Shoji, S. (2014). Japanese epenthetic vowels: How Japanese speakers pronounce English words. In J. Levis & S. McCrocklin (Eds). *Proceedings of the 5th Pronunciation in Second Language Learning and Teaching Conference* (pp. 87-103). Ames, IA: Iowa State University.

# JAPANESE EPENTHETIC VOWELS: HOW JAPANESE SPEAKERS PRONOUNCE ENGLISH WORDS

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The primary objective of this study was to examine which epenthetic vowels Japanese speakers utilize in pronouncing English words. An analysis of Japanese loanwords from English indicates that Japanese speakers utilize [ɯ] as the context-free default epenthetic vowel, and [o] and [i] as the context-dependent epenthetic vowels. In the framework of the Optimality Theory (OT), I propose that these epentheses are explained with the constraints in ranking of, *COMPLEX, CODACOND >> MAX-IO >> PALATAL-FRONT, SYLLABLE INVENTORY STRUCTURE (SIS), IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK >> DEP-I. This study claims that native Japanese speakers pronounce English words based on this constraint-ranking.

## INTRODUCTION

Foreign words include some sounds or phonological patterns that do not fit the phonetic or phonological constraints in another language. Therefore, the pronunciation of foreign words is "repaired" to "do as little violence as possible" to these constraints (Sapir, 1921, p. 210). This paper specifically discusses epenthetic vowels in Japanese speakers' pronunciation of English words in the framework of the Optimality Theory (OT). This analysis relies on the pronunciations of Japanese loanwords from English because loanwords exhibit how the speakers of the recipient languages modify foreign phonemes and phonotactics. While most of the early studies on Japanese loanwords are limited to explaining partial phenomena, this paper aims to include as many epenthetic patterns as possible in a unified explanation with a single ranking of constraints. This study suggests that this single ranking of constraints explains how native Japanese speakers pronounce English words.

### Vowel Epenthesis

The fundamental motivation for epenthetic vowels in loanword adaptation is that recipient languages do not allow codas and consonant clusters. This draws 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 & Lacharité, 1997), epenthesis should be preferred over deletion in order to preserve the input features. An empirical observation shows that a majority of the languages in the world prefer epenthesis rather than deletion (Kang, 2011).

Roughly speaking, epenthetic vowels include context-dependent vowels and context-free default vowels. The context-free default vowel should be as faithful as possible to the empty spot that bears no feature or duration of time. Thus, the epenthesized segment should be the one which is

the least intrusive, the most unmarked, and is perceptually the closest to zero (or silence) in the recipient languages (Hirayama, 2003; Steriade, 2009). In other words, this type of epenthetic vowel should have minimal salience, which would result in the smallest perceptual change between the input and the output.

According to Lehiste (1970), Carr (1999) and Blevins (1995), high vowels are less sonorous and shorter in duration than low vowels. In addition, according to Lombardi (2002), front vowels are more marked than back vowels. Kager (1999) also maintains that [-low, + back, -round] vowels are the most unmarked values for epenthetic vowels. Based on these studies, I propose the constraints of HIGH, *LOW, BACK, *FRONT and *ROUND.

Table 1
*Markedness Constraints for Context-free Epenthetic Vowels*

| Constraints | Functions |
|---|---|
| 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. |

The constraints should be ranked in the order that would most accurately generate the epenthetic vowels that actually occur.

A five-vowel system with [a], [e], [i], [o] and [u] is the most common vowel system in world languages. 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 the back feature such as *FRONT and BACK should be lower ranked than the other constraints in order for the constraints to generate [i] as the epenthetic vowel. The optimality of [i] in Fijian is drawn with the ranking below.

Table 2.
*OT Tableau 1. Generation of [i]: 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 above, it cannot be optimal because [ə] violates HIGH. Here, we need to place the constraint, HIGH, lower. Also, *FRONT has to be higher than HIGH and BACK in order for [ə] to be optimal.
Table 3.

*OT Tableau 2. Generation of [ə]: *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.

Table 4.
*OT Tableau 3. Generation of [i]: *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.

Table 5.
*OT Tableau 4. Generation of [ɨ]: *ROUND, *LOW >> *FRONT >> HIGH, BACK*

| 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] the second best, and [i] 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 inventories. They express this constraint as IS (INVENTORY STRUCTURE), that is, using a segment that exists in the language's inventory. Thus, it is considered 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].

**Japanese Vowel Epenthesis**

*Context-free Default Epenthetic Vowel [ɯ]*

Japanese does not allow consonant clusters or codas (except [n]), and its loanwords prefer epenthesis to deletion. This draws 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 Figure 1 below. Among those vowels, [ɯ] does not accompany lip protrusion, so it is unrounded. Also, [ɯ] is quite centralized in the Japanese inventory. Japanese [e] and [o] are slightly more centralized than equivalent cardinal vowels.

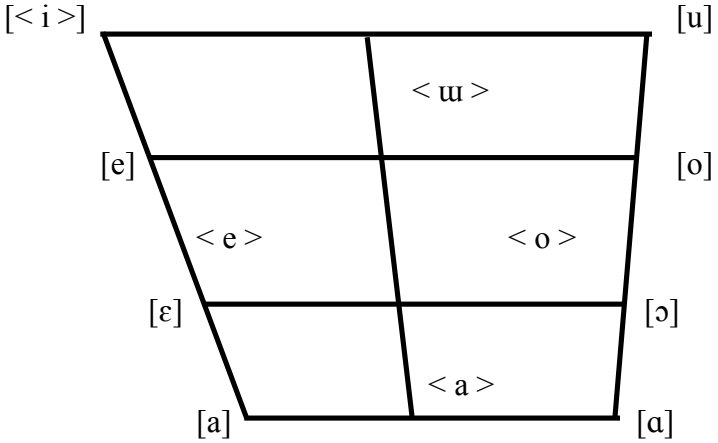


*Figure 1.* Japanese vowels in < > and cardinal vowels in [ ] (Vance, 2008, p. 54)

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 least salient among Japanese vowels, as supported by facts that [ɯ] is "the most readily subject to devoicing" and "weakening and elimination" (Lovins, 1975, p. 106; Mori, 1929, p. 58), and that it rarely attracts an accent (Yoshida, 2006). Also, Han's (1962) examination of the duration of Japanese vowels shows that [ɯ] is the shortest in length. Therefore, if we organize the Japanese vowels in order from shortest to longest, we would get the following series: [ɯ], [i], [o], [e], and [a]. The constraint-ranking from the previous section, which generates the default epenthetic vowels, successfully selects [ɯ] as the most optimal candidate as shown below.

Table 6.

*OT Tableau 5. Generation of [ɯ] in Japanese: *ROUND, *LOW >> *FRONT >> HIGH, BACK*

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

*Context-dependent Epenthetic Vowel [i]*

Some Japanese loanwords also 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.

Table 7.
*Loanwords with Epenthetic [i]*

| Source words | Loanwords |
|---|---|
| *match [*mætʃ] | [mattɕ*i]* |
| *beach [bi*tʃ] | [bi:tɕ*i]* |
| *edge [*ɛdʒ] | [eddʑ*i]* |
| *page [*peɪdʒ] | *[pe:*dʑ*i]* |

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. (Y. Kobayashi, 2005; Kubozono, 1999; Ladefoged & Maddieson, 1996; Lovins, 1975). This easier movement of the tongue draws the constraint, PALATAL-FRONT: vowels after palatals should be front. I add these two constraints, IDENT-IO and PALATAL-FRONT above, to the constraint-ranking in Tableau 5. The two constraints, IDENT-IO and PALATAL-FRONT should be higher ranked than all the constraints in Tableau 5 so that the generation of [ɯ] is canceled.

Table 8.
*OT Tableau 6. Generation of [i] in Japanese: 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 | *! | * | * | | | * | |

*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.

Table 9.
*Loanwords with Epenthetic [o]*

| Source words | Loanwords |
|---|---|
| eight [*eɪt]* | [eito] |
| *mattress [*mætrɪs] | [mattoresɯ] |
| old [*oʊld]* | [o:ɾɯ*do]* |
| *trend [*trɛnd*]* | [to*ɾendo]* |

If the better-qualified 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 the segment that exists in the inventory of the language in question. In this study, IS could be expanded to SYLLABLE INVENTORY STRUCTURE (SIS), that is, using the syllables that exist in the syllable inventory of the language in question. SIS should be more suitable for the analysis of a syllable-oriented (not 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 vowel, [o], which has the third shortest intrinsic duration after [ɯ] and [i] as Han's scale shows in (1).

We add the constraints, SIS, to the ranking in Tableau 6. 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 the epenthetic site. However, we encounter a problem with this tableau; this constraint-ranking generates [e], not [o].

Table 10.
*OT Tableau 7. Failure to Generate [o] in Japanese: 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 | | | *! | | | | | * |

*Note*. 💣 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 the Japanese [o]. We know the 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.3 In Whitman's (1985) study on the pre-old Japanese sound system, [o] is located at the center of the pre-old Japanese vowel inventory, like schwa. Also, Hamano (1998) finds that the Japanese [o] does not accompany protrusion or tenseness. Referring to these observations, I assume that the roundedness of the Japanese [o] is too weak to violate *ROUND. In addition, we find that HIGH needs to be placed higher than BACK to generate right vowels. This reexamination of [o] will rewrite the Tableaux 5, 6 and 7 as below. They generate the correct optimal forms.

Table 11.
*OT Tableau 8. (OT Tableau 5 with modification) Generation of [ɯ] in Japanese: *ROUND, *LOW >> *FRONT >> HIGH >> BACK*

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

Table 12.
*OT Tableau 9. (OT Tableau 6 with modification) Generation of [i] in Japanese: 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 | *! | * | | | | * | |

Table 13.
*OT Tableau 10. (OT Tableau 7 with modification) Generation of [o] in Japanese: 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 | | | *! | | | | | * |

**3 Ladefoged and Maddieson (1996) refer to Japanese [ɯ] as this back unrounded vowel. This paper considers [ɯ] as a central vowel.**

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 can add the four general constraints for epenthesis, *COMPLEX, CODACOND, MAX-IO and DEP-IO. This completes the single ranking as shown in Table 14.

Table 14.
*Constrains and Unified Ranking for Epentheses of [ɯ], [i] and [o] in Japanese*

| Constraints | Functions |
|---|---|
| *COMPLEX, CODACOND | (←Repair coda / consonant clusters) |
| >> MAX-IO | (←Do not delete, do epenthesis) |
| >> SIS, PALATAL-FRONT, IDENT-IO | (←Epenthesize context-dependent vowels) |
| >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK | (←Epenthesize context-free default vowel) |
| >> DEP-IO | |

This constraint-ranking should explain how Japanese speakers modify English phonotactics, which do not fit the Japanese phonological system.

**Irregular Adaptations**
*Epenthesis of [i] after Dorsal Consonant*

In this section, I will discuss some unstable, shaky and irregular patterns of vowel epenthesis in Japanese loanwords. One of the irregular patterns is [i]-epenthesis after non-palatals. This can be explained by historical change of vowel epenthesis. Example loanwords with the irregular [i]-epenthesis are shown below.

Table 15.
*Loanwords with Irregular Epenthesis of [i]*

| Source words | Loanwords |
|---|---|
| cake [keɪk] | [ke:ki] |
| steak [*steɪk*] | [sɯte:ki] |
| *brake [*breɪk] | [bɯ*re:ki]* |
| ink [ɪŋk] | *[in*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, there used to be vowel harmony in the native vocabulary. 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, p. 183). Thus, this epenthesis of [i] in some loanwords such as the ones in Table 15 is considered to be the residue of the vowel harmony in old Japanese.4 It is considered that the use of the epenthetic vowels from vowel harmony have been diachronically replaced by the use of the default epenthetic vowel. Some doublet loanwords and homophone loanwords evidence this analysis.

Table 16.
*Doublets and Homophones*

1. Doublets

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

2. Homophone

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

The loanwords to the right in the tables above were 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, I introduce a constraint, HARMONY, which used to be higher ranked but has been lowered.

Table 17.
*OT Tableau 11. Old Loanwords: Output [ki] as [bu*ɾe:ki*] (< break [breɪk])*

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

**4 Japanese also has some loanwords that show vowel harmony other than [i]. An example is [sarada] (< "salad" [sæləd]).**

Table 18.
*OT Tableau 12. Recent Loanwords: Output [kɯ] as [bureikɯ] (< break [breɪk])*

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

Certain questions remain. If 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 with [k]? First, we know that [i] is 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 the vowel epenthesis in Sesotho, a dorsal consonant does not block harmony between the neighboring vowels. This "transparent" quality of the dorsal consonant and the high qualification of [i] as an epenthetic vowel might have let [i] stay in the epenthetic slots in many loanwords.

*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 Table 19-1. However, in some other loanwords, [r] is deleted, and the preceding vowel is lengthened. The lengthened preceding vowel fills in the position for [r], as shown in Table 19-2. *Also, there are some other loanwords, in which [r] is replaced with [a] as in Table 19-3.*

Table 19.
*Modifications of [r]*

| | Modifications | | Source words | Loanwords |
|---|---|---|---|---|
| *1.* | *r* → ɾɯ / { V_σ, V_C } | | allergy [ælərdʒi] | [areɾɯgi:] |
| | | | tornado [tɔrneɪdoʊ] | [toɾɯne:do] |
| 2. | r → V1 / { V1_σ, V1_C } | | guitar [*gɪtar]* | [gita:] |
| | | | soccer [*sɒkər]* | [sakka:] |
| | | | fork [*fɔrk]* | *[fo:k*ɯ] |
| *3.* | r → a / { V_σ, V_C } | | store [*stɔr, stoʊr]* | [sɯtoa] |
| | | | core [kɔr, koʊr] | [koa] |
| | | | fair [fɛər] | [fea] |

In Table 19-2 and 19-3, the adaptation of [r] does not utilize epenthetic vowels, and it becomes a vowel.5

5 It is common that English syllabic /r/ is analyzed as a rhotic vowel.

## Experiment

An experiment was conducted in order to test whether the modifications that loanwords exhibit are applicable to Japanese speakers' pronunciation of English words. In particular, the experiment tested whether native Japanese speakers' modifications with epenthetic vowels can be predicted by the constraint-ranking in Table 14. Fifteen native Japanese speakers participated in the experiment. They were orthographically provided with 70 nonsense words spelled in alphabets, which included word-final codas and word-initial consonant clusters.6 Their task was to rewrite those non-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, so the participants had to either delete consonants or epenthesize vowels when rewriting the stimuli. The nonsense words in the experiment were in ten different conditions as shown below. Also, the predicted epenthesized vowels according to the constraint-ranking in Table 14 are shown.

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

**6 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 and Clemson University.**

Table 20.
*Conditions for Experiment*

a. Word-final Coda

| Stimuli (Nonsense words) | Predicted epenthetic 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 palato-alveolar affricates: PALATAL-FRONT, IDENT-IO) |
| (iii) [t, d] (e.g. *dmlt, zod*) | [o] (after alveolar stops: 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

| First consonants in stimuli (Nonsense 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 palato-alveolar affricates: PALATAL-FRONT, IDENT-IO) |
| (iii) [t, d] (e.g. *tnoman, dvolt*) | [o] (after alveolar stops: 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]) |

*Results of Word-final Codas*

The table below shows the types of the vowels that the participants epenthesized.

Table 21.
*Types of Epenthesized Vowels: Word-final Coda*

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

*Note*. Expected epentheses are in bold. Unexpected epentheses are underlined.

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

*Results of Word-initial Consonant Clusters*

The adaptations of the word-initial consonant clusters were not as simple as coda. The results are shown below.

Table 22.
*Types of Epenthesized Vowels: Word-initial Consonant Cluster*[7]

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

*Note*. Expected epentheses are in bold. Unexpected epentheses are underlined.

The results of the repairs for consonant clusters exhibit a great variety 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 in many participants. However, how can we explain the epenthesis of [e], [a], and other unexpected vowels 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 vowel harmony effect as summarized below.

**7 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*].**

Table 23.
*Epentheses with Vowel Harmony: Word-initial Consonant Cluster*

| | Total Vowel Harmony | Partial (back feature) Vowel Harmony | 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% |

This indicates that in the present day Japanese is still influenced by vowel harmony to some extent, although the constraint HARMONY has been lowered as shown in the results of condition (iv) in Tables 21 and 22. 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 experiment shows the 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.

## CONCLUSION

This paper showed the patterns of native Japanese speakers' modifications of the pronunciation of English words based on the analysis of loanwords. Japanese speakers utilize the context-free default epenthetic vowel [ɯ] and the context-dependent vowels [i] and [o]. The single-constraint-ranking that explains these epentheses that was shown in Table 14 is repeated: *COMPLEX, CODACOND >> MAX-IO >> SIS, PALATAL-FRONT, IDENT-IO >> *ROUND, *LOW >> *FRONT >> HIGH >> BACK >> DEP-IO.8 In addition, the experiment in this study finds that, to some extent, vowel harmony is still active in native Japanese speakers' selections of epenthetic vowels, especially in pronouncing consonant clusters in English. This implies that a constraint of vowel harmony could be included in the constraint-ranking above. Further study about this harmony effects in Japanese speakers' pronunciation is warranted.

## ACKNOWLEDGEMENTS

**8 This constraint-ranking explains the patterns of vowel epenthesis. This does not explain the alteration of [r] to vowels.**

Many thanks to Professor Eric Holt for supporting this research. I would like to express my gratitude to the editors and the reviewer for their patience.

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