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EFFECTS OF ORTHOGRAPHIC SIMILARITY IN PROCESSING JAPANESE KANJI

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The present study examined whether the processing of orthographic information from two-kanji compound words is affected by contextual information. Twenty-four undergraduate and graduate Japanese students participated in each experiment. Experiment 1 used two-kanji compound words in a lexical decision task to study orthographic processing at the lexical level. Experiment 2 required participants to detect misspellings (i.e., incorrect kanji combinations) of two-kanji compound stimuli embedded in sentences. Experiment 3 used a semantic decision task. In this task, in addition to the sentences used in Experiment 2, contextually incorrect but existing kanji compound words were used as fillers in sentences. In all three tasks, orthographically similar nonwords (矛約 in place of the real word 予約), caused longer reaction times and more errors than orthographically dissimilar nonwords (吐約). However, post-hoc analysis of error rates among the three experiments showed that orthographic processing of orthographically similar nonwords presented individually seems to differ from when the same nonwords are embedded in sentences. This result suggests that contextual information does have an influence on orthographic processing.

Key words: Japanese kanji, orthography, contextual information, orthographic similarity

For various reasons, reading sentences in Japanese involves a very different process from that required for word recognition. One reason may be that the modern Japanese writing system consists of kanji and kana scripts (see details in Kess & Miyamoto, 1999; Tamaoka, 1991; Leong & Tamaoka, 1998). Kanji has both phonetic and semantic value, whereas kana consists of characters used to represent Japanese morae. Another reason may be that sentences are written without spaces between words. Despite the number of reasons, few attempts have been made at studying the role contextual information plays in the recognition of kanji words in sentences.

In Japanese kanji recognition, the correspondence between print and sound are highly complex, and orthography is assumed to be a more important factor than in the case of Japanese kana characters or letters in alphabetic languages (e.g., Saito, 1981). For example, Sakuma, Sasanuma, Tatsumi, and Masaki (1998) examined the role of orthography and phonology using the semantic decision task that was similar to Van Orden (1987). Participants were given a category name (e.g., 植物の栽培, meaning 'the growing of plants') followed by a target word (e.g., 園芸, meaning 'gardening')

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and were asked to judge whether the target word was an example of the given category. In the study by Van Orden (1987), orthographic similarity effects disappeared under pattern-masking conditions, although homophony effects remained strong. In other words, participants' judgement was not varied between orthographically similar spelled foils and less similar foils, whereas they made more false positive errors in homophone foils than in non-homophone foils. In contrary, in the study by Sakuma et al. (1998), however, orthographic similarity effects remained strong, though homophony effects were reduced under masking conditions. Wydell, Patterson and Humphreys (1993) used a similar procedure, and also showed similar results. These studies suggested that orthography is the primary factor in kanji word recognition. The question to consider next is whether orthographic processing is affected by contextual information.

Proofreading is one of the methods that clarifies orthographic similarity effects in reading sentences. In a proofreading task, participants read sentences, and have to detect misspellings. Shimomura and Yokosawa (1995) showed that orthographic similarity strongly affected primal processing in a proofreading task based on comprehension using incorrect two-kanji compound words. In their study, participants missed more orthographically similar nonwords (e.g., 徴熱) that were created from real words (e.g., 微熱, meaning 'a slight fever') than orthographically dissimilar nonwords, though reaction times were not significantly different between the two conditions. Participants judged many orthographically similar nonwords as real words, although when they realized the misspelling, their reaction times were short.

According to Yokosawa (1998), contextual information does not affect orthographic processing. The point is that orthographic similarity effect was only seen in error rates, though the homophony effect was shown in reaction times (Shimomura & Yokosawa, 1991). He argued that there are two stages in the process of detecting misspellings. In the first stage, a reader picks out the candidates for misspelling according to vague orthography. The process of the first stage affects the error rate. In the second stage, a reader judges that the candidates are really misspellings using various information such as phonological information and contextual information. Reaction time reflects the process of the second stage. If this account is correct, orthographic similarity effects would be the same regardless of context. According to the results from a study done by Shimomura and Yokosawa (1995), it was shown that when participants were required to judge for misspellings, orthographic similarity effects could only be seen from the results of error rates regardless of contextual information. If this is true, it follows that Japanese readers process orthographic information without top-down contextual information. Therefore, orthographic similarity effects were examined in this study at both the lexical and sentence levels. This study will help to clarify the effect of contextual information in lexical access.

Three tasks were used with the same stimuli. In a lexical decision task (Experiment 1), stimuli were presented individually. In a proofreading task

(Experiment 2), stimuli were embedded in sentences and participants were asked to find them. In a semantic decision task (Experiment 3), stimuli were embedded in sentences and participants were asked to judge whether the sentences made sense.

EXPERIMENT 1
Lexical Decision of Two-kanji Compound Words

This experiment examined orthographic similarity effect during lexical decision of two-kanji compound words. Experiment 1 used orthographically similar nonwords composed of two kanji. For example, an orthographically similar nonword 矛約 was created from the real word 予約 by changing one kanji. A control nonword was also created by changing one kanji to produce an orthographically dissimilar nonword 吐約. It was expected that orthographically similar nonwords would be missed more than control nonwords (e.g., higher error rates). Orthographically similar nonwords were expected to cause longer reaction times for lexical decision than orthographically dissimilar nonwords.

Method

Participants: Twenty-four graduate and undergraduate students at Hiroshima University (20 females and 4 males) participated in the experiment. Average age of participants was 23 years and 10 months. All participants were native Japanese speakers.

Stimuli: In the lexical decision task for correct 'No' responses, 27 orthographically similar (e.g., 演枝) and 27 orthographically dissimilar (e.g., 演剣) nonwords were created. Both were formed by changing one kanji of existing two-kanji compound words (e.g., 演技). Stimuli are listed in the Appendix. As shown in Table 1, the two groups of nonwords were matched across 14 possible factors using the kanji database created by Tamaoka, Kirsner, Yanase, Miyaoka and Kawakami (2001, in press). The first factor was the school grade in which a kanji is taught. The second factor was the number of strokes in each kanji. The frequency of occurrence of kanji in print was controlled accounting for the third, fourth, and fifth factors. The sixth factor was the kanji neighborhood size of the left-hand side of two-kanji compound words. The term "kanji neighborhood size" refers to the possible combinations one unit of kanji can have with another to create two-kanji compound words. The seventh factor was the kanji neighborhood size of the right-hand side of two-kanji compound words. The eighth factor was the total kanji neighborhood size for both the left-hand and right-hand sides of two-kanji compound words. Neighborhood size, however, accounts for the number of two-kanji compound word combinations without considering word frequency. Thus, the accumulative neighborhood size of the left-hand side and right-hand side of two-kanji compound words, as well as the total of these were controlled (the 9th, 10th, and 11th factors). Single kanji are often composed of two or more constituents: radical and secondary elements. Radical frequency indicates how many of the 1,945 basic kanji share the same radicals. The 13th factor was the number of constituents. A single kanji pronunciation is often shared by multiple kanji. Thus the 14th factor was the number of kanji homophones. With regards to all these 14 factors, there was no significant difference between orthographically similar nonwords and dissimilar nonwords.

The aforementioned 27 existing words were also used for correct 'Yes' responses. In order to avoid presenting the same stimulus to participants repeatedly, the experiment used the cross-counter design of assignment. According to this process, stimuli were divided into three counterbalanced lists, each with 9 real words, 9 orthographically similar nonwords, and 9 orthographically dissimilar nonwords. Nine two-kanji compound words were used as filler items. Because each participant viewed only one list of stimuli, no one saw the same kanji twice. Thus, each participant was presented with a list of 18 real words and 18 nonwords.

Procedure: Real words as well as nonwords were randomly presented to participants in the center of a

Table 1. Characteristics of Two-kanji Compound Nonwords Used in Experiments 1-3

	Kanji characteristics	Orthographically similar nonwords	Orthographically dissimilar nonwords
1	School grades	5.81	5.85
2	Number of strokes	10.33	10.41
3	Kanji frequency (1976)	0.33	0.29
4	Kanji frequency (1998)	5197.00	4353.00
5	CD-ROM kanji frequency (1998)	7501.00	6120.00
6	Kanji neighborhood size of left-hand side	27.85	21.56
7	Kanji neighborhood size of right-hand side	28.78	26.67
8	Total neighborhood size of both sides	56.63	48.22
9	Radical frequency	36.00	32.04
10	Number of kanji constituents	2.15	2.30
11	Number of kanji homophones	16.93	17.07

Note: All these figures are provided by Tamaoka, Kirsner, Yanase, Miyaoka and Kawakami (2001).

computer screen (Toshiba, J-3100 Plasma display) 600 ms after the appearance of an eye fixation point marked by an asterisk '*'. Participants were required to respond as quickly and as accurately as possible in deciding whether the item was a correct Japanese two-kanji compound word. Twenty-four practice trials were given to participants prior to the commencement of the actual testing.

Results

Only correct responses were used for the calculation of mean reaction times. Responses incurring reaction times slower than 2,200 ms were recorded as incorrect. Seven items fell into this category. This is about 0.81% of the total responses of the 24 participants. Before the analysis was performed, reaction times longer or shorter than 2.5 standard deviations from a participant's mean time were replaced by the boundaries established by an individual mean of each participant plus or minus 2.5 standard deviations. Mean reaction times and error rates for the lexical decision task are presented in Table 2. Analyses of variance (ANOVAs) were conducted using both participant (F_1) and item (F_2) means.

A one-way ANOVA showed a significant difference in reaction times in both participant and item means, $F_1(1,23) = 18.55$, $MSE = 6055.7$, $p < .005$, and $F_2(1,52) = 11.90$, $MSE = 1810.0$, $p < .005$, respectively. These results suggested that

Table 2. Means of Reaction Times and Error Rates in Experiment 1

	Reaction times (*SD*)		Error rates (*SD*)	
Correct 'Yes' responses	720 ms	(140)	3.2 %	(6.1)
Correct 'No' responses				
Orthographically similar nonwords	919	(196)	43.1	(22.3)
Orthographically dissimilar nonwords	821	(171)	6.5	(8.6)

Note: Standard deviations (*SD*) are in parentheses.

participants responded to orthographically similar nonwords more slowly than to dissimilar ones. A one-way ANOVA showed a significant difference in error rates in both participant and item means, $F_1(1,23) = 70.40$, $MSE = 228.0$, $p < .005$, and $F_2(1,52) = 35.45$, $MSE = 3.17$, $p < .001$, respectively. The results of error rates showed that participants missed more orthographically similar nonwords than dissimilar ones.

Discussion

Experiment 1 showed that there were strong orthographic similarity effects in lexical decision. Participants took longer and made more errors with orthographically similar nonwords. The results of reaction time suggest that orthographically similar nonwords activate orthographic representations of real words. This effect was inhibitory, thus, causing participants to take extra time in distinguishing between a real word and an orthographically similar nonword. This process of distinction often failed which resulted in higher error rates. Findings from Experiment 1 support the notion that orthography affects both reaction times and error rates in lexical decision. In sentences, however, Shimomura and Yokosawa (1995) showed that orthographic similarity did not affect reaction times. Thus, to clarify matters, orthographic similarity effects were tested at the sentence level using the same stimuli.

Experiment 2

Proofreading of Two-kanji Compound Words at the Sentence Level

Experiment 1 showed orthographic similarity effect during lexical decision. In order to examine whether these same effects occur at the sentence level, the same stimuli from Experiment 1 were embedded in sentences. For example, a sentence like 車は正面から衝突し、運転していた人が怪我をした (/kuruma wa syoRmeN kara syoRtotu si uNteN siteita hito ga kega wo sita/) meaning 'The car collided squarely, and the driver was injured' was used. Another sentence was then created where 衡突 replaced the underlined real word and created a sentence with an orthographically similar nonword. A control condition was established by using yet another sentence where the underlined word was replaced by the orthographically dissimilar nonword 緯突. If orthographic similarity effects in the proofreading task occur and cause the same results as in Experiment 1, then participants would take longer and make more errors with orthographically similar nonwords than with dissimilar ones.

Method

Participants: Twenty-four graduate and undergraduate students at Hiroshima University (21 females and 3 males), who had not participated in Experiment 1, participated in the experiment. The average age of participants was 23 years and 5 months. All participants were native Japanese speakers.

Stimuli: The same stimuli in Experiment 1 were used in the stimuli sentences (see Appendix). Nine filler sentences were also created containing the filler items from Experiment 1. Experiment 2 used the same cross-counter design technique as that of Experiment 1. Thus, each participant was presented with 18 sentences composed of real words and 18 sentences containing a nonword.

Procedure: The 36 sentences were randomly presented to participants in the center of a computer screen (Toshiba, J-3100 Plasma display) 600 ms after the appearance of an eye fixation point. In order to indicate that a sentence would be presented, the eye fixation point was marked by a series of asterisks '*********'. Participants were instructed to respond as quickly and as accurately as possible in deciding whether the two-letter sets in the sentence were correct. Twenty-four practice trials were given to participants prior to the commencement of the actual testing.

Results

Only correct responses were used for the calculation of mean reaction times. Responses incurring reaction times slower than 10,000 ms were recorded as incorrect. Three items fell into this category (about 0.35% of the total responses of the 24 participants). Before performing the analysis, reaction times more than 2.5 standard deviations above or below a participant's mean reaction time were replaced by the boundaries established by an individual mean of each participant plus or minus 2.5 standard deviations. Mean reaction times and error rates for the proofreading task are presented in Table 3. ANOVAs were conducted using both participant (F_1) and item (F_2) means. There were two orthographically similar nonwords that no participant judged correctly. These items were excluded from the item analysis of reaction times.

A one-way ANOVA showed a significant difference in reaction times in both participant and item means, $F_1(1,23) = 9.21$, $MSE = 116084.6$, $p < .01$, and $F_2(1,50) = 10.90$, $MSE = 385576.7$, $p < .005$, respectively. The mean reaction time for judging orthographically similar nonwords was longer than that for dissimilar nonwords. A one-way ANOVA showed a significant difference in error rates in both participant and item means, $F_1(1,23) = 78.11$, $MSE = 316.25$, $p < .0001$, and $F_2(1,52) = 57.86$, $MSE = 3.011$, $p < .0001$, respectively. These results suggested that participants missed more orthographically similar nonwords than dissimilar ones.

Discussion

Experiment 2 showed orthographic similarity effects similar to those in Experiment 1. In detection of incorrect two-kanji compound words, participants took longer and made more errors with orthographically similar nonwords. This result

Table 3. Means of Reaction Times and Error Rates in Experiment 2

	Reaction times (*SD*)		Error rates (*SD*)	
Correct 'Yes' responses	2506 ms	(1024)	4.6 %	(6.5)
Correct 'No' responses				
Orthographically similar nonwords	2618	(1317)	55.6	(16.7)
Orthographically dissimilar nonwords	2088	(451)	10.0	(21.0)

Note: Standard deviations (*SD*) are in parentheses.

suggests that orthographic similarity affects proofreading at the sentence level in the same way as it does lexical decision. The question is, however, whether the context of the sentences affects one's response. In Experiment 2, it was possible for participants to carry out the task without paying attention to the context of the sentence. Therefore, in yet a further experiment, participants were required to carry out the same type of task while being forced to pay attention to sentence context.

Experiment 3
Semantic Decision at the Sentence Level

In Experiment 2, orthographic similarity affected the performance of proofreading at the sentence level. This result suggested that contextual information did not affect the processing of orthographic information. However, participants did not always have to pay attention to the meaning of the sentence. The next experiment was designed to require the processing of contextual information on the part of participants.

Method

Participants: Twenty-four graduate and undergraduate students at Hiroshima University (19 females and 5 males) participated in the experiment. Average age of participants was 23 years and 4 months. All participants were native Japanese speakers.

Stimuli: The sentences used in Experiment 2 were also used in Experiment 3. However, in order to make participants read sentences more carefully, nine dummy sentences were added. These dummy sentences did not contain a nonword but rather a two-kanji compound word that did not suit the sentence. Nine new filler sentences that were semantically correct were also added. Thus, each participant was presented with 27 correct sentences and 27 incorrect sentences.

Procedure: Fifty-four sentences were randomly presented to participants in the center of a computer screen (Toshiba, J-3100 Plasma display) 600 ms after the appearance of an eye fixation point marked by a series of asterisks '*********'. Participants were instructed to read the sentences, to understand their meaning and to respond as quickly and accurately as possible in deciding whether the two-letter sets embedded in the sentence were correct. Twenty-four practice trials were given to participants prior to the commencement of the actual testing.

Results

Only correct responses were used for the calculation of mean reaction times. Responses incurring reaction times slower than 10,000 ms were recorded as incorrect. No item fell into this category. Before the analysis was performed, reaction times

Table 4. Means of Reaction Times and Error Rates in Experiment 3

	Reaction times (*SD*)		Error rates (*SD*)	
Correct 'Yes' responses	2465 ms	(667)	6.0 %	(6.5)
Correct 'No' responses				
Orthographically similar nonwords	2447	(621)	50.0	(18.8)
Orthographically dissimilar nonwords	2228	(637)	4.2	(5.5)

Note: Standard deviations (*SD*) are in parentheses.

more than 2.5 standard deviations above or below a participant's mean reaction time were replaced by the boundaries established by an individual mean of each participant plus or minus 2.5 standard deviations. Mean reaction times and error rates for the proofreading task are presented in Table 4. ANOVAs were conducted using both participant (F_1) and item (F_2) means. No participant responded correctly to 安奏. This item was excluded from the item analysis of reaction times.

A one-way ANOVA showed a significant difference in reaction times by participants, $F_1(1,23) = 11.03$, $MSE = 51920.1$, $p < .005$, and a marginally significant difference by items, $F_2(1,51) = 3.18$, $MSE = 192462.8$, $p < .10$. The results of reaction times showed that participants found orthographically dissimilar nonwords faster than orthographically similar nonwords. A one-way ANOVA showed a significant difference for error rates in both participant and item means, $F_1(1,23) = 141.0$, $MSE = 178.81$, $p < .0001$, and $F_2(1,52) = 62.09$, $MSE = 2.923$, $p < .001$, respectively. These results show that participants missed more orthographically similar nonwords than dissimilar nonwords.

Discussion

Experiment 3 suggested that orthographic similarity affected performance in semantic decision in the same way as in proofreading and lexical decision. These results suggest that orthographic similarity effects are strong and not affected by contextual information. The result of orthographic similarity effects being significant in reaction times seems to conflict with the results from the study done by Shimomura and Yokosawa (1995).

Post-Hoc Analysis of the Three Experiments

Internal correlations of error rates for correct responses of orthographically similar nonwords in Experiment 1–3 are shown in Table 5. Because Experiment 2 and 3 used the same sentences, it is natural that such a correlation be high ($r = .71$,

Table 5. Correlations of Error Rates for 'No' Responses of Orthographically Similar Nonwords Used in Experiments 1–3

	Task	1	2	3
1	Exp #1 – Lexical decision	—		
2	Exp #2 – Incorrect word detection	0.51**	—	
3	Exp #3 – Semantic decision	0.49**	0.71**	—
	Item means	42.59	55.09	50.00
	Standard deviation	29.47	28.85	28.80

Note 1: $n = 27$, $^{*}p < .05$, $^{**}p < .01$.

Note 2: The mean error rates in this table were calculated using item means while the means in Tables 2–4 were calculated using participant means. Thus, figures in this table slightly differ from those in Tables 2–4.

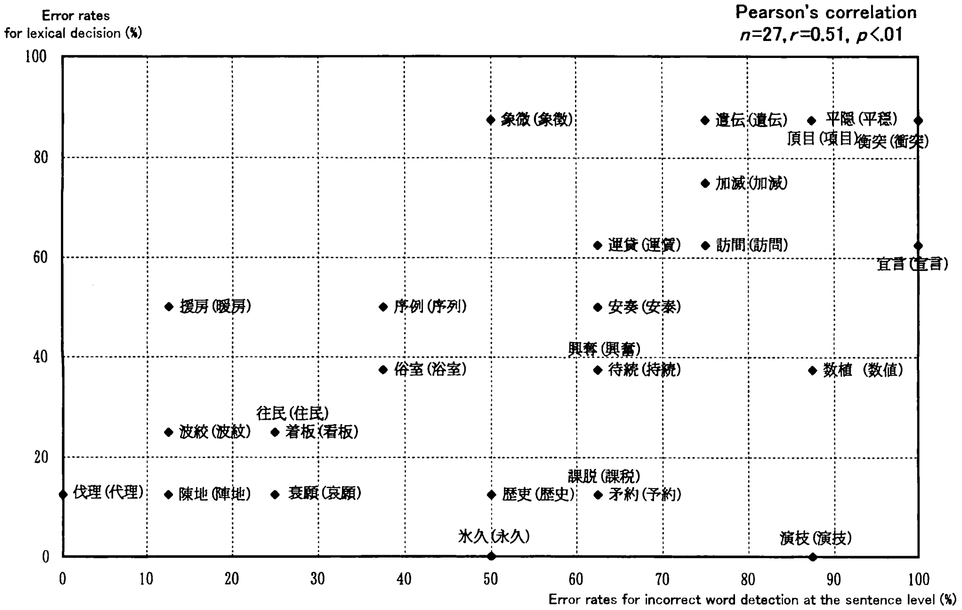

Fig. 1. Plotting of orthographically similar nonwords based on error rates from Experiments 1 and 2.
Note: Two-kanji compound words in brackets are real words which orthographically similar nonwords were patterned after.

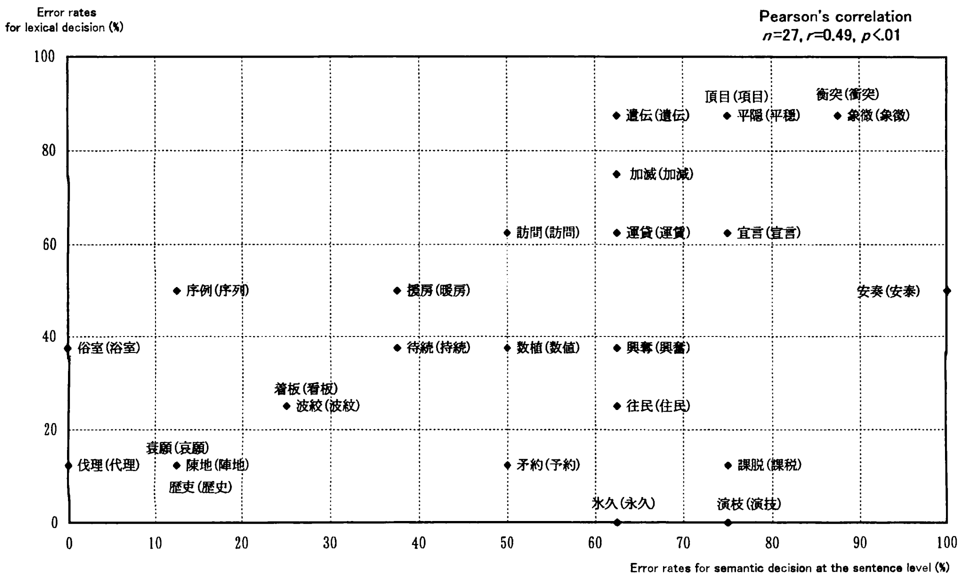

Fig. 2. Plotting of orthographically similar words based on error rates from Experiments 1 and 3.
Note: Two-kanji compound words in brackets are real words which orthographically similar nonwords were patterned after.

$p < .01$). Correlations showed that orthographically similar nonwords that led to many errors caused the same results whether on individual basis or in sentences (between Experiment 1 and 2, $r = .51$, $p < .01$, between Experiment 1and 3, $r = .49$, $p < .01$). However, correlation was highest between Experiment 2 and 3. The plotting of error rates for lexical decision in Experiment 1 and proofreading in Experiment 2 is shown in Fig. 1. The plotting of error rates for lexical decision in Experiment 1 and semantic decision in sentences in Experiment 3 is shown in Fig. 2.

Orthographically similar nonwords were divided into four categories. In the first category were those which were misjudged more than 60% of the time in all three tasks. In the second category were those causing participants to err less than 40% of the time in all three tasks. The third category was composed of orthographically similar nonwords that caused participants to err more than 60% in lexical decision but less than 40% in proofreading and semantic decision. The fourth category had those which caused an error rate of less than 40% in lexical decision, but more than 50% in proofreading and semantic decision.

In the first category, error rates were more than 60% regardless of the task. In this category, nonwords such as 衡突, 平隠, 運貸, 遣伝, and 加滅 were just some of those used among the 27 stimuli presented to participants. These nonwords might have been so similar in orthography to their real counterparts that participants missed their little differences. In other words, when a nonword such as 衡突 was presented, the orthographic representation of the existing word (in this case, 衝突) was highly activated.

In the second category, the error rates caused by orthographically similar nonwords were less than 40% in all three tasks. Stimuli such as 伐理, 波絞, 着板, 衰願, 俗室, and 陳地 were easily detected as nonwords. Even when these nonwords were presented, the orthographic representation of the real words like 代理 or 波紋 were not likely to be activated. This result suggests that the difference between these nonwords and their existing counterparts was great.

As shown in Fig. 1 and Fig. 2, there was no nonword which could be placed in the third category. In other words, if error rates were high in Experiment 1, those in Experiment 2 and 3 were likely to be high as well. Undetectable nonwords in lexical decision are also undetectable when presented in sentences.

Although the first three categories of orthographically similar did not indicate effects of contextual information on orthographic processing, the fourth category did. Orthographically similar nonwords such as 課脱 and 矛約 that led to less than 20% in errors when presented individually, led to more than 50% in errors when in sentences. Especially with 演枝 and 氷久, participants in Experiment 1 made no errors, however error rates were more than 50% in Experiment 2 and 3. Possibly, the context of sentences that included such nonwords caused participants to strongly predict the correct existing words (such as 演技 and 永久) and, thus, slight discrepancies in orthography were overlooked. This result suggests that contextual information could very well have an influence in orthographic processing.

General Discussion

The purpose of this study was to examine whether orthographic similarity effects on the processing of Japanese two-kanji compound words differ depending on three tasks: lexical decision, proofreading at the sentence level, and semantic decision at the sentence level. In Japanese, orthographic information is assumed to have strong effects in reading (e.g., Sakuma, Sasanuma, Tatsumi, & Masaki, 1998; Wydell, Patterson, & Humphreys, 1993). It was expected that orthographic similarity effects would show a similar tendency regardless of context.

This study showed that orthographic similarity effects of incorrect two-kanji compound words was significant in all three tasks. When participants were presented with orthographically similar nonwords, they judged them slower and made more errors than with orthographically dissimilar nonwords. This suggests that orthographic information has a strong effect on lexical processing in reading and is not affected greatly by contextual information as suggested by Yokosawa (1998).

There are, however, two points to discuss further with regards to the difference in findings of this study and of the one done by Shimomura and Yokosawa (1995). First, the results of reaction times in Experiments 2 and 3 did not concur with those found by Shimomura and Yokosawa (1995). In their study, there were no significant orthographic similarity effects on reaction times which served as the basis for their claim that orthography is processed before contextual information. However, this difference in results may have been due to differences in stimuli used. Shimomura and Yokosawa (1995) used longer sentences and mean reaction times were almost 1,300 ms longer than those of this study. The longer the total processing time of a sentence, the weaker the orthographic similarity effects at the lexical level. In addition, experimental conditions were different with respect to the degree with which participants had to pay attention to the context of sentences. In this study, participants had to pay more attention to sentence context due to dummy sentences that were included as stimuli. Shimomura and Yokosawa (1995), however, gave a comprehension test to participants after the completion of the proofreading task in order to make participants understand the context of sentences. This may have had an influence on the result of reaction times and error rates. In other words, orthographic similarity could affect reaction times when the environment is arranged.

Second, the present study provided correlation data between lexical decision and sentence level judgements. There were some nonwords for which error rates were similar in all three tasks. As shown in Fig. 1 and Fig. 2, no nonword was plotted in the area where error rates were more than 60% in lexical decision but less than 40% in proofreading and semantic decision at the sentence level. In other words, when error rates were high in lexical decision, they were also high in proofreading and semantic decision of words in sentences. However, some orthographically similar nonwords are processed differently when presented individually and in sentences. Although error rates for some nonwords such as 演枝 and 氷久 were low when presented individually, they were high when the nonwords were embedded in sentences. In these cases, orthographic processing seemed to be affected by the context of sentences. When these nonwords presented solely, it might not be difficult to realize the difference between 氷久 and 永久. However, when participants read sentences, they could predict 永久 from the context information. 氷久 might fit in with their prediction almost perfectly. Perhaps this prediction would account for the difference between the error rate of lexical decision and sentence level judgement. It is plausible that a high predictable context causes this difference.

Regarding orthographic information, therefore, the following process is assumed. When participants are presented with orthographically similar nonwords, the orthographic representation of the existing word is activated in many cases (unless the altered kanji is not familiar). If there is no notice of the difference in orthography, participants will judge the word as "correct". In some cases, however, participants realize that the orthography of the stimulus does not match the orthography of the existing word perfectly. In this case, it takes time to inhibit the "correct" response and the reaction times become longer. These processes may occur in lexical decision, proofreading at the sentence level or semantic decision at the sentence level. However, error rates are higher in proofreading and semantic decision than in lexical decision for some nonwords. In this case, it may be that context so strongly predicts the orthography for the correct word that nonwords with similar orthography are overlooked.

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Appendix

Stimuli Used in Experiments 1–3

Sentences	Real words	Nonwords: Orthographically similar nonwords	Nonwords: Orthographically dissimilar nonwords
お盆の時期に旅行するので、早めに宿泊の□□をした。	予約	矛約	吐約
この宝石は質が非常に高いので、輝きは□□に変わらない。	永久	氷久	冊久
この町に施設を作るのには、□□の強い反対があった。	住民	往民	邸民
医者に、なんとか息子の命を救って欲しいと□□した。	哀願	衰願	括願
その会議には、社長の□□で出席することになっている。	代理	伐理	妄理
その女優は、すばらしい□□で会場の観客を魅了した。	演技	演枝	演剣
所得が増えたのはよいが、□□の金額も非常に高くなった。	課税	課脱	課郵
就職がなかなか決まらず、いろいろな会社を□□している。	訪問	訪間	訪場
試合は劇的な結果に終わり、□□した客がまだ騒いでいる。	興奮	興奪	興銃
絶え間なく来客があり、緊張を□□させていたので疲れた。	持続	待続	洋続
その国は強国の支配に抵抗し続け、やっと独立を□□した。	宣言	宜言	炎言
ここを新居に選んだ理由の一つは、□□が広いことだ。	浴室	俗室	亭室
条約が締結されたが、納得しがたい□□も残っている。	項目	頂目	酔目
仕事や家族の問題がいろいろあったが、今は□□な毎日だ。	平穏	平隠	平穀
その会社は創立されて三年しかたっておらず、□□が浅い。	歴史	歴吏	歴帆
面会の予定は多いが、重要な人物から□□をつけてある。	序列	序例	序具
解答を出すには、公式にあてはまる□□を代入すればよい。	数値	数植	数湯
その事件の報道には問題が多く、様々な□□を呼んでいる。	波紋	波絞	波尋
ここは老舗で、長男が店をついで□□を守る義務がある。	看板	着板	番板
味方の軍勢が来るまで、□□を奪われずに持ちこたえた。	陣地	陳地	貧地
彼女が病気がちなのは、親の体質が□□したのだろう。	遺伝	遣伝	詳伝
車は正面から□□し、運転していた人が怪我をした。	衝突	衡突	緯突
部屋が乾燥しているのは、□□をつけているからだ。	暖房	援房	装房
何度も電車を乗り継いだせいか、□□が意外に高かった。	運賃	運貸	運換
子どもが相手なのだから、力を□□して勝負するべきだ。	加減	加滅	加誉
公園に鳩がいるのは、平和の□□とされているからだ。	象徴	象微	象雅
国家の□□を願い、熱心に外交の問題に取り組んでいる。	安泰	安奏	安浅