Testing OCP-labial Effect on Japanese Rendaku

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1 Introduction

Japanese rendaku is a morphophonological phenomenon in which a morpheme-initial voiceless obstruent becomes voiced when it is the non-initial member of a compound. It is well known that rendaku is blocked by Lyman's Law if the second member of a compound already contains a voiced obstruent. In addition to Lyman's Law, there are other factors that inhibit rendaku. One of them is that, although /h/ usually becomes labial /b/ when rendaku applies (e.g., *hako* 'box' + *hune* 'ship' → *hako**b**une* 'ark'; *hude* 'pencil' + *hako* 'box' → *hude**b**ako* 'pencil case'), the rendaku application of /h/ is blocked if the following consonant is labial /m/ (e.g., *suna* 'sand' + *hama* 'beach' → *suna**h**ama* 'sand beach'/**suna**b**ama*; *kutsu* 'shoe' + *himo* 'lace' → *kutsu**h**imo* 'shoelace'/**kutsu**b**imo*) (Kawahara et al. 2006; Kawahara 2015). One contributing factor to this rendaku blocking is that, if /h/ became labial /b/, it would beget a sequence of homorganic consonants /**b**…m…/ (labial…labial), which would violate the OCP effect on consecutive labial consonants (OCP-labial) as observed in various languages (see, e.g., Alderete & Frisch 2007; Bye 2011; Odden 1994; Selkirk 1993; Zuraw & Lu 2009 for examples of OCP-labial effects).[1] As far as I know, there is no wug-test study reported on the OCP-labial effect on Japanese rendaku.

The current paper is the first report of an experiment that examined whether this restriction applies productively to nonce words that contain labial consonants. The results show that 1) the OCP-labial effect can be generalized in rendaku; 2) it works locally rather than non-locally; and 3) the applicability of rendaku is gradient according to the following labial consonant: /m/ shows a stronger blocking effect on the applicability of rendaku than /Φ, w/. The last finding is what is observed in various languages: The more similar two consonants are, the more strongly they are disfavored (e.g., Berent & Shimron 2003; Berent et al. 2004; Buckley 1997; Frisch et al. 2004; Greenberg 1950; Pierrehumbert 1993). To account for this gradient effect, I argue that the process involves two OCP-labial constraints: OCP (labial) and OCP (labial, -continuant), and that they show a ganging-up effect with other faithfulness constraints on blocking rendaku.

The organization of the current paper is as follows: Section 2 explicates the restriction on rendaku that this paper focuses on. Section 3 explains the experimental design and reports the results of the current experiment. Section 4 provides an analysis of the results in the Harmonic Grammar (HG) framework (e.g., Legendre et al. 1990, 2006; Pater 2009, 2016; Potts et al. 2010). Section 5 discusses the issue of the nature of the OCP-labial effect. Section 6 gives a brief conclusion.

2 OCP-labial Effect on Japanese Rendaku

Japanese rendaku, called sequential voicing (Martin 1952), is a morpho-phonological phenomenon in which a morpheme-initial voiceless obstruent becomes voiced when it is the non-initial member of a compound (e.g., McCawley 1968; Vance 1987, 2015; see also Vance & Irwin 2016 for a collection of recent papers on rendaku). Illustrative examples are given in (1), where /t, k, s, h/ become [d, g, z, b], respectively.

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[1] For OCP effects, see, e.g., Bye (2011), Goldsmith (1978), Leben (1973), McCarthy (1986), Odden (1986, 1988), Rose (2001), Suzuki (1998), Yip (1988), and many others.

(1) Typical examples of Japanese rendaku

aka	'red'	+	tama	'ball'	→	aka-**d**ama 'red ball'
oo	'big'	+	tako	'octopus'	→	oo-**d**ako 'big octopus'
umi	'sea'	+	kame	'turtle'	→	umi-**g**ame 'sea turtle'
hi	'sun'	+	kasa	'umbrella'	→	hi-**g**asa 'parasol'
oo	'big'	+	same	'shark'	→	oo-**z**ame 'big shark'
oo	'big'	+	sake	'alcohol'	→	oo-**z**ake 'heavy drinking'
hako	'box'	+	hune	'ship'	→	hako-**b**une 'ark'
hude	'pencil'	+	hako	'box'	→	hude-**b**ako 'pencil case'

It is well known that rendaku is blocked by Lyman's Law if the second member of a compound already contains a voiced obstruent, as illustrated in (2). The initial consonant /t, k, s, h/ of the second example does not undergo rendaku because the second member of the compound already contains a voiced obstruent /b, d, g/.

(2) Lyman's Law

hitori	'alone'	+	tabi	'trave l'	→	hitori-tabi/ *hitori-**d**abi 'travelling alone'
ie	'house'	+	kagi	'key'	→	ie-kagi/ *ie-**g**agi 'house key'
kuro	'black'	+	sabi	'rust'	→	kuro-sabi/ *kuro-**z**abi 'black rust'
tori	'bird'	+	hada	'skin'	→	tori-hada/ *tori-**b**ada 'gooseflesh'

In addition to Lyman's Law, there are other factors that block rendaku.[2] As already seen in (1), /h/ usually becomes labial /b/ when rendaku applies, but the rendaku application of /h/ is inhibited if the following consonant is labial /m/, as in (3) (Kawahara et al. 2006; Kawahara 2015a). Note that labial /m/ per se is not the potential segment that blocks rendaku, as can be seen in examples (1). Hypothesizing that the blocking on rendaku may be attributed to OCP-labial effect, the current experiment examines whether it can be generalized in rendaku, and whether it works locally, non-locally, or both.[3]

(3) [b…m]

suna	'sand'	+	hama	'beach'	→	suna-hama/ *suna-**b**ama 'sand beach'
mai	'dancing'	+	hime	'princess'	→	mai-hime/ *mai-**b**ime 'dancing girl'
kutsu	'shoe'	+	himo	'lace'	→	kutsu-himo/ *kutsu-**b**imo 'shoe lace'
ma	'genuine'	+	hamo	'pike conger'	→	ma-hamo/ *ma-**b**amo 'genuine pike conger'

3 Experiment

3.1 Background

Many researchers have been using nonce words to examine whether speakers of a language make a generalization of rules and constraints (see Berent 2011 for discussion). This has been known as the wug-testing approach since Berko (1958). The OCP effect has been examined experimentally in other languages such as Arabic (Frisch & Zawaydeh 2001; Frisch et al. 2004), Hebrew (Berent & Shimron 1997, 2003), and Japanese (Vance 1979, 1980; Kawahara

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[2] See Irwin (2012) for other factors that dampen rendaku.

[3] Regarding the four segments' potential to undergo rendaku, /h/ is the only segment that changes its place feature when rendaku applies. Thus, there seems to be no clue to examine whether there are other OCP effects of place features (i.e., OCP-coronal or OCP-dorsal effect on rendaku).

2012). Following these studies, the current experiment adopts the wug-testing approach by assuming that nonce words are dealt with by the grammar of a language.

Rendaku experiments have been extensively conducted to confirm the generalizability of rendaku rules and the psychological reality of constraints such as Lyman's Law and the Right-Branch Condition (e.g., Kawahara 2012; Kawahara & Sano 2014a, 2014b, 2016; Kozman 1998; Kumagai 2009, 2014; Ohno 2000; Vance 1979, 1980, 2014; see Kawahara 2016 for referential lists). Since there has been no report on the OCP-labial effect on rendaku, I believe that the report of the current experiment can contribute to the discussion.

3.2 Stimuli

As shown in Table 1, the current experiment prepared two conditions to test locality: each target segment was located (i) on the second-initial mora and (ii) on the third-initial mora. For each condition, we had four groups of nonce words: (a) b-h was used as a control group that did not contain any labial consonants, while (b) b-m, (c) b-Φ, and (d) b-w contained a labial consonant, which can violate the OCP-labial constraint if rendaku applies. In each group, the first vowel (V_1) was any of /a, i, u/, and we thus used 24 trimoraic nonce words (2 conditions*4 groups*3vowels each).[4] For V_2 and V_3, we used /a/ in (a, b, d), but /u/ in (c), as the bilabial fricative Φ is an allophone of /h/ after /u/. Note that Φ is represented with brackets (i.e., /Φ/) throughout this paper.

Table 1. Nonce words used in the current experiment

	(a) b-h	(b) b-m	(c) b-Φ	(d) b-w
(i) Local Condition	/b-h/	/b-m/	/b-Φ/	/b-w/
Nonce words /h$V_1C_2V_2$ra/	hV_1hara	hV_1mara	hV_1hura	hV_1wara
	↓	↓	↓	↓
Rendaku	bV_1hara	bV_1**m**ara	bV_1**Φ**ura	bV_1**w**ara
(ii) Non-local Condition	/b-C-h/	/b-C-m/	/b-C-Φ/	/b-C-w/
Nonce words /hV_1raC_3V_3/	hV_1raha	hV_1rama	hV_1rahu	hV_1rawa
	↓	↓	↓	↓
Rendaku	bV_1raha	bV_1ra**m**a	bV_1ra**Φ**u	bV_1ra**w**a

3.3 Survey of Real Native Words

Are there no cases where rendaku applies in real native words with the sequence of each condition (i, ii) in Table 1? I examined whether bi- and tri-moraic real native words with /h…C_2(…C)/ and /h…C…C_3/, where C_2 and C_3 is any of /h, m, Φ, w/, undergo rendaku. The results showed that there were only two bi-moraic words and only three tri-moraic words that undergo rendaku (see Table 2), all of which are mono-morphemic (see Appendix 1 for actual examples). Taking this into consideration, if there are some significant differences in the applicability of rendaku between (a) the control group and (b, c, d) each experimental group, then this suggests that the OCP-labial effect works on rendaku.

[4] In the current paper, the stimuli with the V_1 being /u/ are assumed to be /humara/ rather than /Φumara/. If /Φumara/ is posited as an input, it becomes [bumara] when rendaku applies, which means that it already incurs OCP-labial violation. This predicts that /Φumara/ is less likely to reduce the applicability of rendaku than /hamara/ and /himara/. On closer examination, however, we found that the difference in the V_1 did not yield any significant differences in the applicability of rendaku.

Table 2. Survey of bi- and tri-moraic real native words[5]

	(a) b-h	(b) b-m	(c) b-Φ	(d) b-w
(A) /h…C_2(…C)/	h…h(…C)	h…m(...C)	h…Φ(…C)	h…w(…C)
Real native words	2	40	0	1
Rendaku	0	2*	0	0
(B) /h…C…C_3/	h…C…h	h…C…m	h…C...Φ	h…C…w
Real native words	0	38	0	0
Rendaku	0	3*	0	0

3.4 Participants and Procedure

Participants were sixty-one naïve native speakers of Japanese, all of whom were undergraduate students in Japanese universities. None of them had majored in linguistics.

The participants were told what rendaku is, and given actual examples. In the test, they were told that the target words were used in Old Japanese, and were given two forms (rendaku- and non-rendaku forms) for each nonce word. They were then asked to choose which of the forms was more natural than the other if each target word was combined with the word *nise* 'fake' (e.g., *nise* + *hamara* → *nise**h**amara* or *nise**b**amara*). All stimuli consisted of 24 items. As I used a written questionnaire, the order of the nonce words was the same for each participant.

3.5 Statistics

For analysis, I implemented a generalized mixed-effects logistic regression, using the *glmer()* function of the *language R* and *lme4* packages (Baayen 2008) of R (R Development Core Team 2013). In the current analysis, random effects were subjects and items. As shown below, in each condition, (a) b-h was compared with (b) b-m and with (c/d) b-Φ/b-w.

3.6 Results

The ratio of rendaku application for each condition was shown in Figures 1 and 2, where error bars represented 95% confidence intervals. As shown in Figure 1, in the local condition, the ratio of the rendaku application is as follows: /b-h/ = 0.7; /b-m/ = 0.34; /b-Φ/ (represented as b-f) = 0.52; /b-w/ = 0.51. There were significant differences between /b-h/ and /b-m/ (z = -7.065, $p < 0.001$) and between /b-h/ and /b-Φ/ (or /b-w/) (z = -4.304, $p < 0.001$). We also found that there was a significant difference between /b-m/ and /b-Φ/ (or /b-w/) (z = -4.154, $p < 0.001$), which means that /m/ has a stronger blocking effect on rendaku than /Φ, w/.

[5] This survey includes bi-morphemic words, which are believed to be reluctant to undergo rendaku, due to the Right-branch condition (see Otsu 1980 for his original proposal; see Vance 2007 for discussion; see Kozman 1998; Kumagai 2014 for psycholinguistic experiments).

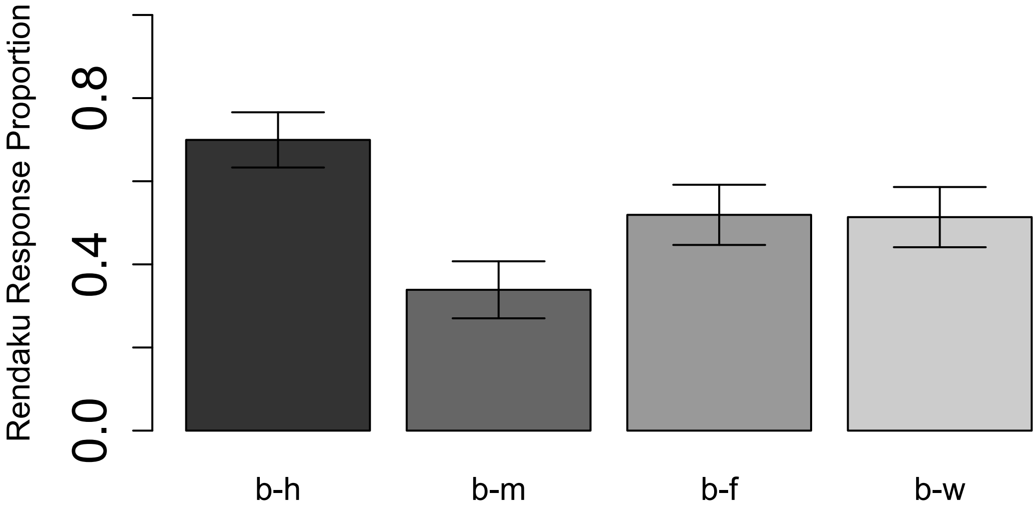

Figure 1. Results of Rendaku Applicability (Local Condition)

As shown in Figure 2, in the non-local condition, the ratio of the rendaku application is as follows: /b-C-h/ = 0.49; /b-C-m/ = 0.46; /b-C-Φ/ (represented as b-C-f) = 0.60; /b-C-w/ = 0.51. There were no significant differences between /b-C-h/ and /b-C-m/ (z = -0.423, *n.s*) and between /b-C-h/ and /b-C-Φ/ (or /b-C-w/) (z = -1.588, *n.s*).

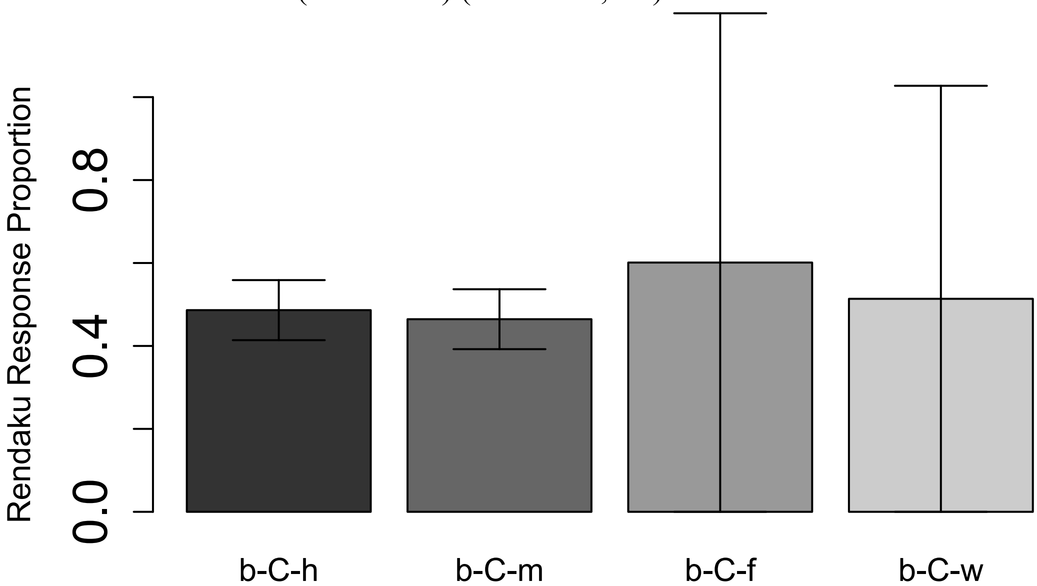

Figure 2. Results of Rendaku Applicability (Non-local Condition)

To summarize, the results of the current experiment shows that 1) the OCP-labial effect can be generalized in Japanese rendaku; 2) that it works locally rather than non-locally; and 3) that the OCP-labial blocking effect is gradient.

3.7 Discussion

We saw in Section 3.3 that real native words with labials rarely undergo rendaku. Nevertheless, the current experiment showed that the OCP-labial effect is gradient in a local condition. This result is not consistent with the studies that show that the statistical pattern of the lexicon matches with the applicability of phonological processes (e.g., Becker et al. 2011; Ernestus & Baayen 2003; Gouskova & Becker 2013; Hayes & Londe 2006; Hayes et al. 2009; Zuraw 2000), but with the studies on OCP effects that demonstrate that the more similar two consonants are, the more strongly they are disfavored (e.g., Berent & Shimron 2003; Berent et al. 2004; Buckley 1997; Frisch et al. 2004; Greenberg 1950; Pierrehumbert 1993). In the current case, similarity can be defined in terms of Place features and continuancy. For Place features, [labial] is specified for /b, m, Φ, w/. For continuancy, /b, m/ have a negative value (i.e., [-continuant]) while [Φ, w] have a positive one (i.e., [+continuant]). From the perspective of the feature specification, /b/ is more similar to /m/ than to /Φ, w/. We can thus account for why /m/ displayed a stronger blocking effect on rendaku than /Φ, w/ did.

Continuancy plays an essential role in accounting for the gradient OCP effect on Japanese rendaku. This can also be found in other languages. Padgett (1991, 1992) argues that continuancy (i.e. stricture) and sonorancy, as well as place features, are the key to account for consonant cooccurrence restrictions in Russian. For example, the root *sad-* 'sit' is well-formed because the value of [continuant] differs between /s/ and /d/, but the root *s'oz-* is ill-formed because the two consonants share [+continuant]. See also Coetzee & Pater (2008), who make a similar assumption in the analysis of Muna and Arabic.

There is a growing body of experiments demonstrating that phonological behavior shows a gradient aspect (e.g., Albright 2009; Berent & Simron 1997; Hayes 2000; Hayes & Londe 2006; Kawahara 2011a, 2011b, 2013a, 2013b; McPherson & Hayes 2016; Zuraw 2000). However, a generative grammar, like standard Optimality Theory (Prince & Smolensky 1993/2004), cannot account for it in a straightforward way, as it holds a two-way distinction between "grammatical/ acceptable" and "ungrammatical/ unacceptable" (see Coetzee & Pater 2008; Coetzee 2008; 2009; Ernestus 2011 for discussion). To model the gradient applicability of rendaku, I will provide an HG analysis in the next section.

4 Harmonic Grammar Analysis

4.1 Harmonic Grammar Analysis

HG (e.g., Legendre et al. 1990, 2006; Pater 2009, 2016; Potts et al. 2010) is a constraint-based theory in which constraints are numerically weighted. Harmony maximization is calculated in terms of the sum of C_i*w_i, where the candidate's violation of each constraint (C_i) is multiplied by the weight (w_i). In the current HG analysis, constraints assign negative scores to candidates, and thus the candidate that has the value closest to zero will be optimal.

The current HG analysis uses five constraints in (4). Following the OT analysis of Japanese rendaku (Itô & Mester 2003), I use REALIZE MORPHEME (RM) and IDENT (voice). In the current case, RM can be interpreted as requiring the initial consonant of the second member to become voiced. I also use IDENT (Place), which penalizes the /h/→[b] alternation, as the OCP violation in question can also be seen in the alternation. To account for the gradient aspect of OCP-labial effect on rendaku, I propose two constraints of OCP-labial: OCP (labial) and OCP (labial, -continuant). Note that the latter is violated only when /b/ is followed by /m/.

(4) Constraint Set

REALIZE MORPHEME	Every morpheme in the input has a nonnull phonological exponent in the output (Itô & Mester 2003:87).
OCP (labial, -continuant)	Bans /b…m/.
OCP (labial)	Bans /b…m/, /b…Φ/, and /b…w/.
IDENT (voice)	A voiced/voiceless consonant must have a correspondent with the same value between input and output.
IDENT (Place)	A consonant must have a correspondent with the same value of Place features between input and output.

The constraint violation profile for each candidate relevant to the current experiment is presented in (5). The non-rendaku forms presented in (5) violate RM, since they do not undergo rendaku. The rendaku forms violate IDENT (voice) and IDENT (Place), since voiceless glottal (or placeless) /h/ becomes voiced labial /b/. For OCP violation, the rendaku forms /b…Φ/ and /b…w/ violate OCP (labial), and the rendaku form /b-m/ violates not only OCP (labial) but also OCP (labial, -continuant). Since all constraints but RM can block rendaku, they can show a gang effect, in which lower-weighted constraints overcome a constraint with a higher weight (e.g., Jäger & Rosenbach 2006; Pater 2009, 2016; Potts et al. 2010).[6]

(5) Constraint Violation Profile under Harmonic Grammar

	REALIZE MORPHEME	OCP (lab, -cont)	OCP (lab)	IDENT (voice)	IDENT (Place)
/+ h-h/					
… h-h	-1(No RM)				
… b-h				-1(h → b)	-1(h → b)
/+ h-Φ/w/					
… h-Φ/w	-1(No RM)				
… b-Φ/w			-1(b…Φ/w)	-1(h → b)	-1(h → b)
/+ h-m/					
… h-m	-1(No RM)				
… b-m		-1(b…m)	-1(b…m)	-1(h → b)	-1(h → b)

4.2 HG Gradual Learning Algorithm

To confirm whether language learners can learn the grammar presented in (5), I used *Praat* to implement the HG Gradual Learning Algorithm (e.g., Boersma & Weenink 2007; Boersma & Pater 2016).[7] In the simulation, I assumed that rendaku does not apply to native words with /h…C_2(…C)/, where C_2 is any of /h, m, Φ, w/ (recall Section 3.3). Since it is generally assumed in OT that markedness constraints are ranked higher than faithfulness constraints in the initial state (e.g., Smolensky 1996; see McCarthy 2002:231 for a referential list), the markedness constraints (i.e., OCP-labial constraints) were given 100 as the initial weight, and the faithfulness constraints (i.e., RM and IDENT) were given 50 (Coetzee & Pater 2008:319; Oh & Hong 2013).[8] The results of calculating weights are shown in Table 3: RM (w = 72.2); OCP (labial, -continuant) (w = 101.32); OCP (labial) (w = 101.06); IDENT (voice) (w = 27.57); IDENT (Place) (w = 26.84). The constraint weights are the mean values acquired by running the learning process ten times (see Appendix 2 for details).

Constraints	Weight
REALIZE MORPHEME	72.2
OCP (labial, -continuant)	101.32
OCP (labial)	101.06
IDENT (voice)	27.57
IDENT (Place)	26.84

Table 3. Constraints and Weights by HG-GLA

The current HG Tableau is presented in (6). In the current experiment, we saw the gradient aspect that /m/ showed a stronger blocking effect on the applicability of rendaku than /Φ, w/. How can this be accounted for? The current HG analysis assumes that harmonic scores of

[6] In a gang effect of HG, one constraint can in principle gang up with another. Japanese loanword devoicing (e.g., Nishimura 2001, 2006; Kawahara 2006, 2015b) is an example of the ganging-up of two markedness constraints: a constraint on voiced geminates and OCP-voice (Pater 2009, 2016; see also Kawahara 2015b). Another pattern is a cumulativity of violations of faithfulness constraints: violations of two faithfulness constraints tradeoff for a violation of a third faithfulness constraint (e.g., Farris-Trimble 2008; Kumagai to appear). The current paper provided us with evidence for the ganging-up of markedness (OCP-labial) and faithfulness (IDENT) constraints.

[7] Default settings in *Praat*: 'LinearOT' decision strategy; 2.0 noise evaluation; 1.0 initial plasticity; 0.1 plasticity decrement. These parameters vary according to research (for other case studies, see, e.g., Coetzee & Pater 2008; Coetzee & Kawahara 2013; Sano 2009; Jesney & Tessier 2009; Zuraw & Hayes to appear).

[8] However, the initial state in HG requires further discussion. See Jesney & Tessier (2011) for a proposal of the plasticity of faithfulness constraints in HG.

candidates can be used to model acceptability judgments (e.g., Coetzee & Pater 2008). The idea here is that, provided that the optimal candidate of each candidate set has the same violation profile, the lower a candidate's harmonic-score is *across* candidate sets, the more unlikely it is to be considered acceptable (cf. Keller 2006). To compare the harmonic score of each rendaku forms, /b…h/ is the most harmonic, /b-m/ is the least, and /b-Φ/ and /b-w/ are intermediate, from which it follows that /b-m/ is less harmonic than /b-Φ/ and /b-w/ and also that /b-Φ/ and /b-w/ is less harmonic than /b-h/.

(6) Harmonic Grammar Tableau

	REALIZE MORPHEME	OCP (lab, -cont)	OCP (lab)	IDENT (voice)	IDENT (Place)	
weight	72.2	101.32	101.06	27.57	26.84	H-score
/+ h-h/						
… h-h	-1					-72.2
… b-h				-1	-1	-54.41
/+ h-Φ/w/						
… h-Φ/w	-1					-72.2
… b-Φ/w			-1	-1	-1	-155.47
/+ h-m/						
… h-m	-1					-72.2
… b-m		-1	-1	-1	-1	-256.79

There is a caveat to the above HG analysis. The current grammar (6) cannot faithfully produce real words with /b…m/ (e.g., *bamen* 'scene'): [b…m] is less harmonic than [d…m], because the former violates OCP-labial constraints whereas the latter does not. There are two solutions. First, it is possible to assume, following Zuraw (2000) and Hayes & Londe (2006), that the production of real words in the lexicon is guaranteed by faithfulness constraints (USELISTED). Since novel (nonce) words are irrelevant to the effect of such faithfulness constraints, they are susceptible to OCP-labial effects. Second, the OCP-labial constraints are assumed to be special constraints in the sense that they do not affect words in the lexicon. This idea will also be discussed in Section 5.

5 General Discussion

The current experiment led us to admit that rendaku involves the OCP-labial constraints. As seen in Section 2, Lyman's Law is a well-known constraint that prevents rendaku from being applied. However, there are two differences between Lyman's Law and OCP-labial constraints. First, while Lyman's Law does work even on an underlying level, OCP-labial constraints do not. Since Lyman's Law prohibits voiced obstruents from occurring twice or more in a word, it can play a role in accounting for the fact that, in Japanese, there are few monomorphemic words with two voiced obstruents. For example, we have *Φuta* 'lid,' *Φuda* 'tag,' *buta* 'pig,' but not *buda* (Itô & Mester 1995:819), the last one of which contains two voiced obstruents. Instead, we find native and loan monomorphemic words with consecutive labial consonants (e.g., *mame* 'bean'; *mimi* 'ear'; *momo* 'peach'; *Φumi* 'letter'; *mawas-u* 'rotate'; *mama* 'Mom'; *memo* 'memo'; *obama* 'Obama'; *maΦuraa* 'muffler'), which means that OCP-labial constraints do not work on an underlying level. Second, while Lyman's Law works even in the long distance, OCP-labial constraints exhibited its effects only in the local condition. Lyman's Law blocks rendaku if the resulting form will contain two or more voiced obstruents (e.g., *kuro* 'black' + *sabi* 'rust' → *kuro-sabi*/ **kuro-zabi* 'black rust'; *oo* 'big' + *sawagi* 'fuss' → *oo-sawagi*/**oo-zawagi* 'big fuss'), but as the current experiment demonstrated, OCP-labial constraints seem not to be active when there is a consonant intervening between initial /h/ and the third labial consonant.

In light of the hallmarks of OCP-labial constraints mentioned above, OCP-labial constraints are similar to Identity Avoidance in Japanese, which bans sequential identical mora. Though there are a number of Japanese words with sequential identical mora (e.g., *mimi* 'ear'; *momo* 'peach'; *nana* 'seven'; *sasa* 'bamboo'; *haha* 'mother'), Kawahara & Sano's (2014a, 2014b, 2016) wug-test studies show that rendaku is triggered or blocked if the resulting sequential mora across the boundary is identical.[9] The features that Identity Avoidance and OCP-labial constraints possess in common are that, in creating novel combination, identical or featurally similar consonants are disallowed from occurring in succession. However, the issue to be resolved is why such constraints do not affect words in the lexicon. Presumably, they could work only in the word formation or (morpho)phonological processes that produce novel combinations, as (some) speakers are more "resistant to novel combination" than to lexicalized words or conventionalized phrases. In this sense, such constraints could be characterized as "psychological constraints." This issue will be left for future exploration.

6 Conclusion

The current paper reported on the wug-test study that examined the OCP-labial effect on Japanese rendaku. The results showed that 1) it can be generalized in rendaku; 2) that it works only in a local condition; and 3) that labial /m/ had a stronger blocking effect on the applicability of rendaku than /Φ, w/. This gradient effect can be captured in the HG framework. In the current analysis, the OCP (labial), the OCP (labial, -continuant), and IDENT (Place) gang up with IDENT (voice) to overcome RM with higher weight.

Appendix 1

Survey of native words (* words that undergo rendaku)

2 mora	h…h (n = 2)	h…m (n = 9)	h…Φ (n = 0)	h…w (n = 0)
	haha 'mother' hoho 'cheek'	hama 'beach' hame 'fitting' hamo 'conger pike' hima 'time to spare' hime 'princess' himo 'string' *humi 'trample; letter' hema 'blunder' *home 'praise'	-	-
3 mora	h…h…C (n = 0)	h…m...C (n = 31)	h…Φ…C (n = 0)	h…w…C (n = 1)
	-	e.g., hamaki 'cigarette' hamono 'knife' himono 'dried fish' humoto 'bottom' homare 'honor'	-	hiwari 'schedule'
3 mora	h…C…h (n = 0)	h…C…m (n = 38)	h…C...Φ (n = 0)	h…C…w (n = 0)
	-	e.g., *hakama 'hakama' hasama 'interval' *hasami 'scissors' *husuma 'husuma' hanawa 'wreath'	-	-

[9] Irwin (2014) rejects this hypothesis based on statistical evidence.

*Actual Examples

asi	‘foot’	+	humi	‘trample’	→	asi-**b**umi ‘halt’
e	‘foot’	+	humi	‘trample’	→	e-**b**umi
koi	‘love’	+	humi	‘letter’	→	koi-**b**umi ‘love letter’
ya	‘arrow’	+	humi	‘letter’	→	ya-**b**umi ‘ ’
beta	‘over-’	+	home	‘praise’	→	beta-**b**ome “overpraise”

sentaku	‘washing’	+	hasami	‘scissors’	→	sentaku-**b**asami
ita	‘board’	+	hasami	‘scissors’	→	ita-**b**asami
kawa	‘leather’	+	hakama	‘hakama’	→	kawa-**b**akama
siro	‘white’	+	hakama	‘hakama’	→	siro-**b**akama
gin	‘silver’	+	husuma	‘husuma’	→	gin-**b**usuma
kiri	‘fog’	+	husuma	‘husuma’	→	kiri-**b**usuma

Appendix 2

Results of 10 trails via *Praat*

Trails	REALIZE MORPHEME	OCP (lab, -cont)	OCP (lab)	IDENT (voice)	IDENT (Place)
1	73.482	98.639	98.074	26.148	24.532
2	69.71	102.814	103.23	26.907	23.746
3	72.644	104.145	100.304	28.359	29.945
4	71.759	99.443	103.644	28.354	26.565
5	69.506	100.327	102.185	30.023	30.434
6	74.161	102.077	99.827	26.526	25.274
7	73.285	102.164	100.849	22.661	28.003
8	75.322	97.989	97.218	29.57	28.126
9	73.608	101.009	102.022	28.517	25.764
10	69.836	101.898	100.258	27.234	23.695
Average	72.2	101.32	101.06	27.57	26.84

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To be added.

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