Gemination in loans from English to Japanese

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When an English word is adapted as a Japanese loan word, some consonants are geminated. I conducted research on gemination in a corpus of 3,399 Japanese loanwords derived from English. In my corpus, most geminates are developed from two source environments: 1) when a consonant is the last single consonant of a source word (i.e. word-final consonant), and 2) when a consonant follows a stressed syllable (i.e. ambisyllabic consonant). In both environments, gemination requires two conditions: the lax vowel condition and the singleton condition. The lax vowel condition requires that the vowel preceding the geminating consonant be lax. The singleton condition requires that the geminating consonant must not be part of a consonant cluster in the source words. Next I focused on the frequencies of gemination. My conclusion is that voiceless affricates and stops are geminated most of the time. In addition, the word-final consonants are more frequently geminated than the ambisyllabic consonants.

1 Introduction

When an English word is adapted to Japanese, some consonants in English are geminated. For example, 'cut' is adapted to [katto] with a geminate while 'meat' is adapted to [mi:to] without a geminate. What is the difference between 'cut' and 'meat'? In addition, some consonants in the middle of words are geminated. For example, [p] in 'apple' is geminated. Is it because of the spelling 'pp'? Furthermore, the Japanese counterparts of 'catch' and 'mix' contain geminates. In addition, the Japanese loan word derived from 'catcher' contains a geminate. Then we expected the loan word from 'mixer' to contain a geminate. However, it does not. These puzzles have been discussed for a long time.

(1) Examples of gemination

	Gloss	English	Japanese	illicit form
a.	'cut'	[kʌt] >	[katto]	[*kato]
b.	'meat'	[mit] >	[mi:to]	[*mi:tto]
c.	'apple'	[ǽpəl] >	[appɯrɯ]	[*apɯrɯ]
c.	'catch'	[kætʃ] >	[kjattʃi]	[*kjatʃi]
d.	'catcher'	[kǽtʃə]>	[kjattʃa:]	[*kjatʃa:]
e.	'mix'	[míks] >	[mikkɯsɯ]	[*mikɯsɯ]

f. 'mixer' [míksə]> [mikisa:] [*mikkisa:]

In this article, I report on the results of a study of the adaptation of loans from English to Japanese which result in gemination. This is the first systematic count and analysis of Japanese loan words, as it is based on a corpus of 3,399 loans.

1.1 General findings

When I started this research, I had two questions: (1) in what contexts do consonants in English become geminated in Japanese, and (2) are certain classes of consonants in English more susceptible to gemination in Japanese. Answers to these questions will be provided in more detail in the remainder of this paper, but the short version is the following:

- The consonants which occur geminated in Japanese are word-final and ambisyllabic consonants (i.e. post-stress consonants) in English. Moreover, the vowel preceding the geminating consonant in English must be lax, and the consonant in a cluster in Enlgish cannot be geminated in Japanese.
- In general, voiceless obstruents undergo gemination more often than voiced obstruents. Of the sonorants, only nasals can occur in geminate form.

1.2 Phonological loan word theory

According to the Theory of Constraints and Repair Strategies proposed by Paradis et al (1995), when words are phonologically adapted from a source language to a target language, they may undergo 'repair strategies', so that the borrowed word complies with the phonological constraints of the target language. Whether or not a word is repaired is determined by the Preservation Principle, the Minimality Principle, the Precedence Convention and the Threshold Principle.

In this section I review the principles of this theory. We will see in 4.6 that the adaptation of English words to Japanese is problematic for this theory, in particular for the Threshold Principle.

1.2.1 Preservation Principle

According to the Preservation Principle, segments in the source word are maximally preserved. For example, the Japanese language does not allow consonant clusters so there are two possible repair strategies: consonant deletion and vowel insertion if foreign words have consonant clusters. The Preservation Principle favors vowel insertion.

(2) Vowel insertion > consonant deletion
a. 'ski' [ski] > [sɯki:] (cf. [*si:] [*ki:])

The example (2) shows that vowel insertion is favored to repair the violation of consonant clusters.

1.2.2 The Minimality Principle

The Minimality Principle requires that the violation of phonological constraints in the target language be repaired at the lowest level and with the least steps.

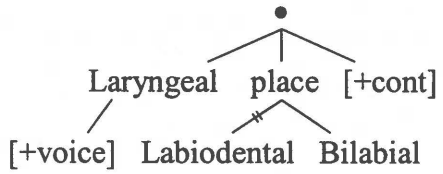
For example, the Japanese language does not have [θ], so [θ] would be adapted to [s] or [t]. The adaptation (*θ → s) requires 1 step while the adaptation (*θ → t) requires 2 steps. In both adaptation processes, the place node changes from inter-dental to alveolar. In addition, *θ → t requires from [+cont] to [-cont]. Thus [θ] is adapted to [s]. This is an example of the Minimality Principle.

1.2.3 The Precedence Convention

The Precedence Convention requires that a repair strategy must apply at the lowest phonological level to which the violated constraint refers. For example, the Japanese language does not have the labiodental phoneme (i.e. the violation occurs under the place node), so the repair takes place under the place node.

(3) Example of the Precedence Convention

*v→ β



Japanese does not have a labiodental fricative but a bilabial fricative[1]. Both share the laryngeal feature [+voice] and are continuous so the bilabial fricative [β] is chosen.

1.2.4 Threshold Principle

Although according to the Preservation Principle, segments should be repaired, not deleted, occasionally in the course of phonological adaptation segments are deleted. According to Paradis et al, if phonological adaptation requires more than a certain number of changes, the segment is deleted. The threshold for all languages is two. Thus if the adaptation requires more than two steps to repair segment preservation, the segment is deleted. However, the Threshold Principle is not applicable for Japanese loan words, which I will explain in 4.6. I use the examples from Paradis (1995). In following examples, French words are adapted to Fula.

(4) Consonant deletion in Fula.

	French		Fula	illicit form	gloss
a.	biscuit	[biskɥi]	[biski]	[*biskuwi]	'biscuit'
b.	voyage	[vwajaʒ]	[waja:s]	[*wuwaja:s]	'trip'

[1] According to Vance (1986), in Japanese bilabial fricative [β] is allophone of bilabial stop [b].

c.	cuivre	[kɥivr]	[kiri]	[*kuwiwri]	'copper'
d.	chewing gum	[ʃwiŋgɔm]	[siŋgɔm]	[*siwiŋgɔm]	'chewing gum'

Compare the above form to the forms below

e.	minuit	[minɥi]	[minwi]	'midnight'
f.	avocat	[avɔka]	[awɔka]	'lawyer'
g.	dimanche	[dimãʃ]	[dima:s]	'Sunday'
h.	classe	[klas]	[kala:s]	'class'

In Fula, [ɥ], [ʃ] and [v] are illicit. In (4)-e, [ɥ] is adapted to [w] while in f [ʃ] is adapted to [s]. In addition, Fula prohibits consonant clusters. The illicit consonant clusters are resolved by vowel insertion as the example (4)-h shows. Based on the adaptation (4)-e and h, we expect [biskuwi] in (4)-a. However, the outcome is [biski] (i.e. the illicit segment [ɥ] is deleted). Paradis et al considered it is because of the violation of the Threshold Principle. The adaptation from [biskɥi] to [biskuwi] requires three steps: 1 nucleus insertion, 2 vowel spreading and 3 delinking coronal node[2]. Since the repair required more than two steps, the illicit segment [ɥ] is deleted.

1.3 Phonological background on English and Japanese

In this section, I supply phonological information about the languages of study, which will allow us to understand the results.

1.3.1 English phonology

In order to understand the process of adaptation, I provide the phonological structure of the source language (i.e. English) here.

1.3.1.1 Tense vs. lax vowels

In English, tense vowels contrast with lax vowels. The following examples illustrate this contrast.

(5) Minimal pairs illustrating lax vs. tense vowel contrasts in English:

	tense vowel		lax vowel	
a.	heɪt	'hate'	hɛt	'het'[3]
b.	hu:d	'who'd'	hʊd	'hood'
c.	hit	'heat'	hɪt	'hit'
c'.	'heat' > [çi:to]		'hit' > [çitto]	

[2] The glide [ɥ] is linked to coronal while [w] is linked to only labial node.

[3] In 'het up'

Since Japanese does not contrast a lax vowel with a tense vowel, tense vowels in English are adapted to Japanese long vowels. (5)-c' illustrates this adaptation.

In English, words do not end with lax vowels unless they are reduced, as seen (6).

(6) Words end with open syllables (Hammond 1997)

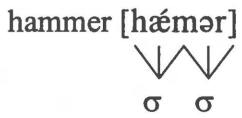
	Open syllables with tense vowels				Close syllables with lax vowels	
a.	bee	[bi]	Tennessee	[tènəsí]	bit	[bɪt]
b.	bay	[be]	delay	[dəlé]	bet	[bɛt]
c.	two	[tu]	kangaroo	[kæ̀ŋgərú]	book	[bʊk]
d.	toe	[to]	hello	[hèló]		
e.	paw	[pɔ]	macaw	[məkɔ́]		
f.	spa	[spá]			mutt	[mʌt]
	Open syllables with diphthongs					
g.	buy	[baɪ]	ally	[əláɪ]		
h.	bow	[baʊ]	allow	[əláʊ]		
i.	boy	[boɪ]	employ	[èmplóɪ]		
j.	cue	[kju]	review	[rəvjú]		

These words indicate that probably English minimal words are a lax vowel plus a coda or a tense vowel except function words in rapid speech.

1.3.1.2 Consonant ambisyllabicity

In English, post-stress, single intervocalic consonants seem to belong to two syllables, as illustrated in (7).

(7) Ambisyllabic consonant



(7) illustrates that the post-stress consonant [m] belongs to both syllables. Post-stressed consonants are called ambisyllabic consonants.

The ambisyllabic consonants that Kahn (1976) defined are single intervocalic consonant, and also first consonants in intervocalic cluster. Ambisyllabic consonants defined by Kahn include following consonants.

(8) Kahn's ambisyllabic consonants.

a. [n] in pony [póni]
b. [s] in Hoskins [hǽskɪnz]

c. [p] in April [éɪprəl]

Ambisyllabic consonants defined by Kahn are intervocalic consonants following stressed vowel and preceding unstressed vowel. In (8)-a and c, the preceding vowels are tense vowels.

Kahn (1976) further observed that the complementary distribution of flapping [t] (i.e. [ɾ]) and aspiration [t] (i.e. [t^h]) was related to ambisyllabicity.

(9) Complementary distribution of flapping and aspiration.

a.	V́CV atom	[ǽtəm]	[ǽɾəm] (alternative)
b.	VCV́C atomic	[ətɑ́mɪk]	[ət^{h}mɪk]

The flap is the pronunciation of ambisyllabic [t].

Fallows (1981) conducted the experiments on the syllable boundaries. In her experiments, the subjects repeated the first syllable of two syllable words based on their intuition. The results of her experiments revealed that the subjects tended to consider that consonants after stressed vowels take part of previous syllable if the preceding vowels are lax. In her definition, the vowels before ambisyllabic consonants are lax.

Hammond proposed that a lax vowel in English is monomoraic and a tense vowel is bimoraic, and that stressed syllables in English are minimally bimoraic. Since the lax vowel is monomoraic, in order to be well-formed syllable, the syllable needs a coda. Consequently the stressed syllable recruits the following consonant as a coda.

I adopt Fallows' definition of ambisyllabic consonants, which is consistent in English loan words in Japanese. Thus in this paper, ambisyllabic consonants are limited to single consonants after stressed lax vowels.

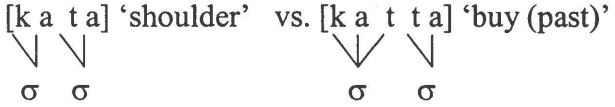
1.3.2 Japanese phonology

The target language of the adaptation is Japanese, so I will provide the phonological information of Japanese in this section.

1.3.2.1 Geminate consonants

The Japanese language has long consonants or geminates. In Japanese, geminates refer to obstruents. A word with geminates contrasts with a word with single consonants. The first part of a geminate belongs to the preceding syllable while the second part of a geminate belongs to the following syllable. Following example illustrates this contrast.

(10) Geminates:



There are no voiced geminates in Japanese native words although voiced obstruents are geminated in Japanese loan words. Ito and Mester (1995) discussed this absence of voiced geminates in Japanese native words. In their arguments, the Japanese language consists of four stratums: Yamato (i.e. Japanese native words), Sino-Japanese (loan words from Chinese), Mimetic and Foreign (loans other than Chinese). Yamato is in the core of the Japanese language so Yamato conforms to all constraints. However, Foreign is located in peripheral of the Japanese language so Foreign does not conform to constraints. Thus voiced geminates are allowed in loan words.

You may wonder if a sonorant is geminated in Japanese. Nasals are geminated, which is discussed in 3.3. However, another sonorant [ɾ] is never geminated in the Japanese language. Poser observed absence of [ɾ] gemination in Japanese (Ito and Mester 1989).

1.3.2.2 Syllable structure

There is no coda in Japanese other than moraic nasals and the first part of a geminate. There are two ways to repair codas in English source words: one is vowel epenthesis and the other is that the coda in English is geminated in Japanese loan words.

(11) The adaptation of codas

a.	'keep'	[kip]	>	[kiː.pɯ]
b.	'cup'	[kʌp]	>	[kap.pɯ]

On one hand, in (11)-a, the illicit coda in English is repaired by vowel insertion so the syllable structure of the source word does not seem to be preserved. On the other hand, in (11)-b, the consonant [p] is geminated so the syllable structure is preserved.

In addition, Japanese does not allow consonant clusters. When an English source word has consonant clusters, vowels are inserted between consonant clusters.

(12) 'abstract' [æbstrækt] > [abɯsɯtoɾakɯto]

(12) shows that consonant clusters in English are repaired by vowel insertion.

Since the Japanese language has a long vowel and allows a coda, you may wonder if the Japanese language has a superheavy syllable. The Japanese language has a few superheavy syllables and most of them are mimetic words like (13)-c.

(13) Superheavy syllables

a.	[nɯːn]	'noon'
b.	[koot.ta]	'freeze-past form'
c.	[paat.to]	'swiftly'

(13) –a is a loan word and (13)-c is a mimetic word, while (13)-b is a native word. Superheavy syllables are seldom found in Japanese native words except mimetic words.

2 Research procedure

The data for this study were taken from Oka (1986). His edited dictionary called Joyoo Gairaigojiten contains loan words derived from English, German, French and other languages. The main purpose of the dictionary is to provide the meaning of Japanese loan words; in addition, the dictionary provides the source language and the orthography of the source words. I selected words derived from English.

I first constructed an Access database with 3,399 Japanese loan words. Then, I sorted the database for geminates. The number of words with geminates in the database is 499. Second, I posited conditions for the gemination based on these words. Third, I compared the words satisfying the conditions for gemination with the words actually containing geminates.

Since the English data in Oka (1986) were provided only in the English orthography, I supplied a phonetic transcription using Wells (1990).

3 Results

In this section, I provide the results of the research. In 3.1, I provide the answer to the question of in what contexts consonants in English become geminated in Japanese. 3.2 answers the question of which classes of consonants in English are more susceptible to gemination in Japanese. In addition, the gemination of nasals is discussed in 3.3

3.1 Environments for gemination

I will discuss in what environments English consonants are geminated in Japanese. As I reported, word final consonants and ambisyllabic consonants in English tend to be geminated in Japanese.

3.1.1 Word-final C

When an English word ends with a syllable with a lax vowel and a single consonant, the last consonant tends to be geminated. 333 of 499 words (66.7%) containing geminates in the database fell into this category.

(14) Word final C

a. 'black' [blæk] > [bɯrakkɯ]
b. 'catch' [kætʃ] > [kjattʃi]
c. 'edge' [ɛdʒ] > [eddʒi]
d. 'cash' [kæʃ] > [kjaʃʃɯ]

These examples show that word final consonants in English are geminated in Japanese.

3.1.1.1 Lax vowel condition

Gemination occurs only if the vowel preceding the consonant at issue is lax.

(15) Word final C - lax vs. tense

Lax vowel

a.	alphabet	[ǽlfəbɛt]	>	[aɾɯɸabetto]
b.	tulip	[tjú:lɪp]	>	[tʃɯ:ɾippɯ]

Tense vowel

c.	escalate	[ɛ́skəleɪt]	>	[esɯkaɾe:to]
d.	keep	[ki:p]	>	[ki:pɯ]

The examples show that if the preceding vowel is a tense, gemination does not occur.

3.1.1.2 Singleton condition.

Gemination tends to occur if an English source word ends with a single obstruent but not a cluster.

(16) Word final C – singleton vs. consonant clusters

Singleton

a.	track	[træk]	>	[toɾakkɯ]

Consonant cluster

b.	abstract	[æbstrǽkt]	>	[abɯsɯtoɾakɯto]

Since (16)-b, the coda is consonant clusters so gemination does not occur.

3.1.2 Ambisyllabic C

The ambisyllabic consonants in Hammond's claim do tend to be geminated. 104 out of 499 words containing geminates belong to this group.

(17) Ambisyllabic C

a.	'cookie'	[kú̟ki]	>	[kɯkki:]
b.	'kitchen'	[kɪ́tʃən]	>	[kittʃiɴ]
c.	'cushion'	[kú̟ʃən]	>	[kɯʃʃoɴ]

The examples in (17) indicate that post-stressed consonants in English are geminated in Japanese.

3.1.2.1 Lax vowel condition

Gemination does not occur unless the primary stressed syllable contains a lax vowel.

(18) Ambisyllabic C – lax vs. tense or diphthong

Gemination					
a	kitchen	[kítʃən]	>	[kittʃiɴ]	
b.	couple[4]	[kʌ́p̩l̩]	>	[kappɯrɯ]	
c.	lesson	[lésn̩]	>	[ressɯɴ]	
Absence of gemination					
d.	mica	[máɪkə]	>	[maika]	(diphthong)
e.	beacon	[bíkən]	>	[bi:koɴ]	(tense V)
f.	attention	[əténʃən]	>	[atenʃoɴ]	(unstressed V)
g.	local	[ləúkl̩]	>	[ro:kaɾɯ]	(tense V)

Compared (18)-a and (18)-d, [tʃ] is geminated but [k] is not geminated because the preceding vowel in (18)-a is a lax vowel but in (18)-d, it is a diphthong. Examples in (18)-e and g indicate that gemination does not occur if the vowels before the consonants at issue are tense. In (18)-f, [t] is not geminated because the preceding vowel is not stressed.

3.1.2.2 Singleton condition

Gemination tends to occur if an ambisyllabic consonant is a single obstruent but not a cluster.

(19) Ambisyllabic C – singleton vs. consonant clusters

Singleton			
a.	hockey	[hɒ́ki]	>[hokke:]
Consonant clusters			
b.	mixer	[míksə]	>[mikisa:]

[4] A subgroup of the ambisyllabic group is words that contain [l̩] and [n̩]. Since they are consonant clusters, Lovins and others were puzzled. However, [l̩] and [n̩] are syllabic, so the consonants before them are ambisyllabic consonants.

(19)-b shows that a consonant in consonant cluster in English is not geminated in Japanese.

3.1.3 Summary

As a summary, the majority of words containing geminates (437 out of 499-87.5%) belong to word-final group and ambisyllabic group. In both groups, the conditions for the gemination are that the vowel preceding the consonant at issue must be lax, and that the geminating consonant in Japanese must not be in consonant clusters in English.

3.1.4 Other environments for gemination

The other 62 words are classified into four groups: (1) Geminates are found at morpheme boundary and at the end of the first word of compound words. In compound words, gemination may occur in both at word final and at morpheme boundary. The portion in this environment is 6.0% of the loan words containing geminates. (2) English words (32 words-6.4%) end with [ks] or [ts]. (3) Double letters[5] in English spelling lead to geminate in Japanese loan words (4 words-0.8%). Ambisyllabic consonants are not counted in this group. Only three out of 499 words (0.6%) are left, and I put them the residue group. All Japanese loan words containing geminates belong to these six groups: word-final, ambisyllabic, morpheme boundary, stop plus [s], double letters, and residue.

(20) Other environments

a. morpheme boundary	'attachment'	[ətǽtʃmənt]	> [atattʃimento]
b. stop plus [s]	'box'	[bɒks]	> [bokkɯsɯ]
c. double letters	'dilettante'	[dɪlətǽnti]	> [dɪrettanto]
d. residue	'cashier'	[kæʃɪə]	> [kyaʃʃaː]

Examples in (20) represent each group.

[5] The consonants are expressed with double letters but not ambisyllabic.

Figure 1 Share of each group.

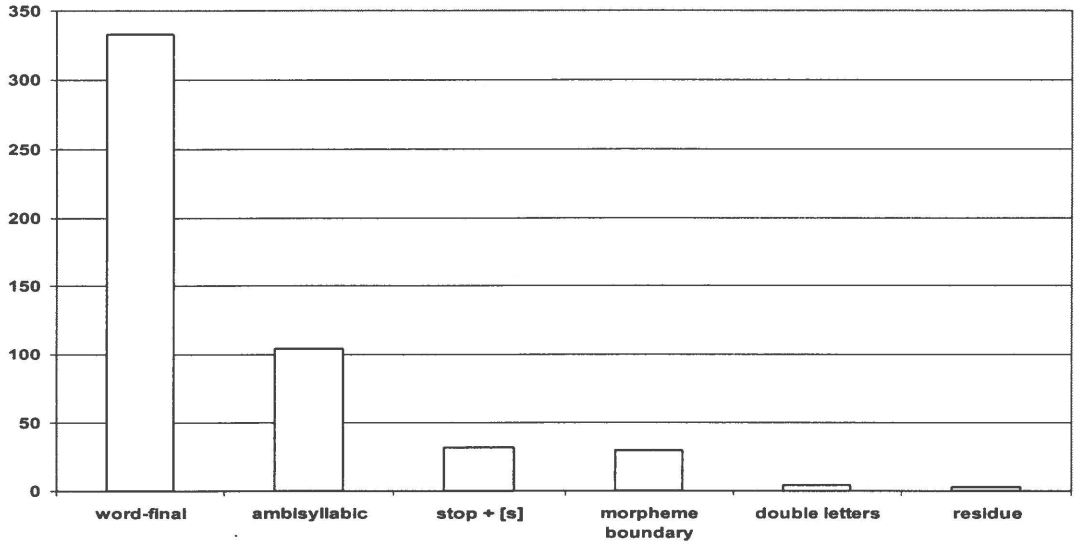


Figure 1 shows that most geminates belong to the word final consonant group and the ambisyllabic group.

3.2 Consonants which geminate

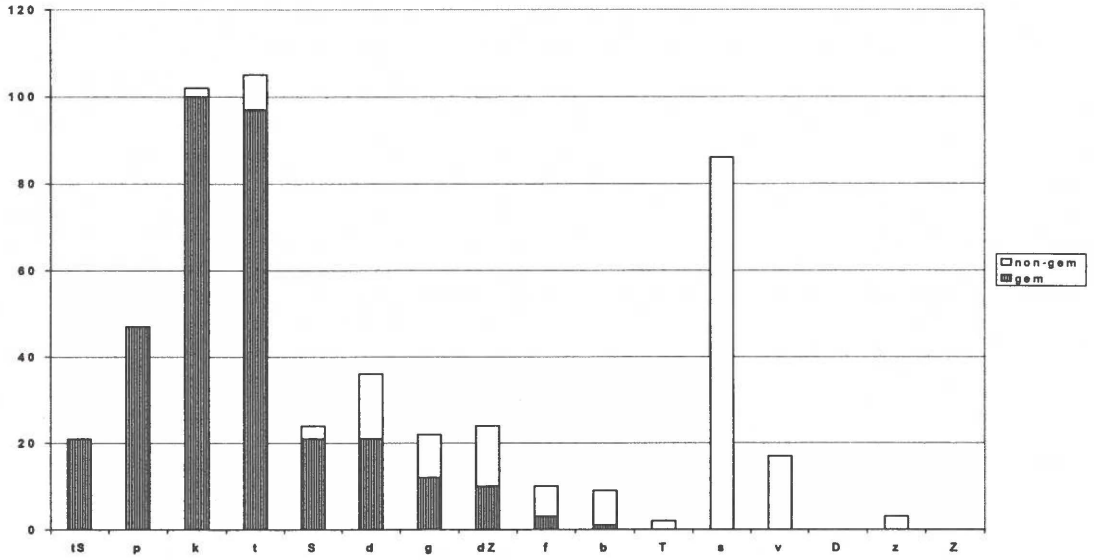
Although consonants in both environments (word final and ambisyllabic) tend to be geminated, not all consonants in both conditions are geminated. Ohso (1973) and Lovins (1975) noticed that final consonants in the English source words tend to be geminated, but they did not examine the English source words that end with a single consonant. I examined the words that satisfy the conditions for gemination. I provide the data tables in the Appendix. These tables show the frequency of gemination; in other words, how many consonants in English that satisfy the conditions for gemination are geminated in Japanese.

Table 1 in the Appendix shows that voiceless affricates are geminated most of the time. However, the geminating rates for voiceless fricatives are variant: [s] is never geminated while [ʃ] is geminated 87.5% of time. The summary of the geminating rates in word final consonants is provided below.

The order of the frequency of gemination in word final position is the following:

voiceless	>> voiceless	>> voiced	>> voiced	>> voiceless	>> voiced
affricates	stops	stops	affricates	fricatives	fricatives

Figure 2 Frequency of gemination in the word final group



(tS = tʃ, S = ʃ, dZ = dʒ, T = θ, D = ð, Z = ʒ)

Figure 2 shows that voiceless obstruents, especially affricates and stops, are highly geminated in Japanese while voiced fricatives are never geminated. Voiced stops are geminated in the half of the time; however, the geminating rate for [b] is strangely low.

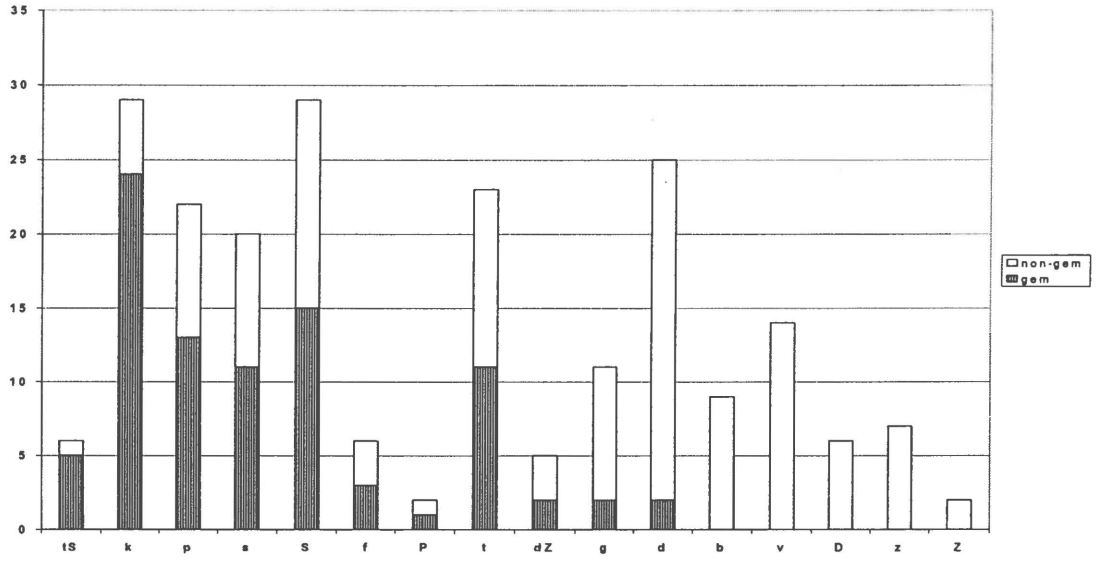
Table 2 in the Appendix shows that geminating rates for ambisyllabic consonants are lower than word-final consonants. Interestingly the geminating rate for ambisyllabic [s] is 55.0 % although word-final [s] is never geminated. Another interesting fact is relatively low geminating rate for ambisyllabic [t].

The order of frequency of gemination in ambisyllabic position is the following:

voiceless >> voiceless >> voiceless >> voiced >> voiced >> voiced
affricates stops fricatives affricates stops fricatives

Compared with word final group, voiceless fricatives are promoted to the third place.

Figure 3 Frequency of gemination in ambisyllabic group



(tS = tʃ, S = ʃ, dZ = dʒ, D = ð, Z = ʒ)

Figure 3 shows that geminating rates in ambisyllabic consonants are lower than word-final consonants. However, voiceless affricates are highly geminated.

3.3 Nasals

Nasals in source words are geminated in Japanese. However, nasal gemination requires ambisyllabicity and double letters.

(21). Source words containing 'mm' or 'nn' in English spelling:

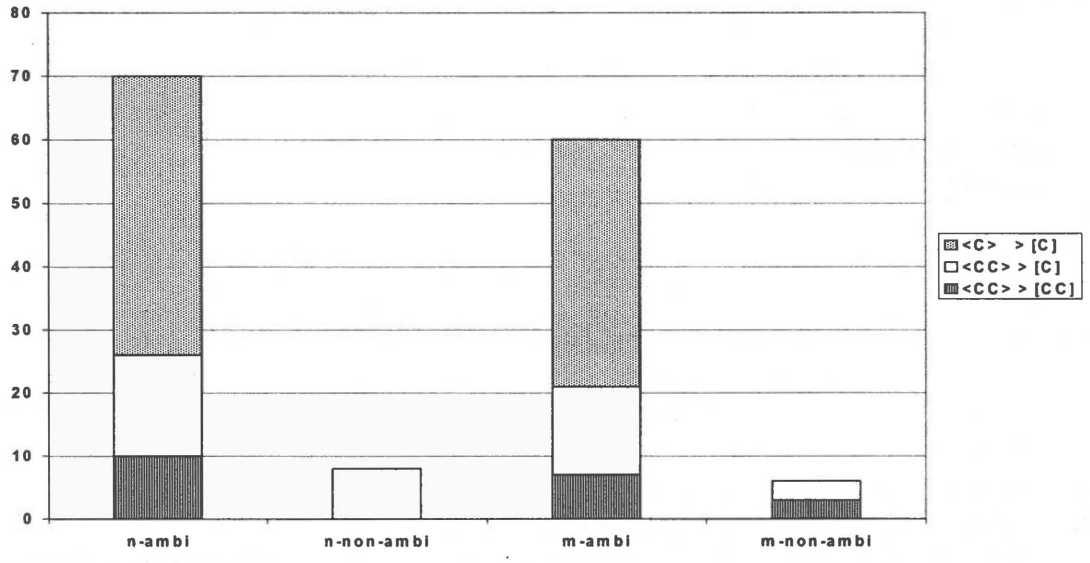
	Gloss	English	Japanese
<mm> not ambisyllabic			
a.	'ammonia'	əmə́uniə	ammonia
b.	'immoral'	ɪmɒ́rəl	immoraɾɯ
<mm> ambisyllabic			
c.	'dilemma'	dɪlɛ́mə	diɾemma
d.	'mammoth'	mǽməθ	mammosɯ
e.	'flannel'	flǽnəl	ɸɯɾannerɯ
f.	'inner'	ɪ́nə	inna:

Geminating [n] in Japanese (8 words) are both expressed with double letters and be ambisyllabic. I compared the percentage of geminating [n]s in both environments: [n]s with double letters and ambisyllabic [n]s. The result was that ambisyllabic [n] is geminated 11% (8 out of 70 words) while [n] with double letters is geminated 47% (8 out of 17 words). Thus [n] gemination requires both spelling in English and ambisyllabicity.

In the case of another nasal [m], ambisyllabic [m] without double letters is never geminated in Japanese. On the contrary, non-ambisyllabic [m] with double letters in 3 English words is geminated. Furthermore, I compared the rates of gemination for double letters with the rates of gemination for ambisyllabic [m]. Ambisyllabic [m] is geminated 11.7% (7 out of 60 words) while [m] with double letters is geminated 28.6% of the time (10 out of 35 words.)

The duration of nasal geminates in Japanese is the duration of moraic nasal (i.e. nasal at coda position) plus the duration of onset. According to the data from Sato (1993), the duration of coda [n] before [t] in English is 79.69 ms while Japanese counterpart (moraic nasal) is 81.56 ms.. The duration of [n] at onset position in Japanese is 42 ms.. Although we should not calculate the duration of geminate nasal based on these data, we could say the duration of nasal geminate in Japanese is significantly longer than the duration of nasal at coda position in English. Furthermore, in contrast to obstruents, nasals do not have aspiration. In other words, Japanese speakers cannot use the absence of aspiration as the second cue for the gemination. Consequently it is hard for Japanese speakers to recognize coda nasals in English as geminates. Thus spelling with double letters is necessary as a visual cue for gemination. Therefore, my conclusion is that gemination for nasals requires both ambisyllabicity and double letters.

Figure 4 Nasal gemination



<C>: single letter, <CC>: double letters, [C]: singleton, [CC]: geminate

Table 3 in the Appendix shows that firstly the nasals are significantly less geminated than obstruents. Secondly, geminating nasals are limited to nasals spelled with double letters. Thirdly, non-ambisyllabic nasals are seldom geminated in Japanese. Thus both ambisyllabicity and double letters are required for nasal gemination.

4 Discussion

4.1 Gemination of final consonants

A final consonant in English is a coda. In addition, according to Hammond, the ambisyllabic consonant serves as a coda. Both geminating consonants are codas in the source words. Since the Japanese language does not allow codas except moraic nasal or the first half of a geminate, the consonant is geminated to preserve the phonological structure; in other words, the second half of a geminate is inserted. Then this second half of a geminate triggers the epenthetic vowel.

Figure 5 Syllable structure preservation

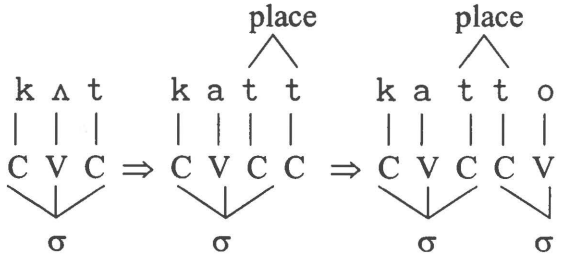


Figure 5 illustrates how the English word 'cut' [kʌt] is adapted to Japanese [katto]. In order to preserve the phonological structure, firstly [t] is geminated, and secondly, a vowel is inserted to syllabify the second half of a geminate.

4.2 Lax vowel condition

Takagi and Mann (1994) and Tsuchida sought the reason for why there are no geminates of consonants after a tense vowel. They considered that it is because a Japanese phonological constraint prohibits superheavy syllables. However, it does not explain why consonants after diphthongs are never geminated in Japanese.

(22) 'right' [ɾaɪt] > [ɾa.i.to] [*ɾa.it.to]

(22) illustrates that the consonant after a diphthong is not geminated in Japanese.

Let us suppose that the reason for non-gemination after a tense vowel is because of the Japanese phonological constraint of *superheavy syllable. We expect that a consonant after a diphthong is geminated in Japanese loan words. However, no consonant after a diphthong in English is geminated in Japanese.

You may argue that [ai] in Japanese is a diphthong. Then [ɾait] is a superheavy syllable. Consequently, [t] in [ɾait] is not geminated because of *superheavy syllable. However, [ai] in Japanese is not a diphthong. For example, in (23), [i] in [nai] in the present form disappears in the past form. If [ai] in Japanese is a diphthong (i.e. one segment), morphological process would not split the segment. In addition, long vowels trigger pitch shift while [ai] does not lead to the pitch shift. Therefore, [ai] in Japanese is not a diphthong; in other words, [ai] is a sequence of two independent vowels.

(23) Morphological evidence

[nai] 'negation present' > [nakatta] 'negation past'

In (23), [i] in [a] disappears so [ai] in Japanese is not a diphthong but a vowel sequence.

Consequently the assumption that *superheavy syllable constraints leads to no-gemination after tense vowel is wrong. I suggest instead that consonants after tense vowels are not geminated because these consonants are not ambisyllabic consonants by Hammond's definition. In other words, they are not necessary to satisfy the minimal requirements for stressed vowels. As a result, consonants after tense vowels in English are not geminated in Japanese.

4.3 Stop plus [s]

Exceptionally [k] and [t] in words ending [ks] and [ts] are geminated. Ohso and Lovins attributed stop gemination before [s] to vowel devoicing. Standard Japanese speakers devoice high vowels ([ɯ] and [i]) between voiceless obstruents. For example, 'tax' is pronounced as [takkɯ̥sɯ̥] by standard Japanese speakers, and it sounds similar to English pronunciation.

4.4 English orthography does not explain gemination

As we have seen in 3.3, nasal gemination requires ambisyllabicity and double letters. On the contrary, obstruents with double letters in spelling do not trigger gemination. This is because obstruents at coda position in English are relatively long, which leads to gemination. I will discuss this in section 4.5.2.

Ohso (1973) considered that the consonant that is spelled with double letters is geminated in Japanese. However, as an English spelling rule, ambisyllabic consonants are spelled with double letters. Ambisyllabic consonants in English source words tend to be geminated in Japanese. As the result, geminating consonants in Japanese loan words are spelled with double letters in the source words.

Since Ohso and Lovins examined only Japanese words with geminates but they did not examine English source words with double letters, they did not notice that double letters in English spelling do not trigger gemination in Japanese in a straight line. Examples in (24) are the cases in which spelling with double letters does not trigger gemination in Japanese.

(24) Words in which double letters do not lead to the gemination.

a.	appointment	[əpɔ́ɪntmənt]	[apointomento]	[*appointomento]
b.	opposition	[ɒpəzíʃən]	[opodʒiʃoN]	[*oppodʒiʃoN]
c.	attention	[əténʃən]	[atenʃoN]	[*attenʃoN]
d.	accident	[æksədənt]	[akɯʃideno]	[*akkɯʃidento]

I examined how often consonants spelled with double letters in English are geminated in Japanese. In the case of [p], 29 English words contain "pp" in spelling but only 14 of [p]s with "pp" in English spelling is geminated in Japanese. Thus [p] with "pp" is geminated 48% of the time, while ambisyllabic [p] is geminated 59% of the time. All geminating [p] in Japanese are ambisyllabic in English source words.

In the case of [t], in 35 source words containing "tt" in their spelling, 18 [t]s are geminated in Japanese. "Ss" with [ʃ] in English pronunciation is geminated 100% of time (11<11) while "ss" with [s] (13<35) is geminated 37% of time. Remaining "ss"s are pronounced with [z] (0<3) and not geminated.

Although 15 words in my corpus contain "cc" in English spelling, only two words in the counterpart Japanese contain geminates; in other words, words with "cc" are geminated only 13% of time. Geminating [k] with "cc" is ambisyllabic consonant in both cases.

Ohso considered that "ck" in spelling would lead to gemination in Japanese. This result proved her hypothesis. 27 [k]s in "ck" are ambisyllabic consonants whereas only one is not ambisyllabic. Therefore, the English spelling "ck" accords with ambisyllabicity.

In addition, the hypothesis that English spelling leads to gemination does not explain the high rates of gemination for affricates (83.3% for [tʃ] and 40.0% for [dʒ]). These examples indicate that gemination is not due to spelling with double letters.

Figure 6 The relationship between double letters and geminates.

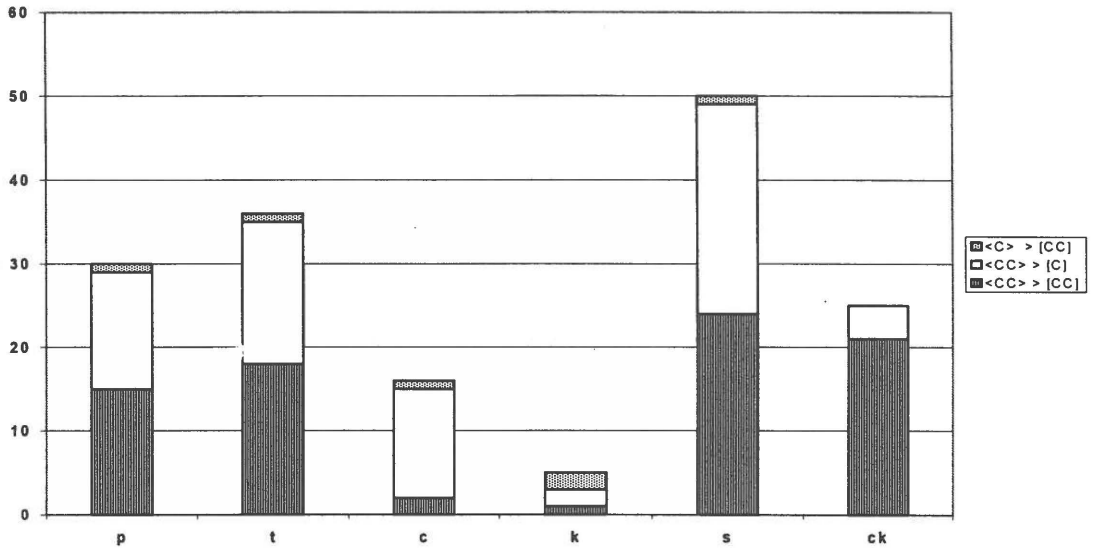


Figure 6 shows that consonants spelled with double letters are geminated almost half of the time.

Figure 7 The relationship among ambisyllabicity, double letters and gemination.

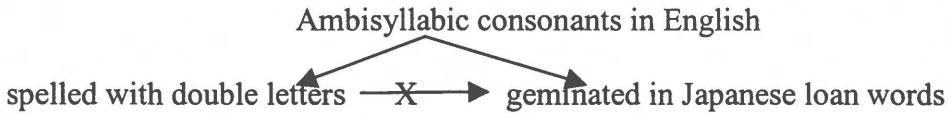


Figure 7 shows that ambisyllabic consonants are spelled with double letters. Concurrently ambisyllabic consonants are geminated in Japanese. However, spelling with double letters does not trigger gemination in Japanese in a straight line.

4.5 Non-gemination of ambisyllabic or final consonants

Not all consonants satisfying the conditions are geminated. Here I speculated the reasons for non-gemination.

4.5.1 Two geminates in a morpheme

The first reason is a phonological constraint. Even if one word satisfies the ambisyllabic conditions and the word final conditions, the word does not contain two geminates within one morpheme. Only word final consonants are geminated in Japanese.

(25) No two geminates in a morpheme

a.	gossip [gɒ́sp]	>	[goʃipɯ]	[*goʃʃippɯ]
b.	packet [pɒ́kɪt]	>	[paketto]	[*pakketto]

Tsuchida (1995) formulated it as "the prohibition of two geminates."

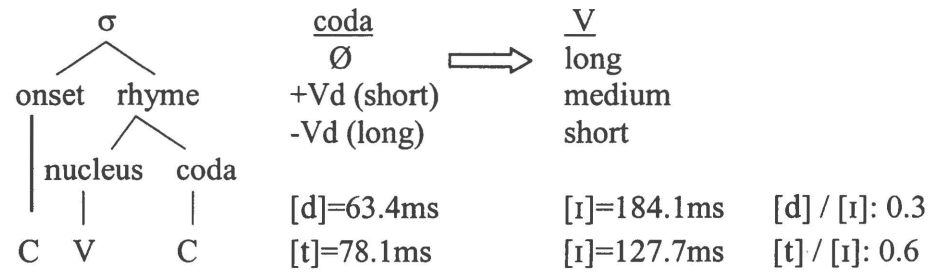
*Two geminates
No more than one geminate is permitted within a morpheme.

4.5.2 Durational differences of phonemes in English

The second reason is the duration of consonant is too short to recognize the duration. In my hypothesis, the longer the duration of each phoneme in the source word, the more frequently Japanese speakers perceive it as geminate.

In English, there is a trade-off relation between the duration of a nucleus and a coda. The research conducted by Luce and Charles-Luce (1985) shows that the duration of voiced stops is shorter than voiceless stops. It leads to less frequency of gemination of voiced consonants. Since each mora in the Japanese language has almost the same duration, Japanese speakers expect a short consonant after a short stressed vowel. However, the duration of voiceless consonants is long while the duration of the preceding vowels is short. As a result voiceless consonants tend to be recognized as geminates. The ratio of voiceless consonants with preceding vowels is 0.6 while the ratio of voiced consonants with preceding vowels is 0.3. Thus voiced consonants are less frequently geminated in Japanese loan words.

Figure 8 Vowel length is adjusted depending on the coda:



In 3.2, we have seen affricates are highly geminated; for example, word final voiceless affricate is geminated 100% of the time; in addition, the frequency of germination for ambisyllabic one is 83.3%. According to Fletcher (1989), the duration of affricates is longer than stops; as a result, the frequency of gemination for affricates is high.

The geminating rate of ambisyllabic [t] (47.8%) is relatively low compared with word-final [t] (92.3%). The allophone of the ambisyllabic [t] in English is a flap [ɾ]; for instance some English speakers pronounce "water" as [waɾɚ]. The duration of a flap is short. Consequently, the frequency of gemination for ambisyllabic [t] is low.

4.5.3 The influence of spelling

The third reason for non-gemination is that some loan words were determined by the spelling of the source words. Although we have seen that double spelling does not trigger gemination directly, some spellings seem to be an obstacle in gemination.

When Japan started diplomatic relationship with European countries, people had to learn Western concepts and technology. Therefore people imported loan words with the new concepts. The people who imported loan words probably learned the concepts by reading more than listening. Some Japanese loan words were determined based on English spelling after the Japanese people in those days learned some basic words, probably by conversation. As an example of the influence of spelling, the Japanese word, "shogun" [ʃo:gɯɴ] 'a military general' is pronounced as [ʃogʌn] by English speakers because of the spelling's resemblance to "gun" [gʌn] although alternative pronunciation [ʃogʊn] or [ʃogɯn] is probably closer to the Japanese source. This example illustrates how spelling influences pronunciation.

(26) Influence of spelling

a.	'average'	[ǽvərɪdʒ]	[abeɾe:dʒi] From "age" [eɪdʒ]
b.	'manage'	[mǽnɪdʒ]	[mane:dʒi]
c.	'chocolate'	[tʃɒ́kələt]	[tʃokoɾe:to] From "ate" [eɪt]
d.	'private'	[práɪvət]	[pɯɾaibe:to]

The fourth reason for non-gemination is that loan words were determined by how Japanese speakers heard the source word. Since these loan words have been imported, each loan word reflected how Japanese speakers were exposed to foreign words when the word was adopted into Japanese. For example, 'cotton' is adapted to two Japanese loan words: [kataN] and [kottoN]. The second one more recently came to the Japanese lexicon than the first one.

4.5.4 Other reasons for non-gemination

As we have seen in 3.2, word final [s] is never geminated. It is odd since voiceless fricatives are longer than voiceless stops. Inconsistently, ambisyllabic [s] is geminated 55% of time. This is probably because standard Japanese speakers tend to devoice the sentence final vowel in [desɯ̥]. Consequently Japanese listeners do not realize the long duration of word final [s].

However, the frequency of gemination for [ʃ] is 87.5% for the word final one and 51.7% for the ambisyllabic one. The frication of sibilants is noisy and lasts long, which leads to high frequency of gemination.

Other voiceless fricatives [f] and [θ] are characterized as weak frication; in addition, these sounds do not exist in Japanese phonemic inventory. Consequently Japanese speakers have trouble recognizing these sounds and their long duration.

Voiced fricatives are cross-linguistically never geminated because of two contradictory requirements: a low oral pressure for voicing and a high oral pressure for fricatives (Stevens 1992).

4.6 Counter-examples to Threshold Principle

According to Paradis et al, a segment is deleted if the illicit segment requires more than two steps to repair. However, the Threshold Principle is not applicable to Japanese loan word adaptation. The following examples illustrate this.

(27) Counter-examples of Threshold Principle

Fula loan word derived from French

a.	cuivre	[kɥivr]	>	[kiri]	[*kuwiwri]	'copper'

Japanese loan word derived from English

b.	idol	[aɪdl]	>	[aidoɾɯ]	[*aido]

Compare 'cuivre' and 'idol': both words have coda clusters, which violates the borrowed language constraints. In addition, both words contain illicit elements: [v] in Fula and [l] in Japanese. However, the results are opposite.

Step 1: consonant clusters are illicit in Fula and Japanese so nucleus is inserted in both.
Step 2: In Fula, vowel spreading while in Japanese, the default vowel [ɯ] is inserted as the nucleus.
Step 3: Illicit segments are adapted to phonetic close segments.

Thus in both words, 3 steps are required to repair coda clusters with illicit segment. However, in Fula, the segment is deleted, but this is not the case in Japanese.

In addition, (28) shows that although the adaptation from [l̩] to [ɾɯ] requires four steps, the illicit segment [l̩] is not deleted.

(28) 'couple' [kʌ́pl̩] > [kappɯɾɯ]

Step1: Syllabic liquid is not allowed ([+syll] → [-syll])
Step 2: Consonant clusters are illicit in Japanese so nucleus is inserted.
Step 3: Default vowel [ɯ] represents the nucleus.
Step 4: Since [l] is illicit, it is adapted to flap [ɾ].

These examples indicate that the Threshold Principle is not applicable in Japanese.

5 Conclusion

When English words are imported to the Japanese language, some consonants are geminated. I conducted the research on the Japanese loan words derived from English. I focused on (1) what consonants in English are geminated in Japanese (2) what conditions are necessary for the gemination, and (3) how often these consonants under the conditions are actually geminated. In addition, I sought the reasons for gemination and non-gemination.

Gemination in borrowed words occurs mostly in two contexts: final consonant following a lax vowel, and ambisyllabic consonant. These consonants serve as codas in the source words. In order to preserve the phonological structure of source words, gemination occurs in Japanese loan words. The conditions for gemination are that the vowel preceding the consonant must be lax and that a geminating consonant in Japanese must not be part of a consonant cluster in English. Most geminating consonants satisfy these conditions.

However, not all consonants satisfying the conditions are geminated. Other factors that determine gemination are the duration of the phoneme in English, the influence of orthography and the universal constraints on length of voiced consonants.

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Appendix

Table 1 Frequency of gemination in word final group.

Final C	# of tokens under the conditions	# of tokens with gemination	% of gemination
tʃ	21	21	100.0%
p	47	47	100.0%
k	102	100	98.0%
t	105	97	92.3%
ʃ	24	21	87.5%
d	36	21	58.3%
g	22	12	54.5%
dʒ	24	10	[6]41.6%
f	10	3	30.0%
b	9	1	11.1%
θ	2	0	0.0%
s	86	0	0.0%
v	17	0	0.0%
ð	0	0	0.0%
z	3	0	0.0%
ʒ	0	0	0.0%

Table 2 Frequency of Gemination in Ambisyllabic group.

Ambisyllabic C	# of tokens under the conditions	# of tokens with gemination	% of gemination
tʃ	6	5	83.3%
k	29	24	82.7%
p	22	13	59.1%
s	20	11	55.0%
ʃ	29	15	51.7%

[6] English words ending with not-geminating voiced affricates are the following: advantage, average, baggage, cottage, coverage, damage, image, manage, mortgage, package, percentage, stoppage and voltage. These words contain the morpheme "-age" that is adapted to [e:dʒi] in Japanese (Lovins called this adaptation as "a spelling pronunciation.") The reason for non-gemination is probably because of overgeneralization with the English word "age" [eidʒ]. If we eliminate these words, the frequency of gemination for voiced affricates is 100%.

Ambisyllabic C	# of tokens under the conditions	# of tokens with gemination	% of gemination
f	6	3	50.0%
θ	2	1	50.0%
t	23	11	47.8%
dʒ	5	2	40.0%
g	11	2	18.2%
d	25	2	8.0%
b	9	0	0.0%
v	14	0	0.0%
ð	6	0	0.0%
z	7	0	0.0%
ʒ	2	0	0.0%

Table 3 Nasal gemination

	Orthographic > phonetic	n	m
Ambisyllabic	<CC> > [CC]	10	7
Ambisyllabic	<CC> > [C]	16	14
Ambisyllabic	<C> > [CC]	0	0
Ambisyllabic	<C> > [C]	44	39
Non-ambisyllabic	<CC> > [CC]	0	3
Non-ambisyllabic	<CC> > [C]	8	11

Table 4: Double letters. [7]

Orthographic > phonetic	p	T	c	k	s	ck
<CC> > [CC]	15	18	2	1	24	21
<CC> > [C]	14	17	13	2	25	4
<C> > [CC]	1	1	1	2	4	NA

[7] I eliminate the words that satisfy the word final conditions for gemination, and compound words; in other words, "back" and "boss" are not included.