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*Perceptual similarity in loanword adaptation: English postvocalic word-final stops in Korean**

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When an English word with a postvocalic word-final stop is adapted to Korean, a vowel is variably inserted after the final stop. Vowel insertion in this position is puzzling not only because of its variability but also because of the fact that it is not motivated by the native phonology in any obvious way. After providing a thorough description of the vowel-insertion pattern on the basis of a survey of a large body of data, the paper proposes that vowel insertion is motivated to improve the perceptual similarity between the English input and the Korean output as well as to obey a morphophonemic restriction in Korean. The paper provides strong evidence that non-contrastive phonetic details of lending or borrowing languages are relevant in the process of loanword adaptation and at the same time suggests a richer view of loanword phonology, one which involves interaction of phonetic, phonemic and morphophonemic factors.

1 Introduction

In this paper, I provide a detailed case study of vowel insertion after a word-final postvocalic stop in English loanwords in Korean. Vowel insertion in this position is puzzling not only because of its variability but also because of the fact that it is not motivated by the native phonology in any obvious way. One of the goals of the paper is to provide an accurate description of the vowel-insertion pattern in this position based on a systematic survey of a loanword list compiled by the National Academy of the

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Korean Language (Kwuklipkwukeyenkwuwen 1991; henceforth the NAKL list). This list contains loans from some 5000 English words and phrases gathered from six daily newspapers and nine magazines published in Korea in 1990. The list also reports the frequency of occurrence of individual loanwords in different newspapers and magazines. The survey confirms previous observations that the likelihood of vowel insertion after a word-final postvocalic stop is affected by at least three phonological factors: vowel insertion is more likely (a) when the pre-final vowel is tense rather than lax, (b) when the final stop is voiced rather than voiceless and (c) when the final stop is coronal rather than non-coronal and when the stop is labial rather than dorsal.

Based on the results of the survey, it is proposed that the motivation of vowel insertion is the maximisation of the perceptual similarity between the English input and the Korean output, as well as to obey a morphophonemic restriction in Korean. Specifically, it is proposed that post-stop vowel insertion yields a good perceptual approximation to stop release and, given the fact that final stops are more frequently released after a tense vowel than after a lax vowel in English, that perceptual similarity considerations account for the vowel-tenseness effect. Perceptual similarity also explains the voicing effect; post-stop vowel insertion brings the Korean output closer to the voiced stops of English, due to phonetic processes in Korean such as intervocalic voicing of plain stops and open syllable lengthening of vowels. On the other hand, the higher frequency of vowel insertion after coronal stops is attributed to morphophonemic restrictions on underlyingly /t/-final nouns in Korean.

The findings of the paper bear on the ongoing debate in loanword phonology regarding the nature of input and output of loanword adaptation. Oh (1996) and LaCharité & Paradis (2001) claim that subphonemic phonetic variants of sounds are 'unimportant' in loan adaptation, listing instances of adaptation where non-contrastive phonetic information of source and target languages is ignored and only the *phonemic* distinction is attended to. For example, in Korean, the coronal stops in *tie* and *stick* are uniformly adapted as aspirated stops (/tʰɑi/ and /sɨtʰik/), even though a tense stop (*/sɨt'ik/) would be the best approximation to the unaspirated variant of the coronal stop in *stick* (Oh 1996). A similar adaptation pattern is reported for Hindi (Paradis & LaCharité 1997). Adaptation of the American English flap to Korean and Quebec French provides an additional example of phonemic mapping. In American English, the coronal stops /t/ and /d/ are often realised as a flap. But these stops are adapted according to their phonemic identity in Korean and Quebec French (Oh 1996, LaCharité & Paradis 2001). For example, in Korean *lighter* and *radar* are adapted as [rɑitʰɑ] and [rɛitɑ], respectively, although *[rɑirʌ] and *[rɛirʌ] would be phonetically closer to the English inputs.

Others claim that loanword adaptation is sensitive to subphonemic phonetic details of sounds in such a way that foreign inputs are mapped to native strings that are closest in their *phonetic* shape. For example, contrary to what is found in Korean, in Cantonese the English word *tie* is adapted

as /tʰaj/, with an aspirated stop /tʰ/, but the English word *stick* is adapted as /sitik/, with a plain stop /t/ (Silverman 1992). Apparently, Cantonese speakers are attending to the surface acoustic characteristics of the English sounds rather than to the phonemic membership of these sounds in English. Adaptation of English /s/ to Korean provides another example where speakers attend to the subphonemic phonetic details of speech sounds in loan adaptation; English /s/ is adapted to Korean as plain fricative /s/ if the fricative occurs preconsonantally in English (e.g. *slump*, *smog*, *test*, *disk*), but as tense fricative /s'/ if the fricative occurs prevocalically or word-finally in English (e.g. *salary*, *size*, *gas*, *bus*, etc.). Kim (1999) argues that Korean speakers are sensitive to the durational difference of English /s/ in different contexts, and map English /s/ to Korean /s'/ when the fricative is long in English but to Korean /s/ when the fricative is short in English.

Moreover, there are cases of loan adaptation where standard phonological representation is too coarse to reflect speakers' knowledge of phonetic similarity exhibited in adaptation patterns. For example, when English words are adapted to Cantonese, sibilants in complex syllable margins are preserved in all contexts (*stamp*→/sitam/, *tips*→/tʰipsi/, *forecast*→/fokʰasi/), while stops in complex syllable margins are realised as zero unless they are adjacent to a liquid or a vowel in the English word (*post*→/pʰosi/, */pʰosit/, *lift*→/lip/, */liptʰi/); Silverman (1992). Steriade (2001a) argues that the different adaptation patterns of stops and sibilants in these words are due to the fact that the perceptual cues for the stops are weaker than those for the sibilants and that the perceptual distance between zero and the stops is smaller than the distance between zero and the sibilants in these words.

Kenstowicz (to appear) demonstrates that perceptual similarity also plays a role in adaptation of French uvular /ʁ/ to Fon, a sub-group of Gbe (Ewe). In prevocalic position, /ʁ/ is adapted as /l/, with an additional dorsal component word-initially (*bureau*→/bīlô/, *greve*→/glěvù/, *rideau*→/ʁlīdô/). In contrast, /ʁ/ in preconsonantal or word-final positions is realised as zero (*gare*→/gă/, *torche*→/tɔ́ʧì/). This behaviour contrasts sharply with that of /l/ in preconsonantal or word-final position, which is systematically adapted as a sequence of /l/ plus a vowel (*col*→/kɔ́lù/, *Delphine*→/dɛ̄lūfínì/). The exceptional behaviour of /ʁ/ in preconsonantal or word-final positions is attributed to the fact that the perceptual cues for /ʁ/ are particularly weak in these positions, such that it is perceptually very similar to zero.

Similarly, Fleischhacker (2001) proposes that perceptual similarity can explain the otherwise puzzling generalisations regarding vowel insertion in initial CC clusters in loanword adaptation and inter-language phonology. In a voiceless sibilant + stop cluster, a vowel tends to be inserted before the cluster (ST→VST: e.g. Hindi /ɪskul/ 'school') while in an obstruent + sonorant cluster, a vowel tends to be inserted into the cluster (TR→TVR: e.g. Hindi /pɪlɪz/ 'please'). Experimental studies show that ST clusters are judged to be more similar to VST than SVT sequences, while TR clusters are judged to be more similar to TVR than VTR sequences.

The current paper provides additional evidence that inter-language mapping crucially refers to subphonemic phonetic details of sounds of the source and borrowing languages, such as the optional release of word-final stops in English and phonetic voicing of intervocalic stops in Korean. The findings provide further support for the claim that loan adaptation may be sensitive to different allophonic realisations of phonemes of participating languages (Holden 1976, Silverman 1992, Kim 1999, Fleischhacker 2001, Steriade 2001a, Peperkamp & Dupoux 2003, Kenstowicz, to appear) – contrary to the claim that inter-language mapping applies essentially on a *phoneme-to-phoneme* basis (Oh 1996, LaCharité & Paradis 2001). At the same time, the current paper demonstrates that the maximisation of phonetic similarity is only one of the factors affecting the pattern of loan adaptation, such that it competes with and at times is overridden by other factors, e.g. morphophonemic restrictions in the borrowing language. In sum, the current paper argues for a richer view of loanword phonology, where loan adaptation involves a complex interplay of phonetic, phonemic and morphophonemic factors.

2 Data

2.1 Overview

Korean does not have a voicing contrast in stops, but has a three-way laryngeal contrast among plain, aspirated and tense stops. Vowel length is considered to be non-contrastive in standard Korean, particularly for younger generations of speakers (Sohn 1999, Cho 2003). The phoneme inventory of Korean is given in (1).

(1) *Inventory of Korean phonemes*

p	p^h	p’	t	t^h	t’	k	k^h	k’			i	ɨ	u
			ts	ts^h	ts’						ɛ	ʌ	o
			s		s’				h		æ	ɑ	
m			n			ŋ							
			ʟ[1]								j		w

Generally, when English words are borrowed into Korean, English voiced and voiceless stops in prevocalic position are mapped to plain and aspirated stops of Korean, respectively. Examples are given in (2).[2]

(2) *Adaptation of English prevocalic stops to Korean*

tennis	→ **t^h**ɛ.nɪ.sɨ	data	→ **t**ɛ.i.t^hɑ
camera	→ **k^h**ɑ.mɛ.ʟɑ	guitar	→ **k**i.t^hɑ
panorama	→ **p^h**ɑ.no.ʟɑ.mɑ	body	→ **p**ɑ.ti

[1] /ʟ/ represents a liquid phoneme which is realised as [r] or [l], depending on the syllable position (Cho 1997, Lee 2001, Seo 2002).

[2] The majority of the examples cited in the paper come from the NAKL list. However, when no relevant examples were available from the list, examples were found using an online search engine (http://kr.yahoo.com); these are marked with †.

In older loanwords, English prevocalic voiced stops are very often realised as tense stops; e.g. *game*→/k'ɛim/, *bar*→/p'ɑ/. Kwon (1995) conjectures that these words were borrowed through Japanese. However, due to the standard orthographic convention for English loanwords, which avoids use of tense consonant letters, these words are usually written with plain stops.[3] Since English non-prevocalic stops, the focus of the current study, are rarely adapted as tense stops, this detail is not crucial to the main content of the paper. Therefore, throughout the paper, rather than marking the tense consonants based on my subjective judgments, I will faithfully report the forms as given in the NAKL list.

When a stop is postvocalic and word-final, a vowel, /ɨ/, is variably inserted after the stop. For one group of words, /ɨ/ is consistently inserted after the word-final stop. Some examples are given in (3).

(3) *Vowel insertion after postvocalic word-final stops*

bat	→ pæ.**tʰɨ**	pad	→ pʰæ.**tɨ**
deck	→ tɛ.**kʰɨ**	gag	→ kæ.**kɨ**
hip	→ hi.**pʰɨ**	tube	→ tʰju.**pɨ**

Note that in (3), the contrast between English voiceless and voiced stops is maintained as aspiration contrast in Korean forms. For another group of words, such as those in (4), no vowel is inserted after the final stop.

(4) *No vowel insertion after postvocalic word-final stops*

flat	→ pʰɨL.Læ**t**		
pack	→ pʰæ**k**	bag	→ pæ**k**
cap	→ kʰæ**p**	club	→ kʰɨL.Lʌ**p**

In Korean, laryngeal contrasts among obstruents are neutralised in coda position. Thus, without vowel insertion, the word-final stops end up in coda position and the contrast between English voiced and voiceless stops is neutralised. For example, /k/ in *pack* and /g/ in *bag* are both realised as the plain stop /k/ in Korean. For yet another group of words, forms with final vowel insertion and forms without final vowel insertion co-occur. Some examples are given in (5).

(5) *Variable insertion after postvocalic word-final stops*

cut	→ kʰʌ.**tʰɨ**	~	kʰʌ**t**
cake	→ kʰɛ.i.**kʰɨ**	~	kʰɛ.i**k**
jeep	→ tsi.**pʰɨ**	~	tsi**p**
pyramid	→ pʰi.Lɑ.mi.**tɨ**	~	pʰi.Lɑ.mi**t**
zigzag	→ tsi.kɨ.tsæ.**kɨ**	~	tsi.kɨ.tsæ**k**

[3] Therefore, the orthographic convention also does not reflect the fact that English /s/ is systematically adapted as tense fricative /s'/ in prevocalic or word-final position (cf. Kim 1999). Also not reflected in the standard orthography is the regular process of post-obstruent tensing of plain obstruents.

Vowel insertion in this position is puzzling, because it is not motivated by the phonology of English or Korean in any straightforward way. Korean allows only a limited number of consonants (/p t k m n ŋ l/) in coda position. Specifically, an aspirated consonant is not allowed in coda position. To put it in optimality-theoretic terms (Prince & Smolensky 1993), Korean has a high-ranked markedness constraint against aspirated consonants in coda position (*Asp/Coda). Since English voiceless stops are adapted as Korean aspirated stops in general, one may argue that the vowel insertion after an English voiceless stop is motivated by the Korean phonotactic restriction *Asp/Coda. However, in the native phonology, potential violations of *Asp/Coda are resolved by deaspiration, not by vowel insertion, as the examples in (6) show.

(6) *Coda neutralisation in Korean native vocabulary*

/pɑtʰ/	pɑt	'field'	cf. /pɑtʰ-ɛ/	pɑtʰɛ	'in the field'
/ɑpʰ/	ɑp	'front'	/ɑpʰ-ɛ/	ɑpʰɛ	'in the front'
/puʌkʰ/	puʌk	'kitchen'	/puʌkʰ-ɛ/	puʌkʰɛ	'in the kitchen'

For example, when the word 'field' occurs in non-prevocalic position, the underlying aspirated stop /tʰ/ surfaces as a plain stop [t]. A tableau illustrating the derivation of /pɑtʰ/→[pɑt] 'field' is given in (7).

(7) *Native Korean* /pɑtʰ/ 'field' → [pɑt]

/pɑtʰ/	*Asp/Coda	Dep(V)	Ident[asp]
a. pɑtʰ	*!		
b. pɑtʰɨ		*!	
☞ c. pɑt			*

The faithful candidate, (7a), violates *Asp/Coda and is ruled out. The constraint against vowel insertion, Dep(V), crucially dominates the constraint against deaspiration, Ident[asp], and therefore (7c), the candidate with deaspiration, is chosen over (7b), the candidate with vowel insertion. According to this constraint ranking, final vowel insertion in loanwords is still an unexpected outcome, as the tableau in (8) demonstrates for *deck*.

(8) *English loanword* deck → [tɛkʰɨ]

/tɛkʰ/	*Asp/Coda	Dep(V)	Ident[asp]
a. tɛkʰ	*!		
☞ b. tɛkʰɨ		*!	
☞ c. tɛk			*

The English word *deck* is adapted to Korean with final vowel insertion, as in (8b). However, according to the constraint ranking operative in the native phonology of Korean – namely, Dep(V) ≫ Ident[asp] – (8b) cannot be chosen as output.

Vowel insertion after an English voiced stop is even more puzzling, since Korean freely allows plain stops in coda position, as the tableau in (9) illustrates for the derivation of /kæk/→[kæk] 'guest'.

(9) *Native Korean* /kæk/ 'guest' → [kæk]

/kæk/	*Asp/Coda	Dep(V)
☞ a. kæk		
b. kækɨ		*!

The faithful candidate, (9a), does not violate *Asp/Coda or any high-ranking markedness constraint in Korean and therefore surfaces as the winner. Given the fact that English voiced stops are in general adapted as Korean plain stops, vowel insertion after a final voiced stop is completely unexpected, as the tableau in (10) illustrates for *gag*.

(10) *English loanword* gag → [kækɨ]

/kæk/	*Asp/Coda	Dep(V)
☞ a. kæk		
☜ b. kækɨ		*!

The English word *gag* is adapted with final vowel insertion. But (10a), the output with vowel insertion, incurs a violation of Dep(V), while (10b), the candidate without vowel insertion, violates neither Dep(V) nor *Asp/Coda. Therefore, the faithful candidate, (10a), is incorrectly chosen as the winner.

One might resort to re-ranking in loanword phonology to accommodate the unexpected vowel insertion in loanwords, but this solution leads to unsatisfactory result. Ku (1999) proposes that loanwords are subject to a constraint ranking different from that of native phonology, such that a constraint against an obstruent in coda position, *Obs/Coda, outranks the constraint against vowel insertion, Dep(V).[4] The tableaux in (11) illustrate how the re-ranking analysis works.

(11) a. *Native Korean* /kæk/ 'guest' → [kæk]

/kæk/	Dep(V)	*Obs/Coda
☞ i. kæk		*
ii. kækɨ	*!	

b. *English loanword* gag → [kækɨ]

/kæk/	*Obs/Coda	Dep(V)
i. kæk	*!	
☞ ii. kækɨ		*

[4] See Lee (1995) for a similar proposal.

In the native phonology, *OBS/CODA is ranked low, and a word with a final stop surfaces without vowel insertion, as shown in (11a). But in loanwords, the ranking is reversed, and a vowel is inserted after a final stop, as shown in (11b). However, for many reasons this type of arbitrary re-ranking in loanword phonology is an inadequate solution.

First, it does not explain what would motivate Korean speakers to posit a ranking for loanwords that is the opposite of the native ranking. Second, the analysis makes the incorrect prediction that vowel insertion is found in all instances of a potential obstruent coda. But this is simply not the case. When a voiceless stop is followed by another stop within the same morpheme, vowel insertion never applies: *chapter*→/ts^{h}æpt^{h}ʌ/, */ts^{h}æp^{h}ɨt^{h}ʌ/; *victory*→/pikt^{h}oLi/, */pik^{h}ɨt^{h}oLi/, etc. Thirdly, it is unclear how an analysis based on the re-ranking of syllable structure constraints would explain the variability found in vowel insertion. Ku (1999) suggests that words showing no vowel insertion are more recent loans and are less integrated. He proposes that vowel insertion does not apply to the less integrated loanwords because the constraint ranking is reversed in these words (DEP(V) ⫸ *OBS/CODA), which is in fact identical to the ranking for native words. But Ku's proposal contradicts the generally accepted view in loanword phonology that the more nativised a form is, the more likely it is to adhere to the native constraint ranking (Itô & Mester 1999). Moreover, it is not true that the likelihood of vowel insertion after a word-final stop correlates with the degree of nativisation in general. For example, no vowel is inserted after the final stop in *group* (/kɨLup/), but it is the seventh most common loanword according to the NAKL list, with 873 occurrences, suggesting its use as a loanword is widespread. On the other hand, the NAKL list reports only one occurrence of *solid*, but it appears with final vowel insertion: /soLLitɨ/. Assuming that the frequency of occurrence is an indicator of the degree of nativisation of a loanword, the behaviour of *group* and *solid* is problematic for Ku. A comprehensive examination of the NAKL list also shows that Ku's proposal cannot be maintained. Figure 1 tabulates the frequency of occurrence reported in the NAKL list for those loanwords whose English source word ends in a postvocalic stop. The histogram in (a) gives the frequency distribution for words which do not show final vowel insertion, while that in (b) gives the frequency distribution for those which show final vowel insertion.

If the likelihood of vowel insertion correlates with the degree of nativisation, as Ku proposes, we would expect different patterns of frequency distribution for the two groups of words; namely, the words with vowel insertion would show concentration in the high-frequency region while the words without insertion would show concentration in the low-frequency region. But the histograms in Fig. 1 show no discernible difference in frequency distribution between the two groups of words.

Why, then, does vowel insertion apply in this position? To better understand this, we first need to examine the patterns of vowel insertion. There are three major phonological factors affecting the likelihood of vowel insertion after postvocalic word-final stops which have been

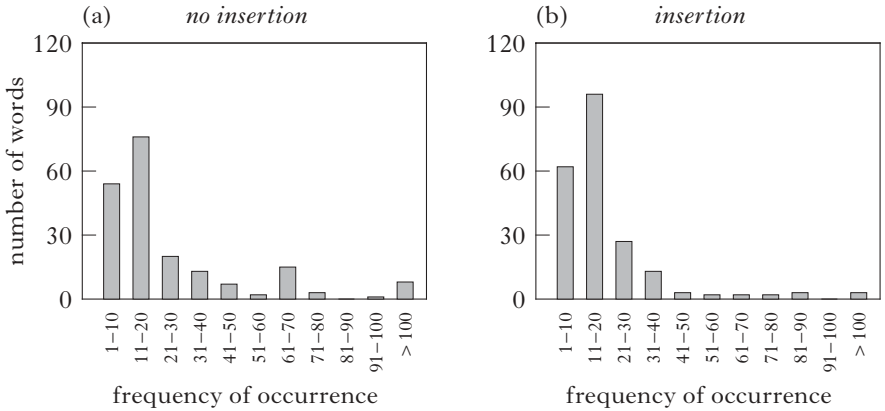


Figure 1

Frequency of occurrence distribution of loanwords whose English source word ends in a postvocalic stop. (a) shows the frequency distribution of loans adapted from English with no final vowel insertion; (b) shows the same for loans adapted from English with final vowel insertion. All data are based on the NAKL list.

suggested (Hirano 1994, Nam & Southard 1994, Broselow & Park 1995, H. Kang 1996, O. Kang 1996, Pouplier 2001, Rhee & Choi 2001, Jun 2002).[5,6] They are summarised in (12), along with some examples demonstrating the relevant contrast.

[5] I became aware of the statistical survey of post-stop vowel epenthesis by Rhee & Choi (2001) only after the completion of my own study. Rhee & Choi's survey, based on 409 loanwords, does not separate vowel insertion after word-final stops from vowel insertion after word-medial stops, but their results are in general agreement with the results of my survey. They uncover an additional phonological factor: vowel insertion is more likely in monosyllabic than in polysyllabic words. The vowel-insertion pattern in the NAKL list is in agreement with this finding; the frequency of final vowel insertion for monosyllabic words (67·6%) is higher than that for polysyllabic words (36·0%). Unfortunately, at the time of writing, I am unable to access the TIMIT corpus and cannot examine whether the word-length effect can be explained by the asymmetry in stop release frequencies of English. I leave this question for future research.

[6] Jun (2002) examined adaptation patterns of English nonce words in a large-scale study involving 260 college students, and found three additional factors affecting the likelihood of vowel insertion after postvocalic word-final stops; the frequency of vowel insertion was higher when the English words were presented in written forms than in oral forms, when the final stop in oral inputs were released than unreleased and when the final syllable was stressed than not. The stress effect is also corroborated in my survey of the NAKL list; the frequency of vowel insertion is higher when the final syllable is stressed (51·0%) than unstressed (14·1%) among polysyllabic words with final postvocalic stops in the NAKL list.

(12) *Phonological factors affecting the likelihood of vowel insertion after postvocalic word-final stops*

a. *Tenseness of the pre-final vowel*

Vowel insertion applies after a postvocalic word-final stop if the pre-final vowel is long or tense in English, but not when it is short or lax.

lax: no insertion	quick	→ $k^hwi\mathbf{k}$
tense: insertion	week	→ $wi\mathbf{k^hi}$

b. *Voicing of the final stop*

Vowel insertion applies after a postvocalic word-final stop if the stop is voiced in English, but not when it is voiceless.

voiceless: no insertion	kick	→ $k^hi\mathbf{k}$
voiced: insertion	MIG	→ $mi\mathbf{gi}$

c. *Place of articulation of the final stop*

Vowel insertion is more likely to apply after a postvocalic word-final stop when the stop is coronal than when it is non-coronal, and is more likely when the stop is dorsal than when it is labial.[7]

labial/dorsal: no insertion	tip, kick	→ $t^hi\mathbf{p}$, $k^hi\mathbf{k}$
coronal: insertion	hit	→ $hi\mathbf{t^hi}$

All three generalisations come with a fair number of counterexamples. This is not surprising, given the fact that the three factors are in conflict in many cases. Given the variable nature of the phenomenon, it is necessary to verify the validity of these factors on the basis of a large body of data, and to find out the extent to which these factors affect vowel insertion. This prompted me to carry out a survey of vowel insertion after postvocalic word-final stops in Korean loanwords from English, based on the NAKL list. The survey confirms all three factors to be statistically significant. I will now turn to the results of my survey.

2.2 Survey of the NAKL list

I collected all instances of loanwords in the NAKL list whose English source words end in a postvocalic stop. Of the 447 English words with a final postvocalic stop found in the list, 225 are consistently adapted with final vowel insertion and 195 are consistently adapted without final vowel insertion, while 27 words show variable vowel insertion. This is summarised in Table I. The complete list of loanwords is provided in the appendix.

[7] The tendency for vowel insertion to be infrequent after labial stops was first pointed out to me by Hosung Nam.

vowel insertion	variable insertion	no vowel insertion	*total*
225 (50·3%)	27 (6·0%)	195 (43·6%)	447

Table I

Overall frequency of final vowel insertion in loanwords in the NAKL list whose English source words end in a postvocalic stop.

I will now turn to each of the three generalisations mentioned in the previous section, the vowel-tenseness effect (§2.2.1), the stop voicing effect (§2.2.2) and the stop place of articulation effect (§2.2.3).

2.2.1 *Tenseness of the pre-final vowel and final vowel insertion.* Recall that it has been suggested that the tenseness or length of the pre-final vowel affects the likelihood of vowel insertion after a word-final stop; that is, when the pre-final vowel is long or tense, a vowel is more likely to be inserted after the word-final stop than when the pre-final vowel is short or lax. The vowel inventory of English assumed in the paper is given in (13), with tense vowels shown in bold (Halle & Mohanan 1985, *The Shorter Oxford English Dictionary* 1989, Durand 1990, Spencer 1996). Here, tenseness is defined on purely phonotactic grounds; tense vowels are those that can appear word-finally in a stressed syllable (Chomsky & Halle 1968, Parker & Walsh 1981, Hammond 1999, Green 2001, Ladefoged 2001).[8]

(13) *Vowel inventory of English* (*tense vowels in bold*)

ɪ	*bit*, *[bɪ]			ʊ	*put*, *[pʊ]
ij	*beet*, *bee*			**uw**	*boot*, *boo*
ɛ	*bet*, *[bɛ]	ʌ	*butt*, *[bʌ]		
ej	*bait*, *bay*			**ow**	*boat*, *bow*
æ	*bat*, *[bæ]	ɑ	GA *pot*, *[pɑ]	ɒ	RP *pot*, *[pɒ]
		ɑː	*balm*, *ma*	**ɔː**	*bought*, *paw*
		aw	*bout*, *bough*	**ɔj**	*void*, *boy*
		aj	*bite*, *bye*		

[8] As the associate editor points out, vowel + coda [r] sequences – [ɑr ɔr ər] – are in fact realised as [ɑː ɔː ɜː] in RP, and even in General American English they are acoustically a lot more like a diphthong than a vowel + coda consonant. In line with this observation, vowel + coda [r] sequences are adapted to Korean as single vowels: *card* → /kʰɑtɨ/, */kʰɑɾtɨ/, /kʰɑɾitɨ/. Since these vowels can occur word-finally (e.g. *car*, *four*, *err*), they should be considered tense (Green 2001). There are 30 loanwords in the NAKL list that end in a stop preceded by one of these vowels; 22 of them are consistently realised with final vowel insertion (e.g. *concert* → /kʰonsʌtʰɨ/), while the other eight show variable insertion (e.g. *short* → /sjotʰɨ/ ~ /sjot/). The high frequency of vowel insertion (73·3%) in these words is compatible with the generalisation that post-stop vowel insertion is more likely when the pre-final vowel is tense than lax.

It needs to be mentioned that while RP maintains a clear tense/lax distinction among low vowels, there is no agreement on what counts as tense and what counts as lax among low vowels in General American English (GA). For example, while the vowel inventory in (13) assumes a distinction between /ɑ/ and /ɑː/ in GA, Hammond (1999) and Ladefoged (2001) do not make the distinction, and classify the vowel as tense.[9] Also, as a reviewer points out, in some dialects of American English the contrast between /ɑ/ and /ɔː/ has merged to /ɑː/ (cf. Ladefoged 1999), and in these dialects the vowel should be considered tense according to the phonotactic definition of tenseness. Given the inter-dialect and inter-speaker variability, it is difficult to test the hypothesis that the tenseness of the pre-final vowel affects the frequency of word-final vowel insertion without making some arbitrary decisions about what counts as tense and what counts as lax among low vowels. In this paper, I will classify English low vowels as summarised in Table II, relying on the representations of GA and RP in the *Merriam-Webster Online Dictionary* (2003; http://www.merriam-webster.com) and *The Shorter Oxford English Dictionary* (1989), respectively.

GA	RP	classification assumed in this paper	
ɑ	ɒ	lax (ɑ/ɒ)	e.g. *stop*, *yacht*
ɔː ~ ɑ	ɒ	tense (ɔː)	e.g. *catalog*(*ue*), *fog*, *dog*
ɔː	ɔː	tense (ɔː)	e.g. *talk*, *chalk*

Table II

Classification of English low vowels assumed in this paper, based on the *Merriam-Webster Online Dictionary* (2003) and *The Shorter Oxford English Dictionary* (1989).

The GA vowel /ɑ/ that corresponds to RP /ɒ/ is classified as lax, while GA /ɔː/, corresponding to RP /ɔː/, is classified as tense. The pre-final vowel in the words ending in *-og*(*ue*) is /ɒ/ in RP, but varies between /ɔː/ and /ɑ/ in GA. I classify the vowel in these words as tense /ɔː/, not as lax /ɑ, ɒ/, because in the NAKL list these words are consistently adapted in Korean as /o/, patterning with other words with pre-final /ɔː/. In contrast, words with English /ɑ, ɒ/ are variably adapted in Korean as /o/ or /ɑ/.

Table III provides a summary of final vowel insertion patterns for loanwords in the NAKL list whose English source word ends in a vowel + stop, according to the quality of the English pre-final vowel. The

[9] Parker & Walsh (1981) and Green (2001) do not make a phonemic distinction between [ɑ] and [ɑː], but argue that the vowel should be still considered lax since there are only very few words in English that end in a stressed [ɑː] – *bra*, *hurrah*, *Shah*, *spa*, etc. – and most of them are recent loans or show an alternate pronunciation with a tense vowel: e.g. *hurrah* ~ *hurray*.

pre-final vowel	vowel insertion	variable insertion	no vowel insertion	*total*
aw	0 (0·0%)	1 (12·5%)	7 (87·5%)	8
ɪ	20 (16·5%)	8 (6·6%)	93 (76·9%)	121
ɑ/ɒ	8 (25·0%)	3 (9·4%)	21 (65·6%)	32
æ	14 (29·8%)	2 (4·3%)	31 (66·0%)	47
ʌ	9 (32·1%)	1 (3·6%)	18 (64·3%)	28
ʊ	3 (33·3%)	0 (0·0%)	6 (66·7%)	9
ə	6 (40·0%)	2 (13·3%)	7 (46·7%)	15
ɛ	19 (61·3%)	4 (12·9%)	8 (25·8%)	31
uw	16 (80·0%)	3 (15·0%)	1 (5·0%)	20
ij	19 (90·5%)	1 (4·8%)	1 (4·8%)	21
ej	35 (92·1%)	2 (5·3%)	1 (2·6%)	38
aj	37 (97·4%)	0 (0·0%)	1 (2·6%)	38
ow	22 (100·0%)	0 (0·0%)	0 (0·0%)	22
ɔj	4 (100·0%)	0 (0·0%)	0 (0·0%)	4
ɔː	13 (100·0%)	0 (0·0%)	0 (0·0%)	13

Table III

Frequency of vowel insertion, variable insertion and no vowel insertion after a word-final postvocalic stop according to the quality of the pre-final vowel in loanwords in the NAKL list. (Tense vowels in bold.)

frequency of vowel insertion varies, depending on the quality of the pre-final vowel. The vowels in the upper half of the table show lower frequencies of vowel insertion than those in the lower half. All vowels in the first group except for /aw/ are lax, while those in the second group are tense. In other words, final vowel insertion is in general more likely when the pre-final vowel is tense than when it is lax, as summarised in Fig. 2. A contingency table analysis shows that this effect is statistically significant ($\chi^2 = 162{\cdot}6$, df = 2, $p \leq 0{\cdot}0001$).

2.2.2 *Voicing of the final stop and final vowel insertion.* It has been proposed that voicing of the final stop affects the frequency of vowel insertion, i.e. vowel insertion is more likely when the final stop is voiced than when it is voiceless. Figure 3 summarises the pattern of final vowel insertion according to the voicing of the word-final stop in English. The results confirm the observation that final vowel insertion is more frequent after a voiced stop than after a voiceless stop. This effect is statistically significant ($\chi^2 = 75{\cdot}12$, df = 2, $p \leq 0{\cdot}0001$).

2.2.3 *Place of articulation of the final stop and final vowel insertion.* Finally, it has been proposed that place of articulation of the final stop affects the frequency of vowel insertion, i.e. vowel insertion is more likely when the final stop is coronal than when it is dorsal, and more likely when the final

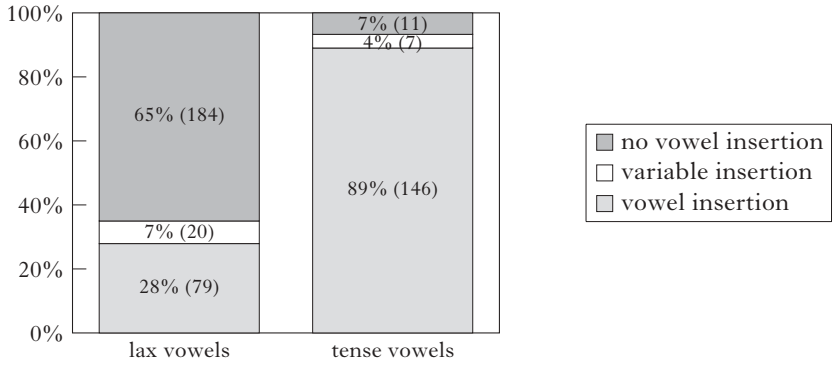


Figure 2

Frequency of vowel insertion after a word-final postvocalic stop according to tenseness/laxness of the pre-final vowel.

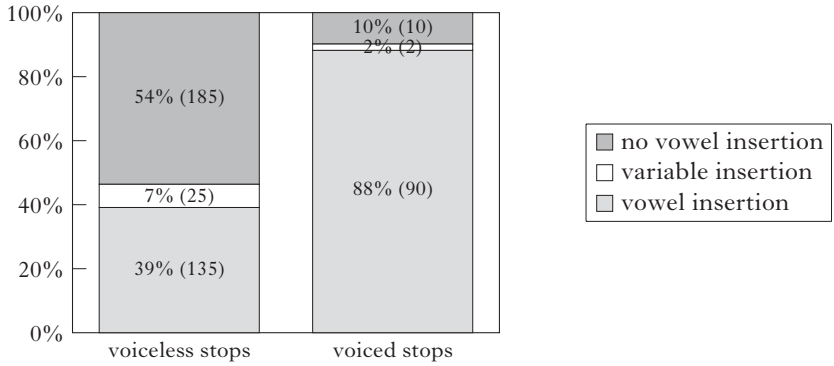


Figure 3

Frequency of vowel insertion after a word-final postvocalic stop according to voicing of the final stop.

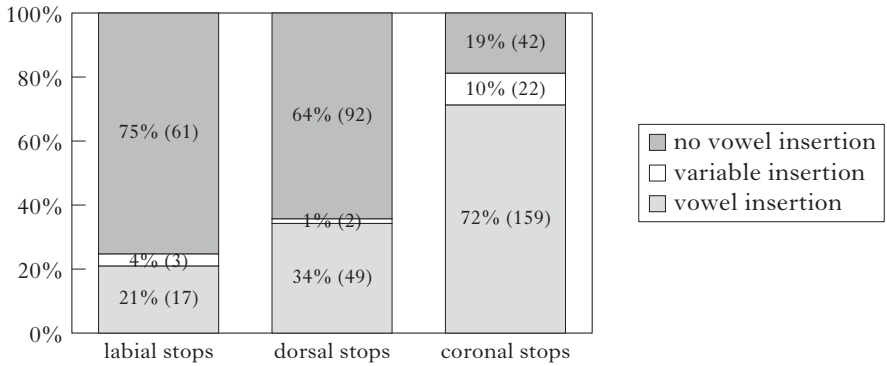


Figure 4

Frequency of vowel insertion after a word-final postvocalic stop according to place of articulation of the final stop.

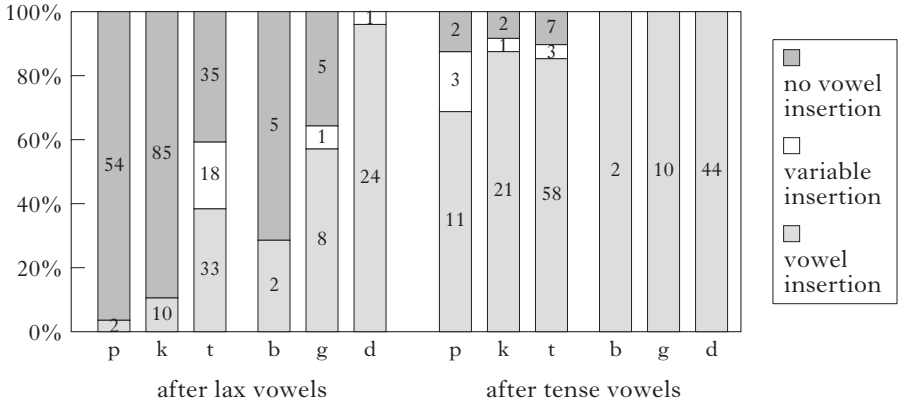


Figure 5

Frequency of vowel insertion after a word-final postvocalic stop in different contexts, cross-classified by the tenseness of the pre-final vowel and the voicing and place of articulation of the final stop.

stop is dorsal than when it is labial. Figure 4 summarises the pattern of final vowel insertion according to the place of articulation of the final stop. In accordance with the observations above, the frequency of vowel insertion is higher when the final stop is coronal than when it is non-coronal, and higher when it is dorsal than when it is labial. The difference between coronal stops and dorsal stops is statistically significant and the difference between dorsal stops and labial stops narrowly misses significance (coronal *vs.* dorsal: $\chi^2 = 81{\cdot}59$, df = 2, $p \leq 0{\cdot}0001$; dorsal *vs.* labial: $\chi^2 = 5{\cdot}24$, df = 2, $0{\cdot}1 \leq p \leq 0{\cdot}05$).

To recapitulate, all three factors previously proposed to affect the likelihood of final vowel insertion have been shown to be relevant. They are summarised in (14):

(14) *Phonological factors affecting the likelihood of vowel insertion after a postvocalic word-final stop in English loanwords in Korean*

a. *Tenseness of the pre-final vowel: tense > lax*
Final vowel insertion is more likely when the pre-final vowel is tense than when it is lax.

b. *Voicing of the final stop: voiced > voiceless*
Final vowel insertion is more likely when the final stop is voiced than when it is voiceless.

c. *Place of articulation of the final stop: coronal > dorsal = labial*
Final vowel insertion is most likely when the final stop is coronal and least likely when the final stop is labial.

Figure 5 summarises the vowel-insertion pattern in different contexts, cross-classified in terms of the tenseness of the pre-final vowel and the voicing and place of articulation of the final stops.

pilot survey	p	k	t	b	g	d
lax pre-final vowel	2%	17%	43%	14%	61%	93%
tense pre-final vowel	64%	72%	78%	100%	100%	100%
NAKL survey						
lax pre-final vowel	4%	11%	38%	29%	57%	96%
tense pre-final vowel	69%	88%	85%	100%	100%	100%

Table IV
Percentage of English words adapted with consistent final vowel insertion in the pilot survey and in the survey of the NAKL list.

Overall, the three generalisations remain valid when each sub-context is examined; the vowel-tenseness effect holds true when different final-stop contexts (/t d k g p b/) are examined separately; the voicing effect also holds true when /p/ *vs.* /b/, /k/ *vs.* /g/ and /t/ *vs.* /d/ contexts are compared separately for different pre-final vowel contexts; the place of articulation effect remains more or less valid in different voicing and vowel contexts.[10]

Finally in this section, it should be mentioned that since the NAKL list is based on written texts, there is a potential problem of interference from normative orthographic conventions. Prior to examining the NAKL list, I collected 306 English words ending in a postvocalic stop which have corresponding Korean loanwords, using English rhyming dictionaries. Korean dictionaries were consulted to verify the status of individual words as loanwords in Korean. For each English word in the list, I determined whether a vowel is inserted or not in the Korean loanword, on the basis of my own speech. Table IV shows the percentage of words adapted with final vowel insertion in the different contexts found in this pilot survey, and compares the results with those from the NAKL survey. Despite occasional differences in the vowel-insertion pattern of individual words, my own judgements and the NAKL list are in general agreement regarding the overall pattern of vowel insertion. I therefore assume that the discrepancy between actual speech and what is represented in the NAKL list is minimal as far as final vowel insertion is concerned.

3 Explanation

I now turn to the explanation of the data. One of the main claims is that the motivation for final vowel insertion is to a large extent an improvement

[10] The only exception is the relatively high number of words with no vowel insertion after final /t/ when the pre-final vowel is tense. This may be attributed to a ceiling effect. Also, it is notable that all seven of these words end in the morpheme *-out*. The exceptional behaviour of the diphthong /aw/ will be addressed in §3.1.3.

in the perceptual similarity between the English input and the Korean output. The explanation crucially refers to non-contrastive phonetic details of the English input and the Korean output. At the same time, it is proposed that phonetic similarity is not the only factor that influences the vowel-insertion pattern. Morphophonemic restrictions in the borrowing language also seem to play a role. I will discuss specific explanations for each of the three phonological generalisations in turn.

3.1 The vowel-tenseness effect

In this section, I provide an explanation for the vowel-tenseness effect in vowel insertion, i.e. vowel insertion is more frequent when the pre-final vowel is tense than lax. In §3.1.1, I argue that post-stop vowel insertion makes the Korean output perceptually similar to English released stops. In §3.1.2, I present additional evidence from other loanword-adaptation processes that demonstrate the correlation between post-stop vowel insertion and stop release. Next, in §3.1.3, I show that word-final stops in English are more frequently released after a tense vowel than after a lax vowel and then propose that the vowel-tenseness effect is a reflection of the corresponding asymmetry in stop-release frequency in English.

3.1.1 *Release-to-vowel insertion hypothesis*. In Korean, stops in coda position – including those in word-final position – are strictly unreleased (Martin 1951, Huh 1965, McCawley 1967, Kim 1971, Kim-Renaud 1974, Chung 1986, Sohn 1987, Baek 1991, Lee 1994, Kim & Rhee 1997, Kim 1998, Rhee 1998, among others).[11] On the other hand, in English, word-final stops may or may not be released (Rositzke 1943, Malécot 1958, Gimson 1980, Selkirk 1982, Crystal & House 1988, Byrd 1992, Kim 1998). Many Korean linguists have proposed that vowel insertion after a stop in loanwords is related to the release of the stops in English (Kim-Renaud 1977, Nam & Southard 1994, H. Kang 1996, O. Kang 1996, Lee *et al.* 1999, Sohn 2001). The following passage, from Kim-Renaud (1977:252), illustrates the view:

> When the unreleased stop is heard, it is usually analyzed at the surface value. Thus English *cup* is pronounced as [kʰəp⁼]; English *cook* as [kʰuk⁼]. When both released and unreleased variants are heard in the original language, Koreans analyze them in two ways, i.e., one with an epenthetic *ɨ* and the other without it. Thus, one finds coexisting forms [pʰikʰɨñikʰɨ] and [pʰikʰɨñik⁼] and [pʰiŋñik⁼] for English *picnic*.

[11] Kim (1998) defines released stops as follow: 'release [of an oral stop] is associated with the presence of a pulmonic egressive airstream which flows through the oral tract after the removal of the oral closure, before or during the articulation of a following segment … Thus ''release''… is acoustically-manifested as a sharp rise in the energy curve, followed by a high-energy plateau. This can be characterised by aspiration, a short voicing lag or full voicing, usually in prevocalic position.' For further discussion on the definition of release, see Henderson & Repp (1982) and Kim (1998).

A recent study by Jun (2002) examined adaptation patterns of English nonce words in Korean and found that vowel insertion occurred with a far higher frequency when the postvocalic word-final stops in English source words were pronounced with release (88·1%) than without (25·9%), corroborating the proposed correlation between stop release and vowel insertion in English loanwords.

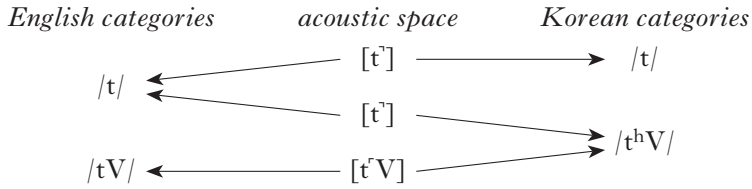
In fact, the correlation between stop release and vowel insertion is quite natural, given the fact that they are acoustically very similar. The Korean stop + [ɨ] sequence is quite similar to the corresponding English released stop. Parker (1977) notes that in English 'a released voiced stop is an acoustic syllable consisting of a stop plus a vocalic sound'. For English released voiceless stops, there is no voicing, and the release burst is followed by aspiration noise. Korean also has a process much like the vowel devoicing of Japanese and Montreal French, where a high vowel is devoiced following a voiceless consonant (Jun & Beckman 1994, Jun *et al.* 1997). According to these authors, when a high vowel (/i ɨ u/) follows a phrase-medial aspirated stop, it is partially or fully devoiced 60 to 70% of the time.[12] In other words, we can assume that an inserted vowel following an aspirated stop in Korean is very often devoiced. The resulting voiceless vowel is acoustically quite similar to the release portion of an English voiceless stop. Moreover, the high central vowel /ɨ/ in Korean is in general quite weak, in that it is 'often deleted, especially in a weak, non-initial open syllable' (Kim-Renaud 1987).

Moreover, it is well known that speech perception is greatly affected by the sound patterns of the native language (Trubetzkoy 1939, Massaro & Cohen 1983, Werker & Tees 1984, Jusczyk *et al.* 1993, 1994, Best 1994, Dupoux *et al.* 1997, Pitt 1998, Dupoux *et al.* 1999). Speech perception by babies as young as 8 to 10 months old shows significant influences from the ambient language; they have difficulty discriminating phonetically similar sounds that do not form separate categories in their native language, while they have no trouble distinguishing contrasting sounds of the language. Aspects of native language that affect speech perception are not limited to the segmental inventory. Phonotactics also affects speech perception, such that listeners tend to hear segments that respect the phonotactics of their language. For example, Dupoux *et al.* (1999) found that, given the same acoustic stimuli of VCCV sequences (e.g. [ebzo]), Japanese speakers very often perceive an illusory vowel inside the consonant cluster ([ebuzo]), while French speakers almost never do. They attribute the behaviour of Japanese speakers to the phonotactic restriction in Japanese that bars such VCCV sequences. In other words, it seems that the same acoustic space is cut into perceptual categories in different ways, depending on the distribution of sounds in the listener's native language.

[12] These studies did not examine high vowels in phrase-final positions, but Sun-Ah Jun (personal communication) informs me that a phrase-final vowel is also likely devoiced after an aspirated stop, since a phrase-final vowel is very weak in amplitude and is very often breathy or creaky.

For the case at hand, Korean and English differ significantly in their treatment of word-final released stops, as illustrated in (15).

(15) *Perception of released stops in English and Korean*



In English, word-final stops are variably released, so released stops, e.g. [tʳ], and unreleased stops, e.g. [t˺], do not form separate categories, but in Korean, stops in coda position – including those in word-final position – are strictly unreleased, and hence released and unreleased stops are likely to form separate categories. On the other hand, given the fact that a high central vowel is frequently deleted in casual speech, released stops are likely to form a category with stop + vowel sequences [tʳV].

3.1.2 *Further evidence of the correlation between stop release and vowel insertion.* There are other loan-adaptation patterns in Korean where vowel insertion shows a correlation with release of stops in the English input: in contexts where English stops are normally unreleased, vowel insertion does not occur following the unreleased stop, while in contexts where English stops are normally released, vowel insertion applies after the released stop.

When a postvocalic voiceless stop is followed by another stop within the same morpheme in English, no vowel is inserted after the first stop in the corresponding loanword in Korean. This generalisation holds true without exception in the NAKL list.[13] Some examples are given in (16).

(16) a. chapter → tsʰæ**p**.tʰʌ
octave → o**k**.tʰɑ.p**ɨ**
napkin → næ**p**.kʰin
doctrine → to**k**.tʰ**ɨ**.ʟin

b. compact → kʰom.pʰæ**k**.tʰ**ɨ** *kʰom.pʰæ.**kʰɨt**
intercept†[14] → intʰʌsɛ**p**.tʰ**ɨ** *intʰʌsɛ**pʰɨt**

[13] In the NAKL list, there are 11 words where a postvocalic voiceless stop is followed by another stop *across* a morpheme boundary. For ten of these words, there is no vowel insertion after the postvocalic, morpheme-final stops; for example, *football* is adapted as /pʰutpoʟ/. The only exception is *gateball* → /kɛitʰɨpoʟ/. The rather unexpected vowel insertion in *gateball* may be attributed to the fact that *gate* is adopted as an independent word with final vowel insertion: /kɛitʰɨ/. Thus, a kind of output–output faithfulness effect seems to be in action.

[14] A search for /intʰʌsɛp.tʰɨ/ in http://kr.yahoo.com (September 2003) yielded 156 matches, while a search for */intʰʌsɛpʰɨt/ yielded none.

For example, *chapter* is adapted without vowel insertion as /tsʰæptʰʌ/, not as */tsʰæpʰɨtʰʌ/. In particular, when English words end in two stops, there is no vowel insertion in the cluster, as the examples in (16b) illustrate. Rather, a vowel is inserted after the final stop, even though vowel insertion in the cluster would do just as well to avoid a complex coda, which is unacceptable in Korean. Note that in English, a sequence of stops is produced with a gestural overlap, such that there is no audible release for the first stop (Henderson & Repp 1982, Browman & Goldstein 1990). Under the hypothesis that post-stop vowel insertion correlates with the release of the stop, the lack of vowel insertion in these stop sequences finds a natural explanation; the first stop in these sequences is not released in English, and hence no vowel insertion applies after the first stop. Unlike pre-final stops, the final stop in words like *compact* and *intercept* is at least optionally released, particularly in careful speech. Thus, given a choice between vowel insertion in the cluster and vowel insertion after the final stop as strategies to avoid a complex coda, insertion after the final stop provides a better approximation to the stop-release pattern of the English input.[15]

Similarly, when English words end in a sequence of a sonorant + stop, a vowel is consistently inserted after the final stop rather than between the sonorant and the stop. Some examples are given in (17).

(17) a. mint → min.tʰɨ
diamond → tɑ.i.ɑ.mon.tɨ ~ tɑ.i.ʌ.mʌn.tɨ
lamp → ʟæm.pʰɨ
tank → tʰæŋ.kʰɨ

b. world → wʌʟ.tɨ
green belt → kɨ.ʟin.pɛʟ.tʰɨ
milk → miʟ.kʰɨ
pulp† → pʰʌʟ.pʰɨ

For example, *mint* is adapted with final vowel insertion, as /mintʰɨ/, not with insertion in the consonant cluster, as */minɨt/. Since Korean does not allow complex codas, at least one epenthetic vowel is necessary unless segmental deletion takes place. Given the fact that the final stops in these words are at least optionally released, but the pre-final sonorants are never realised with release, the release-to-vowel insertion hypothesis correctly predicts vowel insertion after the final stop, not after the sonorant.

Additional support for the claim that release of a stop in foreign inputs correlates with vowel insertion after the stop in Korean loanwords comes from words of French origin. French words with word-final stops are consistently adapted with vowel insertion (H. Kang 1996, O. Kang 1996, Park 1996). Some examples are given in (18).

[15] A third possible alternative to avoid a complex coda is to delete one of the two stops. In the NAKL list, there is a single case of stop deletion in a final stop cluster; *concept* is variably adapted with final vowel insertion or with final stop deletion: /kʰʌnsɛptʰɨ/ ~ /kʰʌnsɛp/. In general, segmental deletion is rarely attested in loan adaptation in Korean.

(18) avec → ɑ.pɛ.**k'ɨ**
patte → p'ɑ.**t'ɨ**

It has been conjectured that the consistent vowel insertion after the final stop in loanwords of French origin is due to the fact that word-final stops in European French are fairly consistently realised with release (Tranel 1987), unlike word-final stops in English, which are only variably released.

3.1.3 *Release of the final stop and the vowel-tenseness effect in vowel insertion.* I now turn to the more specific question: why vowel insertion after a final stop is more frequent when the pre-final vowel is tense in English than when it is lax. I propose that the asymmetry in vowel-insertion frequency stems from the asymmetry of release frequency in the English input – i.e. other things being equal, word-final stops are more likely to be released after a tense vowel than after a lax vowel in English, and this difference is in turn reflected in vowel insertion in loanwords in Korean.

Parker & Walsh (1981) point out that release of word-final stops in English is not random, but is conditioned by the tenseness of the preceding vowel.[16] They found a significantly higher frequency of release for final stops when the preceding vowel is tense /ij ej uw ow ɔ:/ than lax /ɪ ɛ æ ɑ ʌ ʊ/. The data is summarised in Table V.

pre-final vowel	released stops		*total*
lax	18	(25·0%)	72
tense	50	(83·3%)	60

Table V
Frequency of release for stops in word-final postvocalic position in English according to the tenseness of the pre-final vowel, based on Parker & Walsh (1981).

Unfortunately, only Parker & Walsh (1981) have systematically studied the frequency of stop release in English as conditioned by the quality of the preceding vowel, as far as I know. Moreover, their study suffers from two weaknesses; they employed only two subjects and they investigated only coronal stops. I therefore conducted a survey of the TIMIT corpus (available September 2003 at http://www.ldc.upenn.edu/lol/timit.html), in order to examine the release pattern of postvocalic word-final stops. The TIMIT corpus contains recordings of 2342 different sentences read by 630 speakers from eight major dialects of American English, resulting in a total of 6300 sentences. For each utterance in the corpus, phonetic transcriptions are included along with a speech waveform file. The phonetic transcriptions provide information regarding whether a stop is

[16] I would like to thank Louis Goldstein for drawing my attention to Parker & Walsh (1981).

pre-final vowel	released stops		*total*
ə	0	(0·0%)	1
aw	8	(28·6%)	28
ɪ	66	(34·7%)	190
ɛ	29	(36·7%)	79
ʌ	16	(44·4%)	36
ɑ	18	(52·9%)	34
aj	25	(54·3%)	46
ej	27	(56·3%)	48
æ	26	(57·8%)	45
ʊ	11	(64·7%)	17
uw	20	(64·5%)	31
ow	22	(66·7%)	33
ɔː	6	(66·7%)	9
ij	37	(69·8%)	53

Table VI

Frequency of release for stops in sentence-final postvocalic position in English according to the quality of the pre-final vowel, based on the survey of the TIMIT corpus. (Tense vowels in bold.)

realised with or without release. I examined only postvocalic word-final stops in sentence-final position, partly due to time constraints, but also due to the fact that stop release in sentence-medial position is likely affected by additional factors such as the following segmental context and the syntactic or prosodic position of the word. The search found a total of 650 sentence-final postvocalic stops. A sentence-final postvocalic stop is coded as released or unreleased, based on the TIMIT phonetic transcriptions. /t/ is sometimes realised as a glottal stop; I counted the glottal stop realisation of a coronal stop as unreleased. Of the 650 stops found, 311 (47·8%) were released and 339 (52·2%) were unreleased. Table VI shows the percentages of released sentence-final postvocalic stops according to the quality of the preceding vowel.

There was no instance of a sentence-final stop preceded by /ɔj/ in the TIMIT corpus, and only one token of a final stop preceded by /ə/. Stops following lax vowels tend to show lower frequency of release than those following tense vowels, although the two groups are not as well segregated as in the Korean loanword data in Table III. Figure 6 tabulates the frequency of final stop release according to the tenseness of the pre-final vowels, based on the survey of the TIMIT corpus, and shows that the final stop is more likely to be released when the pre-final vowel is tense than lax ($\chi^2 = 18{\cdot}13$, df = 1, $p \leq 0{\cdot}0001$).

When different stop contexts are examined separately, the generalisation remains by and large valid. The results are summarised in Fig. 7. The vowel-tenseness effect is statistically significant for coronal and labial stop contexts (/t/: $\chi^2 = 8{\cdot}92$, df = 1, p = 0·01; /p/: $\chi^2 = 8{\cdot}49$, df = 1, p = 0·01;

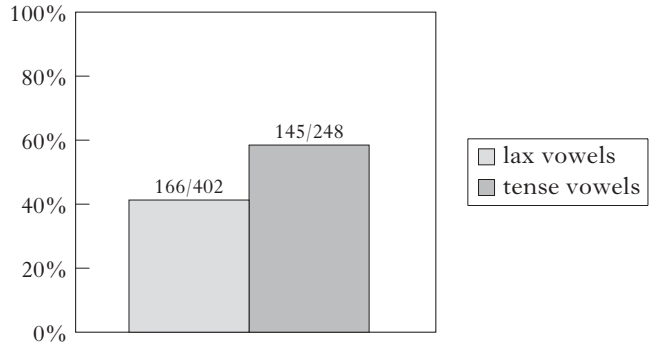


Figure 6

Frequency of release for stops in sentence-final postvocalic position in English according to the tenseness of the pre-final vowel, based on the survey of the TIMIT corpus.

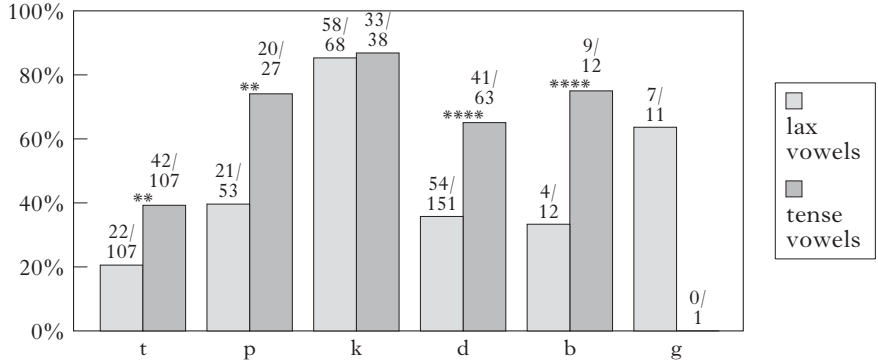


Figure 7

Frequency of release for stops in sentence-final postvocalic position in English according to the tenseness of the pre-final vowel for different final stops, based on the survey of the TIMIT corpus (* significant at $p \leq 0{\cdot}05$, ** at $p \leq 0{\cdot}01$, **** at $p \leq 0{\cdot}0001$).

/d/: $\chi^2 = 15{\cdot}47$, df = 1, p = 0·0001; /b/: $\chi^2 = 4{\cdot}20$, df = 1, p = 0·05). The lack of statistically significant vowel-tenseness effect for the /k/ context is attributed to the ceiling effect ($\chi^2 = 0{\cdot}05$, df = 1, p = 0·8264). There is only one token of a sentence ending in a tense vowel + /g/ in the TIMIT corpus, and this stop is unreleased ($\chi^2 = 1{\cdot}53$, df = 1, p = 0·2165). Hence the 0% of release in this context is not significant.

Available data indicates the Korean ESL speakers show a similar asymmetry in their pronunciation of English final stops; they pronounce English final stops with release more frequently when the pre-final vowel is tense than lax (Goad 2002).

There is a functional explanation for the asymmetry in the frequency of release of final stops after tense and lax vowels in English: the release of a final stop is more important for the correct perception of the stop when the preceding vowel is tense than lax (Householder 1956, Halle *et al*. 1957, Lisker 1999). Since a tense vowel can occur word-finally, there is a potential ambiguity between $V_{tense}T\#$ and $V_{tense}\#$, and the final release provides an important cue for the presence of a stop. On the other hand, since a lax vowel cannot be word-final, no such ambiguity exists for a final stop following a lax vowel: $V_{lax}T\#$, $*V_{lax}\#$ (Parker & Walsh 1981). Furthermore, almost all tense vowels end in a diphthongal glide, and this diminishes the effectiveness of the closing transition cues for the final stop in $V_{tense}T\#$. Release cues are therefore relatively more significant for stops following a diphthongal (i.e. tense) vowel than for those following a monophthongal (i.e. lax) vowel (Lisker 1999).

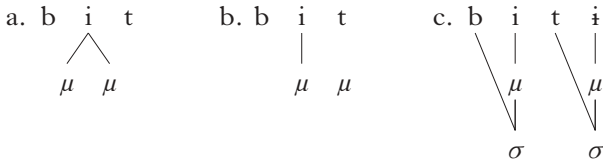
Under the view that final stop release has a functional basis, the exceptionally low frequency of release for word-final stops preceded by /aw/ in English (cf. Table VI) and the correspondingly low frequency of post-stop vowel insertion in Korean loanwords is explicable. Although, like other tense vowels, /aw/ can occur word-finally as well as non-finally, /t/ and /d/ are the only stops that can occur word-finally after /aw/ (Hammond 1999). Thus there is no ambiguity as to the place of articulation of the final stops. Accordingly, the relative functional load of stop release is reduced, compared to stops after other tense vowels. Moreover, as Lisker (1999) points out, even though /aw/ is diphthongal, the diphthongal transitions to /w/ are in the opposite direction to the transitions to a coronal stop. Accordingly, Lisker (1999) finds that identification of /t/ after /aw/, unlike after other diphthongs, is not affected by the removal of stop release at all, indicating the low functional value of release. To summarise, coronal stops are not frequently released after /aw/ because the VC transitions seem to provide adequate cues for the final coronal stop, and so the release is relatively unimportant.

To summarise the explanation of the vowel-tenseness effect in vowel insertion, Korean speakers perceive word-final released stops of English as similar to a sequence of a stop + a phonetically weak vowel, /ɨ/, and, given the correlation between stop release in English and post-stop vowel insertion in Korean, the fact that word-final stops are more frequently released after a tense vowel than after a lax vowel in English accounts for the corresponding asymmetry in post-stop vowel insertion in loanwords in Korean.

Finally, it needs to be emphasised that this explanation makes crucial reference to a subphonemic phonetic detail of the English input – whether the final stop is released or not. Before closing the section, I will briefly review previous explanations of the vowel-tenseness effect that do not make any reference to such phonetic information. Broselow & Park (1995) propose that Korean speakers perceive the vowel-length distinction in English, but cannot produce the contrast in Korean because Korean does not allow bimoraic nuclei. Thus, to preserve the mora count of the English

long vowel, a vowel is inserted to take on the stranded mora. For example, adaptation of *beat* proceeds as illustrated in (19).

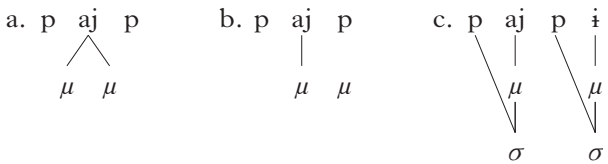
(19) *Adaptation of* beat



First, *beat* is perceived with two moras on the vowel, as in (19a). But, due to the restriction against bimoraic nuclei in Korean, one of the moras delinks from the vowel, as shown in (19b). The stranded mora is then assigned to a separate syllable node and its nucleus is filled by vowel insertion, as shown in (19c).

This explanation, however, does not account for vowel insertion after stops following a short or diphthongal vowel. When the pre-final vowel is short, Korean speakers analyse the vowel as monomoraic, so there is no left-over mora that can motivate vowel insertion. Therefore, the analysis cannot in itself explain why there is vowel insertion after stops following a lax vowel. Also unexplained is vowel insertion after stops following a diphthongal vowel. Broselow & Park's (1995) analysis of vowel insertion after a stop following a diphthongal vowel is illustrated in (20) for the adaptation of *pipe*.

(20) *Adaptation of* pipe



They propose that like long vowels, English diphthongs are perceived by Korean speakers as bimoraic, as shown in (20a), but are produced as monomoraic, as shown in (20b), and that vowel insertion applies to support the left-over mora, as shown in (20c). This explanation, however, is based on the incorrect assumption that English diphthongs are produced as monosyllabic diphthongs in Korean. In fact, Korean has no falling diphthongs – except for /ɨj/, which is itself in the process of monophthongisation (Kang 1997) – and English diphthongs are realised as two separate syllabic nuclei in Korean;[17] for example, *pipe* /paj$_{\mu\mu}$p/ is

[17] English diphthongs are written as bisyllabic vowel sequences in *Hangul* and behave as bisyllabic in accentual adaptation in North Kyungsang Korean (cf. Kenstowicz & Sohn 2001).

adapted as /$p^h a_\mu . i_\mu . p^h i_\mu$/, not as */$p^h a j_\mu . p^h i_\mu$/, as Broselow & Park (1995) assume. Therefore, the two moras of the English diphthong are properly housed by the bisyllabic vowel sequences in Korean and there is no left-over mora that can authorise vowel insertion.

Hirano (1994) proposes that an epenthetic vowel is inserted after a final stop following a tense or long vowel because an obstruent cannot close a syllable with a branching nucleus in Korean. Hirano (1994)'s explanation of the vowel-tenseness effect does not refer to phonetic details of English, and suffers from problems similar to those of Broselow & Park (1995). In particular, the analysis cannot in itself explain why there is vowel insertion after stops following a lax vowel.

Goad (2002) proposes that a released final stop is phonologically the onset of a headless syllable. Under this view, the fact that Korean ESL speakers produce final stops with release more often after a long vowel than after a short vowel is attributed to the universal markedness of tri-moraic syllables. This asymmetry in turn feeds the asymmetry in vowel-insertion frequency in loanwords. However, this analysis still does not refute my claim that a proper understanding of the vowel-insertion phenomenon crucially involves the optional release of final stops in English, which is a subphonemic phonetic detail.

In sum, a purely phonological explanation that relies solely on structural constraints but does not take phonetic information into account (i.e. the release of word-final stops in English) fails to explain the vowel-insertion pattern in Korean loanwords, particularly the vowel-tenseness effect.

3.2 The voicing effect

I turn now to the voicing effect, i.e. that vowel insertion is more frequent after a voiced stop than after a voiceless stop. I first show that, unlike the vowel-tenseness effect, the voicing effect cannot be attributed to an asymmetry in the release frequency of stops in the English input. Rather, I propose that vowel insertion is more frequent after a voiced stop because it improves the phonetic similarity between the English input and the Korean output, regardless of whether the stop is released or not in the English input. Specifically, when the final stop is voiced in the English input, vowel insertion creates an intervocalic context for the final stop, where a plain stop is realised as phonetically voiced in Korean and vowel insertion opens up the preceding syllable, making the pre-final vowel longer than otherwise. Both factors contribute to bringing the Korean output perceptually closer to the English input.

3.2.1 *Voicing and release of the final stop*. Recall from Fig. 3 that vowel insertion applies in English loanwords in Korean far more frequently when the final stop is voiced (88 %) than voiceless (39 %). Given the discussion in the previous section, a hypothesis one might consider is that

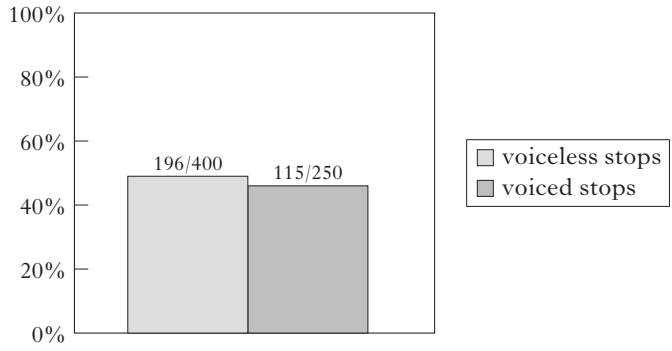


Figure 8

Frequency of release for stops in sentence-final postvocalic position in English according to the voicing of the final stop, based on the survey of the TIMIT corpus.

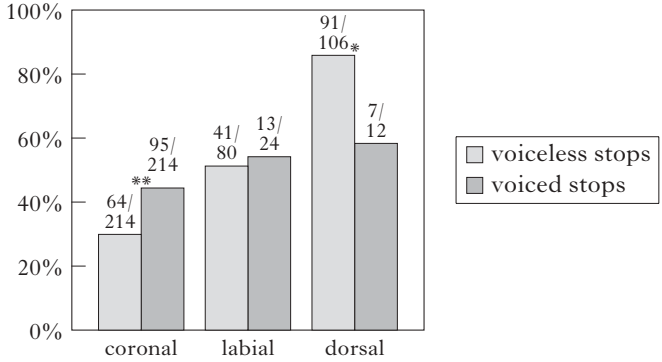


Figure 9

Frequency of release for stops in sentence-final postvocalic position in English according to the voicing of the final stop for different places of articulation, based on the survey of the TIMIT corpus (* significant at $p \leq 0{\cdot}05$, ** at $p \leq 0{\cdot}01$).

vowel insertion applies more frequently after a voiced stop than after a voiceless stop because the former are released more often in the English source than the latter (cf. O. Kang 1996). However, available evidence from the literature and my own survey of the TIMIT corpus do not support this hypothesis. The survey of the TIMIT corpus found that there is no statistically significant difference in frequency of release between voiced and voiceless stops in sentence-final postvocalic position ($\chi^2 = 0{\cdot}55$, df = 1, $p = 0{\cdot}4563$), as shown in Fig. 8.

When stops with different places of articulation are examined separately, the voicing effect was not uniform across stops of different places of articulation, as Fig. 9 shows; coronal stops show a higher frequency of release when they are voiced than when they are voiceless ($\chi^2 = 9{\cdot}62$, df = 1, $p = 0{\cdot}01$), while dorsal stops show an asymmetry in the opposite direction

($\chi^2 = 5{\cdot}80$, df = 1, p = 0·05). Labial stops show no statistically significant asymmetry ($\chi^2 = 0{\cdot}80$, df = 1, p = 0·0629).

Available data from the literature paints a similarly ambiguous picture. As mentioned above, Parker & Walsh (1981) studied /d/ and /t/-final words, and found that when the preceding vowel was lax, /d/ was released 33% (12/36) of the time, while /t/ was released 17% (6/36) of the time. However, the release frequencies were identical for two stops when the preceding vowel was tense (83%; 25/30). Rositzke (1943) studied 124 monosyllabic TVT words (where T is a stop and V is a vowel), read by five General American English speakers three times each. When the data is examined for individual speakers, there is no clear difference in release frequency between voiced and voiceless stops. I pooled the data across subjects to see if there is any noticeable trend. Overall, voiced stops are released at a higher frequency than voiceless stops: 67% (564/840) *vs.* 57% (581/1020). But, when stops with different places of articulation are examined separately, the voicing effect is again not uniform; coronal stops show a higher frequency of release when they are voiced than when they are voiceless (63% *vs.* 38%; $\chi^2 = 61{\cdot}80$, df = 1, p = 0·0001), but dorsal stops show the opposite pattern (82% *vs.* 93%; $\chi^2 = 12{\cdot}09$, df = 1, p = 0·001), and labial stops do not show any statistically significant trend (68% *vs.* 58%; $\chi^2 = 3{\cdot}05$, df = 1, p = 0·0805).

In sum, the English data does not show any clear asymmetry in frequency of release between voiced and voiceless stops in word-final postvocalic position.[18] Therefore, I conclude that the asymmetry in vowel-insertion frequency between voiced and voiceless stops cannot be attributed to an asymmetry in stop-release frequency in the English input.[19]

3.2.2 *Intervocalic voicing, open syllable lengthening and the voicing effect in vowel insertion.* I propose that there are perceptual factors other than stop release that promote vowel insertion after word-final stops. Certainly, release or non-release of stops cannot be the only phonetic detail that determines perceptual similarity between strings of sounds. I argue that an English postvocalic voiced stop is quite similar to a sequence of a postvocalic plain stop + /ɨ/ in Korean, and that this promotes vowel insertion after the final voiced stops.

[18] Crystal & House (1988) and Byrd (1992) examined all instances of word-final stops, including non-postvocalic ones, and found a higher frequency of release for voiceless stops than voiced stops.

[19] An alternative possibility is that Korean speakers perceive English voiced stops as released even when they are not. While unreleased stops in Korean are characterised by complete lack of energy during and after the closure of the stops, English voiced stops, even when unreleased, contain some acoustic energy in the form of voicing murmur or extended F1 transition into the stop closure. Therefore, the ratio of stop release for voiced stops as perceived by Korean speakers may in fact be higher than what is actually found in English. This hypothesis is plausible, especially given the fact that Korean ESL speakers produce voiced stops with release at a higher frequency than voiceless stops, exhibiting an asymmetry that is not found in the English data (Goad 2002). Further experimental studies are necessary.

First, Korean plain stops have different allophonic realisations, depending on segmental context; word-initially the stop is voiceless and slightly aspirated, while word-finally it is voiceless and unreleased. But when the plain stop occurs in intersonorant position, it is voiced (Silva 1992, Jun 1993). When an English word with a postvocalic word-final voiced stop is adapted, vowel insertion puts the final stop in intervocalic position, and it is realised as voiced: e.g. *gag*→[kægɨ].[20] Without vowel insertion, the final stop would be realised as voiceless (*[kækˀ]). In this respect, vowel insertion after voiced stops makes the Korean output perceptually more similar to the English input than it would be otherwise.

Secondly, it is a well-documented fact that one of the most important acoustic cues for voicing contrast in word-final stops in English is duration of the preceding vowel. For example, the vowel in *pad* is significantly longer than the vowel in *pat* (Chen 1970, Raphael 1972). According to Chang & Idsardi (2001), Korean speakers do perceive the vowel-length difference in pairs such as *pad* and *pat*, and to some extent employ the vowel-length cue in the identification of English final stops. Moreover, in Korean, as in many languages, a vowel is longer in an open syllable than in a closed syllable (Lim 2000). When an English word with a postvocalic word-final voiced stop is adapted, insertion of a vowel opens up the preceding syllable and the pre-final vowel is realised longer than otherwise: e.g. *gag*→[kæːgɨ], *[kăkˀ]. This again makes the Korean output more similar to the English input than otherwise.

In contrast, after voiceless stops, no comparable improvements in perceptual similarity are gained by vowel insertion. Whether a vowel is added or not, the final stop is realised as voiceless and vowel insertion does not make the pre-final vowel any shorter than otherwise (Lim 2000): e.g. *pack*→[pʰăkˀ], *[pʰăkʰɨ].[21] Therefore, there is no additional incentive for vowel insertion when the final stop is voiceless.

Finally, Davidson (2001) found that, given various consonant clusters that are illegal in English, English speakers are more likely to epenthesise a vowel in voiced consonant clusters than in voiceless consonant clusters. Fleischhacker (2001) conjectures that a voiced environment is more similar to a vocalic element than a voiceless environment, such that vowel insertion is more tolerable in the former than in the latter. This could be an additional contributing factor favouring vowel insertion after voiced stops in Korean loanwords.

There is further evidence that post-stop vowel insertion in English loanwords in Korean is sensitive to the voicing of the stop; there are contexts where vowel insertion applies after a voiced stop (but not after a voiceless stop), even though vowel insertion is not motivated by any other factors, such as syllable structure constraints or release of the stop in the

[20] I would like to thank Michael Kenstowicz for drawing my attention to the relevance of intervocalic voicing of stops in final vowel insertion.

[21] Lim (2000) reports that open syllable lengthening is not attested when the following consonant is aspirated or tense. In this regard, these consonants behave as if they are geminates (cf. Kim 1992, Jun 1994, Han 1997).

English input. In the NAKL list, when a postvocalic *voiceless* stop is followed by another obstruent within the same morpheme (cf. note 13), no vowel is inserted after the stop, without exception, as the examples in (21) illustrate.

(21) *No vowel insertion after a voiceless stop*

se[**k**ʃ]ion	→ sɛ**k**sjʌn	*sɛ**k^{h}i**sjʌn
cha**p**ter	→ ts^{h}æ**p**t^{h}ʌ	*ts^{h}æ**p^{h}i**t^{h}ʌ

For example, *section* is adapted without vowel insertion, as /sɛksjʌn/, not with vowel insertion, as */sɛk^{h}isjʌn/. Since English stops are not audibly released in this position in general, given the correlation between stop release and vowel insertion, no vowel insertion is expected in this position. On the other hand, if the stops are voiced in a similar context, vowel insertion may still apply. Some examples are given in (22).

(22) *Variable vowel insertion after a voiced stop*

a. *Vowel insertion*

e[gz]act†	→ i**k**i̯tsækt^{h}i̯	[iːg**i̯** …]	*i**k**tsækt^{h}i̯
vodka	→ po**t**i̯k^{h}ɑ	[…oːd**i̯** …]	*po**t**k^{h}ɑ

b. *No vowel insertion*

rugby	→ ʟʌ**k**pi
o[bz]erver	→ ʌ**p**tsʌpʌ ~ o**p**sʌpʌ

While the words in (22b) are adapted without post-stop vowel insertion, patterning with the words in (21), the words in (22a) are adapted with post-stop vowel insertion. For example, a search for /iki̯tsækt^{h}i̯/ 'exact' in http://kr.yahoo.com (September 2003) yielded eight matches, but no match was found for */iktsækt^{h}i̯/.

In sum, vowel insertion after a voiced stop brings the Korean output closer to its English input, due to open syllable vowel lengthening and intersonorant voicing of plain stops in Korean. The explanation here again makes crucial reference to subphonemic phonetic information in English and Korean: in English, a pre-final vowel is longer before a voiced consonant than before a voiceless consonant; in Korean, plain stops are voiced in intersonorant position and vowels are longer in open syllables than in closed syllables. As for alternative analyses not involving phonetic information, there is no concrete proposal in the literature, as far as I know. H. Kang (1996) suggests that vowel insertion after voiced stops has a functional motivation, to maintain the voicing contrast of English. Due to laryngeal neutralisation in Korean, if no vowel were added after final stops, English voiced and voiceless stops would both be realised as plain voiceless stops in Korean, and the voicing contrast would be lost: *pad*→*/p^{h}æt/, *pat*→/p^{h}æt/. A vowel is therefore added after voiced stops to avoid the neutralisation of contrast with voiceless stops: *pad*→/p^{h}æti̯/, *pat*→/p^{h}æt/. But this alone does not explain why it should be the voiced stops rather than the voiceless stops that more readily induce

vowel insertion. If maintaining the voicing contrast is the sole motivation for vowel insertion, there is no reason why voiced stops should be singled out to invite more vowel insertion than voiceless stops.

3.3 The place of articulation effect

In this section, I will discuss the place of articulation effect, i.e. vowel insertion applies more often when the final stop is coronal (71·3 %) than when it is non-coronal, and more often when the final stop is dorsal (34·5 %) than when it is labial (21·0 %). First, I show that the hypothesis that vowel-insertion frequency depends on the frequency of release of English stops can explain only half of the generalisation – namely, the difference between labial and dorsal stops. Then I argue that the unexpectedly high frequency of vowel insertion after coronal stops is due to a constraint promoting uniform realisation of a morpheme across the paradigm. Korean does not allow a noun that is underlyingly /t/-final. If no vowel is inserted after English words that end in a coronal stop, they inflect as if they are /s/-final. Due to coda neutralisation in Korean, which turns /s/ into [t] in coda position, an alternation between [s] (before a vowel-initial suffix) and [t] (elsewhere) is introduced, creating a non-uniform paradigm. On the other hand, if a vowel is inserted after English words ending in a coronal stop, no alternation is introduced. Therefore, a constraint that penalises a non-uniform paradigm favours vowel insertion after a coronal stop, but no such motivation for vowel insertion exists for non-coronal stops.

3.3.1 *Place of articulation and release of the final stop.* The first hypothesis I consider is again that the place of articulation effect follows from the patterns of stop release in the English input. Under this hypothesis, we expect the highest frequency of release for coronal stops and the lowest frequency for labial stops. However, this expectation is not completely borne out. My survey of the TIMIT corpus found that the release frequency for sentence-final postvocalic stops is lowest for coronal stops and highest for dorsal stops. The difference between coronal stops and labial stops and between labial stops and dorsal stops is statistically significant (coronal *vs.* labial: $\chi^2 = 7{\cdot}61$, df = 1, p = 0·01; labial *vs.* dorsal: $\chi^2 = 24{\cdot}37$, df = 1, p = 0·0001). The result is summarised in Fig. 10.

Rositzke (1943)'s data, pooled across subjects, is in agreement with the findings from the TIMIT corpus; the release frequency is lowest for coronal stops and highest for dorsal stops (coronal 51 % *vs.* labial 62 % *vs.* dorsal 89 %), and the difference between coronal stops and labial stops and between labial stops and dorsal stops is statistically significant (coronal *vs.* labial: $\chi^2 = 128{\cdot}89$, df = 1, p = 0·0001; labial *vs.* dorsal: $\chi^2 = 20{\cdot}27$, df = 1, p = 0·0001).[22]

[22] Crystal & House (1988) and Byrd (1992), on the other hand, found that coronal stops are released at a slightly higher frequency than labial stops, but they examined all instances of word-final stops, including non-postvocalic ones.

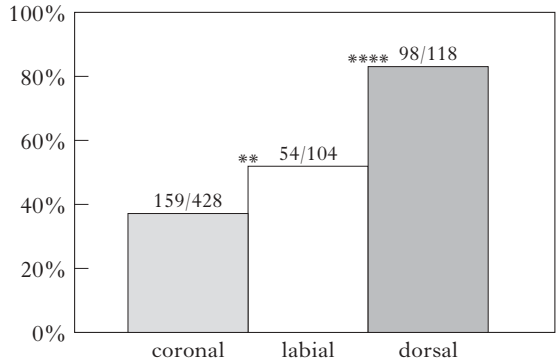


Figure 10

Frequency of release for stops in sentence-final postvocalic position in English according to the place of articulation of the final stop, based on the survey of the TIMIT corpus (** significant at $p \leq 0{\cdot}01$, **** at $p \leq 0{\cdot}0001$).

In the English data, labial stops are released at a lower frequency than dorsal stops. This is in line with the asymmetry in vowel-insertion frequency between the dorsal stop and labial stop contexts in the Korean data. However, the release-to-vowel insertion hypothesis cannot explain the high frequency of vowel insertion after coronal stops; coronal stops are released least often in English, but vowel insertion applies most frequently after coronal stops in Korean loans. In sum, the frequency of release of English stops can explain only half of the place of articulation effect. Also, it does not seem to be the case that vowel insertion after coronal stops better achieves the perceptual similarity between the input and the output in other ways.

3.3.2 *Paradigm uniformity and the coronal place effect in vowel insertion.* I propose that the high frequency of vowel insertion after coronal stops is due to a morphophonemic restriction against underlyingly /t/-final nouns in Korean. Korean has no underlyingly /t/-final nouns, i.e. there is no noun that is realised as [t]-final before a vowel-initial suffix; */pɑt/ ~ /pɑt-ɛ/ ~ /pɑt-ɨL/. Historically, most nouns that used to be underlyingly /t/-final have changed to /s/-final nouns (Kwak 1984, Choi 1986, Ko 1989, Kang 2003).[23] Some examples are given in (23).

(23)	C15	C21		*citation form*
	pu**t**-ɛj	> pu**s**-ɛ	'brush LOC'	put
	mo**t**-ɔL	> mo**s**-ɨL	'nail ACC'	mot

Due to coda neutralisation in Korean, whereby contrasts among all coronal obstruents are neutralised to [t] in codas, these nouns are still realised

[23] The only exception is /pits/ 'debt' (< C15 /pit/), which is /ts/-final in the standard dialect. But, in some other dialects, the word is /s/-final, i.e. /pis/ (Kwak 1984).

with final [t] in citation form, resulting in an alternation between [t] in citation form and [s] in prevocalic position. Similarly, nouns ending in other coronal obstruents, /ts tsʰ tʰ/, either have changed to /s/-final nouns or currently show optional variants with final [s] (Kwak 1984, Choi 1986, Ko 1989, Kang 1993, Kang 2003). These words are also realised with final [t] in citation forms, due to coda neutralisation. Some examples are given in (24).

(24)

				citation form
C15	oski**ts**-ɔL > C21	otki**s**-ɨL	'collar ACC'	otkit
C18	pi**tsʰ**-ɨLo > C21	pi**tsʰ**-ɨLo ~ pi**s**-ɨLo	'light INST'	pit

In other words, all nouns ending in a coronal obstruent are moving toward /s/-final nouns, creating an alternation between [t] in the citation form and [s] in prevocalic position. The propensity toward the paradigm with [t] ~ [s] alternation affects not only native words, as shown in (25a), but also loanwords from English, as shown in (25b), such that when an English word is adapted with final [t] in citation form, it inflects as if it were /s/-final (Ko 1989, Kang 1999, Sohn 2001).

(25) a. t-*to*-s *alternation in native words*

		ACC	LOC
'name of letter *t*'	tikɨ**t**	tikɨ**s**-ɨL	tikɨ**s**-ɛ
'to receive (STEM)'	pɑ**t**	pɑ**s**-ɨL	pɑ**s**-ɛ
	cf. pɑt-ɑ 'to receive', pɑt-ɨni 'receive-therefore'		

b. t-*to*-s *alternation in loanwords*

'cut'	kʰʌ**t**	kʰʌ**s**-ɨL	kʌ**s**-ɛ
'plot'	pʰɨLLo**t**	pʰɨLLo**s**-ɨL	pʰɨLLo**s**-ɛ
'pyramid'	pʰiLɑmi**t**	pʰiLɑmi**s**-ɨL	pʰiLɑmi**s**-ɛ

The obligatory alternation between [t] and [s] in nouns inevitably creates a non-uniform paradigm. When the [t]-final word is a loanword, however, it differs crucially from native words, insofar as there is often a variant form with final vowel insertion. If a vowel is inserted, the obligatory alternation between [t] and [s] is no longer relevant and hence uniformity across the paradigm can be maintained. (26) compares the paradigms, based on two possible adaptations (with or without vowel insertion) of the English word *cut*.

(26) *Adaptation of* cut

		ACC	LOC	
no vowel insertion	kʰʌt	kʰʌs-ɨL	kʌs-ɛ	non-uniform paradigm
vowel insertion	kʰʌtʰɨ	kʰʌtʰɨ-LɨL[24]	kʌtʰɨ-ɛ	uniform paradigm

[24] The accusative suffix has suppletive allomorphs /ɨL/ and /LɨL/. Their distribution is prosodically conditioned; /ɨL/ after a consonant-final noun and /LɨL/ after a vowel-final noun.

When a vowel is added, the noun is uniformly realised as [$k^hʌt^hɨ$] across the paradigm, but when no vowel is added, the noun is subject to the [t] ~ [s] alternation, and cannot be uniformly realised. Consequently, a preference for a uniform paradigm serves as an additional incentive for vowel insertion when English words ending in a coronal stop are adapted. But no comparable advantage exists for vowel insertion in words ending in a dorsal or labial stop.

3.4 An optimality-theoretic analysis

I now turn to an optimality-theoretic analysis of the data. I assume that the foreign input to the adaptation process contains various phonetic details of the sounds, as well as information about the phonemic status of the sounds in the source language, allowing the mapping to refer to the subphonemic details of the sounds as well as the phonemic membership of sounds in the source language.

Steriade (2001a, b) argues that grammar includes a component called the P-MAP, which encodes the relative perceptual similarity between strings of sounds and reflects all aspects of speakers' knowledge of perceptual similarity, which is consistently observed in experimental situations and in versification, as well as in loan adaptation, but is very often not properly reflected in standard phonological representations. A series of correspondence constraints are projected from the P-map, which penalises changes that are perceptually too distinct.

For the case at hand, I propose two constraints that promote perceptual similarity between the input and the output strings of sounds, BESIMILAR[release] and BESIMILAR[voice]. BESIMILAR[release] penalises a correspondence between a released and an unreleased stop, and since the perceived difference between the two is salient to Korean speakers, this constraint is relatively highly ranked in Korean.[25] The definition of the constraint is given in (27).[26]

(27) BESIMILAR[release]
Strings of sounds in correspondence should be similar in the release characteristics of their stops.

Recall that when English words with a final voiced stop are adapted with final vowel insertion, the vowel preceding the stop is lengthened and the stop itself is realised as voiced, which closely approximates the

[25] I assume that specifics of the P-map are not universal, but they can and do differ from language to language (cf. §3.1.1). Therefore, although each correspondence constraint may be universal, the ranking between the constraints may differ from language to language to a limited extent.

[26] A similar constraint, IDENT[release], is proposed by O. Kang (1996). Here I refrain from using the standard featural correspondence constraint, IDENT[F], to make it explicit that the correspondence constraints at hand promote the perceptual similarity of strings that cannot necessarily be stated in terms of distinctive features.

phonetic details of the final voiced stop of English. The constraint BeSimilar[voice], defined in (28), encapsulates this effect.

(28) BeSimilar[voice]
Strings of sounds in correspondence should be similar in stop voicing and vowel length.

Both constraints crucially dominate the faithfulness constraint against vowel insertion, Dep(V). Therefore, when the stop in the English input is released, high-ranking BeSimilar[release] forces vowel insertion after the stop. When the stop in the input is variably released, both inputs are available, but to different degrees. For a given adaptation, the choice between the two inputs is determined probabilistically. The tableau in (29) illustrates the adaptation of the English word *jeep*.[27]

(29) *Adaptation of* jeep → [tsip^{h}ɨ] ~ [tsip]

a.	tsijp^{r}	BeSimilar[rel]	BeSimilar[voi]	Dep(V)
	☞ i. tsip^{h}ɨ [...p^{hr}ɨ]			*
	ii. tsip [...p$^{\neg}$]	*!		
b.	tsijp$^{\neg}$			
	i. tsip^{h}ɨ [...p^{hr}ɨ]	*!		*
	☞ ii. tsip [...p$^{\neg}$]			

Given the English word *jeep*, the final stop in the English input may or may not be released for a particular adaptation and, accordingly, final vowel insertion may or may not apply in the Korean output. When the stop in the input is released, BeSimilar[release] chooses the candidate with vowel insertion, (29a.i), as output. On the other hand, when the stop in the input is not released, BeSimilar[release] will choose the candidate without vowel insertion, (29b.ii), as output. Similarly, variation between vowel insertion and no vowel insertion is expected in a comparable word with a pre-final lax vowel. However, since the stop is released at a lower frequency in English when the pre-final vowel is lax rather than tense, vowel insertion is a less likely outcome when the pre-final vowel is lax. A similar explanation applies to the asymmetry in vowel-insertion frequency between the dorsal and labial stop contexts.

A remark is in order regarding the variability of vowel insertion in these words. Since all word-final postvocalic stops in English may be variably released, given the proposed correlation between stop release in English and vowel insertion in loanwords in Korean, we might expect variable insertion for all loanwords. However, only 6% of the relevant loanwords in the NAKL list show variable vowel insertion. I conjecture this is due to the fact that languages are in general intolerant of true synonyms

[27] A candidate with final stop release and no vowel insertion, [tsip^{hr}], is ruled out by a constraint against a released non-prevocalic stop, which is undominated in Korean.

(cf. the blocking effect of Aronoff 1976); once a borrowed word gains currency and begins to obtain the status of an established loanword, variations are eliminated, and one form is adopted as standard for each meaning (cf. Zuraw 2000: 119). Some forms may still fail to converge, however. Interestingly, such doublets are sometimes associated with two different usages. In my own speech, *type* is adapted with vowel insertion when it is used a verb (/tʰɑipʰɨ-hɑtɑ/ 'to type'), but without vowel insertion when it is used as a noun (/næ tʰɑip/ 'my type'). Similarly, *check* is adapted with vowel insertion when it is used as a verb (/tsʰɛkʰɨ-hɑtɑ/ 'to check'), but without vowel insertion when it is used as a noun (/tsʰɛk/ '(personal) check').

As for the voicing effect, note that, since the final stop of the English input is voiceless in (29), BeSimilar[voice] is irrelevant and is vacuously satisfied by all candidates. On the other hand, when the English stop is voiced, BeSimilar[voice] makes a difference. This is illustrated in (30) for the adaptation of *zigzag*.

(30) *Adaptation of* zigzag → [tsikɨtsækɨ] ~ [tsikɨtsæk]

		BeSimilar[rel]	BeSimilar[voi]	Dep(V)
a.	zɪgzæg˺			
	☞ i. tsikɨtsækɨ […æːg˺ɨ]			*
	ii. tsikɨtsæk […æk˺]	*!	*!	
b.	zɪgzæg˺			
	☞ i. tsikɨtsækɨ […æːg˺ɨ]	*		*
	☞ ii. tsikɨtsæk […æk˺]		*	

When the final stop in the input is released, the candidate with vowel insertion, (30a.i), is chosen as the output, because it satisfies both BeSimilar[release] and BeSimilar[voice]. On the other hand, when the stop in the input is not released, BeSimilar[release] and BeSimilar[voice] are in conflict with each other. Assuming that the ranking between the two constraints is variable (cf. Boersma & Hayes 2001), both vowel insertion and non-vowel insertion are possible outcomes.

In other words, unlike voiceless stops, for which final vowel insertion is possible only when the input stop is released (i.e. (29b.i) is never a possible outcome), voiced stops may induce vowel insertion even when the input stop is not released (i.e. (30b.i) is a possible outcome), due to the fact that not only similarity in release but also similarity in voicing matters. Therefore, other things being equal, vowel insertion is more likely to apply after a voiced stop than after a voiceless stop.

Before moving to the analysis of coronal place effect, I introduce a distinction between established loanwords and online adaptations (i.e. nonce forms) (cf. Shinohara 1997). During production of online adaptations, speakers take the English forms as inputs and produce appropriate Korean outputs. On the other hand, during production of an established loanword, speakers take a loanword already adapted by others and reproduce

it. Therefore, while the phonetic details of the English source words directly affect online adaptation forms, they affect established loanwords only indirectly. Other things being equal, the patterns found in the outcome of online adaptation will carry over to the established loanwords, such that established loanwords reflect certain facts about the phonetics of English source words. For the vowel-tenseness and voicing effects, this is all we need to say; since final stops are more likely to be released when the pre-final vowel is tense and when the final stop in English is voiced, vowel insertion is more likely during online adaptation after a stop following a tense vowel, and after a voiced stop. In turn, the form with vowel insertion is more likely to be available as input to the rest of speech community when the pre-final vowel of the English source word is tense and when the final stop of the English source word is voiced, leading to the asymmetry observed in established loanwords.

Unlike the vowel-tenseness and voicing effects, the coronal place effect – i.e. the high frequency of vowel insertion after a coronal stop – cannot be attributed to the perceptual similarity between the English input and the Korean output. Since coronal stops are released less frequently than dorsal or labial stops in English, we would expect vowel insertion to apply least frequently after coronal stops, if phonetic similarity were the only factor. Rather, the coronal effect arises from a constraint of a different nature, i.e. a morphophonemic restriction in Korean, and I argue that the propensity for vowel insertion after coronal stops is not introduced during the online adaptation stage, but during the propagation of the adapted forms to the rest of the speech community.

Recall from §3.3.2 that in Korean there is a strong preference for nouns that end in [t] in the citation form to be realised with final [s] before a vowel-initial suffix. Hayes (1999) proposes that grammar contains 'anti-correspondence constraints', which are relatively ad hoc language-specific constraints that require alternation between morphologically related forms, and that these constraints arise from 'statistically useful, albeit imperfect' generalisations of pre-existing alternations. The [t] ~ [s] alternation in Korean nouns, though productive, is not consistent with a phonetically well-motivated phonotactic constraint; rather, the alternation is driven by a language-specific constraint that has arisen by analogy to a dominant alternation pattern observed in the language (Kang 2003). An anti-correspondence constraint that captures this alternation, T→S, as defined in (31), is proposed by Kang (2002).

(31) T→S

When a noun ends in [t] in the citation form, change the stop to [s] before a vowel-initial suffix.

Since this constraint compels alternation, it is inherently in conflict with transderivational identity constraints, which demand similarity among morphologically related words (Burzio 1996, Kenstowicz 1996, Benua 1997, Steriade 2000). I employ Kenstowicz's (1996) BASE-IDENTITY, as defined in (32).

(32) BASE-IDENTITY[28]

Given an input structure [X Y], output candidates are evaluated for how well they match [X] and [Y] if the latter occur as independent words.

BASE-IDENTITY is ranked lower than the anti-correspondence constraint T→S, and its violation is forced by T→S. The tableau in (33) illustrates how the interaction of these constraints derives the alternation between [t] and [s] in native words.[29]

(33) *Native Korean* [tikɨt] 'name of letter *t*'

tikɨt	T→S	DEP(V)	BASE-IDENT
a. tikɨt, tikɨt-ɛ	*!		
☞ b. tikɨt, tikɨs-ɛ			*
c. tikɨtɨ, tikɨtɨ-ɛ		*!	

The candidate with no alternation, (33a), fatally violates T→S, although it satisfies BASE-IDENTITY. On the other hand, the candidate with [t] ~ [s] alternation, (33b), satisfies T→S at the cost of violating BASE-IDENTITY. Both T→S and BASE-IDENTITY can be satisfied by inserting a vowel after the noun, as shown by (33c). But this candidate fatally violates DEP(V) and is ruled out. In other words, in the native phonology, BASE-IDENTITY cannot force vowel insertion.

On the other hand, in English loanwords, since word-final coronal stops are variably released in English, online adaptation produces a form with vowel insertion as well as one without, and both are initially available as input for the rest of speech community who use them as loanwords. The tableau in (34) illustrates the production of loanwords for *cut*.

(34) *Production of loanwords for* 'cut'

		T→S	DEP(V)	BASE-IDENT
a.	$k^hʌt^hɨ$			
	☞ i. $k^hʌt^hɨ$, $k^hʌt^hɨ$-ɛ			
	ii. $k^hʌt$, $k^hʌs$-ɛ			*!
	iii. $k^hʌt$, $k^hʌt$-ɛ	*!		
b.	$k^hʌt$			
	i. $k^hʌt^hɨ$, $k^hʌt^hɨ$-ɛ		*!	
	☞ ii. $k^hʌt$, $k^hʌs$-ɛ			*
	iii. $k^hʌt$, $k^hʌt$-ɛ	*!		

[28] I assume that BASE-IDENTITY is not a single constraint, but a family of constraints that regulate different aspects of cross-derivational correspondence (Ko 2002). For the data at hand, BASE-IDENTITY is more accurately specified as BASE-IDENTITY [continuant], which requires identity with corresponding segments in the base form with respect to the feature [continuant].

[29] I assume that paradigms are evaluated as candidates. In the current tableaux, only the citation form and the locative form are listed, for ease of exposition.

Note that in the production of loanwords, one of the input forms, /$k^h\Lambda t^h\text{ɨ}$/, already has a final vowel, so there is no actual DEP(V) violation. When the form with vowel insertion is chosen as input, the candidate paradigm that contains a final vowel throughout the paradigm, (34a.i), will be chosen as output. When the form without vowel insertion is chosen as input, the candidate paradigm with the [t] ~ [s] alternation, (34b.ii), is chosen as output. When these two outputs are compared, the form with vowel insertion is preferred, because it better satisfies BASE-IDENTITY. Therefore, despite the fact that the frequency of stop release in English predicts a low frequency of vowel insertion after coronal stops, established loanwords nevertheless show a high percentage of vowel-insertion forms.

On the other hand, when the final stops are not coronal, T→S and BASE-IDENTITY are irrelevant. For example, when the English word *jeep* is borrowed, online adaptations will produce outputs with or without vowel insertion (/$tsip^h\text{ɨ}$/ ~ /tsip/), which will in turn be available to be used as loanwords. But neither form violates T→S, BASE-IDENTITY or DEP(V), and there is no extra incentive for the form with vowel insertion to be preferred. The pattern of vowel insertion found in online adaptation will therefore carry over to the established loanwords.

Incidentally, words ending in coronal stops show a disproportionately high frequency of variable vowel insertion (9·9%) compared to words ending in labial (3·7%) or dorsal stops (1·4%) (cf. Fig. 4). One might conjecture that the high frequency of variable vowel insertion for words ending in coronal stops is due to the fact that the two factors influencing the choice of final outcome are in conflict with each other; a faithful approximation of phonetic details of the English input predicts a low frequency of vowel insertion after coronal stops, but the morphophonemic constraint in Korean prefers vowel insertion after coronal stops.

4 Conclusion

In this paper, I have provided a detailed case study of vowel insertion after word-final postvocalic stops in English loanwords in Korean. A survey of the NAKL list confirms three phonological factors previously proposed to affect the likelihood of vowel insertion in this position: tenseness of the pre-final vowel, and voicing and place of articulation of the final stop. It was proposed that vowel insertion is principally motivated to improve the perceived similarity between the English input and the Korean output. There are two perceptual factors that promote vowel insertion in this position; vowel insertion yields a good approximation to stop release and stop voicing in English. Constraints that promote the perceived similarity between corresponding strings of sounds were proposed: BESIMILAR[release] and BESIMILAR[voice]. These constraints outrank a constraint against vowel insertion (DEP(V)), and vowel insertion applies variably, depending on whether the stop in the English input is released and/or voiced. Final stops are released more frequently after a tense vowel than

after a lax vowel in English, and vowel insertion is accordingly more likely to apply in Korean loanwords when the pre-final vowel in the English source word is tense than when it is lax. The high frequency of vowel insertion after voiced stops, on the other hand, cannot be attributed to frequency of stop release in English. Rather, there are other phonetic factors – namely, the intervocalic voicing of plain stops and open syllable lengthening of vowels of Korean – that promote vowel insertion after voiced stops, regardless of whether the stop in the input is released or not. Therefore, other things being equal, vowel insertion is found more often after a voiced stop than after a voiceless stop.

The high frequency of vowel insertion after coronal stops, on the other hand, cannot be explained on the basis of perceptual factors. The tendency toward vowel insertion after coronal stops is introduced not during online adaptation but during the lexicalisation of these forms. For a given word ending in a coronal stop, online adaptation produces both outputs, with and without vowel insertion. These two variants compete with each other as the word gains currency and begins to establish its position in the Korean lexicon. Due to a language-specific morphophonemic restriction in Korean (T→S), an alternation is forced upon the variant without vowel insertion, leading to a violation of BASE-IDENTITY. On the other hand, the variant with vowel insertion is immune to T→S and does not violate BASE-IDENTITY. This gives the variant with vowel insertion the upper hand in its bid for the sole position in the lexicon.

Finally, the paper provides strong evidence that non-contrastive phonetic details of lending or borrowing languages are relevant in the process of loanword adaptation and at the same time suggests a richer view of loanword phonology, one which involves the interaction of phonetic, phonemic and morphophonemic factors.

Appendix

The Korean forms in the following list faithfully reflect the orthographic representations provided in the NAKL list. The words that are pronounced as [t]-final in the citation form are written with final /s/, reflecting the fact that they inflect as if they are /s/-final nouns.

1 Lax vowel + /p/

	pre-final vowel	*English word*	*Korean form*
vowel insertion (2)	ɪ	hip	hip^{h}ɨ
	ɑ/ɒ	SWAP	sɨwɑp^{h}ɨ
variable insertion (0)			
no vowel insertion (54)	ɪ	assistantship	ʌsisɨt^{h}ʌnt^{h}ɨsip
		brinkmanship	pɨɭiŋk^{h}ɨmænsip
		championship	ts^{h}æmp^{h}iʌnsip
		chip	ts^{h}ip

	dip	tip
	gossip	k'ɑsip
	grip	kɨʟip
	leadership	ʟitʌsip, ʟitʌswip
	membership	mɛmpʌsip
	microchip	mɑikʰɨʟotsʰip
	partnership	pʰɑtʰɨnʌsip
	polyp	pʰoʟʟip
	showmanship	sjomænswip
	skinship	sɨkʰinswip
	skip	sɨkʰip
	slip	sɨʟʟip
	sportsmanship	sɨpʰotsʰɨmænsip
	tip	tʰip
	tulip	tʰjuʟʟip, tʰjuuʟʟip
ɛ	step	sɨtʰɛp
æ	cap	kʰæp
	gap	kæp
	handicap	hæntikʰæp
	lap	ʟæp
	overlap	opʌʟæp
	scrap	sɨkʰɨʟæp
	slap	sɨʟʟæp
	snap	sɨnæp
	tap	tʰæp
	trap	tʰɨʟæp
	wrap	ʟæp
ʌ	back-up	pækʌp
	change-up	tsʰɛintsiʌp
	close-up	kʰɨʟʟotsɨʌp, kʰɨʟʟosɨʌp
	cup	kʰʌp
	lay-up	ʟɛiʌp
	make-up	mɛikʰɨʌp
	pick-up	pʰikʌp
	set-up	sɛtʌp
	up	ʌp
	warming-up	wʌmiŋʌp
	wind-up	wɑintɨʌp
ɑ/ɒ	bebop	pipɑp
	desktop	tɛsɨkʰɨtʰɑp
	go-stop	kosɨtʰop
	laptop	ʟæptʰɑp
	nonstop	nonsɨtʰop
	pop	pʰɑp
	shop	sjop
	stop	sɨtʰop
	top	tʰop
	workshop	wʌkʰɨsjop, wʌkʰɨsjɑp
ʌ	Europe	juʟʌp
	ketchup	kʰɛtsʰʌp, kʰɛtsʰɑp

2 Tense vowel + /p/

vowel insertion (11)	ej	cape	kʰɛipʰɨ
		drape	tɨʟɛipʰɨ
		videotape	pitiotʰɛipʰɨ
	aj	pipe	pʰɑipʰɨ
		stripe	sɨtʰɨʟɑipʰɨ
	uw	hoop	hupʰɨ
		Hula-Hoop	huʟʟɑhupʰɨ
		loop	ʟupʰɨ
	ow	rope	ʟopʰɨ
		scope	sɨkʰopʰɨ
		slope	sɨʟʟopʰɨ
variable insertion (3)	ij	jeep	tsip, tsipʰɨ
	ej	tape	tʰɛipʰ, tʰɛipʰɨ[30]
	uw	soup	supʰ, supʰɨ, sɨpʰɨ
no vowel insertion (2)	aj	type	tʰɑip
	uw	group	kɨʟup

3 Lax vowel + /k/

vowel insertion (10)	ɪ	mosaic	motsɑikʰɨ
	ɛ	check	tsʰɛkʰɨ
		deck	tɛkʰɨ
		high-tech	hɑitʰɛkʰɨ
		neck	nɛkʰɨ
		tech	tʰɛkʰɨ
	ɑ/ɒ	knock	nokʰɨ
		lock	ʟʌkkʰɨ
		shock	sjokʰɨ
	ʊ	Mook	mukʰɨ
variable insertion (0)			
no vowel insertion (85)	ɪ	academic	ɑkʰɑtɛmik
		acoustic	ʌkʰusɨtʰik
		aerobic	ɛʌʟopik
		aerodynamic	ɛʌʟotɑinɑmik
		anabolic	ɑnɑpoʟʟik
		ascorbic	asɨkʰoʟɨpik
		automatic	otʰomætʰik
		BASIC	pɛitsik
		bioceramic	pɑiosɛʟɑmik
		bioplastic	pɑiopʰɨʟʟɑsɨtʰik
		catholic	kʰɑtʰoʟʟik, kɑtʰoʟʟik
		ceramic	sɛʟɑmik
		classic	kʰɨʟʟæsik
		clinic	kʰɨʟʟinik
		comic	kʰomik
		cosmetic	kʰosɨmɛtʰik

[30] The NAKL list records /tʰɛipʰ/ 'tape' and /supʰ/ 'soup' with final aspirated stops. But these words inflect as if they are /p/-final, not /pʰ/-final: /tʰɛip-ɛ/, */tʰɛipʰ-ɛ/ 'tape LOC'; /sup-ɛ/, */supʰ-ɛ/ 'soup LOC'.

	dramatic	tɨɹɑmɑtʰik, tɨɹʌmætʰik
	dynamic	tɑinɑmik, tɑinæmik
	economic	ikʰonomik
	electric	iɹɹɛktʰɨɹik
	erotic	ɛɹotʰik
	ethnic	ɛsɨnik
	fantastic	pʰæntʰɑsɨtʰik, hwɑntʰɑsɨtʰik
	geographic	tsiokɨɹɑpʰik
	Gothic	kotik
	graphic	kɨɹæpʰik
	Hispanic	hisɨpʰænik
	isometric	ɑisomɛtʰɨɹik
	joystick	tsoisɨtʰik
	kick	kʰik
	lipstick	ɹipsɨtʰik
	magic	mætsik
	magnetic	mɑkɨnɛtʰik
	music	mjutsik
	Nordic	noɹɨtik
	Olympic	oɹɹimpʰik
	philharmonic	pʰiɹhɑmonik
	photogenic	pʰotʰotsænik
	picnic	pʰikʰɨnik
	plastic	pʰɨɹɹɑsɨtʰik
	Platonic	pʰɨɹɹɑtʰonik
	politic	pʰoɹɹitʰik
	polyphonic	pʰoɹɹipʰonik
	prologic	pʰɨɹoɹoɹtsik
	public	pʰʌpɨɹɹik
	quick	kʰwik
	Realpolitik	ɹiɑɹpʰoɹɹitʰik
	romantic	ɹomæntʰik
	sidekick	sɑitɨkʰik
	Slavic	sɨɹɹɑpik
	stick	sɨtʰik
	symphonic	simpʰonik
	topic	tʰopʰik
	trick	tʰɨɹik
	typographic	tʰɑipʰokɨɹæpʰik
ɛ	(Star) Trek	tʰɨɹɛk
æ	attack	ʌtʰæk
	back	pæk
	black	pɨɹɹæk
	Cadillac	kʰætiɹɹæk
	comeback	kʰʌmpæk
	crack	kʰɨɹæk
	feedback	pʰitɨpæk, hwitɨpæk
	fullback	pʰuɹpæk
	halfback	hɑpʰɨpæk

		kayak	kʰɑjɑk
		pack	pʰæk
		sack	s'æk
		snack	sɨnæk, sɨnɛk
		stack	sɨtʰæk
		track	tʰɨʟæk
	ʌ	duck	tʌk
		truck	tʰɨʟʌk
	ɑ/ɒ	antirock	æntʰiʟok
		bloc	pɨʟʟok
		block	pɨʟʟʌk, pɨʟʟok
		rock	ʟok
		shuttlecock	sjʌtʰɨʟkʰok
	ʊ	book	puk
		guidebook	kɑitɨpuk
		handbook	hæntɨpuk
		hook	huk
		look	ʟuk
		scrapbook	sɨkʰɨʟæppuk
	ə	lilac	ʟɑiʟʟɑk
4 Tense vowel + /k/			
vowel insertion (21)	ij	newspeak	njusɨpʰikʰɨ
		peak	pʰikʰɨ
		teak	tʰikʰɨ
		unique	junikʰɨ
		week	wikʰɨ
	ej	brake	pɨʟɛikʰɨ
		shake	sjɛikʰɨ
		steak	sɨtʰɛikʰɨ
		tiebreak	tʰɑipɨʟɛikʰɨ
	aj	mike	mɑikʰɨ
		spike	sɨpʰɑikʰɨ
		strike	sɨtʰɨʟɑikʰɨ
	ow	folk	pʰokʰɨ
		joke	tsokʰɨ
		oak	okʰɨ
		stroke	sɨtʰɨʟokʰɨ
	ɔː	ba(u)lk	pokʰɨ
		Black Hawk	pɨʟʟæk hokʰɨ
		cakewalk	kʰɛikʰɨwʌkʰɨ
		chalk	tsʰokʰɨ
		talk	tʰokʰɨ
variable insertion (1)	ej	cake	kʰɛik, kʰɛikʰɨ
no vowel insertion (2)	ij	technique	tʰɛkʰɨnik
	ej	hotcake	hɑtkʰɛik
5 Lax vowel + /t/			
vowel insertion (33)	ɪ	audit	otitʰɨ
		bit	pitʰɨ

		bucket	pɑkʰɛtsʰɨ
		circuit	sʌkʰitʰɨ
		hit	hitʰɨ
		kit	kʰitʰɨ
		knit	nitʰɨ
		megabit	mɛkɑpitʰɨ
		mitt	mitʰɨ
		no-hit (no-run)	nohitʰɨ
		summit	sʌmitʰɨ
		unit	junitʰɨ
		violet	pɑioʟʟɛtʰɨ
		wit	witʰɨ
	ɛ	jet	tsɛtʰɨ
		minuet	minjuɛtʰɨ
		motet	motʰɛtʰɨ
		net	nɛtʰɨ
		preset	pʰɨʟisɛtʰɨ
		set	sɛtʰɨ, sɛttʰɨ
		Soviet	sopiɛtʰɨ, sopijɛtʰɨ
	æ	bat	pætʰɨ
		hat	hætʰɨ
		mat	mætʰɨ
	ʌ	gut	kʌtʰɨ
		nut	nʌtʰɨ
		putt	pʰʌtʰɨ
	ɑ/ɒ	dot	totʰɨ
		fagott	pʰɑkotʰɨ
		watt	wɑtʰɨ
		yacht	jotʰɨ
	ə	diet	tɑiʌtʰɨ
		marmot	mɑʟɨmotʰɨ
variable insertion (18)	ɪ	bonnet	ponis, ponnɛs, ponnitʰɨ
		carpet	kʰɑpʰɛs, kʰɑpʰis, kʰɑpʰɛtʰɨ
		credit	kʰɨʟɛtis, kʰɨʟɛtitʰɨ
		delicate	tɛʟʟikʰis, tɛʟʟikʰitʰɨ
		merit	mɛʟis, mɛʟitʰɨ
		pamphlet	pʰæmpʰɨʟʟis, pʰæmpʰɨʟʟɛs, pʰɑmpʰɨʟʟis, pʰɑmpʰɨʟʟɛs, pʰɑmpʰɨʟʟɛtʰɨ
		rocket	ʟokʰɛs, ʟokʰis, ʟokʰɛtʰɨ
	ɛ	cassette	kʰɑsɛs, kʰɑsɛtʰɨ, kʰɑsɛttʰɨ
		cornet	kʰonɛs, kʰoʟɨnɛs, kʰonɛtʰɨ
		offset	opʰɨsɛs, opsɛtʰɨ
		silhouette	siʟʟuɛs, siʟʟuɛtʰɨ
	æ	technocrat	tʰɛkʰɨnʌkʰɨʟæs, tʰɛkʰɨnokʰɨʟɑtʰɨ

	ʌ	cut	kʰʌs, kʰʌtʰɨ
	ɑ/ɒ	boycott	poikʰos, poikʰotʰɨ, poikʰottʰɨ
		mascot	masɨkʰos, masɨkʰotʰɨ
		spot	sɨpʰos, sɨpʰotʰɨ
		trot	tʰɨɪos, tʰɨɪotʰɨ
	ə	robot	ɪopos, ɪopotʰɨ
no vowel insertion (35)	ɪ	basket	pɑsɨkʰɛs, pɑsɨkʰis
		chocolate	tsʰokʰoɪɪis, tsʰokʰoɪɪɛs, tsʰokʰʌɪɪis, tsʰokʰoɪɛs
		helmet	hɛɪmɛs
		jacket	tsækʰis, tsɑkʰɛs, tsjɑkʰɛs
		KERMIT	kʰʌmis
		market	mɑkʰɛs
		packet	pʰækʰis
		picket	pʰikʰis
		pocket	pʰokʰɛs, pʰokʰis
		racket	ɪɑkʰɛs
		socket	sokʰɛs
		supermarket	s(j)upʰʌmɑkʰɛs, s(j)upʰʌmɑkʰis
		target	tʰɑkɛs, tʰɑkis
		ticket	tʰikʰɛs, tʰikʰis
		trumpet	tʰɨɪʌmpʰɛs, tʰɨɪʌmpʰis
		ultraviolet	uɪtʰɨɪɑpɑioɪɛs
	ɛ	alphabet	ɑɪpʰɑpɛs
		cabinet	kʰæpinɛs, kʰæpinis
		clarinet	kʰɨɪɑɪinɛs
		diskette	tisɨkʰɛs
		duet	tjuɛs
		quartet	kʰwʌtʰɛs
		sextet	sɛksɨtʰɛs
	æ	flat	pʰɨɪæs
		format	pʰomæs
	ʌ	coconut	kʰokʰonʌs, kʰokʰonɑs
		doughnut	tonʌs
	ɑ/ɒ	hot	hɑs
		plot	pʰɨɪos
		Semi-trot	sɛmitʰɨɪos
		shot	sjɑs
		slot	sɨɪos
		subplot	sʌpɨpʰɨɪos
	ə	carat	kʰæɪʌs
		Pilot	pʰɑiɪʌs

6 Tense vowel + /t/

vowel insertion (58)	ij	concrete	kʰonkʰɨɪitʰɨ
		feet	pʰitʰɨ
		seat	sitʰɨ

	sheet	sitʰɨ
	skeet	sɨkʰitʰɨ
	spreadsheet	sɨpʰɨlɛtɨsitʰɨ, sɨpʰɨlɛtɨswitʰɨ
	street	sɨtʰɨlitʰɨ
	sweet	sɨwitʰɨ
ej	classmate	kʰɨllʌsɨmɛitʰɨ
	coordinate	kʰotinɛitʰɨ
	date	tɛitʰɨ
	eight	ɛitʰɨ
	elevate	ɛllipɛitʰɨ
	gate	kɛitʰɨ
	illustrate	illʌsɨtʰɨlɛitʰɨ
	mate	mɛitʰɨ
	plate	pʰɨllɛitʰɨ
	room-mate	lummɛitʰɨ
	skate	sɨkʰɛitʰɨ
	slate	sɨllɛitʰɨ
	state	sɨtʰɛitʰɨ
	straight	sɨtʰɨlɛitʰɨ
	syndicate	sintikʰɛitʰɨ
	teammate	tʰimmɛitʰɨ
	tollgate	tʰolkɛitʰɨ
	Watergate	wʌtʰʌkɛitʰɨ
	weight	wɛitʰɨ
aj	byte	paitʰɨ
	dynamite	tainʌmaitʰɨ
	ebonite	ɛponaitʰɨ
	fight	pʰaitʰɨ
	headlight	hɛtɨlaitʰɨ
	highlight	hailaitʰɨ
	light	laitʰɨ
	magnesite	makɨnɛsaitʰɨ
	megabyte	mɛkapaitʰɨ
	night	naitʰɨ
	right	laitʰɨ
	skylight	sɨkʰailaitʰɨ
	spotlight	sɨpʰoslaitʰɨ, sɨpʰotʰɨlaitʰɨ
	superlight	sjupʰʌlaitʰɨ
	tight	tʰaitʰɨ
	upright	ʌplaitʰɨ
	white	waitʰɨ
uw	boot	putʰɨ
	grapefruit	kɨlɛipʰɨpʰulɨtʰɨ, kɨlɛipʰɨpʰulɨtʰo
	lute	ljutʰɨ
	recruit	likʰɨlutʰɨ
	root	lutʰɨ
	route	lutʰɨ

		suit	sut^{h}ɨ
	ow	boat	pot^{h}ɨ
		coat	k^{h}ot^{h}ɨ
		creosote	k^{h}ɨlɛosot^{h}ɨ
		motorboat	mot^{h}ʌpot^{h}ɨ
		note	not^{h}ɨ
		remote	limot^{h}ɨ
		vote	pot^{h}ɨ
variable insertion (3)	aw	scout	sɨk^{h}aus, sɨk^{h}aut^{h}ɨ
	uw	flute	p^{h}ɨllus, p^{h}ɨllut^{h}ɨ
		shoot	sjus, sjut^{h}ɨ
no vowel insertion (7)	aw	out	aus
		dugout	tʌkaus
		fade-out	p^{h}ɛitɨaus
		layout	lɛiaus
		pitchout	p^{h}its^{h}iaus
		shutout	sjʌsaus
		strikeout	sɨt^{h}ɨlaik^{h}ɨaut

7 Lax vowel + /b/

vowel insertion (2)	a/ɒ	nob	nopɨ
	ʌ	pub	p^{h}ʌpɨ
variable insertion (0)			
no vowel insertion (5)	ɪ	ad lib	ætɨlip
	æ	jab	tsæp
	ə	Arab	alap
	ʌ	club	k^{h}ɨllʌp
		nightclub	nait^{h}ɨk^{h}ɨllʌp

8 Tense vowel + /b/

vowel insertion (2)	uw	multi-cube	mʌlt^{h}ik^{h}jupɨ
		tube	t^{h}jupɨ
variable insertion (0)			
no vowel insertion (0)			

9 Lax vowel + /g/

vowel insertion (8)	ɪ	MIG	mikɨ
	æ	gag	kækɨ
		plaque[31]	p^{h}ɨllakɨ, p^{h}ɨlakɨ
		tag	t^{h}ækɨ
	ʌ	bug	pʌkɨ
		debug	tipʌkɨ
		plug	p^{h}ɨllʌkɨ
		slug	sɨllʌkɨ
variable insertion (1)	æ	zigzag	tsikɨtsæk, tsikɨtsækɨ

[31] *Plaque* is classified as /g/-final because it is adapted to Korean as if it ends in /g/ rather than /k/. The generalisations presented in the paper stand regardless.

no vowel insertion (5)	ɪ	big	pik
	æ	bag	pæk
		handbag	hæntɨpæk
	ʌ	drug	tɨlʌk
		jitterbug	tsilɨpɑk, tsilupɑk

10 Tense vowel + /g/

vowel insertion (10)	ij	league	likɨ
	ow	rogue	lokɨ
	ɔː	analogue	ɑnɑllokɨ
		catalogue	$k^hɑt^hɑ$llokɨ, $k^hæt^hʌ$llokɨ
		dog	tokɨ
		epilogue	$ɛp^hi$llokɨ
		(Pepper) Fog	p^hokɨ
		Prolog	$p^hɨ$lollokɨ
		prologue	$p^hɨ$lollokɨ
		smog	sɨmokɨ
variable insertion (0)			
no vowel insertion (0)			

11 Lax vowel + /d/

vowel insertion (24)	ɪ	(Sports) Illustrated	illʌsɨt^{h}ɨlɛit^{h}itɨ
		orchid	ok^{h}itɨ
		solid	sollitɨ
	ɛ	bed	pɛtɨ
		dead	tɛtɨ
		head	hɛtɨ
		overhead	opʌhɛtɨ
		scanhead	sɨk^{h}ænhɛtɨ
		skinhead	sɨk^{h}inhɛtɨ
		red	lɛtɨ
	æ	Asiad	ɑsiɑtɨ
		bad	pætɨ
		CAD	k^{h}ætɨ
		keypad	k^{h}ip^{h}ætɨ
		Olympiad	ollimp^{h}iɑtɨ
		PAD	p^{h}ætɨ
		pad	p^{h}ætɨ
		Universiad	junipʌsiɑtɨ
	ʌ	Scud	sɨk^{h}ʌtɨ
	ʊ	hood	hutɨ
		wood	utɨ
	ə	ballad	pɑllɑtɨ
		period	p^{h}ɛliʌtɨ, p^{h}iliʌtɨ
		salad	sælʌtɨ
variable insertion (1)	ɪ	pyramid	p^{h}ilɑmitɨ, p^{h}ilɑmis
no vowel insertion (0)			

12 Tense vowel + /d/

vowel insertion (44)

ij	lead	lit̚
	read	lit̚
	reed	lit̚
	seed	sit̚
	speed	sɨpʰit̚
ej	arcade	ɑkʰɛit̚
	barricade	pɑlikʰɛit̚
	grade	kɨlɛit̚
	handmade	hænt̚mɛit̚
	parade	pʰʌlɛit̚
	serenade	sɛlɛnɑtɛ
	shade	swɛit̚
	suede	sɨwɛit̚
	trade	tʰɨlɛit̚
aj	acetaldehyde	ɑsɛtʰɨɑltɛhit̚
	aldehyde	ɑltɛhit̚
	formaldehyde	pʰolɨmɑltɛhit̚
	fried	pʰɨlɑit̚, hulɑit̚
	glycoside	kɨllikʰosɑit̚
	guide	kɑit̚
	inside	insɑit̚
	offside	opʰɨsɑit̚
	peptide	pʰɛptʰɑit̚
	polyamide	pʰollɪɑmit̚
	pride	pʰɨlɑit̚
	ringside	lɪŋsɑit̚
	side	sɑit̚
	slide	sɨllɑit̚
	wide	wɑit̚
uw	etude	ɛtʰjut̚
	food	pʰut̚
	mood	mut̚
	nude	nut̚
ow	code	kʰot̚
	episode	ɛpʰisot̚
	load	lot̚
	mode	mot̚
	node	not̚
	ode	ot̚
	road	lot̚
oj	celluloid	sɛllullɔit̚
	Polaroid	pʰollɑlɔit̚
	steroid	sɨtʰɛlɔit̚
	tabloid	tʰɑpɨllɔit̚

variable insertion (0)

no vowel insertion (0)

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