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Masked Priming by Two Types of Japanese Suffixes Attached to Conjunctive Verb Forms[1)]

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Abstract

This study investigated how two types of Japanese suffixed words are processed in the early stages of visual processing. The one type is suffixes whose root can be written in kanji, and the other type is suffixes that can be written only in kana. According to Nakano and Kishimoto (2019), when morphologically complex words of Chinese origin are visually presented in hiragana, the kanji that corresponds to the word root is activated; in the masked priming paradigm, this is indicated by partial priming. Given the different orthographic properties of Japanese suffixes, the two types of suffixed words may be processed differently. Therefore, we tested them through a masked priming experiment (SOA = 50 ms). Forty native speakers of Japanese participated. The results indicate a partial priming effect when target words have a suffix whose root can be written in kanji, but no priming effect when target words have a suffix that has no corresponding kanji and can be written only in kana. The different priming patterns imply a processing difference between two types of suffixed words due to orthographic types.

Key words: suffix priming, masked priming, derivational suffixes, morphology, Japanese

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I. Introduction

1. Processing morphologically complex derived words of different origins

The processing of morphologically complex words in the early stages of visual recognition has been investigated for over two decades. Some researchers have assumed that in processing morphologically complex words (e.g., *walker,* derived from the verb *walk*), they are decomposed into a root (*walk*) and an affix (*er*) (Marslen-Wilson, 2007; Rastle et al. 2000), and this process is referred to as morpho -orthographic decomposition. Most studies have focused on priming by word stems and roots; only a limited number has investigated suffix priming (Crepaldi et al., 2016; Lázaro et al., 2016). Derivational affixes are important for distinguishing the meanings of one word from those of another (e.g., *childish* and *childlike*), particularly when they share the same root (*child*). Therefore, how derivational affixes are processed in derived words will shed light on our understanding of visually presented, morphologically complex words. Further, most previous studies have centered on alphabetic languages; not many have been conducted on non-alphabetic languages, including Japanese. Many morphologically complex words in Japanese are written with a mixture of different scripts. For instance, a word root is written in logographic kanji, and affixes are in the moraic script hiragana. Since they involve different access routes to the mental lexicon, complex words in Japanese may be processed differently from those in alphabetic languages. Therefore, we investigated suffix priming in Japanese.

2. Masked priming studies

Priming effects found in previous masked priming experiments have been considered empirical evidence of morphological decomposition. In a masked priming experiment, after a mask (#####), a prime word is presented for approximately 30 to 80 ms; at its offset, a target word is shown, and the participant is asked to make a lexical decision on the target word (Forster et al., 2003). Since prime words are presented for a very short time, most participants do not notice the presence of prime words. However, the different types of prime words influence the recognition of target words differently. In a simple experimental design, a set of stimuli constituting a target word (*WALK*) and two types of prime words are constructed. A critical type of prime word is a derived form of the target word (*walker*)—the *test* condition; the second type of prime word is phonologically and semantically unrelated to the target word (*singer*)—the *control* condition. If a derived word is morphologically decomposed into a root (*walk*) and an affix (*er*), the root has an identical form to the target word *WALK,* and a lexical decision on the target word will be facilitated, compared to the control condition, resulting in a masked priming effect.

Masked priming effects have been reported not only when prime words are derived words (*walker-WALK*), but also pseudo-derived words that end in the same letter string with an existing suffix *-er* (*corner-CORN*). However, when prime words have an affix-like ending such as *el,* if the affix does not exist (brothel-*BROTH*), no priming occurs (Rastle, et al. 2004). Masked priming effects for words with pseudo-affixes have been reported not only in English, but also in other languages (Arabic: Boudelaa & Marslen-Wilson 2005; French: Longtin & Meunier 2005; German: Clahsen & Neubauer 2010; and Russian: Kazanina et al. 2008). Hence, morphemes are considered crucial for morpho-orthographic decomposition.

3. Suffix priming studies

Since masked priming effects have been reported on prime and target words that share the same root and stem, it is conceivable that when prime and target words share the same suffix, suffixes can also trigger a priming effect. There have been some studies on suffix priming. One example is the masked priming experiment by Crepaldi et al. (2016). In Experiment 1, they tested masked suffix priming (SOA = 42 ms) in English. One type of target word (*TEACHER*) constituted a root (*teach*) and a suffix (*er*). All prime words were non-words and constituted an existing root (*sheet*) with three types of endings: (1) an existing derivational suffix identical to the suffix of the target word *er* (*related* prime: *sheeter*); (2) an existing but different derivational suffix from that of the target word *al* (*suffix control* prime: *sheetal*); and (3) a suffix-like ending, *el* (*unrelated* prime: *sheetel*). The other type of target word was monomorphemic (APPAREL) and was also paired with three types of prime words (related: *colourel*; control: *colouric*; and unrelated: *colourut*). The main effect of target type and the interaction of prime and target types were found. The masked priming effect was observed only in morphologically complex targets, but not in monomorphemic targets. The other example is the masked priming experiment conducted by Lázaro et al. (2016). They studied the priming effect of Spanish suffixes in a masked priming experiment by comparing three conditions. In the complex condition, a real suffix (*-ero*) of the target (*COCINERO "cooker"*) or an unrelated real suffix (*-ista*) was presented as the prime; in the pseudo-suffixed condition, the letters (*-eza*) at the end of target (*CERVEZA "beer"*) or unrelated letters (*-ista*) were presented as the prime, and a complex word was the target. In the simple condition, a letter pattern (*-bro*) or unrelated letter pattern was presented as the prime; they preceded targets (*CEREBRO*). Lázaro et al. revealed that the experimental primes yielded shorter response times than the unrelated primes in the complex and pseudo-suffixed conditions, but not in the simple condition. In sum, the results of these two studies indicate that not only the stem of a word but also its suffixes are important for word identification.

Previous suffix priming studies have mainly centered on alphabetic languages; no study has ever been conducted on non-alphabetic languages such as Japanese. Therefore, we investigated the priming of derivational suffixes and the influence of orthography in Japanese.

II. Studies on Japanese

1. Orthography in Japanese

Three types of scripts are used in Japanese: the logographic *kanji* and two types of moraic scripts called *kana* (hiragana and katakana). Kanji is mostly used for word roots, hiragana is used for affixes, and katakana is used for loan words of European origin and the scientific names of animals and plants. Since the nature of these three scripts is different, the way to process words written in different scripts can be distinct.

Japanese verbs can be classified into three groups (I, II, and III). According to Fushimi et al. (2007), the distribution of the three groups is as follows: Group I verbs account for 61%, Group II verbs for 37%, and Group III verbs for 2%. Thus, Group I and II verbs are the most common; we used these two groups of verbs. Since the stems of Group I verbs end with a consonant that is unpronounceable in Japanese, either an epenthetic vowel is inserted, or a phonological change occurs (/ɾ/ becomes /Q/). Further, the stem-end consonant is not scriptable either and is merged with the epenthetic vowel and written as one letter. Hence, morphological boundaries are not orthographically indicated in Group I verbs or some words derived from them. It seems that orthographically unindicated morphological boundaries are challenging in terms of ortho-morphological decomposition.

2. Masked priming effects in Japanese studies

Even if Japanese words are visually presented and written with a mixture of the three types of scripts, masked priming effects have been reported for morphologically complex words (Clahsen & Ikemoto, 2012; Fiorentino et al., 2016; Nakano et al. 2016). Clahsen and Ikemoto (2012) conducted a masked priming experiment (SOA = 50 ms); critical primes were deadjectival nouns with a nominalizing suffix *-sa* or *-mi,* while targets were adjectives that shared the same roots with primes. The suffix *-sa* is highly productive and implies the degree of the adjective to which it is attached, while the suffix *-mi* applies to a limited number of adjectives. As such, it is unproductive, and adds additional meaning to nominalized adjectives such as “place” (e.g., the word *takami “a high place”* was derived from the adjective *takai "high"*). Some researchers have assumed that the qualitative difference between -*sa* and -*mi* leads to different processes: Words with the suffix *sa* are decomposed, and words with the unproductive suffix *mi* are treated as a whole word. Both primes and targets are visually presented in hiragana (primes−targets: やすさ /yasɯsa/ "cheapness"−やすい /yasɯi/ "cheap," よわみ /yowami/ "weakness"−よわい /yowai/ "weak"), and control primes are unrelated to target words (つらい /tɯɾai/ "hard"−やすい /yasɯi/ "cheap," あわい /awai/ "pale"−よわい /yowai/ "weak"). These hiragana-written primes and targets are most commonly written with a mixture of kanji and kana: word roots in kanji and suffixes in hiragana. For example, やすさ /yasɯsa/ "cheapness" is most commonly written as 安さ, in which 安 /yasɯ/ is the root written in kanji and is followed by the suffix さ /sa/ in hiragana; やすい /yasɯi/ "cheap" is written as 安い, in which 安 is kanji and is followed by the non-past suffix of the adjective い /i/ in hiragana; よわみ /yowami/ "weakness" is written as 弱み, in which 弱 /yowa/ is the root written in kanji, followed by the suffix み/mi/ in hiragana; よわい /yowai/ "weak" is written as 弱い, in which 弱 is kanji, followed by い /i/ in hiragana. Mean RTs are shorter in the critical condition versus the unrelated condition for both -*sa* and -*mi* suffixed words; hence, masked priming effects have been found in the -*sa* and -*mi* suffixed conditions. Fiorentino et al. (2016) also tested Japanese deadjectival nouns with a masked priming experiment (SOA = 49 ms), but in contrast to Clahsen and Ikemoto (2012), they visually presented the non-past form of adjectives as primes and deadjectival nouns as targets. Furthermore, they constructed materials for controlling orthographic overlaps between primes and targets (つづく /tɯzɯkɯ/ "continue"−つづり /tɯzɯɾi/ "spelling"). They presented primes and targets with a mixture of kanji and hiragana. The results for productive and unproductive suffixed words facilitated lexical decisions compared to the unrelated control condition; no priming effect was observed for orthographic controls. Therefore, Fiorentino et al. (2016) replicated masked priming effects based on the work of Clahsen and Ikemoto (2012). In sum, these findings indicate the occurrence of morphological decomposition.

However, there is another possibility that causes a masked priming effect in processing Japanese morphologically complex words: the *activation of kanji* that corresponds to a word root. Nakano et al. (2016) tested the orthographic influence of processing complex Japanese words using a masked priming experiment. Critical primes (はこび /hakobi/ "process") were phonologically, orthographically, morphologically, and semantically unrelated to targets (ウン /ɯn/ "luck") unless written in kanji (運), while primes were visually presented in hiragana and targets in katakana. Nakano et al. found a masked priming effect, and argued that the priming effect was due to the activation of kanji, which corresponds to word roots.

As mentioned in Section II, because of the different properties of kanji and kana, some researchers have assumed that words written in kanji directly access their corresponding lexical memory but that words written in kana access their corresponding lexical memory via phonological representations (Saito, 1981; Coltheart, et al., 2001). Other researchers have claimed that words in kana also access their corresponding abstract orthographic representations (Bowers & Michita, 1998; Kinoshita et al., 2019). Bowers and Michita (1998) tested the priming of two-character kanji words with a lexical decision task. When targets were two-character kanji words and primes were written in hiragana, a priming effect was observed; they also found a priming effect when primes were written in hiragana and targets were two-character kanji words. However, when primes were presented auditorily and targeted visually, no priming effect was observed. These results suggest the presence of an abstract orthographic representation. Nakamura et al. (2005) carried out priming experiments with and without a mask. In one condition, the primes were written in hiragana and the targets were written in kanji; in the other condition, the primes were written in kanji and the targets were written in hiragana. In both conditions, words were visually presented, and in both masked and unmasked experiments, the condition where primes were written in hiragana and the targets in kanji yielded a larger priming effect than the condition where the primes were written in kanji and the targets in hiragana. Given the results of Bowers and Michita (1998) and Nakamura et al. (2005), it is conceivable that abstract orthographic representations activate lexical memory for kanji-written targets.

3. Full and partial priming effects

Two types of priming effects have been reported: full and partial. If a derived word is morphologically decomposed into a root (*walk*) and an affix (*er*), the psychological situation in the test condition is the same as that in the identity condition. Thus, on the one hand, the lexical decision latencies for the test and identity conditions do not differ. On the other hand, the lexical decision latencies for the test and control conditions differ, leading to the masked priming effect; this type of priming effect is referred to as the full priming effect. Contrastingly, if the lexical decision latency is shorter in the identity than in the test condition, and the lexical decision latency is also shorter in the test than in the control condition, the priming effect is referred to as the partial priming effect. Partial priming effects are attributed to the spreading activation of prime and target words (Sonnenstuhl, et al., 1999).

Although Nakano et al. (2016) had test and control conditions, they had no identity condition. Thus, Nakano and Kishimoto (2019) included the identity condition and conducted a masked priming experiment, and found that RTs were longer in the test than in the identity condition, but were shorter than in the control condition (i.e., a partial priming effect). Nakano and Kishimoto (2019) replicated the masked priming effect due to the activation of kanji corresponding to word roots.

In sum, since no other studies have investigated suffix priming in Japanese, one purpose of our study was to investigate whether suffixed words are decomposed into a root and a suffix through a masked priming experiment and to examine whether suffix priming is obtained in Japanese suffixed words. Considering the different orthographic characteristics of Japanese scripts and subsequent processing differences, our other purpose was to determine whether the suffix root activates kanji when prime words have suffixes that can be written in kanji and kana, compared to prime words with suffixes that can be written only in kana and have no corresponding kanji; hence, no activation of kanji should occur.

III. Study

We conducted a masked priming experiment with two types of targets preceded by one of three types of suffixed words as the prime. One type of target word constituted the conjunctive form of a verb and a derivational suffix whose root could be written in kanji. We chose four suffixes to use in the target words: (1) カタ /kata/ "a way (to do)"; (2) ヤスイ /yasɯi/ "easy (to do)"; (3) ニクイ /nikɯi/ "hard (to do)"; and (4) ガチ /gatʃi/ "tendency (to do)." Target words were presented in katakana (オドリカタ/odoɾikata/, "a way to dance," and オドリ/odoɾi/ is a conjunctive form of the verb meaning "to dance"); カタ /kata/ "way" is most often written in kanji (方). Although the four suffixes were presented in katakana, their roots could be written in kanji and some of them were followed by a hiragana-written ending (i.e., カタ→方, ヤスイ→易い, ニクイ→難い, ガチ→勝ち; words written in kanji are underlined). We also constructed three types of prime words and presented them in hiragana. Critical prime words had the same suffix as target words, but were unrelated to the target words except the suffix (さがしかた /sagaʃikata/, "a way to look for (something)"−ワライカタ /waɾaikata/, "a way to laugh (at)")—the *test* condition. One control prime word (わらいかた /waɾaikata/) was identical to the target words (ワライカタ /waɾaikata/)—the *identity* condition. The other control prime words were unrelated to the target words and ended with a suffix different from that of the target words (もの/mono/ "thing"), but shared the same word root with the prime in the test condition (さがしもの /sagaʃimono/ "a thing that one is looking for"−ワライカタ); that is, the *control* condition. Regarding the other types of target words, we also constructed three types of primes for the target word, with indigenous Japanese suffixes that could be written only in kana in the same way. We chose four suffixes: (1) ポイ /poi/ "easily (do something)”; (2) ップリ /Qpɯɾi/ “way”; (3) ッコ /Qko/ “(doing something) together as a game”; and (4) ガテラ /gateɾa/ “(doing something) at the same time”). Target words were presented in katakana and prime words were in hiragana. For instance, for the test condition, the prime word みせっこ /miseQko/ “show something to each other” consisted of the conjunctive verb form みせ(る) /miseɾɯ/ “show” and the suffix っこ /Qko/. For the identity condition, the prime word かえっこ /kaeQko/ “exchange something” was identical to the target word カエッコ /kaeQko/. For the control condition, the prime word みせがね /misegane/ “show money” consisted of the same word root with the prime word in the test condition, みせ /mise/ “show” and the noun がね /gane/ “money”, meaning “show or bait money.” Target words were written in katakana, カエッコ/kaeQko/, to help the participants distinguish between the prime and target words in the identity condition.

The prediction for the experimental results is as follows. When morphologically complex prime words with suffixes whose root can be written in kanji and suffixes that can be written only in kana are presented in hiragana, if they are morphologically decomposed, a full priming effect will be observed, but if the kanji characters that correspond to the suffix are activated, a partial priming effect will be seen in the former type of suffix.

IV. Method

1. Participants

Forty native Japanese speakers participated (17 males, 23 females, mean age: 20.73).

2. Stimuli

For the critical materials, we constructed 60 sets of triplets of prime words (identity, test, and control prime words) and a suffixed word as the target. Half of them had target words with suffixes whose roots could be written in kanji; the rest had target words whose suffixes could not be written in kanji, but only in kana. To check the influences of semantic and orthographic overlaps between the prime and target words, we constructed 24 sets of triplets of prime words and a target word for the semantic and orthographic conditions, respectively. We counter-balanced the three prime types with respect to frequency and the number of morae (Table 1) to the extent that there was no statistical difference across prime types.

Critical materials were divided into three lists, each of which was mixed with the aforementioned filler items. The final version of each list consisted of 400 pairs of prime and target words.

Table 1 Descriptive statistics of the targets in Experiment 1

	Frequency	*N*	*Mora length*
Suffixes with kanji-written roots	0.37	24	5.25(2.53)
Suffixes written only in kana	0.05	24	5.42(2.62)

Note: Standard deviations are shown in parentheses. *Frequency* = Frequency per million words. *N* = six suffixed words for the four types of suffixes.

3. Procedure

The experiment was conducted with each participant in a quiet room. After explaining the purpose and content of the experiment, we obtained informed consent from each participant. The experimental stimuli were presented on a laptop with a 15-inch monitor using the psycholinguistic software program DMDX (Forster & Forster, 2003). After a 500-ms fixation, a string of hash tags—whose number was two letters longer than that of the prime words—was presented for 500 ms; at its offset, a prime word was presented for 50 ms, followed by a target word for 500 ms. Since the participants were not likely to notice the presence of prime words, we did not mention the presence of a prime word in the instructions. The participants were instructed to decide whether a string of letters existed in Japanese, and to press the yes or no button of the response box as fast and as accurately as possible. The time for the lexical decision and the button the participant pressed on the laptop were recorded. After 500 ms, another trial began. A pause was inserted every 100 trials. The order of the trials was pseudorandomized, but the assignment and order of presentation of prime-target sets and filler items were parallel across the three lists. To reduce the effect of fatigue, we constructed a list of reversed orders for the three lists. Each participant received one of the six lists and saw individual targets only once.

Ten trials were given as practice items. Immediately after the practice session, we gave the participants a list of the 10 prime words, and out of the 10 target words, we instructed them to circle the words they had seen in the practice session to check whether or not they had noticed the presence of masked prime words.

V. Results

1. Data analysis

Before data analysis, we removed the data of five participants whose accuracy rates were below 80%, one participant who answered that he could read most prime words in the post-experimental questionnaire, wrong lexical judgments beyond the range of 2.5 standard deviations, and lexical decision latencies of over 4000 ms. The mean response times were computed from the remaining data, as shown in Table 2.

Table 2 ***Mean response times in Experiment 1***

Target words	*Prime type*		
	test	*identity*	*control*
Suffixes with kanji-written roots	876 (297)	777 (274)	957 (329)
Suffixes written only in kana	853 (289)	848 (349)	900 (326)
Semantic control	595 (148)	582 (152)	631 (292)
Orthographic control	708 (212)	684 (306)	763 (190)

Note: Standard deviations are in parentheses ( ).

Linear mixed effect regression models were fitted to analyze lexical decision response times (RTs) using *R* (R-Development Core Team, 2018) and the *lem4* package (Bates et al., 2015). We adopted the maximal random-effects structure with random intercepts and slopes for both subjects and items in all models (Barr et al., 2013); in cases of convergence failure, the models with the next maximal structure were adopted. For the overall analyses, fixed factors were suffix type (suffixes whose roots can be written in kanji, and suffixes that can be written only in kana) and prime type (test, identity, and control). Subject and item were random factors, the frequencies of target words were covariates, and RT was the dependent variable. Post-hoc analyses were also conducted with linear mixed effects regression models in two stages. In the first stage, the models were fitted to analyze RTs for each suffix type with prime type (test, identity, and control) as a fixed factor, subject and item as random factors, and frequency as a covariate. In the second stage, dummy codes were assigned to each condition (test, identity, and control) and the linear mixed effects regression models were fitted to compare the impact of the three prime type conditions (the test vs. identity conditions, and the test vs. control conditions).

2. Results for response times

The overall accuracy rate was 0.90, and the accuracy rate for target words with a suffix whose root could be written in kanji was 0.95; that of target words with a suffix written only in kana was 0.85.

The overall analyses for the RTs are as follows. The adopted model was "Formula: *RT ~ PrimeType * SuffixType + (1 + PrimeType * SuffixType | ss) + (1 + PrimeType * SuffixType | item) + Frequency.*"[2] The main effect of prime type had a significant effect on RTs ($\beta = -116.61$, $SE = 30.92$, $df = 15.67$, $t = -3.77$, $p = 0.00173$), but no reliable effect of suffix type on RTs ($\beta = 12.44$, $SE = 41.05$, $df = 15.76$, $t = 0.30$, $p = 0.77$) was found, and the interaction of suffix type and prime

2) *ss*: subject

type approached significance ($\beta = -119.73$, SE = 62.02, df = 15.54, t = 15.54, p = .07). Frequency had a significant effect on RTs ($\beta = -65.87$, SE = 26.93, df = 8.17, $t = -2.45$, $p = 0.04$).

The prime types for each suffix type were as follows: For target words with a suffix whose root can be written in kanji, prime type had a significant effect on RTs ($\beta = -179.06$, SE = 30.24, df = 80.65, $t = -5.92$, $p < 0.001$), and frequency had a marginally significant effect ($\beta = -62.01$, SE = 27.43, df = 8.27, $t = -2.26$, p = 0.05)[3].

On the one hand, the test condition yielded longer RTs than the identity condition ($\beta = -113.02$, SE = 28.80, df = 227.54, $t = -3.92$, $p < .001$). On the other hand, it yielded shorter RTs than the control condition ($\beta = 64.66$, SE = 30.77, df = 125.58, t = 2.10, p = 0.038)[4], leading to partial priming[5]. Frequency had a marginally significant effect on RTs ($\beta = -63.13$, SE = 28.13, df = 8.19, $t = -2.24$, p = 0.054).

As for target words with suffixes written only in kana, no effect of Prime Type on RTs ($\beta = -69.42$, SE = 53.06, df = 9.29, $t = -1.31$, p = 0.22) was found; only the covariate *frequency* indicated a significant effect ($\beta = -909.04$, SE = 334.72, df = 5.65, $t = -2.72$, p = 0.04)[6].

As for the multiple comparisons of conditions for prime type, no difference was found between the identity and test conditions ($\beta = -30.19$, SE = 45.46, df = 10.23, $t = -0.66$, p = 0.52) or between the test and control conditions ($\beta = 27.47$, SE = 66.17, df = 11.68, t = 0.42, p = 0.69); only the covariate *frequency* had a significant effect on RTs ($\beta = -1068.71$, SE = 287.81, df = 10.59, $t = -3.71$, p = 0.036)[7].

Linear mixed effect regression models were also fitted to data for semantic and orthographic controls with prime type (test, identity, and control) as a fixed factor, subject and item as random effects, and frequency as a covariate. Regarding

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3) The model "*Formula: RT ~ PrimeType + (1 + PrimeType | ss) + (1 + PrimeType | item) + frequency*" was adopted.

4) The model "*Formula: RT ~ identity * control + (1 + identity + control | ss) + (1 + identity + control | item) + frequency*" was adopted.

5) A separate analysis through a linear mixed effect regression also revealed that RTs were significantly shorter for the identity condition than for the control condition ($\beta = 177.676$, SE = 30.313, df = 78.345, t = 5.861, p = 1.03 e-07). The model "*Formula: RT ~ test * control + (1 + test + control | ss) + (1 + test + control | item) + frequency*" was adopted.

6) The model "*Formula: RT ~ PrimeType + (1 + PrimeType | ss) + (1 + PrimeType | item) + frequency*" was adopted.

7) The model "*Formula: RT ~ identity * control + (1 + identity + control | ss) + (1 + identity + control | item) + frequency*" was adopted.

semantic controls, prime type had a trend but was not significant ($\beta = -60.56$, *SE* = 30.24, *df* = 27.96, *t* = −2.00, *p* = 0.055), and frequency had a significant effect ($\beta = -0.58$, *SE* = 0.24, *df* = 67.95, *t* = −2.42, *p* = 0.018)[8)]. Further analyses indicated no difference between the identity and test conditions ($\beta = -16.61$, *SE* = 15.29, *df* = 169.14, *t* = −1.09, *p* = 0.279) or between the test and control conditions ($\beta = 46.76$, *SE* = 33.29, *df* = 23.51, *t* = 1.41, *p* = 0. 173); hence, no priming effect was found. As for orthographic controls, the main effect of prime type had a significant impact on RTs ($\beta = -80.29$, *SE* = 27.52, *df* = 17.92, *t* = −2.92, *p* = 0.009), but no effect of frequency was found ($\beta = -0.32$, *SE* = 0.45, *df* = 103.79, *t* = −0.71, *p* = 0.480)[9)]. Further analyses revealed that no difference was found between the identity and test conditions ($\beta = -31.69$, *SE* = 27.46, *df* = 26.56, *t* = −1.15, *p* = 0.26) but the test condition yielded shorter RTs than the control condition ($\beta = 48.47$, *SE* = 22.70, *df* = 478.97, *t* = 2.14, *p* = 0.03), leading to a full priming effect[10)].

VI. Discussion

Our first purpose was to investigate whether suffixed words are decomposed into a root and a suffix through a masked priming experiment and to examine whether suffix priming is obtained in Japanese suffixed words. On the one hand, we did not observe a difference for RTs across the conditions of prime type of complex words with indigenous Japanese suffixes that can be written only in kana; therefore, we did not witness a priming effect in words with suffixes written only in kana. On the other hand, we noted a partial priming effect in complex words with suffixes whose roots can be written in kanji. Namely, RTs were longer in the test than in the identity condition, but longer in the test than in the control condition. This pattern of results can be interpreted as a partial priming effect, which suggests that the source of the priming effect is not morpho-orthographic decomposition, but some other factor. Therefore, we did not find evidence of the morpho-orthographic decomposition of suffixed words.

Our second purpose was to investigate whether the suffix root activates kanji when prime words have suffixes whose root can be written in kanji, compared to suffixes that are written only in kana and do not have any corresponding kanji. The different outcomes of the two types of suffixed words could be because different

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8) The model "*Formula: RT ∼ PrimeType + (1 + PrimeType | ss) + (1 + PrimeType | item) + frequency*" was adopted.

9) The model *"Formula: RT ∼ PrimeType + (1 + PrimeType | ss) + (1 + PrimeType | item) + frequency" was adopted.*

10) The model "Formula: RT ∼ identity * control + (1 / ss) + (1 + identity + control / item) + frequency" was adopted.

processes are involved in each type of suffixed word due to the orthographic characteristics of each suffix type. Presented in hiragana, suffixes whose root can be written in kanji activate kanji characters corresponding to their roots, whereas suffixes that are written only in kana do not have any kanji corresponding roots; hence, neither the activation of kanji nor any priming effect may have occurred. The results for words with a suffix whose root can be written in kanji are compatible with the findings of Nakano et al. (2016) and Nakano and Kishimoto (2019), and it is conceivable that kanji that corresponds to the roots of suffixes could be activated.

Importantly, the results for semantic controls indicated no priming effect. This means that the partial priming effect of words with suffixes whose roots can be written in kanji is not due to semantic relatedness between prime and target words. Unlike the outcomes for complex words with suffixes whose roots can be written in kanji, the results for orthographic controls indicate the full priming effect. This also means that the partial priming effect is not due to orthographic overlaps between prime and target words.

VII. Conclusion

We investigated whether complex words with suffixes whose roots can be written in kanji or only in kana are processed differently in the early stages of visual processing through a masked priming experiment. Presented in hiragana, the former type of suffixed words implies a partial priming effect, whereas the latter type shows no priming effect. Hence, in hiragana, the kanji characters of the suffix roots are activated.

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