferrand and Grainger's stimuli, the orthographic overlap was 75–80% for their orthographically similar homophones (i.e., words with a homophonic mate that is also a higher frequency orthographic neighbor) because they used words that were four to five letters in length. Thus, there is the possibility that the inhibitory neighborhood frequency effect for the orthographically similar homophones was much weaker in our experiment, resulting in our failure to detect any effect of orthographic similarity. Nonetheless, our results do indicate that the direction of the homophone effect in kanji is not modulated by the orthographic similarity among homophones.

As previously noted, one obvious alternative proposal for why homophone effects differ in English versus logographically scripted languages such as Chinese and Japanese kanji is that the nature/size of the homophone effect is determined by the number of homophonic mates possessed by the target word (e.g., Chen et al., 2009; Ziegler et al., 2000). In order to provide an initial analysis of this proposal, we counted the number of homophonic mates for each target word in Experiment 2 using Amano and Kondo's (2003b) word frequency database. The mean numbers of homophones were 5.33 (ranging from 1 to 17) for the homophones with orthographically similar mates, 3.56 (ranging from 1 to 13) for the homophones with orthographically dissimilar mates, and 0.00 for the nonhomophones. We next conducted multiple regression analyses on lexical decision latencies and error rates of the

[6] The results in Experiment 2 were not entirely consistent with the results from the ANCOVA in Experiment 1, because there was no sign of a processing advantage for homophones in the Experiment 1 analysis. A closer examination of Tamaoka's (2007) stimuli suggests a number of possible reasons why his stimuli may have not produced a homophone advantage. First, among his stimuli, familiarity ratings from Amano and Kondo (2003a) were significantly negatively correlated with the number of homophonic mates a word has, $r(54) = -.393$, $p < .01$. With this negative correlation, detecting a facilitatory homophone effect would be extremely difficult after removing the variance due to the familiarity ratings. Second, some of his homophones were sufficiently high in frequency that all their homophonic mates were lower in frequency, according to Amano and Kondo's (2003b) frequency database. As Chen et al. (2007) reported, a significant homophone advantage is essentially limited to low-frequency homophones with higher frequency mates. Third, even when the homophones possessed higher frequency homophonic mates, some of these mates were pronounced in somewhat different ways than the target homophones. That is, although these homophonic mates do share the same basic phonology (phonemes, morae) with the target homophones, the fact that they were pronounced with different accent types may have made them less homophonic. Finally, there was also a potential problem with Tamaoka's nonhomophones, in that not all of them were nonhomophones. When counting the number of homophonic mates using Amano and Kondo's frequency database, the mean numbers of homophonic mates were 9.48 for Tamaoka's homophones and 2.37 for his nonhomophones. All of these factors would have made it difficult to detect a homophone advantage using his stimuli.

"Word" trials using the number of homophonic mates as one of the predictor variables. Other predictors were familiarity ratings, orthographic neighborhood size, and the number of morae. All the predictor variables were simultaneously entered into the analyses. The pairwise correlations of these variables are shown in Table 3, and the results of the regression analyses are summarized in Table 4.[7]

In the regression analysis of lexical decision latencies, the regression equation explained a significant amount of variance in lexical decision latencies, $R^2 = .354$, $F(4, 76) = 10.39$, $MSE = 2{,}005.18$, $p < .001$. As shown in Table 4, in addition to familiarity ratings and orthographic neighborhood size, the number of homophonic mates was a significant predictor. Lexical decision latencies were faster for words with more homophonic mates. In the analysis of error rates, the regression equation also explained a significant amount of variance, $R^2 = .376$, $F(4, 76) = 11.45$, $MSE = 156.43$, $p < .001$. The significant predictor variables detected in this analysis were familiarity ratings and orthographic neighborhood size.

The results from the regression analyses suggest that the overall number of homophonic mates does play an important role in determining lexical decision performance. We, thus, designed Experiments 3 and 4 to explicitly test the hypothesis that the direction of the homophone effect is determined by the number of homophonic mates possessed by the target word.

Experiment 3

The results of Experiment 2 suggest that when some variables potentially affecting lexical decision performance (including familiarity ratings) are sufficiently well controlled for kanji words, lexical decision latencies for homophones are faster than lexical decision latencies for nonhomophones. This result parallels those reported in the previous Chinese studies (e.g., Chen et al., 2009; Ziegler et al., 2000).

The main factor determining the direction of a homophone effect is not yet clear. The direction of a homophone effect may merely depend on the nature of the script used in the different languages. That is, inhibitory homophone effects may be observed for alphabetic languages such as English and French, with facilitatory effects arising for logographically scripted languages such as Chinese or with Japanese kanji words.

Alternatively, as suggested by the post hoc analyses in Experiment 2, it is possible that the direction of a homophone effect is determined by the number of homophonic mates a word has. As previously noted, most English homophones possess only a single homophonic mate and what has been repeatedly reported in the previous English studies is a processing disadvantage for homophones (e.g., Edwards et al., 2004; Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002; Rubenstein et al., 1971). In contrast, most Chinese homophones (as well as the kanji homophones used in Experiment 2) have multiple homophonic mates, and what has been reported is a processing advantage for those homophones (e.g., Chen et al., 2009; Ziegler et al., 2000).

In order to address these alternatives, in Experiment 3, we examined the homophone effect for homophonic kanji words that had only a single homophonic mate, as is typically the case for English homophones. If the direction of a homophone effect depends on the nature of the script, we should observe a facilitatory homophone effect, as in Experiment 2. In contrast, if the direction of the effect is determined by the number of homophonic mates a word has, we should observe an inhibitory effect, as in the English studies.

In addition, we again attempted to examine the effect of orthographic similarity between homophone mates. For this purpose, we used two types of homophones: homophones with a single orthographically similar homophonic mate and homophones with a single orthographically dissimilar homophonic mate. Lexical decision performance for the two types of homophones was compared with that for nonhomophonic controls.

Method

Participants. Forty-two 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 any of the previous experiments.

Table 3
Pairwise Correlations of the Predictors Used in the Regression Analyses in Experiment 2

Predictor	NoH	Fam	N	Morae
NoH	—	.082	−.100	−.125
Fam		—	.013	.055
N			—	.092

Note. NoH, Fam, N, and Morae stand for mean number of homophones, mean familiarity rating from Amano and Kondo (2003a), mean orthographic neighborhood size computed according to National Language Research Institute (1993), and mean number of morae, respectively.

Table 4
Summary of the Results From the Multiple Regression Analyses on Lexical Decision Latencies and Error Rates of the "Word" Trials in Experiment 2

Predictor variable	β	*t*
Analysis of lexical decision latencies		
No. homophonic mates	−.274	−2.93**
Familiarity rating	−.475	−5.12**
Orthographic neighborhood size	−.198	−2.13*
No. morae	.047	0.50
Analysis of error rates		
No. homophonic mates	−.028	−0.31
Familiarity rating	−.575	−6.32**
Orthographic neighborhood size	−.202	−2.21*
No. morae	.073	0.79

Note. $df = 76$.
* $p < .05$. ** $p < .01$.

[7] Familiarity ratings, orthographic neighborhood size, and the number of morae were included as predictor variables due to the fact that these factors tend to influence word latencies. In the regression analyses, we used familiarity ratings instead of word frequency, because word frequency was significantly correlated with the number of morae, $r(81) = -.228$, $p < .05$, and orthographic neighborhood size, $r(81) = -.256$, $p < .025$.

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Stimuli. Seventy-two kanji words were initially selected from Amano and Kondo's (2003b) frequency database. These were all two-character kanji words with three or four morae. Their frequency counts were all less than 3,000 (10.42 per million) according to Amano and Kondo's database. Forty-eight of these kanji words were homophones, and the rest were nonhomophones. Half of the homophones had only a single orthographically similar homophonic mate. That is, each word possessed only a single higher frequency homophonic mate with which it shares a kanji character (e.g., for 悪習 [bad habit], /a.ku.sju.u/, 悪臭 [bad smell] was the only higher frequency homophone sharing a single character). Mean word frequencies of these 24 homophones and their homophonic mates were 564.83 (1.96 per million) and 10,187.88 (35.40 per million), respectively. In contrast, the rest of the homophones were those with only a single orthographically dissimilar homophonic mate. That is, each word possessed only a single higher frequency homophonic mate with which it does not share any characters (e.g., for 血管 [blood vessel], /ke.Q.ka.N/, 欠陥 [defect] was the higher frequency homophone not sharing any character). Mean frequencies of these 24 homophones and their homophonic mates were 566.50 (1.97 per million) and 2,866.96 (9.96 per million), respectively. The accent type was identical for the homophone and its homophonic mate for all the homophones according to Amano and Kondo's (2003a) accent type database. Mean frequency of the 24 nonhomophones was 554.88 (1.93 per million).

Word length and the number of morae were exactly matched across the two groups of homophones and the group of nonhomophones. In addition, as shown in Table 5, word frequency, familiarity ratings, summed character frequency, and orthographic neighborhood size were equated across the three word groups (Fs < 1).

As in Experiment 2, we attempted to match the character variables that would potentially affect lexical decision performance for compound words. In order to equate the degree of transparency of the constituent characters and the compounds, we attempted to match the relatedness ratings between the compound and the left (right) constituent using the ratings collected in Experiment 2. The ratings between the compound and the left constituent and the ratings between the compound and the right constituent were both comparable across the three word groups (Fs < 1). In addition, family sizes of the left constituents, family sizes of the right constituents, family frequencies of the left constituents, and family frequencies of the right constituents were all equated across the three word groups (Fs < 1.6). The forward and backward predictabilities were also comparable across the three word groups (Fs < 1).

In addition, the orthographic-phonological consistency index values were comparable across the three word groups. When orthographic neighbors with a phonemic alternation were classified as phonological enemies, the mean index values for the homophones with an orthographically similar mate, the homophones with a dissimilar mate, and the nonhomophones were .82, .80, and .80, respectively, $F(2, 69) = 0.05$, $MSE = 0.06$. When neighbors with a phonemic alternation were classified as phonological friends, the mean values were .93, .85, and .85, respectively, $F(2, 69) = 1.18$, $MSE = 0.04$. The three groups of kanji words are listed in Appendix B.

In addition to the 72 kanji words, 72 kanji nonwords were created by arbitrarily pairing two kanji characters, each having a single pronunciation. According to Amano and Kondo's (2003b) word frequency database, 25 of these nonwords were pseudohomophones. The number of morae was matched for the 72 kanji words and the 72 kanji nonwords. The 72 nonwords are listed in Appendix D. Nine two-character kanji words and 9 two-character kanji nonwords that were not among the 144 experimental stimuli were also used as practice stimuli.

Procedure. The procedure in this experiment was identical to that in Experiments 1 and 2. Eighteen practice trials were given prior to the 144 experimental trials for each participant.

Table 5
Stimulus Characteristics of the Three Groups of Kanji Words Used in Experiment 3

	Word group		
Variable	Homophones with a dissimilar mate	Homophones with a similar mate	Nonhomophones
Morae	3.54	3.54	3.54
Freq	566.50	564.83	554.88
Fam	4.97	5.00	5.05
CF	454,000.04	468,871.83	502,154.08
N	44.00	48.83	51.29
Rel to left	4.76	4.97	5.03
Rel to right	5.08	5.25	5.27
Left FS	18.03	23.88	19.29
Right FS	25.92	24.96	32.00
Left FF	31,703.54	60,389.46	75,127.42
Right FF	67,045.88	87,522.71	99,904.00
Forward P	0.106	0.031	0.065
Backward P	0.077	0.029	0.035

Note. Morae, Freq, Fam, CF, and N stand for mean number of morae, mean word frequency, mean familiarity rating, mean summed character frequency, and mean orthographic neighborhood size, respectively. Rel to left (right) stands for mean relatedness rating between the left (right) constituent character and the kanji compound. Left (Right) FS and Left (Right) FF stand for mean family size and mean family frequency of the left (right) constituent, respectively. Forward (Backward) P stands for the forward (backward) predictability computed by dividing the frequency of the compound by the left (right) constituent family frequency.

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Results

Lexical decision 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, 2.05% (62 data points) of the "Word" trials were classified as outliers and excluded from the statistical analyses. Further, 14.62% (442 data points) of the "Word" trials were errors and, hence, these trials were also excluded from the latency analyses. Mean response latencies and error rates for the "Word" trials were calculated across both subjects and items and submitted to one-way ANOVAs. Word type (homophones with an orthographically similar mate, homophones with an orthographically dissimilar mate or nonhomophones) was a within-subject factor in the subject analysis and a between-item factor in the item analysis. The mean lexical decision latencies and error rates from the subject analyses are presented in Table 6.

In the analyses of lexical decision latencies, the main effect of word type was significant in both analyses, $F_1(2, 82) = 35.10$, $MSE = 360.11$, $p < .001$, $\eta_p^2 = .46$; $F_2(2, 69) = 3.18$, $MSE = 4{,}363.34$, $p < .05$, $\eta_p^2 = .08$. Pairwise comparisons revealed that the 31-ms difference between homophones with an orthographically dissimilar mate and nonhomophones was significant in both analyses, $F_1(1, 41) = 48.29$, $MSE = 418.79$, $p < .001$, $\eta_p^2 = .54$; $F_2(1, 46) = 5.64$, $MSE = 4{,}586.25$, $p < .025$, $\eta_p^2 = .11$. The 29-ms difference between homophones with an orthographically similar mate and nonhomophones was also significant in both analyses, $F_1(1, 41) = 53.31$, $MSE = 330.34$, $p < .001$, $\eta_p^2 = .57$; $F_2(1, 46) = 4.86$, $MSE = 2{,}880.75$, $p < .05$, $\eta_p^2 = .10$. Crucially, in both cases, the direction of the homophone effect was inhibitory. The 2-ms difference between the two types of homophones was not significant in either analysis (Fs < 1).

In the analyses of error rates, the main effect of word type was significant in both analyses, $F_1(2, 82) = 28.01$, $MSE = 46.77$, $p < .001$, $\eta_p^2 = .41$; $F_2(2, 69) = 3.62$, $MSE = 205.34$, $p < .05$, $\eta_p^2 = .10$. Pairwise comparisons further revealed that 11.12% difference between homophones with an orthographically dissimilar mate and nonhomophones was significant in both analyses, $F_1(1, 41) = 68.18$, $MSE = 38.08$, $p < .001$, $\eta_p^2 = .62$; $F_2(1, 46) = 6.07$, $MSE = 242.81$, $p < .025$, $\eta_p^2 = .12$. The 6.48% difference between homophones with an orthographically similar mate and nonhomophones was also significant in both analyses, $F_1(1, 41) = 18.99$, $MSE = 46.37$, $p < .001$, $\eta_p^2 = .32$; $F_2(1, 46) = 4.41$, $MSE = 113.41$, $p < .05$, $\eta_p^2 = .09$. Again, these differences reflect an inhibitory homophone effect. The 4.64% difference between the two types of homophones was significant in the subject analysis, $F_1(1, 41) = 8.10$, $MSE = 55.87$, $p < .01$, $\eta_p^2 = .17$, although not in the item analysis, $F_2(1, 46) = .99$, $MSE = 259.79$, reflecting the tendency for the error rates to be higher for the homophones with an orthographically dissimilar mate than for the homophones with an orthographically similar mate.[8]

Discussion

In contrast to the results of Experiment 2, a homophone disadvantage was observed in Experiment 3, a result similar to the processing disadvantage typically observed when homophones possess only a single homophonic mate in the previous English (and French) studies (e.g., Edwards et al., 2004; Ferrand & Grainger, 2003; Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002; Rubenstein et al., 1971). Note also that in the latency data, the effect size was comparable for the two types of homophones (with the effect in the error data actually being slightly larger for the homophones with a dissimilar mate), further supporting the idea that the homophone competition for kanji words is not larger for homophones that are orthographically similar to their homophonic mates.

In addition, because three homophones with a single orthographically dissimilar mate produced more than 50% error rates (巨砲 [huge gun], 美文 [elegant prose], and 採否 [adoption and rejection]), we reanalyzed the data with these items being removed. The mean error rate for the homophones with an orthographically dissimilar mate dropped to 14.02%. As a result, the main effect of word type was now significant only in the subject analysis of error rates, $F_1(2, 82) = 11.47$, $MSE = 44.63$, $p > .001$, $\eta_p^2 = .22$; $F_2(2, 66) = 2.11$, $MSE = 134.53$, and the mean error rates became comparable for the two types of homophones, $F_1(1, 41) = 0.28$, $MSE = 54.36$; $F_2(1, 43) = 0.07$, $MSE = 154.91$, while the results from the analyses of lexical decision latencies were essentially unchanged. As such, it appears that the higher error rates for the homophones with an orthographically dissimilar mate were due to these specific stimuli rather than to orthographic dissimilarity among homophones per se.

Together with the results from Experiment 2, these results support the idea that the active factor when processing homophones is the number of homophonic mates. When homophones possess only a single homophonic mate, as most of English homophones do, a processing disadvantage is observed in a lexical decision task. When homophones possess multiple homophonic mates, as most Chinese homophones do, however, a processing advantage emerges in a lexical decision task, with the size of the advantage growing as the number of homophonic mates increases.[9]

[8] In order to make sure that the effects observed in Experiment 3 were not familiarity effects, as in Experiment 1, we conducted ANCOVAs for item means of lexical decision latencies and error rates using familiarity ratings from Amano and Kondo (2003a) as the covariate. In the analyses of lexical decision latencies, the main effect of word type was significant in the ANCOVA, $F_2(2, 68) = 3.76$, $MSE = 2{,}942.97$, $p < .05$. In the analyses of error rates, the main effect of word type was also significant in the ANCOVA, $F_2(2, 68) = 6.44$, $MSE = 86.55$, $p < .01$. As such, in contrast to the results from Experiment 1, the homophone disadvantage observed in Experiment 3 cannot be attributed to the difference in familiarity across word groups.

[9] Given the significant inhibitory homophone effect in Experiment 3, one may wonder whether Tamaoka (2007) observed an inhibitory effect, because most of his homophones had few mates (rather than a poor matching of familiarity). As previously noted, the mean numbers of homophonic mates were 9.48 and 2.37 for his homophones and nonhomophones when counting the number of homophones using Amano and Kondo's (2003b) frequency database. However, when counting the number of higher frequency homophonic mates of his stimuli, the means were 1.70 and 0.19 for his homophones and nonhomophones, indicating that most of the homophonic mates were somewhat low in frequency. If some of these homophonic mates were sufficiently low in frequency to be unknown to participants, it may be that at least a part of Tamaoka's inhibitory effect was due to the fact that, functionally, his homophones actually had few homophonic mates.

Table 6
Mean Lexical Decision Latencies (RT) in Milliseconds and Error Rates (ER) in Percent for the Three Types of Kanji Words in Experiment 3

Condition	RT	ER	Homophone effect RT	Homophone effect ER
Homophones with a dissimilar mate	642 (18.80)	19.57 (2.10)	−31	−11.12
Homophones with a similar mate	640 (19.19)	14.93 (1.87)	−29	−6.48
Nonhomophones	611 (17.45)	8.45 (1.24)		

Note. Standard error of the mean is in parentheses. Mean lexical decision latency and error rate for the 72 nonwords were 674 ms ($SEM = 27.30$) and 8.64% ($SEM = 1.06$), respectively.

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Experiment 4

In order to firm up these conclusions, we conducted one further lexical decision experiment in which we manipulated the number of homophonic mates for kanji words. Three groups of kanji words were used. The first group consisted of kanji words with no homophonic mate (i.e., nonhomophones). The second group consisted of kanji words with only a single, higher frequency homophonic mate. The third group consisted of kanji words with more than three homophonic mates (at least one of which was higher in frequency). If the direction of the homophone effect is determined by the number of homophonic mates, we should observe a processing disadvantage for homophones with only a single homophonic mate (as in Experiment 3) and, at the same time, a processing advantage for homophones with multiple homophone mates (as in Experiment 2).

Method

Participants. Forty 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 any of the previous experiments.

Stimuli. Seventy-five kanji words were selected from Amano and Kondo's (2003b) frequency database. These were all two-character kanji words with three or four morae. Their frequency counts were all less than 3,000 (10.42 per million) according to the frequency database. Fifty of these kanji words were homophones, and the rest were nonhomophones. Half of the homophones were those with only a single, higher frequency homophonic mate (e.g., for 妥当 [validity], /da.to.u/, 打倒 [defeat] was the only higher frequency homophonic mate). Mean frequencies of the 25 homophones and their homophonic mates were 408.96 (1.42 per million) and 9,451.76 (32.84 per million), respectively. The accent type of the homophonic mate was the same as that of the target homophone according to Amano and Kondo's (2003a) accent type database. The rest of the homophones were those with more than three homophonic mates (e.g., for 子宮 [uterus], /si.kju.u/, 四球 [base on balls in baseball], 支給 [issue], and 至急 [immediately] were homophonic mates). The average number of homophonic mates of these homophones was 9.44, ranging from 4 to 25. For each of the homophones with multiple homophonic mates, there were at least two homophonic mates that possessed the same accent type as the homophone itself according to Amano and Kondo's accent type database. In addition, at least one of the homophonic mates with the same accent type was higher in frequency than the homophone itself. The mean number of higher frequency homophonic mates was 2.68 (range 1–8). Mean frequencies of the 25 homophones and their higher frequency homophonic mates with the same accent type were 466.16 (1.62 per million) and 13,884.12 (48.24 per million), respectively. Mean frequency of the lowest frequency mate of these 25 homophones was 3.84 (0.01 per million). Mean frequency of the 25 nonhomophones was 437.16 (1.52 per million).

The stimulus set for Experiment 4, therefore, involved three groups of kanji words: 25 homophones with a single homophonic mate, 25 homophones with multiple homophonic mates, and 25 nonhomophones. As shown in Table 7, word length and the number of morae were exactly matched across the three word groups. In addition, word frequency, familiarity ratings, summed character frequency, and orthographic neighborhood size were equated across the three word groups ($F\text{s} < 1$).

Further, as in Experiments 2 and 3, we attempted to match the character variables that would potentially affect lexical decision performance for compound words. In order to equate the degree of transparency of the constituent characters and the compounds, we matched the relatedness ratings between the compound and the left (right) constituent using the ratings collected in Experiment 2. The ratings between the compound and the left constituent and the ratings between the compound and the right constituent were both comparable across the three word groups ($F\text{s} < 1.2$). In addition, family sizes of the left constituents, family sizes of the right constituents, family frequencies of the left constituents, and family frequencies of the right constituents were all equated across the three word groups ($F\text{s} < 1$). The forward and backward predictabilities were also comparable across the three word groups ($F\text{s} < 2.2$).

In addition, as in Experiments 2 and 3, the orthographic-phonological consistency index values were computed for the three groups of kanji words. When orthographic neighbors with a phonemic alternation were classified as phonological enemies, the mean index values for the homophones with a single mate, the homophones with multiple mates, and the nonhomophones were .86, .88, and .74, respectively, $F(2, 72) = 2.53$, $MSE = .05$, $p < .10$. As such, there was a slight tendency that the degree of orthographic-phonological consistency was lower for the nonhomophones. When neighbors with a phonemic alternation were classified as phonological friends, however, the mean values were .91, .88, and .78, and no difference was detected across the three

Table 7
Stimulus Characteristics of the Three Groups of Kanji Words Used in Experiment 4

	Word group		
Variable	Homophones with multiple mates	Homophones with a single mate	Nonhomophones
Morae	3.36	3.36	3.36
Freq	466.16	408.96	437.16
Fam	5.03	5.02	5.01
CF	430,484.40	441,997.04	429,134.56
N	42.12	48.32	42.20
NoH	9.44	1.00	0.00
NoHFH	2.68	1.00	0.00
Rel to left	4.88	4.60	4.95
Rel to right	4.88	5.03	5.41
Left FS	18.64	22.28	15.56
Right FS	23.36	26.04	26.64
Left FF	69,728.84	43,085.32	73,722.78
Right FF	73,039.44	87,181.32	93,537.40
Forward P	0.042	0.019	0.087
Backward P	0.097	0.013	0.048

Note. Morae, Freq, Fam, CF, N, NoH, and NoHFH stand for mean number of morae, mean word frequency, mean familiarity rating, mean summed character frequency, mean orthographic neighborhood size, mean number of homophones, and mean number of higher-frequency homophones, respectively. Rel to left (right) stands for mean relatedness rating between the kanji compound and the left (right) constituent. Left (Right) FS and Left (Right) FF stand for mean family size and mean family frequency of the left (right) constituent, respectively. Forward (Backward) P stands for the forward (backward) predictability computed by dividing the frequency of the compound by the left (right) constituent family frequency.

word groups, $F(2, 72) = 2.30$, $MSE = .05$. The three groups of kanji words are listed in Appendix C.

In addition to the 75 experimental kanji words, the stimulus set involved 15 filler two-character kanji words and 90 kanji nonwords. As in Experiments 1 and 3, the nonwords were created by arbitrarily pairing two kanji characters, each with a single pronunciation. According to Amano and Kondo's (2003b) word frequency database, 24 of the 90 nonwords were pseudohomophones. The 90 nonwords are listed in Appendix D.

The mean number of morae for the 15 filler words was 3.20, ranging from 3 to 4. The mean number of morae for the 90 nonwords was 3.33, which was identical to that for the 90 kanji words. In addition, 9 two-character kanji words and 9 two-character kanji nonwords that were not among the 180 experimental stimuli were used as practice stimuli.

Procedure. The procedure was identical to that in Experiments 1, 2, and 3. Eighteen practice trials were given prior to the experimental trials.

Results

Lexical decision 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, 2.13% (64 data points) of the experimental kanji word trials were classified as outliers and excluded from the statistical analyses. In addition, 10.50% (315 data points) of the experimental kanji word trials were errors. These error trials were excluded from the latency analyses. Mean response latencies and error rates for the experimental kanji word trials were calculated across both subjects and items and submitted to one-way ANOVAs. Word type (homophones with a single mate, homophones with multiple mates, or nonhomophones) was a within-subject factor in the subject analysis but a between-item factor in the item analysis. The mean lexical decision latencies and error rates from the subject analyses are presented in Table 8.

In the analyses of lexical decision latencies, the main effect of word type was significant in both analyses, $F_1(2, 78) = 19.97$,

Table 8
Mean Lexical Decision Latencies (RT) in Milliseconds and Error Rates (ER) in Percent for the Three Types of Kanji Words in Experiment 4

			Homophone effect	
Condition	RT	ER	RT	ER
Homophones with multiple mates	623 (14.58)	6.78 (0.94)	22	0.40
Homophones with a single mate	676 (20.77)	15.40 (1.42)	−31	−8.22
Nonhomophones	645 (15.31)	7.18 (1.21)		

Note. Standard error of the mean is in parentheses. Mean lexical decision latency and error rate for the 90 nonwords were 713 ms ($SEM = 27.14$) and 5.96% ($SEM = 0.80$), respectively.

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MSE = 1,384.94, $p < .001$, $\eta_p^2 = .34$; $F_2(2, 72) = 6.10$, MSE = 3,806.20, $p < .01$, $\eta_p^2 = .15$. Pairwise comparisons further revealed that the 53-ms difference between the two types of homophones was significant in both analyses, $F_1(1, 39) = 29.83$, MSE = 1,839.13, $p < .001$, $\eta_p^2 = .43$; $F_2(1, 48) = 11.47$, MSE = 3,974.41, $p < .01$, $\eta_p^2 = .19$. As such, a significant effect of number of homophones was observed in the present experiment. The 31-ms processing disadvantage for the homophones with a single homophonic mate relative to the nonhomophones was also significant in both analyses, $F_1(1, 39) = 11.27$, MSE = 1,632.89, $p < .01$, $\eta_p^2 = .22$; $F_2(1, 48) = 4.03$, MSE = 4,343.00, $p = .05$, $\eta_p^2 = .08$. The 22-ms processing advantage for the homophones with multiple homophonic mates relative to the nonhomophones was significant in the subject analysis, $F_1(1, 39) = 14.23$, MSE = 682.81, $p < .01$, $\eta_p^2 = .27$, although not in the item analysis, $F_2(1, 48) = 2.13$, MSE = 3,101.19.

In the analyses of error rates, the main effect of word type was significant in both analyses, $F_1(2, 78) = 47.16$, MSE = 20.10, $p < .001$, $\eta_p^2 = .55$; $F_2(2, 72) = 5.47$, MSE = 111.81, $p < .01$, $\eta_p^2 = .13$. Pairwise comparisons further revealed that the 8.62% difference between the two types of homophones was significant in both analyses, $F_1(1, 39) = 70.19$, MSE = 21.20, $p < .001$, $\eta_p^2 = .64$; $F_2(1, 48) = 7.02$, MSE = 137.88, $p < .025$, $\eta_p^2 = .13$. The 8.22% processing disadvantage for the homophones with a single homophonic mate relative to the nonhomophones was also significant in both analyses, $F_1(1, 39)$ = 50.42, MSE = 26.83, $p < .001$, $\eta_p^2 = .56$; $F_2(1, 48) = 6.66$, MSE = 129.92, $p < .025$, $\eta_p^2 = .12$. The 0.40% difference between the homophones with multiple homophonic mates and the nonhomophones was not significant in either analysis, $F_1(1, 39) = 0.26$, MSE = 12.28; $F_2(1, 48) = 0.04$, MSE = 67.63.[10]

As in Experiment 3, lexical decision responses were slower and less accurate for homophones with only a single homophonic mate than those for nonhomophonic controls. In addition, as in Experiment 2, lexical decision responses were faster for homophones when they possessed more homophonic mates.

Discussion

In Experiment 4, we successfully replicated both the processing disadvantage for homophones with only a single homophonic mate and the processing advantage for homophones with multiple homophonic mates in a single lexical decision task. What is also worth noting is that the number of homophones was highly correlated with the number of higher frequency homophones for our word stimuli, $r(75) = .729$, $p < .01$. It is possible, therefore, that higher frequency mates may play a central role in the facilitation processes.

The conjecture that the number of higher frequency mates may play a central role in producing facilitation (i.e., more higher frequency mates produce more facilitation), along with the fact that there is inhibition in the single mate condition, raises an interesting possibility. It may be the existence of exactly one higher frequency mate that creates the conditions for inhibition.[11] In order to look more closely at this issue, we performed an analysis after removing the six (of 25) words in the multiple mate condition that had exactly one higher frequency mate (as well as a similar number of words from the other conditions in order to maintain a balance on factors such as frequency and length). This analysis, however, produced the same pattern as the original analysis (i.e., it once again showed a significant difference between the multiple mate condition and the nonhomophone condition in the subject ANOVA but not in the items ANOVA). Therefore, although, as noted, it is not clear whether the key factor in producing facilitation is the number of mates or the number of higher frequency mates, it does not appear that words having exactly one higher frequency mate have any special status.

The most important point here is that the results of the present experiments clearly support the claim that the contradictory findings for homophones in the previous English and Chinese studies were due to the difference in the number of homophonic mates for English and Chinese homophones. In the previous English studies (e.g., Edwards et al., 2004; Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002; Rubenstein et al., 1971), a homophone disadvantage has been repeatedly reported in lexical decision tasks. It is quite likely that such an effect emerged because the English homophones used possess only a single (higher frequency) homophonic mate. In the previous Chinese studies (e.g., Chen et al., 2009; Ziegler et al., 2000), on the other hand, what has been generally reported is a homophone advantage. Based on the present results, it appears that a homophone advantage was observed in these studies because most Chinese homophones possess multiple homophonic mates.

General Discussion

Although homophone effects have been reported in a number of previous studies using lexical decision tasks, the direction of the effect has varied across the studies. In particular, although a number of studies using English and French stimuli have consistently reported a processing disadvantage for homophones (e.g., Edwards et al., 2004; Ferrand & Grainger, 2003; Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002; Rubenstein et al., 1971), a processing advantage for homophones has been consistently reported in the studies using Chinese stimuli (e.g., Chen et al., 2009; Ziegler et al., 2000).

In order to resolve this apparent contradiction, we examined homophone effects for Japanese kanji words using a lexical decision task. English and French are alphabetic languages, but Chinese and Japanese kanji are logographically scripted languages. Hence, if the direction of a homophone effect is determined by script type, a homophone advantage is expected for Japanese kanji words. Kanji words also allow a manipulation of the number of homophonic mates across a wide range of values from words with a single homophonic mate, as with most English homophones, to words with multiple mates, as with most Chinese homophones. In

[10] In order to make sure that the effects observed in Experiment 4 were not familiarity effects, as in Experiments 1 and 3 we conducted ANCOVAs for item means of lexical decision latencies and error rates using familiarity ratings from Amano and Kondo (2003a) as the covariate. In the analyses of lexical decision latencies, the main effect of word type was significant in the ANCOVA, $F_2(2, 71) = 7.99$, MSE = 2,898.86, $p < .01$. In the analyses of error rates, the main effect of word type was also significant in the ANCOVA, $F_2(2, 71) = 7.80$, MSE = 78.80, $p < .01$. As such, the effects observed in Experiment 4 cannot be attributed to the difference in familiarity across word groups.

[11] We thank Marcus Taft for suggesting this analysis.

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addition, there are homophonic kanji mates that are orthographically dissimilar, as with many Chinese homophones, and there are also homophonic kanji mates that are orthographically similar, as with many English homophones. In our lexical decision experiments using two-character kanji words, therefore, we attempted to determine whether the direction of the homophone effect depends on (a) the nature of script type, (b) orthographic similarity of homophonic mates, and/or (c) the number of homophonic mates.

Although we were able to replicate Tamaoka's (2007) inhibitory homophone effect using his kanji stimuli in Experiment 1, we found that his results were contaminated by differences in familiarity ratings for his homophones and nonhomophones. Using a new set of stimuli with a number of variables (including familiarity ratings) that could potentially affect lexical decision performance being controlled across word groups in Experiment 2, we observed a facilitatory homophone effect, paralleling the results in the Chinese studies (e.g., Chen et al., 2009; Ziegler et al., 2000). In addition, the facilitatory effects were comparable regardless of the orthographic similarity between the target homophone and its homophonic mates, suggesting that the orthographic similarity among homophones plays little role in producing a facilitatory homophone effect for kanji words. Further, additional regression analyses provided evidence that what is important in producing a homophone advantage is having a large number of homophonic mates.

The results from Experiment 2 suggest that it is either the nature of script type (logographic versus alphabetic) or the number of homophonic mates that determines the direction of a homophone effect. We attempted to discriminate between these alternatives in Experiment 3. In particular, we evaluated the homophone effect for kanji words with only a single homophonic mate. Regardless of the orthographic similarity between the target homophone and its homophonic mate, we observed a homophone disadvantage for homophones with only a single mate, a result paralleling to those in the previous English studies. These results clearly point to the conclusion that it is the number of homophonic mates that determines the direction of the homophone effect. Thus, in Experiment 4, we manipulated the number of homophonic mates in an attempt to replicate the inhibitory homophone effect for homophones with a single mate and the facilitatory effect for homophones with multiple mates. These replications were successful. As such, the results of our experiments support the hypothesis that the impact of homophony is determined by the number of homophonic mates possessed by target homophones: Although homophones with only a single (higher frequency) homophonic mate are processed slowly, producing a processing disadvantage in comparison to nonhomophones, homophones with multiple homophonic mates are processed more rapidly, producing a processing advantage in comparison to nonhomophones. In addition, because the number of homophones and the number of higher frequency homophones were highly correlated with one another for our word stimuli in Experiment 2, $r(81) = .637$, $p < .01$; Experiment 3, $r(72) = 1.00$, $p < .01$; and Experiment 4, $r(75) = .729$, $p < .01$, these results could be interpreted as showing that the number of higher frequency homophonic mates is important in producing the facilitatory effect. However, the most important conclusion is that the contradictory homophone effects in the previous English and Chinese studies are due to differences in the number of homophonic mates for English and Chinese homophones.

Consistent with Chen et al. (2009) and Ziegler et al. (2000), therefore, we were successful in producing a facilitatory homophone effect using kanji words with multiple homophonic mates in Experiments 2 and 4, and at the same time, we were also successful in producing an inhibitory homophone effect for kanji words with only a single homophonic mate consistent with studies using alphabetic languages, (e.g., Edwards et al., 2004; Ferrand & Grainger, 2003; Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002; Rubenstein et al., 1971). As such, although we only used two-character kanji compound words in our experiments, it appears that the conclusions from our results can be extended to both monomorphemic words in logographically scripted languages (e.g., Chinese) and monomorphemic and polymorphemic words in alphabetic languages (e.g., English and French). That is, regardless of the direction of the effect, an effect of homophony would suggest that automatic phonological activation arises when reading a word. In addition, regardless of script type and morphological structure, the reading speed of a word would be modulated by the number of homophonic mates a word has: the reading speed would be slowed when there is a single homophonic mate but would be facilitated when there are multiple mates. It also appears that the processes responsible for producing these effects are not unusual ones but rather are ones that are commonly involved when reading a word regardless of its script type and morphological structure. In what follows, we discuss the nature of the processes potentially responsible for producing these effects.

Why Is One Homophonic Mate Bad and Multiple Mates Good?

As noted earlier, the processing disadvantage for homophones with a single homophonic mate can be explained by competition created by feedback from the phonological level to the orthographic/lexical level as suggested by Pexman and colleagues (e.g., Edwards et al., 2004; Kerswell et al., 2007; Pexman & Lupker, 1999; Pexman et al., 2001, 2002). If so, one would expect a similar process to occur when reading kanji or Chinese. Therefore, the question becomes what changes when multiple mates exist that creates a homophone advantage.

Ziegler et al. (2000) and Chen et al. (2009) each offered explanations of the homophone advantage when there are multiple mates. Ziegler et al. suggested that the advantage is due to the fact that the cumulative phonological frequencies for homophones with multiple mates are substantially higher than those for nonhomophones. Chen et al. (2009), on the other hand, suggested that if one assumes phonological feedback to the orthographic/lexical level, the global orthographic/lexical activation would be substantially higher for words with more homophonic mates. Under this circumstance, rapid "Word" decisions could be based on this higher level of global orthographic/lexical activity. Although both Ziegler et al.'s and Chen et al.'s accounts were also based on the assumption that the strength of the competition at the orthographic/lexical level is modulated by the orthographic similarity between the target homophone and its homophonic mates (an assumption that appears to be incorrect for Japanese kanji words), neither account requires this assumption; hence, it will not be part of the subsequent discussion.

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Global activity account (Chen et al., 2009). As noted, according to this account, a processing advantage for homophones arises due to higher global orthographic/lexical activity in situations where positive lexical decisions can be made based on such activity (e.g., the Σ criterion in Grainger and Jacobs's 1996 MROM). This account would, of necessity, carry with it the assumption that such would not be the case when homophones have only one mate because a single mate would not cause a large increase in global orthographic/lexical activity. In that situation, decisions would presumably be based on the activity in the orthographic/lexical unit of the presented word (e.g., the M criterion in MROM), activity that would be slow to grow due to the competition from the homophonic mate. With these assumptions, this account would appear to provide an explanation not only for the present data but also for the pattern in the literature showing a processing disadvantage for English and French homophones and a processing advantage for Chinese homophones.

A clear problem for this type of account, however, is that, as Chen et al. (2009) pointed out, it cannot explain the homophone advantage in their naming task. That is, in order to name a word aloud, a correct pronunciation would have to be retrieved and, hence, a single lexical unit would have to be selected regardless of the number of homophonic mates. Presumably, such would be particularly true in a logographically scripted language like Chinese or with a logographic script like Japanese kanji, because in both cases word naming is assumed to be a lexically-based, rather than an assembly-based, process. Therefore, although this account can explain the processing advantage and disadvantage for homophones in our lexical decision experiments, it would seem to have considerable difficulty explaining the processing advantage observed in Chen et al.'s (2009) and Ziegler et al.'s (2000) naming experiments. Note also that this type of account would not predict a processing advantage for words with multiple homophonic mates in perceptual identification and semantic categorization tasks because these tasks require participants to specifically identify the presented word (and retrieve its meaning) before responding.

Higher phonological frequency for homophones (Ziegler et al., 2000). The question is, therefore, can phonological familiarity also explain the homophone advantage in naming in addition to the effect in lexical decision. As Ziegler et al. (2000) suggest, the answer would seem to be yes. That is, in addition to increasing the overall lexical activation, hence, aiding lexical decision making, phonological familiarity would aid in the creation of output phonology. That is, in a naming task, a processing advantage may emerge because the phonological representation that must be produced has been activated many different times by many different words in the past. The further implication, of course, is that higher frequency homophonic mates would tend to be more beneficial, a proposal that is relatively consistent with the data in our Experiment 4. In essence, then, the homophone advantage in naming in kanji and Chinese would be assumed to be an output phonology effect rather than a lexical effect.

Note that this explanation is also reasonably consistent with what has been reported when examining homophone naming in English. That is, in English, the impact of homophones in naming is much weaker and apparently not facilitatory. For example, Pexman et al. (2002) observed no significant effect in their naming and phonological lexical decision tasks using the same stimuli that produced a disadvantage in lexical decision. Edwards et al. (2004) even reported a significant processing disadvantage for homophones in their naming task, although the effect size was much smaller in naming than in lexical decision. There is also a second English study reporting a significant homophone disadvantage in a naming task (i.e., Biedermann, Coltheart, Nickels, & Saunders, 2009). As such, although one cannot say that there definitely is a true homophone disadvantage in naming in English, the bulk of the evidence does support the claim that there is little, if any, evidence for a processing advantage for homophones in the previous English naming studies.

If phonological familiarity were the explanation for the homophone advantage in naming in Chinese, the pattern noted above is essentially what would be expected in English. That is, there would be an inhibitory effect on naming in English (due to orthographic/lexical competition). However, that effect would be muted to some degree by either the small degree of phonological familiarity available for English homophones or, from a dual-route perspective, by the fact that the naming of English words can also be accomplished (or aided) by processing on a nonlexical route (Biedermann et al., 2009).

Note that this explanation of the homophone advantage in Chinese and Japanese kanji is based on the shared representation view (i.e., a shared phonological representation is assumed for homophones). Such an idea certainly has precedent in the literature. For example, Jescheniak and Levelt (1994) reached a similar conclusion based on the results in their translation task. Jescheniak and Levelt asked Dutch–English bilinguals to translate English words into Dutch and compared the translation performance for three types of Dutch words: low-frequency homophones, low-frequency nonhomophonic controls, and high-frequency nonhomophonic controls whose frequencies were matched with the cumulative frequencies of the homophonic pairs. Consistent with Ziegler et al.'s (2000) naming data, the translation latencies for the low-frequency homophones were similar to those for the high-frequency controls, which were significantly shorter than those for the low-frequency controls.

What does need to be noted, however, is that, although Chen et al. (2009) observed a number of homophones effect in their lexical decision and naming tasks, they failed to observe a cumulative frequency effect of homophones in these tasks. In addition, Caramazza, Costa, Miozzo, and Bi (2001) failed to observe a cumulative frequency effect of homophones in their picture naming and translation tasks (see Biedermann et al., 2009, for a review). Therefore, the mechanism by which these phonological codes come to gain their familiarity and their ability to influence performance is not yet well understood. More research is clearly needed to gain a better understanding of these issues (i.e., the development of phonological familiarity and its impact on the nature of phonological representations).

Conclusions

Although a homophone disadvantage has been repeatedly reported in the previous English (and French) studies, a homophone advantage has been consistently reported in the previous Chinese studies. In order to resolve these apparently contradictory findings, we examined the homophone effect using Japanese kanji words in four lexical decision experiments. In our experiments, a processing disadvantage was observed when homophones possessed only a single homophonic mate. At the same time, a processing advantage was observed when homophones possessed multiple homophonic mates. Given the fact that most English homophones possess only a single homophonic mate but most Chinese homophones possess multiple homophonic mates, our results suggest that differences in the number of homophonic mates do explain the apparent contradiction.

As argued by Pexman et al. (2002), the homophone disadvantage is likely due to the competition at the orthographic/lexical level created by phonological feedback, especially when there is only a single homophonic mate. The homophone advantage, in contrast, may have two sources, the higher global orthographic/lexical activity created by phonological feedback in lexical decision (as suggested by Chen et al., 2009) and the impact of very high phonological familiarity for homophones in naming (as suggested by Ziegler et al., 2000). As such, in either situation, the impact of multiple homophonic mates would be to allow the system to overcome any competition at the orthographic/lexical level, producing a processing advantage for homophones with multiple mates.

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(*Appendices follow*)

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Appendix A

Homophones With No Orthographically Similar Homophonic Mate, Homophones With at Least One Higher Frequency Orthographically Similar Homophonic Mate, and Nonhomophones Used in Experiment 1 Along With Their English Translations

Homophones with orthographically dissimilar homophonic mates		Homophones with orthographically similar homophonic mates		Nonhomophones	
Kanji word	English translation	Kanji word	English translation	Kanji word	English translation
試演	rehearsal	校務	school duties	所望	desire
府政	prefectural administration	初診	initial medical examination	尿意	a desire to urinate
任地	one's post	捕捉	capture	地底	depths of the earth
添加	addition	固体	solid	返書	reply, response
容姿	appearance	患部	affected part	社風	corporate culture
計器	gauge	自律	autonomy	炊事	cooking
辞令	appointment letter	既定	default	殺意	intent to kill
酸化	oxidation	異状	abnormality	切除	resection
水位	water level	事典	encyclopedia	歌曲	song, melody
刺殺	stabbing to death	最期	one's last moment	自決	suicide
仮定	assumption	不審	doubt, suspicion	節度	moderation
妥当	validity	飼料	fodder	出家	priest, entering the priesthood
子宮	uterus	精度	precision	初演	first performance
競技	game, match	避難	evacuation	査察	inspection
能動	active	週給	weekly pay	閉門	closing of a gate
即金	payment in full	張力	tension	沸点	boiling point
執心	enthusiasm	純水	pure water	谷底	bottom of valley
偏食	biased nutrition	洋品	haberdashery	直送	direct delivery
神前	before god	新説	new theory	放任	noninterference
転回	rotation	降水	precipitation	職能	function, work ability
洋食	Western-style meal	廃水	waste water	接客	serving customers
結石	calculus	高給	high salary	着席	sit down
開廷	opening of trial	発泡	foaming	適法	legality
定刻	on time	消失	disappear	真空	vacuum
特典	privilege	開校	opening a school	触発	being inspired
水深	depth of water	全勝	complete victory	水爆	hydrogen bomb
再三	repeatedly	校内	within a school	管轄	jurisdiction

(Appendices continue)

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Appendix B

Homophones With a Single Higher Frequency Orthographically Dissimilar Homophonic Mate, Homophones With a Single Higher Frequency Orthographically Similar Homophonic Mate, and Nonhomophones Used in Experiment 3 Along With Their English Translations

Homophones with an orthographically dissimilar homophonic mate		Homophones with an orthographically similar homophonic mate		Nonhomophones	
Kanji word	English translation	Kanji word	English translation	Kanji word	English translation
相似	huge gun	葬具	funeral items	世人	people
懐疑	fighting sport	素因	basic factor	所望	desire
仕様	difficulty	着岸	reaching the shore	作図	drawing figures
容姿	milk tooth	木像	wooden statue	尿意	a desire to urinate
計器	pregnancy	悪習	bad habit	段落	paragraph
酸化	elegant prose	図上	on a diagram	閉門	closing of a gate
仮定	talented person	中段	the middle of the stairs	沸点	boiling point
子宮	biased nutrition	終業	end of work	寝顔	sleeping face
正妻	old state of affairs	戸別	door-to-door	谷底	bottom of valley
執心	meal ticket	漂白	bleaching	直送	direct delivery
神官	adoption or rejection	私営	privately operated	地底	depths of the earth
感傷	thin ice	旧友	old friend	突撃	charge, dash
校務	calculus	特級	special grade	骨盤	pelvis
冬期	private-school student	個数	number of articles	返書	reply, response
師弟	one’s post	異存	objection	放任	noninterference
視角	modesty	患部	affected part	適法	legality
捕捉	on time	産出	produce	切除	resection
事典	appointment letter	直系	direct descent	真空	vacuum
自律	withdrawal	乗務	doing transport-related work	歌曲	song, melody
飼料	water level	酒類	alcoholic drinks	自決	suicide
閉校	validity	演芸	entertainment	節度	moderation
感光	blood vessel	精度	precision	管轄	jurisdiction
降水	repeatedly	月刊	monthly publication	送金	remittance
高給	production	実効	practical effect	組長	boss

(*Appendices continue*)

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Appendix C

Homophones With Multiple Homophonic Mates, Homophones With a Single Homophonic Mate, and Nonhomophones Used in Experiment 4 Along With Their English Translations

Homophones with multiple homophonic mates		Homophones with a single homophonic mate		Nonhomophones	
Kanji word	English translation	Kanji word	English translation	Kanji word	English translation
相似	similarity	難易	difficulty	作図	drawing figures
懐疑	skepticism	格技	fighting sport	隠語	secret language, jargon
仕様	method, specification	巨頭	leader	顕著	remarkable
容姿	appearance	任地	one’s post	地底	depths of the earth
計器	gauge	軽油	diesel oil	切除	resection
酸化	oxidation	妥当	validity	歌曲	song, melody
仮定	assumption	食券	meal ticket	出家	priest, entering the priesthood
子宮	uterus	定刻	on time	段落	paragraph
正妻	legal wife	特典	privilege	沸点	boiling point
執心	enthusiasm	脱会	withdrawal	直送	direct delivery
神官	Shinto priest	巨像	colossus	骨盤	pelvis
感傷	sentiment	不敗	invincibility	管轄	jurisdiction
校務	school duties	図上	on a diagram	所望	desire
冬期	wintertime	戸別	door-to-door	恥骨	pubic bone
師弟	teacher and student	私営	privately operated	寝顔	sleeping face
視角	visual angle	捕球	catch	世評	public opinion
捕捉	capture	異存	objection	悲恋	disappointed love
事典	encyclopedia	患部	affected part	旅路	journey
自律	autonomy	乗務	doing transport-related work	炊事	cooking
飼料	fodder	精度	precision	鎖国	national isolation
閉校	closing a school	前菜	relishes	節度	moderation
感光	exposure, sensitization	漂白	bleaching	曲解	distortion
降水	precipitation	悪習	bad habit	谷底	bottom of valley
高給	high salary	敗色	signs of defeat	突撃	charge, dash
校内	within a school	演芸	entertainment	送金	remittance

(*Appendices continue*)

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Appendix D

Two-Character Kanji Nonwords Used in Experiments 2, 3, and 4

Eighty-One Two-Character Kanji Nonwords Used in Experiment 2

朱淑, 酪予, 詐紺, 亜姻, 是紳, 蚊悦, 窒稚, 詞勲, 炉廉, 陛簿, 嫡惰, 赦爵, 曜吏, 需囚, 百妃, 賦賓, 獄邪, 糾揮, 扶爆, 痴諾, 魅膜, 宇衛, 妥胆, 弐毒, 尿徒, 即貯, 恩佳, 寧派, 以域, 季識, 理倫, 魔密, 純諸, 他泰, 意逸, 巨却, 未紋, 碑能, 微堂, 銀具, 部鉄, 電途, 論零, 録了, 隆烈, 料敏, 脈盟, 陽勅, 徳僕, 翌抄, 尺典, 徹撤, 忠朕, 俊陣, 迅約, 享乙, 刑逐, 警芸, 欧該, 没匿, 屈遇, 傑穀, 湾宅, 英械, 駅週, 喫禅, 帳俗, 賛遵, 楼欄, 浪厘, 畔猟, 領督, 弁擁, 閣譲, 丹核, 晩髄, 籍胞, 妙銅, 禁嚇, 菌呈, 宴校

Seventy-Two Two-Character Nonwords Used in Experiments 3

炉廉, 赦爵, 需囚, 百妃, 嫡惰, 曜吏, 賦賓, 獄邪, 糾揮, 扶爆, 痴諾, 魅膜, 宇衛, 妥胆, 弐毒, 尿徒, 即貯, 恩佳, 寧派, 以域, 理倫, 季識, 純諸, 魔密, 他泰, 意逸, 巨却, 未紋, 碑能, 銀具, 微堂, 部鉄, 電途, 楼欄, 籍胞, 浪厘, 徹撤, 欧該, 喫禅, 丹核, 菌呈, 享乙, 賛遵, 畔猟, 脈盟, 翌抄, 傑穀, 録了, 料敏, 陽勅, 刑逐, 湾宅, 閣譲, 徳僕, 没匿, 駅週, 隆烈, 忠朕, 妙銅, 俊陣, 弁擁, 帳俗, 領督, 禁嚇, 英械, 晩髄, 屈遇, 宴校, 尺典, 迅約, 論零,警芸

Ninety Two-Character Kanji Nonwords Used in Experiment 4

部鉄, 銀具, 碑能, 巨却, 意逸, 純諸, 魔密, 理倫, 季識, 恩佳, 即貯, 弐毒, 尿徒, 妥胆, 痴諾, 魅膜, 扶爆, 賦賓, 獄邪, 赦爵, 需囚, 百妃, 嫡惰, 窒稚, 陛簿, 炉廉, 雲砂, 巨順, 句陣, 妻斜, 糸豚, 酒雪, 秋手, 是則, 値末, 笛座, 麻北, 未紋, 他泰, 寧派, 宇衛, 完義, 県序, 宿位, 条賀, 身羽, 相土, 抵府, 牧夏, 門技, 斗帝, 欧蛾, 塑斥, 微堂, 蚊悦, 幹魚, 特魔, 電途, 以域, 曜吏, 益岩, 題盆, 明幕, 友粒, 涙店, 論零, 録了, 隆烈, 料敏, 脈盟, 陽勅, 徳僕, 翌抄, 尺典, 徹撤, 忠朕, 俊陣, 迅約, 享乙, 刑逐, 警芸, 欧該, 没匿, 屈遇, 傑穀, 湾宅, 英械, 駅週, 錯央, 領督

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