Vowel Epenthesis and Consonant Deletion in Japanese Loanwords from English

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1. Introduction

In general, borrowing of foreign words often entails their phonetic and phonological modification. Borrowed words often include some sounds or phonological patterns that do not fit the phonetic or phonological constraints in the recipient language, so the source words are 'repaired' to 'do as little violence as possible' to the recipients' constraints (Sapir 1921: 210). This paper specifically discusses epenthetic vowels in Japanese loanwords from English in the framework of optimality theory (OT). The primary objective of the current study is to examine how Japanese speakers/communities select epenthetic vowels in modifying English words. A number of early studies attempted to find out the epenthetic patterns of Japanese loanwords. For example, Otaki (2012) tries to explain it comprehensively in the framework of OT. However, most of the early studies are either limited to explaining partial phenomena or seem not to succeed in explaining all the patterns of the vowel epenthesis in Japanese loanwords. This paper aims to include as many epenthetic patterns as possible in a unified explanation with a single ranking of constraints. Also, two experiments were conducted to empirically test the analysis that this paper suggests.

2. Vowel Epenthesis

The fundamental motivation for epenthetic vowels in loanword adaptation is that recipient languages do not allow codas and consonant clusters. This invokes the markedness constraints of NOCODA / CODACOND and *COMPLEX. In order to repair codas and consonant clusters, recipient languages apply deletion or epenthesis based on the faithfulness constraints, DEP-IO or MAX-IO, respectively. According to the preservation principle (Paradis and Lacharité 1997), epenthesis should be preferred over deletion in order to preserve the input features. In reality, an empirical observation shows that a majority of the languages in the world prefers epenthesis rather than deletion (Kang 2011).

Roughly speaking, epenthetic vowels are context-dependent vowels and context-free default vowels. Regarding the context-free default vowel, it should be as faithful as possible to the empty spot that bears no feature and no duration of time. Thus, the epenthesized segment should be the one that is the least intrusive, the most unmarked, and perceptually the closest to zero (or silence), in the recipient languages (Steriade 2001, Hirayama 2003). Epenthetic vowels with minimal salience would result in a smaller perceptual change between the input and output.

According to Lehiste (1970), Carr (1999) and Blevins (1995), high vowels are less sonorous and shorter in duration than low vowels. Also, Lombardi (2002) states that front vowels are more marked than back vowels, and Kager (1999) states that [-low, + back, -round] vowels are the most unmarked values for epenthetic vowels. Based on these studies, we propose the constraints of HIGH, *LOW, BACK, *FRONT and *ROUND. The constraints should be ranked in the order that would generate actual epenthetic vowels.

(1) Markedness constraints for context-free epenthetic vowels

HIGH:	Vowels should be high.
*LOW:	Vowels should not be low.
BACK:	Vowels should be back.
*FRONT:	Vowels should not be front.
*ROUND:	Vowels should not be rounded.

* Many thanks to Professor Eric Holt supporting this research. We would like to express my gratitude to the audiences of my presentation and the readers of this paper. Also, We thank the editors and reviewers for their patience.

Proceedings of *Phonology 2013*
Completed February 15, 2014

According to the observation of the vowel systems in languages in the world, the five-vowel system with [a], [i], [u], [e] and [o] is the most common vowel system. Fijian is one of the languages that have this five-vowel system. Kenstowicz (2003) observes that [i] is the default epenthetic vowel of Fijian, and it is perceptually the closest to zero among the five vowels. However, this is a front vowel. Thus, the constraints about back feature such as *FRONT and BACK should be lower ranked than the other constraints. The optimality of [i] in Fijian is drawn with the ranking below.

(2) HIGH, *LOW, *ROUND >> BACK, *FRONT

CVC	HIGH	*LOW	*ROUND	BACK	*FRONT
CVCa	*!	*(!)		*	
☞ CVCi				*	*
CVCu			*!		
CVCe	*!			*	*
CVCo	*!		*(!)		

Meanwhile, Kager's (1999) observation of many languages in the world indicates that [ɨ], [ə] and [i] are the most common epenthetic vowels. If we add [ə] to the tableau in (2) above, it cannot be optimal because [ə] violates HIGH. Here, we need to place the constraint, HIGH, lower in the ranking. Also, *FRONT has to be higher than HIGH and BACK in order for [ə] to be optimal.

(3) *ROUND, *LOW >> *FRONT >> HIGH, BACK

CVC	*ROUND	*LOW	*FRONT	HIGH	BACK
CVCa		*!		*	*
CVCi			*!		*
CVCu	*!				
CVCe			*!	*	*
CVCo	*!			*	
☞ CVCə				*	*

If we check again the Fijian epenthetic vowel [i] with this constraint-ranking, we can confirm that [i] is successfully generated.

(4) *ROUND, *LOW >> *FRONT >> HIGH, BACK

CVC	*ROUND	*LOW	*FRONT	HIGH	BACK
CVCa		*!		*	*
☞ CVCi			*		*
CVCu	*!				
CVCe			*	*!	*
CVCo	*!			*	

If all the most common epenthetic vowels in the world, [ɨ], [ə] and [i], are available in a language's vowel inventory, the constraint-ranking above would generate [ɨ] as the optimal epenthetic vowel as shown below.

(5)

CVC	*ROUND	*LOW	*FRONT	HIGH	BACK
CVCa		*!		*	*
CVCi			*!		*
CVCu	*!				
CVCe			*!	*	*
CVCo	*!			*	
CVCə				*!	*
☞ CVCɨ					*

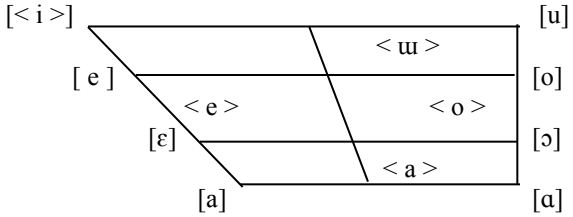
According to this analysis, among the three most common epenthetic vowels, [ɨ], [ə] and [i], [ɨ] is considered to be the best qualified epenthetic vowel, [ə] is the second best, and [i] is the third best, although

all three are equally common epenthetic vowels. According to Harrison and Kaun (2000), a language has to utilize vowels that exist in its vowel inventory. They express this constraint as IS (INVENTORY STRUCTURE): using a segment that exists in the language's inventory. Thus, it is purported that, in world languages, [ɨ] is not as common as [ə] or [i]; and [ə] is not as common as [i]. If a language does not have [ɨ], it utilizes [ə]; if a language does not have [ɨ] or [ə], it utilizes [i]. IS would also explain why other high back unrounded vowels such as [ɯ] are not as common epenthetic vowels as [ɨ], [ə] and [i]: not many languages have [ɯ] while many of them commonly have [ɨ], [ə] and [i].

3. Japanese Vowel Epenthesis

3.1. *Context-free default epenthetic vowel [ɯ]* Japanese does not allow consonant clusters or codas (except [n]), and its loanwords prefer epenthesis to deletion. This invokes the following ranking: *COMPLEX, CODACOND >> MAX-IO >> DEP-IO. Japanese has a five-vowel system of [a], [e], [i], [o], and [ɯ] as shown in (6) below. Among those vowels, [ɯ] is unrounded and quite centralized in the Japanese inventory. Japanese [e] and [o] are slightly more centralized than the equivalent cardinal vowels.

(6) Japanese vowels in < > and cardinal vowels in [ ]



(Vance 2008: 54)

In most Japanese loanwords, the epenthetic vowel is [ɯ], which works as the context-free default epenthetic vowel. It is the most unmarked and perceptually the least salient among Japanese vowels, as supported by the facts that [ɯ] is 'the most readily subject to devoicing' and to 'weakening and elimination' (Lovins 1975: 106, Mori 1929: 58 as cited in Lovins 1975: 106), and that it rarely attracts the accent (Yoshida 2006). Also, Han's (1962) examination of the duration of Japanese vowels shows that [ɯ] is the shortest in length as shown below.

(7) Longest [a] - [e] - [o] - [i] - [ɯ] Shortest

If we check the generation of [ɯ] with the constraint-ranking from the previous section, which generates the default epenthetic vowels, we find that *HIGH needs to be placed higher than BACK for [ɯ] to be generated, as shown below.

(8) *ROUND, *LOW >> *FRONT >> HIGH >> BACK

CVC	*ROUND	*LOW	*FRONT	HIGH	BACK
CVCa		*!		*	*
CVCi			*!		*
☞ CVCɯ					*
CVCe			*!	*	*
CVCo	*!			*	

3.2. *Context-dependent epenthetic vowel [i]* Some Japanese loanwords exhibit the context-dependent epenthetic vowels, [i] and [o]. As for [i], it appears after the palato-alveolar affricates, [tʃ] and [dʒ], in source words. Examples are shown below.

(9)

Source words	Loanwords
match [mætʃ]	[mattɕi]
beach [bitʃ]	[bi:tɕi]
page [peɪdʒ]	[pe:dʑi]

The palato-alveolar affricates, [tʃ] and [dʒ], in the source words are adapted as [tɕ] and [dʑ] in Japanese loanwords, both of which are palatal affricates. I use the constraint of IDENT-IO for this featural alteration from [tʃ] and [dʒ] to [tɕ] and [dʑ]. Preceded by these affricates, [i] is physically more economical to epenthesize than [ɯ] because the articulation of palatalized segments raises the front of the tongue toward a position closer to that for [i] on a primary gesture. (Lovins 1975, Ladefoged & Maddieson 1996, Kubozono 1999, and Kobayashi 2005). This easier movement of the tongue draws the constraint, PALATAL-FRONT: vowels after palatals should be front. We add these two constraints above, IDENT-IO and PALATAL-FRONT, to the constraint-ranking in (8). The two constraints, IDENT-IO and PALATAL-FRONT should be higher ranked than all the constraints in (8) so that the generation of [ɯ] is canceled.

(10) PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK

…tʃ/dʒ	PALATAL-FRONT	IDENT-IO	*ROUND	*LOW	*FRONT	HIGH	BACK
tɕ/dʑ a	*!	*		*		*	*
☞ tɕ/dʑ i		*			*		*
tɕ/dʑ ɯ	*!	*					*
tɕ/dʑ e		*			*	*!	*
tɕ/dʑ o	*!	*	*			*	

3.3. *Context-dependent epenthetic vowel [o]* Another context-dependent epenthetic vowel in Japanese loanwords is [o], which is epenthesized after alveolar stops, [t] and [d]. Examples are shown below.

(11)

Source words	Loanwords
eight [eɪt]	[eito]
mattress [mætrɪs]	[mattoresɯ]
trend [trɛnd]	[torendo]

If the better-qualified vowel as an epenthetic vowel, [ɯ] or [i], were epenthesized after [t] or [d], the output would be [tɯ, dɯ] or [ti, di], which the Japanese syllable inventory does not have. As mentioned earlier, the constraint, IS, only allows for segments that exist in the inventory of the language in question. In this study, IS could be expanded to SYLLABLE INVENTORY STRUCTURE (SIS): using the syllables that exist in the syllable inventory of the language. SIS should be more suitable for the analysis of a syllable-oriented (rather than segment-oriented) language such as Japanese. The possible outputs, [tɯ, dɯ, ti, di], would violate SIS. Also, if [ɯ] or [i] were still epenthesized after [t] or [d] without violating SIS, [t] and [d] would have to be altered. As a result, the outputs would be [tsɯ, dzɯ, tɕi, dʑi], which indeed exist in the Japanese syllable inventory, but the alteration of [t] or [d] violates IDENT-IO. In order not to violate SIS and IDENT-IO, Japanese speakers avoid epenthesizing [ɯ] or [i]. Instead, they epenthesize another non-low back vowel, [o], which has the third shortest intrinsic duration after [ɯ] and [i] as Han's scale shows in (7).

We add the constraints, SIS, to the ranking in (10). This constraint is ranked as high as PALATAL-FRONT and IDENT-IO. As shown in the tableau below, they evaluate the candidates with [t] and [d] that precede epenthetic site. However, we encounter a problem with this tableau; this constraint-ranking generates [e], not [o].

(12) SIS, PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK

…t/d	SIS	PALATAL-FRONT	IDENT-IO	*ROUND	*LOW	*FRONT	HIGH	BACK
t/d a					*!		*	*
t/d i	*!					*		*
t/d ɯ	*!							*
💣 t/d e						*	*	*
√ t/d o				*!			*	
tɕ/dʑ i			*!			*		*
ts/dz ɯ			*!					*

(💣 stands for an unpredicted optimal candidate, which nevertheless is generated. √ stands for a predicted optimal candidate, which nevertheless is not generated.)

Here, we reexamine the quality of Japanese [o]. We know Japanese [o] is more centralized than cardinal [o]. Ladefoged and Maddieson (1996) state that, although back vowels are usually rounded, sometimes a language has relaxed the linkage between backness and rounding. In Whitman's (1985) study on Japanese sound system, [o] is located at the center of the pre-old Japanese vowel inventory, like schwa. Also, Hamano (1998) finds that Japanese [o] does not accompany protrusion or tenseness. Referring to these observations, we assume that the roundedness of Japanese [o] is too weak to violate *ROUND. This reexamination of [o] will rewrite the tableaux (8), (10) and (12) as below. They generate the correct forms.

(13) a. *ROUND, *LOW >> *FRONT >> HIGH >> BACK (Modification with (8))

CVC	*ROUND	*LOW	*FRONT	HIGH	BACK
CVCa		*!		*	*
CVCi			*!		*
☞ CVCɯ					*
CVCe			*!	*	*
CVCo				*!	

b. PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK (Modification with (10))

…tʃ/dʒ	PALATAL-FRONT	IDENT-IO	*ROUND	*LOW	*FRONT	HIGH	BACK
tɕ/dʑ a	*!	*		*		*	*
☞ tɕ/dʑ i		*			*		*
tɕ/dʑ ɯ	*!	*					*
tɕ/dʑ e		*			*	*!	*
tɕ/dʑ o	*!	*				*	

c. SIS, PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK (Modification with (12))

…t/d	SIS	PALATAL-FRONT	IDENT-IO	*ROUND	*LOW	*FRONT	HIGH	BACK
t/d a					*!		*	*
t/d i	*!					*		*
t/d ɯ	*!							*
t/d e						*!	*	*
☞ t/d o							*	
tɕ/dʑ i			*!			*		*
ts/dz ɯ			*!					*

Overall, this set of constraints in the ranking successfully generates the epenthesis of [ɯ] as the default vowel, [i] after palatals, and [o] after alveolar stops.

In the analysis above, we constructed the ranking of SIS, PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK. To this ranking, we add the four general constraints for epenthesis, *COMPLEX, CODACOND, MAX-IO and DEP-IO. This completes the single ranking as shown in (14).

(14) *COMPLEX / CODACOND >> MAX-IO >> SIS, PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK >> DEP-IO

This constraint-ranking should explain the most modifications of English phonotactics, which does not fit the Japanese phonological system.

4. Irregular Adaptations

4.1. *Epenthesis of [i] after dorsal consonant* In this section, we will discuss some unstable, shaky and irregular patterns of modification of loanwords. One of the irregular patterns is [i]-epenthesis after non-palatals, which can be explained by historical change of vowel epenthesis. Example loanwords with the irregular [i]-epenthesis are shown below.

(15)

Source words	Loanwords
cake [keɪk]	[ke:ki]
brake [breɪk]	[bɯɾe:ki]
shake [ʃeɪk] (as a fast food)	[se:ki]

When observing the loanwords and source words above, we see that [i] is epenthesized after the voiceless dorsal consonant [k], and the neighboring vowels of [k] in the source words are front vowels such as [ɪ] and [ɛ]. This appears to be a vowel harmony of the back feature.

In Old Japanese, the native vocabulary utilized vowel harmony. Ichikawa observes that, '[i] was added where the neighboring vowel was a front vowel like [e] or [i], and . . . [ɯ] or [o] occurred when it was preceded or followed by a back vowel. In this we see a sort of vowel harmony' (1930: 183). Thus, this epenthesis of [i] in some loanwords such as the ones in (15) is considered to be the residue of the vowel harmony in old Japanese. The choice of the epenthetic vowels from vowel harmony is considered to have been diachronically replaced by the use of the default epenthetic vowel. Some doublet loanwords and homophone loanwords evidence this analysis.

(16) a. Doublets

Source words	Old loanwords (Vowel harmony)		Recently-made doublet (Default [ɯ])
shake [ʃeɪk] (as a fast food)	[se:ki]	→	[ʃeikɯ]
ink [ɪŋk]	[inki]	→	[inkɯ]

b. Homophones

Source words	Old loanword (Vowel harmony)	Recently-made loanword (Default [ɯ])
brake [breɪk]	[bɯɾe:ki]	
break [breɪk]		[bɯreikɯ]

The loanwords to the right in the tables above are more recently coined than the ones to the left. The recent loanwords exhibit the default epenthetic vowel [ɯ] while the old loanwords exhibit vowel harmony although the pronunciations of the source words are the same. Based on this irregular [i]-epentheis after non-palatals, we introduce a constraint, HARMONY, which used to be higher ranked but has been lowered.

(17) a. Old loanwords: Output [ki] as [bɯɾe:ki] (< *break* [breɪk])

…ɪk	SIS	PALATAL-FRONT	IDENT-IO	HARMONY	*ROUND	*LOW	*FRONT	HIGH	BACK
…ɪk a				*!		*		*	
☞ …ɪk i							*		*
…ɪk ɯ				*!					*
…ɪk e				*!			*	*	*
…ɪk o				*!				*	

b. Recent loanwords: Output [kɯ] as [bɯreikɯ] (< *break* [breɪk])

…ɪk	SIS	PALATAL-FRONT	IDENT-IO	*ROUND	*LOW	*FRONT	HIGH	BACK	HARMONY
…ɪk a					*!		*		*
…ɪk i						*!		*	
☞ …ɪk ɯ								*	*
…ɪk e						*!	*	*	*
---ik o							*!		*

Certain questions remain. If the vowel harmony was diachronically replaced by the use of the default epenthetic vowel, why does epenthetic [i] still survive in some loanwords, particularly in the context of [k], dorsal? First, we know that [i] is also highly qualified as an epenthesized vowel, generally speaking: [i] is [+high, -round], and the intrinsic duration of [i] is the second shortest next to [ɯ]. In addition, referring to Rose and Demuth's (2006) study on vowel epenthesis in Sesotho, a dorsal consonant does not block the harmony between the neighboring vowels. This 'transparent' quality of dorsal consonant and the high

qualification of [i] as an epenthetic vowel might have allowed [i] to remain in the epenthetic slots of many loanwords.

4.2. *Adaptation of [r]* The adaptation of [r] shows various patterns. In some loanwords, the default vowel [ɯ] is epenthesized after [r], as shown below in (18a). However, in some other loanwords, [r] is deleted, and the preceding vowel is lengthened. The lengthened preceding vowel fills in the position of [r], as shown in (18b). Also, there are some other loanwords in which [r] is replaced with [a], as shown in (18c).

(18)	Modification		Source words	Loanwords
a.	r → ɾɯ /	V_σ	allergy [ælərdʒi]	[aɾeɾɯgi:]
		V_C	tornado [tɔrneɪdoʊ]	[toɾɯne:do]
b.	r → V1 /	V1_σ	guitar [gɪtɑr]	[gita:]
		V1_C	fork [fɔrk]	[fo:kɯ]
c.	r → a /	V_σ	store [stɔr, stoʊr]	[sɯtoa]
		V_C	core [kɔr, koʊr]	[koa]
			fair [fɛər]	[fea]

In (18b) and (18c), the adaptation of [r] does not utilize epenthetic vowels, and it turns to a vowel.[1]

5. Experiment 1

5.1. *Method* An experiment was conducted in order to test whether the analyses of the loanwords above hold true in Japanese speakers' modification in their pronunciation of English. In particular, the experiment tested whether the constraint-ranking in (14) predicts which vowel native Japanese speakers epenthesize. Fifteen native Japanese speakers participated in the experiment. They were orthographically provided with 70 nonce words spelled in Latin script, which included word-final codas and word-initial consonant clusters.[2] Their task was to rewrite those nonce words in Japanese characters. A Japanese character represents a mora-bearing unit, which is basically a syllable such as V or CV. In its syllabic writing system, there is no way to write coda consonants or consonant clusters in Japanese characters, so the participants had to either delete consonants or epenthesize vowels when rewriting the stimuli. The non-words in the experiment were in ten different conditions as shown below. Also, the predicted epenthesized vowels according to our constraint-ranking in (14) are shown.

(19) Conditions

a. Word-final coda

Stimuli (Nonce words)	Predicted epenthesized vowels
(i) [b, f, m, p, q, s, v, z] (e.g. *gamb, ktnof*)	[ɯ] (default vowel)
(ii) [tʃ, dʒ], which were spelled with *ch* and *dge*, respectively. (e.g. *consuch, zodge*)	[i] (after palate-affricates: PALATAL-FRONT, IDENT-IO)
(iii) [t, d] (e.g. *dmlt, zod*)	[o] (after alveolar stop: SIS, IDENT-IO)
(iv) [k, g] (dorsal) preceded by *i* (e.g. *ponkik, pog*)	[ɯ] (default vowel)
(v) [r] (e.g. *hmor*)	[ɯ] or alternation of [r] to vowels (either preceding vowel or [a])

b. Word-initial consonant cluster

Stimuli (Nonce words)	Predicted epenthetic vowels
(i) [b, f, m, p, q, s, v, z] (e.g. *bkautu, fmil*)	[ɯ] (default vowel)
(ii) [tʃ, dʒ], which were spelled with *ch* and *j*, respectively. (e.g. *chki, jktap*)	[i] (after palate-affricates: PALATAL-FRONT, IDENT-IO)

[1] It is common that English syllabic /r/ is analyzed as a rhotic vowel.

[2] The ages of the participants ranged from 19 to 42. They were the students of the undergraduate program and ESL school, which belong to the University of South Carolina.

(iii) [t, d] (e.g. *tnoman, dvolt*)	[o] (after alveolar stop: SIS, IDENT-IO)
(iv) [k, g] (Dorsal) followed by *i* (e.g. *ktmos, gsamol*)	[ɯ] (default vowel)
(v) [r] (e.g. *rbran*)	[ɯ] or alternation of [r] to vowels (either preceding vowel or [a])

The condition (iv) might show some epenthetic [i] due to the vowel harmony, but this constraint should be ranked low in modern Japanese, so default [ɯ]-epenthesis should apply in most cases.

5.2. *Result of word-final codas* The table below shows the types of the vowels that the participants epenthesized.

(20) Types of epenthesized vowels: Word-final Coda

	Epenthesized vowels					Other types of repair			
	ɯ	i	o	a	e	r → a	r → :	deletion	n.a.
(i) [b, f, m, p, q, s, v, z]	**96.7**					-	-	0.8	2.5
(ii) [tʃ, dʒ] spelled with *ch* and *dg*	12.2	**85.6**				-	-		2.2
(iii) [t, d]	5.6		**91.1**			-	-	2.2	1.1
(iv) [k, g] (dorsal) preceded by [i]	**95.6**	**3.3**				-	-		1.1
(v) [r]	**28.9**			2.2		**33.3**	**35.6**		

(Numbers are percentages. Expected epentheses are in bold. Unexpected epentheses are underlined.)

Despite the small number of discrepancies, the results mostly agreed with our constraints in (14). For the condition (ii) and (iii) with affricates and alveolar stops, some participants epenthesized the default [ɯ] instead of [i] or [o], respectively. This indicates that the participants tend to place the constraints for the default vowel higher than PALATAL-FRONT, IDENT-IO, and SIS in their ranking.

5.3. *Result of word-initial consonant clusters* The adaptation of the word-initial consonant clusters was not as simple as for the codas. The results are shown below.

(21) Types of epenthesized vowels: Word-initial Consonant cluster[3]

	Epenthesized vowels					Other types of repair			
	ɯ	i	o	a	e	r → a	r → :	deletion	n.a.
(i) [b, f, m, p, q, s, v, z]	**90.8**	1.7	5.0	1.7	0.8	-	-		
(ii) [tʃ, dʒ] spelled with *ch* and *j*	23.7	**34.4**	4.4	6.3	3.0	-	-	1.5	26.7
(iii) [t, d]	32.2	7.8	**45.6**		3.3	-	-	8.9	2.2
(iv) [k, g] (dorsal) preceded by [i]	**71.0**	**15.6**		2.2		-	-	10	
(v) [r]	**71.1**		6.7	6.7		**8.9**	-	6.7	

(Numbers are percentages. Expected epentheses are in bold. Unexpected epentheses are underlined.)

The result of the repairs for consonant clusters exhibits a great variety in the selection/choice of epenthetic vowels. The [ɯ]-epenthesis after affricates ([tʃ, dʒ]) and alveolar stops ([t, d]) can be explained; the constraints that generate the default [ɯ] were higher ranked than SIS, IDENT-IO and PALATAL-FRONT for many participants. However, how can we explain the epenthesis of [e], [a], and other unexpected vowel epentheses in the word-initial consonant cluster condition?

A closer observation of the unexpected epenthetic vowels in the results revealed the effect of vowel harmony; 58.9% of the unexpected epenthetic vowels exhibited the vowel harmony effect in the consonant cluster condition. This is summarized below.

[3] For the condition (ii), only 73.3% of the answers interpreted the spelling of *ch* and *j* as [tʃ] and [dʒ]. Other answers interpreted *ch* as [k] or [ʃ].

(22) Vowel harmony in the word-initial consonant cluster condition

	Total V harmony	Partial V Harmony (Back feature)	No Harmony
(i) [b, f, m, p, q, s, v, z]	100%		
(ii) [tʃ, dʒ] spelled with *ch* and *j*	71.1%		28.9%
(iii) [t, d]		27.8%	72.2%
(v) [r]	44.4%		55.6%

These results seem to indicate that in the present day Japanese is influenced by vowel harmony to some extent, although the constraint HARMONY has been lowered as shown in the results of condition (iv) in (20 and (21). However, the question is why vowel harmony was much more present for word-initial consonant clusters than for word-final codas. In observing this, we should think about the directionality of vowel harmony. The current experiments showed a regressive harmony (in the cluster condition) much more often than the progressive harmony (in the coda condition). This could be explained by Hansson (2001), who states that regressive (right-to-left) assimilation is the default direction of harmony. Further, the constraint, HARMONY, might have to be divided into REGRESSIVE HARMONY and PROGRESSIVE HARMONY and be ranked independently as REGRESSIVE HARMONY >> PROGRESSIVE HARMONY. This can be a topic of a further study.

6. Epenthesis or deletion

6.1. *Adaptation with deletion* In this study, we have argued how Japanese speakers epenthesize which vowel appears in their loanword adaptation. However, we have not touched the fact that, although epenthesis is the primary strategy in Japanese loanword adaptation as mentioned previously, there are several loanwords that exhibit deletion. In addition, Japanese have some doublet loanwords, one of which shows epenthesis, and the other shows deletion. The example loan words with deletion are shown below.

(23)

a. Loanwords with deletion

Source words	Loanwords
don't mind [doʊnt maɪnd]	[don.mai]
all right [ɔl raɪt]	[o: ɾai]

b. Doublets with deletion and epenthesis

Source words	Loanwords (deletion)	Loanwords (epenthesis)
pocket [pɒkɪt]	[pokke]	[poketto]
handkerchief [hæŋkərtʃɪf, -tʃif]	[hankatɕi]	[hankatɕi:fɯ]
pudding [pʊdɪŋ]	[pɯɾin]	[pɯdingɯ]

The adaptation of source words with deletion places DEP-IO higher than MAX-IO. It contradicts the ranking that prefers epenthesis to deletion.

6.2. *Deletion from lack of perception* We suggest a perceptual account to explain deletion in some Japanese loanwords: when native Japanese-speaking borrowers did not perceive a coda or one of the consonant clusters, they delete them. (This is not even a case of deletion because the codas and consonant clusters were not perceived.) For example, the doublet-loanwords for a source word, *handkerchief*, has two forms, [hankatʃi] and [hankatʃif ɯ]. Borrowers who perceived the coda [f] epenthesized the vowel [ɯ], while other borrowers who did not perceive the coda deleted it. In the former case, the input for the OT tableau is [hæŋkərtʃɪf], but in the latter case, the input is [hæŋkərtʃɪ] without the coda [f]. Also, this lack of perception would be more likely to occur when the input was aurally introduced because, when the input was orthographically introduced, borrowers could not help visually perceiving all the segments. The two adaptations with deletion and epenthesis for aural input can be expressed as shown below in the tableaux.

(24)

Source word	Loanword (deletion) with aural input	Loanword (epenthesis) with written input
handkerchief [hæŋkərtʃɪf, -tʃif]	[hankatɕi]	[hankatɕi:fɯ]

(i) Aurally introduced source word:
[hæŋkərtʃif, -tʃif]
↓ (←Borrowers did NOT perceive the coda [f], so the input lacks the coda.)

Input: hæŋkərtʃɪ	MAX-IO	*ROUND	*LOW	*FRONT	HIGH	BACK	DEP-IO
☞ …tɕi_							

(ii) Orthographically introduced source word:
[hæŋkərtʃif, -tʃif]
↓ (←Borrowers perceived the coda [f], so the input has the coda.)

Input: hæŋkərtʃif	MAX-IO	*ROUND	*LOW	*FRONT	HIGH	BACK	DEP-IO
…tɕi_	*!						
…tɕi:f a			*!		*	*	*
…tɕi:f i				*!		*	*
☞ …tɕi:f ɯ						*	*
…tɕi:f e				*!	*	*	*
…tɕi:f o					*!		*

This analysis simply differentiates the input according to the different patterns of perception, and this differentiation is done before it is put in the tableau to get evaluated by constraints.

7. Experiment 2

7.1. *Method* In the analysis of the deletion for the aural input, we maintained that Japanese loanwords do not include the segments that borrowers did not perceive. Those segments do not appear in the OT input, and thus are not evaluated. As a result, the optimal output appears as deletion. This analysis implies that, epenthesis still often occurs for aurally adapted loanwords, but borrowers utilize more deletion than for orthographically adapted loanwords. The reason for this is that, for aural input, borrowers are more likely to fail to perceive segments relative to orthographic input. In order to test this analysis, an experiment was conducted with fifteen native Japanese speakers, and we investigated their adaptations of aurally input nonce words spoken by native English speakers. This experiment used the same set of nonce words as Experiment 1, but different participants from those in Experiment 1.[4] The task of participating Japanese speakers was, just as in Experiment 1, to write the input nonce words in Japanese characters; however,the input was aurally given in Experiment 2. All stimuli were spoken by three different native English speakers: a female speaker in her thirties, a male speaker in his twenties, and a male speaker in his fifties. The experiment was conducted in a quiet classroom environment.

7.2. *Results* The results show that the participants' use of deletion clearly increased compared to when the stimuli were orthographically given in Experiment 1, in which the use of deletion was below 0.1%.

(25) a. Word-final coda

	epenthesis	**deletion**	others	n.a.
(i) [b, f, m, p, q, s, v, z]	84.9%	6.2%	3.3% (m → n)	5.5%
(ii) [tʃ, dʒ]	100%			
(iii) [t, d]	88.9%	11.1%		
(iv) [k, g] (dorsal)	98.9%	1.1%		
(v) [r]	20%		80% (r → a)	
Total	**88.6%**	**4.7%**		

b. Word-initial consonant cluster (Deletion of the first consonant of the cluster)[5]

[4] The ages of the participants ranged from 19 to 30. They were the residents in North Carolina.
[5] There were a small number of answers with deletion of the second consonants in the clusters; 2.2% of [r].

	epenthesis	**deletion**	others	n.a.
(i) [b, f, m, p, q, s, v, z]	92.8%	0.4%	2% (m → n)	4.7%
(ii) [tʃ, dʒ]	100%			
(iii) [t, d]	98.9%	1.1%		
(iv) [k, g] (dorsal)	98.9%	1.1%		
(v) [r]	51.1%	22.2%	26.7% (r → a / u)	
Total	**93.9%**	**2.2%**		

This increase was considered to be due to the lack of perception of the consonants in coda and clusters. In order to confirm this, we conducted a follow-up experiment in more distracting or noisy environment at cafés or cafeterias. The participants were different from those in Experiments 1 and 2.[6] The procedure was the exactly the same as Experiment 2 above. We expected that participants would not perceive more input segments in a noisy environment, and that would lead them to show more deletion. The results are shown below.

(26) a. Word-final coda

	epenthesis	**deletion**	others	n.a.
(i) [b, f, m, p, q, s, v, z]	73.3%	19.4%	3.9% (m → n / V, V→ n)	3.3%
(ii) [tʃ, dʒ]	99.1%	0.4%		0.4%
(iii) [t, d]	85.6%	14.4%		
(iv) [k, g] (dorsal)	76.7%	21.1%		2.2%
(v) [r]	51.1%		42.2% (r → a / n)	6.7%
Total	**85.1%**	**9.1%**		

b. Word-initial consonant cluster (Deletion of the first consonant of the cluster)

	epenthesis	**deletion**	others	n.a.
(i) [b, f, m, p, q, s, v, z]	85.6%	12.2%	1.1% (m →V, b→ V)	1.1%
(ii) [tʃ, dʒ]	96.7%	2%		1.3%
(iii) [t, d]	83.3%	12.2%		4.4%
(iv) [k, g] (dorsal)	90%	10%		
(v) [r]	33.3%	22.2%	37.78% (r → a or u)	6.7%
Total	**85.9%**	**9.1%**		

The results clearly show more deletion than in the preceding two experiments, although epenthesis is still the primary way to adapt loanwords. The results confirm our analysis about deletion in some Japanese loanwords: borrowers did not perceive coda or consonants in clusters in noisy environment where they received the input words.

8. Conclusion

This study showed the patterns of epenthesizing vowels in Japanese loanwords from English. Japanese loanword adaptation utilizes context-free default epenthetic vowel [ɯ] and the context-dependent vowels [i] and [o]. The single constraint-ranking in (14) that observed the epentheses is again shown below.

(27) (= (14)) *COMPLEX / CODACOND >> MAX-IO >> SIS, PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK >> DEP-IO

Also, this paper claims that some loanwords prefer deletion to epenthesis in the adaptation, and this is attributed to the lack of perception of the aurally input source words. Although epenthesis is the dominant strategy for adapting foreign words in Japanese, deletion occurs when the input segments are not perceived.

When considering the loanword adaptation, however, we should note that, as mentioned in the earlier section, the adaptation patterns change diachronically. It appears that people in younger generations tend to

[6] The ages of the participants ranged from 19 to 23. They were the residents in North Carolina and the students of the Clemson University.

respect the sounds in source words, victimizing the Japanese sound system (i.e. ignoring SIS). For example, in the last few decades many people have begun producing [tɯ] in many loanwords. (e.g. *two* [tu] → [tɯ]).

In addition, there still are several words that the analysis in this study cannot explain. For example, an English source word, 'tree' ([tri]), is adapted as [ʧɯɾi:] in Japanese, as opposed to the predicted form of [tori:]. Also, a source word 'salad' ([sæl əd]) is adapted as [saɾada] in Japanese. This looks like the vowel harmony effect, but our analysis about vowel harmony in this study applies only to [i] after [k]. Those could be the topics of a future study. With the further research, the vowel epenthesis in Japanese loanwords would be more comprehensively explained.

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