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Correspondences between loanwords, L2 perception and L2 production

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Abstract

Correspondences between loanwords, L2 perception and L2 production

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The influence of perception on loanwords and second language (L2) production has been long debated. Some researchers believe that the perceptual categorization of foreign sounds successfully predict the patterns found in loanwords and L2 production; in this view, L2 perception is viewed as the driving force behind loanword adaptation and L2 speech production. Others have posited that the influence of perception on loanwords and L2 speech is not as straightforward; in this view, it is suggested that other factors (e.g., phonological abstraction of the input form, orthography, production difficulties, social conventions, etc.) are also important in the derivation process.

In this vein, the current study aims to elucidate the role of non-native perception on loanword adaptation and L2 production through a quantificational comparison their maps. In particular, Koreans' interaction with the English interdental fricatives is observed in varying vowel contexts and prosodic positions. A perception experiment and a production experiment are conducted on 47 native Korean speakers. The results collected from the two experiments are compared to a Korean loanword corpus obtained from a previous study. Correspondence rates are calculated between the probabilities of the three processes in an attempt to observe the degree to which L2 perception predicts loanword adaptation and L2 production. This study finds low correspondences between the three processes in investigation, which indicates that the relationship between loanwords, L2 perception and L2 speech is indirect.

Keywords: L2 perception, loanwords, L2 production, interdental fricatives

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1 Introduction

1.1 Role of Perception in Loanwords

There has been a considerable amount of discussion regarding the role of perception in loanwords. Although there are many views that have their distinct approaches in characterizing the nature of loanword adaptation, the importance of perception in the adaptation process seems to be supported in many recent works (Silverman 1992, Kenstowicz 2001/2005, Steriade 2001/2008, Kim & Curtis 2002, Peperkamp & Dupoux 2003, Iverson & Lee 2006, Shinohara 2006 and Peperkamp et al. 2008 among others).

1.1.1 Phonological Abstraction vs. Phonetic Approximation

Currently, there are two main approaches to loanwords. Some researchers posit that loanword adaptation requires some type of phonological abstraction, in which fine acoustic cues are largely irrelevant (Paradis & LaCharité 1997/2008/2009, LaCharité & Paradis 2002/2005, Shinohara 2004, Paradis & Tremblay 2009). In this view, the input to loanword adaptation is a phonological or mental representation of a foreign sound and subphonemic acoustic properties play a very small role. Here, loanwords are primarily

adapted by sophisticated bilinguals who can discern the phonological distance[1] between categories of the source (L2) and the recipient language (L1). L1 segments that are judged to be phonologically closest to target L2 segments are selected in the adaptation process.

Another line of thought assumes that all phonetic details of the source language are important in loanword adaptation, regardless of whether or not an acoustic detail has phonological status in the recipient language (Peperkamp & Dupoux 2003, Vendelin & Peperkamp 2004, Peperkamp 2005 and Peperkamp et al. 2008 among others). In this view, the input to loanwords is an acoustic representation of the source language. Adaptation is based on auditory perception and foreign sounds are mapped onto the closest-sounding phoneme of the recipient language. In this approach, it is the inaccurate perception of L2 sounds which gives rise to all transformations in loanwords. It is suggested that "loanword adaptations are basically phonetic rather than phonological in nature, and originate in the process of phonetic decoding during speech perception" (Peperkamp 2005: 350). In this sense, loanword adaptation is essentially equivalent to ordinary speech perception that relies on perceived phonetic similarity.

1.2 Role of Perception in L2 Production

The importance of perceptual factors in the performance of L2 speakers has also been noted in literature. In early phonological theory, inaccurate

[1] Phonological distance in terms of features (e.g., [voice])

productions in a second language were said to have its basis in the misperception of L2 sounds (Polivanov 1931, Trubetzkoy 1969). More recent works have also argued for the primacy of perception over production in second language acquisition, suggesting that accurate perception is a prerequisite for accurate production (Borden et al. 1983, Neufeld 1988, Barry 1989, Flege 1991/1993 and Rochet 1995 among others). Moreover, L2 production errors have been said to be a result of erroneous perceptual mappings of the source language to the recipient language (Best & Strange 1992, Hancin-Bhatt 1994a/1995b, Brown 1997/1998, Flege et al. 1997, Flege et al. 1999, Jia et al. 2006 and Cebrian 2007 among others). For example, in a study by Rochet (1995), it was shown that the French vowel /y/ was perceived and produced as /i/ by Portuguese subjects while the same vowel was perceived and produced as /u/ by English subjects. This suggests that the substitutions that are found in L2 production are motivated by the perceptual categorization of L2 sounds into L1 categories.

It should be noted, however, that not all patterns that are found in L2 production can be explained solely in terms of its basis in perceptual mappings. L2 production is susceptible to articulatory influences from surrounding segments, which can be largely irrelevant to perception. For example, the English word *online*, which is loaned into Korean and written as /on.ɾa.in/, is often produced as [ol.la.in] or [on.na.in] due to L1 transfer effects that encourage assimilation. These variations cannot be viewed as having a strong perceptual basis if we assume that speakers are aware of the underlying phonemic form, which most speakers would have access to through the word's orthographic form. This study therefore concerns L2 production at a monosyllabic level so that L1 transfer effects that occur across syllables are

excluded from the scope of the study.

1.3 Loanwords vs. Second Language

A potential problem with current uses of the terms loanwords and second language is that they are sometimes used interchangeably and the distinction between the two is often blurred. Some linguists refer to how a speaker of a recipient language "produces" the source language when they are discussing loanwords. Major (2001) proposes that loanwords represent the phonology of a rudimentary state in L2 acquisition, where it is largely dependent on L1 transfer; loanwords typically use only native segments and incorporations from the L2 system are very uncommon.

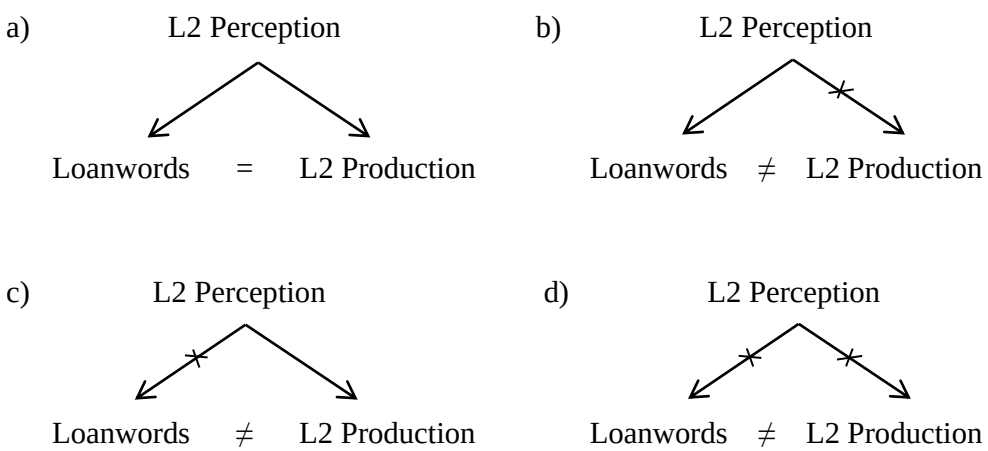
In this paper, loanwords are defined as foreign words that are borrowed and adapted into a language. They are stored in the recipient language lexicon with relatively fixed forms. L2 production includes all attempts made by non-native speakers until they reach native-like proficiency in the target language. L2 production patterns can thus be quite different depending on the proficiency level of individual speakers.

1.4 Hypothesis

Based on the reasoning provided above, perceptual mappings should be a good indicator of loanword mappings and L2 production tendencies if we assume that loanword adaptation is nothing more than subphonemic perception as

suggested by Peperkamp and her colleagues, and if the claim that novice learners' L2 phonology is equal to loanword phonology (Major 2001) holds true. In such a case, the mapping probabilities of all three processes (loanword adaptation, perceptual categorization of L2 sounds, L2 production) should correspond highly with each other (1a). On the other hand, if loanwords and L2 production do not have an extensive perceptual basis nor resemble each other, correspondences between the three should be low (1d). The full range of possibilities is listed below in (1).

(1) Possible Correspondences



⟶ : essentially equivalent to the perceptual categorization of L2 sounds

⟶ : not equivalent to the perceptual categorization of L2 sounds

This study examines correspondences between loanword, L2 perception and L2 production maps through the observation of Korean contact with the English interdental fricatives (i.e., the *th*-sounds in *thumb* [θ] and *them* [ð]). If

the distributions of the three maps turn out to be very similar, the findings of this study will provide strong evidence for the primacy of perceptual motivation in loanwords and novice L2 learners' productions. If not, the findings of this paper will shed light on the manner in which the three processes diverge.

The rest of this paper is organized in the following way. Section 2 clarifies the reasons for specifically observing Koreans' adaptation, perception and production of the English interdentals for the purpose of this paper. Section 3 describes two experiments (perception and production) that are conducted; the data collected in the experiments are used to test the hypotheses that are outlined in (1). Section 4 provides a discussion of the results and elucidates the implications of the findings. A conclusion is given in Section 5.

2 Background

Cross-linguistically, the interdental[2] fricatives are not very common, existing in only about 7% of the UPSID languages (Maddieson 1984). Not only are the interdental fricatives uncommon, they pose great difficulty for most second language learners of English[3] (Gonet & Pietroń 2004, Szpyra-Kozłowska 2004). Due to the rare phonemic status of the interdental fricatives and their relative difficulty in production, the adaptation of these sounds has garnered special attention in the study of second language acquisition. The widely-accepted notion is that interdental substitution patterns vary across languages (e.g., /θ/ → /s/ in Japanese, /θ/ → /t/ in Thai) but not within a language (Ioup & Weinberger 1987, Weinberger 1988 and Lombardi 2003 among others).

2.1 Loanword Data

Unlike the dominant view in previous literature, Korean exhibits a one-to-multiple mapping with these sounds in loanwords where one English phoneme is mapped onto multiple Korean phonemes.

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[2] The term *interdental* is used because the place of articulation of /θ/ and /ð/ is interdental (between the upper and lower teeth) for most speakers of North American English (Ladefoged & Disner 2012: 131). For British English speakers, the place of articulation is *dental* (Ladefoged & Disner 2012: 122). Since this study concerns the perception and production of North American English, /θ/ and /ð/ will be called *interdental*.

[3] The importance of the English interdental fricatives on intelligibility, however, has been debated. While Jenkins (2000) suggests that the mispronunciation of the English interdental fricatives is unimportant for intelligibility, Gimson and Cruttenden (1994) assert that replacing the English interdentals with /tʰ/ and /dʰ/ significantly impedes intelligibility.

(2) Korean Substitutions for English Interdentals[4]

/θ/	→	/s/	*theater*	[si.ʌ.tʰʌ]
			healthy	[hɛl.si]
			math	[mɛ.sɨ]
/θ/	→	/s̝/	*theater*	[s̝i.ʌ.tʰʌ]
			healthy	[hɛl.s̝i]
			math	[mɛ.s̝ɨ]
/θ/	→	/d̥/[5]	*Thatcher*	[d̥ɛt̚.ʨʰʌ]
			ethernet	[i.d̥ʌ.nɛt̚]
			with	[wi.d̥ɨ][6]
/θ/	→	/t̝/	*Thank You*[7]	[t̝ɛŋ.kʰyu]
			Hello Youth[8]	[hɛl.ɾo.yu.t̝ɨ.]
/θ/	→	/tʰ/	*theraphy*	[tʰɛ.ɾa.pʰi]
			marathon	[ma.ɾa.tʰon]
			absinthe	[ap̚.sɛŋ.tʰɨ]
/ð/	→	/d̥/	*others*	[a.d̥ʌ.sɨ]
			soothing	[su.d̥iŋ]
			breathe	[b̥ɨ.ɾi.d̥ɨ]
/ð/	→	/ʤ̥/	*algorithm*	[al.g̊o.ɾi.ʤ̥ɨm]

Syllable boundaries marked by '.'

As it can be seen in (2), voiceless interdentals are adapted as the Korean alveolar plosives in loanwords, namely /d̥/, /t̝/ and /tʰ/, although they are most

[4] This is a rough generalization about Koreans' substitution of the English interdentals that is formulated based on the author's knowledge. Loanword forms (e.g., [hɛl.s̝i] and [hɛl.si] for English word *healthy*) were collected from an online open dictionary of a popular Korean web portal (www.naver.com).

[5] Korean lax plosives and affricates are written as /d̥/, /b̥/, /g̊/, and /ʤ̥/ following the conventions found in Lee (1996).

[6] This may be an example of /ð/ → /d̥/ substitution, not /θ/ → /d̥/, because *with* can be produced as both [wiθ] and [wið]. It is used in this illustration under the assumption that it is more commonly produced as [wiθ].

[7] The title of a Korean television program

[8] The title of a Korean radio program
(However, /θ/ → /t̝/ substitutions in word-final position are rare)

commonly substituted to /s/ or /s̪/. Voiced interdentals are usually adapted as /d̥/, and in some exceptional cases, as /dz̪/.

The probability of these substitution types appearing in loanwords can be found in De Jong and Cho (2012). In their study, a corpus comprising 4,031 English loanwords in Korean was collected (from loanword dictionaries, an online portal and other sources). This corpus focused on 10 English consonants (/p/, /b/, /f/, /v/, /θ/, /ð/, /t/, /d/, /s/, /z/) and their adaptation in Korean; the words in the corpus contained 14,576 target segments. Based on this corpus, interdental adaptations occur with the following probabilities (see (3)).

(3) Probabilities of English interdentals being adapted as a particular Korean consonant (from De Jong & Cho 2012: 364-366)

Initial position (CV)			Final position (VC)		
/θ/ →	/s̪/	(37.8%)	/θ/ →	/s̪/	(40.2%)
	/s/	(33.5%)		/s/	(40.2%)
	/tʰ/	(18.3%)		/t̪/	(13.6%)
	/t̪/	(7.0%)		/d̥/	(5.9%)
	/d̥/	(3.5%)			
/ð/ →	/d̥/	(100%)	/ð/ →	/d̥/	(68.4%)
				/s̪/	(15.8%)
				/s/	(15.8%)

In De Jong and Cho's loanword data, voiceless interdentals in initial position are commonly adapted as /s/ or /s̪/ (71.3%) and less commonly as /tʰ/, /t̪/ or /d̥/. For voiceless interdentals in final position, /s/ adaptations and /s̪/ adaptations are also highly probable (80.4%), and substitutions to /t̪/ or /d̥/ are less likely. Voiced interdentals, on the other hand, are always adapted as /d̥/ in initial

position. /ð/ → /d̥/ is again the most common adaptation pattern found in final position (68.4%), but substitutions to /s/ and /s̻/ also occur.

2.2 Perception Data

De Jong and Cho also observed Koreans' perception of the 10 target English consonants. A perception experiment was conducted on 40 Korean listeners, and the data obtained from the experiment were compared to their loanword corpus in 4 prosodic positions, namely CV, V́CV, VCV́, VC (e.g., sa, ása, asá, as). This study tested the findings of Peperkamp and her colleagues' line of work: the extent of agreement between perceptual categorizations and loanword maps. For the most part, this empirical study found that the loanword adaptation probabilities conformed highly to the probabilities found across perceptual maps.

There were, however, a few exceptions. First, while there were no meaningful perception-loanword divergences between initial position (CV), prestressed intervocalic position (V́CV) and poststressed intervocalic position (VCV́), loanwords deviated substantially from the perceptual maps in final position (VC). Second, loanword maps did not correspond highly with perceptual maps in the case of English interdental fricatives. Koreans' perception of the English interdentals, as found in De Jong and Cho's study, is given in (4).

(4) Probabilities of English interdentals being perceived as a particular Korean consonant (from De Jong & Cho 2012: 364-366)

Initial position (CV)			Final position (VC)		
/θ/ →	/s̪/	(40.0%)	/θ/ →	/b̥/	(31.9%)
	/t̪/	(24.4%)		/s̪/	(25.0%)
	/pʰ/	(16.3%)		/h/	(13.1%)
	/d̥/	(6.9%)		/s/	(11.3%)
	/p̪/	(6.9%)		/pʰ/	(4.4%)
	/s/	(4.4%)		/t̪/	(3.1%)
				/p̪/	(3.1%)
				/tʰ/	(2.5%)
/ð/ →	/d̥/	(75.5%)	/ð/ →	/b̥/	(31.3%)
	/b̥/	(15.0%)		/l/	(19.4%)
	/pʰ/	(13.0%)		/h/	(15.0%)
	/t̪/	(13.0%)		/pʰ/	(8.8%)
				/d̥/	(7.1%)
				/s/	(3.8%)
				/s̪/	(3.1%)
				/tʰ/	(1.9%)

While the cause of other perception-loanword discrepancies can be found in orthographic prescriptions[9] and historical influences[10], there is a lack of evidence for the differences found between the perception and adaptation of the interdentals. For example, while the voiceless form is often heard as /t̪/ in initial position (24.4%), this mapping is uncommon in loanwords (7.0%). Also,

[9] The high probability of English /s/ → Korean /s/ adaptations found in loanwords, which is different from the prevailing perceptual tendency (i.e., English /s/ → Korean /s̪/), is largely motivated by the standard orthographic conventions of the National Institute of the Korean Language (www.korea.go.kr) that prescribe the use of Korean /s/ for loanwords containing English /s/.

[10] English /f/ → Korean /h/ adaptations are argued to have their basis in an abstraction of another language system; in early twentieth century, Korean contact with English was heavily influenced by Japanese speakers, who typically mapped English /f/ onto Japanese [ɸ], an allophone of Japanese /h/ (Lee & Cho 2006 and Cho & Lee 2010 among others).

the voiced interdental is often perceived as a bilabial plosive (/b̥/ or /pʰ/) in initial position (28%) and as /l/ in final position (19.4%), while these tendencies are never found in loanwords. Therefore, the investigation of (1.) the adaptation and perception of the interdental fricatives and (2.) the comparison of final position with other prosodic environments may reveal important information about the loanword-perception discrepancy.

2.2.1 Vowel context

One element that the previous literature fails to take into consideration is vowel context. Many studies have shown that the F2 formant transitions of surrounding vowels affect the perception of fricatives (Shadle et al. 1996, Wagner et al. 2006, Johnson & Babel 2010). In Johnson and Babel's study (2010), both English-speaking and Dutch-speaking listeners found /f/ and /θ/ to be perceptually similar between [i] (i.e., i_i: [ifi], [iθi]); similarity ratings for the two consonants were not as high in other vowel contexts (i.e., u_u; a_a). Furthermore, Dutch-speaking listeners found /θ/ to be more similar to /s/ and /ʃ/ in some vowel contexts (i.e., i_i; u_u) than did English-speaking listeners. This study then illustrates the importance of vowel context on fricative perception, which can be language-specific (e.g., /θ/-/s/-/ʃ/ perceived similarity found with Dutch listeners in specific vowel contexts) or language-independent (e.g., /f/-/θ/ perceived similarity in i_i context for both Dutch and English listeners).

De Jong and Cho's study, however, used a single vowel, namely [a], for all of their perceptual stimuli. They then compared the results of the perception test to loanword probabilities that were accumulated for consonants in

numerous vowel contexts. Accordingly, the observed loanword-perceptual contrasts may have been rooted in neighboring vowel effects. If this is the case, perception mappings collected from various vowel environments may resemble the loanword data to a higher extent, adding weight to the credibility of the phonetic approach to loanword adaptation, as proposed by Peperkamp and her colleagues.

In fact, Schmidt (1996) had observed vowel influences on Koreans' perception of the English interdentals (see (5)), in which she found perceptual place mismatches to be more common in some vowel contexts than others.

(5) Korean labels given to English interdentals in initial position (CV) across 3 vowel contexts (from Schmidt 1996: 3207)

Korean	English					
	/θa/	/θi/	/θu/	/ða/	/ði/	/ðu/
/b̥/	.03	.03	.03	.05	.12	.30
/pʰ/	.05	.08	.33		.03	.02
/p̞/	.03		.18			.03
/d̥/	.08			.48	.73	.32
/tʰ/	.05	.05				
/t̞/	.23	.25	.05	.45	.12	.30
/s/	.08		.03			
/s̞/	.40	.60	.37	.03		
/dʑ̥/						.03
/tɕʰ/	.02					
/h/	.02	.13				

In particular, interdentals were far more likely to be perceived as bilabial when they appeared with [u]; voiceless forms were perceived as /b̥/, /pʰ/ or /p̞/ in 54% of the data when they preceded [u], and voiced forms were categorized as

bilabial 35% of the time. When interdentals appeared with different vowels (i.e., [i], [a]), bilabial place mismatches were less probable, appearing in only 5-15% of the data. This is somewhat in line with Shadle and her colleagues' study (1996) in which it is proposed that non-sibilant fricatives are more sensitive to following vowels than sibilants because of their relatively small front resonating cavity. It is suggested that the smaller size of the front resonating cavity leads to greater variability in spectral shape with lip rounding and back vowels.

2.3 L2 Production Data

Regarding L2 production, the results of one particular study allude to a high correspondence between Koreans' perception and production of the English interdentals. In a study that examined Koreans' substitution of the interdental fricatives in a number of vowel environments (Kim 2009), a corpus that comprised English read-speech data from 16 Korean participants' was analyzed[11]. As it can be seen in (6), the substitution probabilities that are found in Kim's study are very similar to the perception tendencies found in previous studies.

[11] All 16 Korean participants were reported to be low proficient learners of English with little (< 1 year) to no experience in an English-speaking community.

(6) Probabilities of English voiceless interdentals being substituted as a particular Korean consonant in word-initial position (Kim 2009: 165)

Initial position		
/θ/ →	[s̻]	(42.1%)
	[t̻]	(36.8%)
	[d̥]	(8.8%)
	[s]	(5.3%)
	[tʰ]	(3.5%)
	[ð]	(3.5%)

Unlike the loanword data, in which the probabilities of /s/ and /s̻/ adaptations are equally high for voiceless interdentals in initial position, Kim's data demonstrate high probabilities for substitutions to /s̻/ and /t̻/ and relatively low probabilities for /d̥/, /s/ and /tʰ/ substitutions, which closely resemble the tendencies observed in previous perception studies (Schmidt 1996, De Jong & Cho 2012).

While it would be ideal to use this data for the purposes of the current study, Kim contends that the high ratio of /t̻/ substitutions is a result of the selected word list[12] and that it does not reflect actual tendencies among Korean learners of English. She concludes that the mapping of English /θ/ to Korean /s̻/ is the most prominent pattern, and other substitutions are largely viewed as exceptions. Furthermore, it is found that a portion of the data used in the analysis is not reliable because some of the participants lacked knowledge of

[12] For example, a great proportion of /θ/ → /t̻/ substitutions arose with the target word *thank*, which is often lexicalized as /t̻/ in Korean. It is assumed that the high ratio of /t̻/ substitutions is a result of this word being included in the word list.

target word pronunciations[13]. Given such shortcomings, utilizing this data for a proper comparison is rendered difficult.

More importantly, if perception and production data are collected from a separate set of participants, it is impossible to determine whether dissimilarities between the two are due to the change in groups or from inherent asymmetries between perception and production.

2.4 Current Study

The current study is carried out in the following three steps. First, a perception experiment is conducted. This experiment observes Koreans' perception of the English interdental fricatives across varying vowel conditions and prosodic positions. Second, a production experiment is conducted on the same group of participants. This experiment examines Koreans' production of the English interdental fricatives in different vowel environments and word positions. Third, a straightforward comparison of the loanword, L2 perception and L2 production maps is carried out in order to test the hypotheses in (1). Loanword mapping probabilities from De Jong and Cho's study are employed for the purposes of this paper.

2.4.1 Quality of Perception Data

In order to meet the goals of the current study, the perception data is collected

[13] This is suggested by the frequent use of [ð] for [θ], and vice versa.

in a careful manner. Although they were not explicitly told, De Jong and Cho predict that it is very likely that their participants knew that they were listening to segments produced by English speakers due to the manner in which the perception test was performed (2012: 346-347). In a pilot test that was administered prior to the current study, it was found that subjects mapped the voiceless interdental to the Korean /s/ or /s̄/ in almost all instances when they assumed the stimuli language to be English. Subjects seemed to be very sensitive to loanword orthography and accepted prominent patterns found in loanwords to be "correct". This implies that an awareness of the stimuli language can alter subjects' judgments to a great extent.

In addition, the participants in De Jong and Cho's study listened to the perception test stimuli over loud speakers with other participants[14] (as stated in Park & De Jong 2008: 713). The presence of background noise or interference from other subjects taking part in the perception test may have had influences on the listeners' perception.

In Schmidt's perception study (1996), the selected subjects had resided in the United States for 3 years on average upon their participation (range: 4 months to 5.5 years). While her study is conducted based on the idea that the selected group's perception is no different than those of relatively low proficiency listeners, it is possible that the selected subjects demonstrated altered perception systems, making their categorizations different from naïve or elementary learners of English. The fact that the listeners had a mean length of residence of 3 years in the target L2 community at the time of their

[14] The perception data used in De Jong & Cho (2012) was originally collected for Park & De Jong (2008) and Park (2008). In Park & De Jong (2008), it is stated that the subjects participated in the perception test in groups of ten.

participation suggests that they had rich exposure to the target language, which could have had perceptual consequences.

2.4.2 Quality of Production Data

Likewise, the production data is carefully collected so that it best reflects Koreans' production of the English interdentals. One factor that is taken into great consideration is participants' knowledge of target pronunciations. During a pilot test, in which subjects were requested to read from a word list, it was evident that numerous mispronunciations originated from unfamiliarity with the target words (e.g., target word *thigh* produced as [t^hi] or [θiŋ], errors in voicing contrast, etc.), affecting the reliability of the analysis[15].

The current study, therefore, takes into consideration the full range of factors discussed above and attempts to minimize the effects of all elements that can potentially yield results that deviate from the desired data.

[15] For example, if a participant who did not know the correct pronunciation of *thigh* produced it as [t^hi] based on their knowledge of words like *Thai* or *Thomas*, this cannot be considered to be a case of /θ/ → /t^h/ substitution.

3 Experiments

3.1 Perception Experiment

The experiment described in this section is performed to explore the influence of vowel conditions and prosodic positions on English interdental perception. Previous perception studies consider only one of the two aspects; De Jong and Cho (2012) observed the effects of prosodic position on Koreans' perception of English consonants but used a single vowel for their stimuli, and while Schmidt (1996) examined L2 perception in three vowel contexts, all of her stimuli contained target segments in initial position. The experiment in the current study takes both factors into consideration.

3.1.1 Method

The perception experiment involved an identification task that required Korean listeners to label the English interdentals as a Korean phoneme upon hearing recordings of stimuli words containing the target sounds.

3.1.2 Stimuli Creation

The English stimuli for the perception test were recorded by two native

talkers[16] (1 male, 1 female) of North American English. The talkers did not exhibit obvious speech production problems or strong regional dialects, and they did not report hearing impairments. The talkers were familiarized with the pronunciation of syllable structures with a pronunciation guide, especially for non-occurring sequences such as [θu]. The talkers produced 80 words (20 target, 60 filler), and the list of stimuli words was repeated three times. This created three recordings of each stimulus word. For the current study, only one repetition of each stimulus was selected. There was no significant effect of talker; the agreement between the responses of the two groups was high (r = 0.986, $p < 0.05$).

Recordings were made in a sound-attenuated booth at the Seoul National University Phonetics Lab using a Shure Beta 87A vocal microphone and a Sound Devices USBPre 2 portable high-resolution audio interface hooked up to a laptop computer. The sampling rate of the recordings was 48 kHz, all audible clicks were removed, and all stimuli were normalized for peak amplitude.

Target stimuli included voiced and voiceless interdentals in initial (CV) and final (VC) position with five vowels of differing height and frontness (see (7)). Initial position was selected for ease over other prosodic positions because De Jong and Cho (2012) did not find great loanword-perception divergences among CV, ÍCV and VCÍ positions (this can also be seen in Park (2008)). In addition, although the use of existing English words as the stimuli would have provided a fair comparison across the three processes in investigation, since loanword and L2 production mapping probabilities are based on real word data, nonce words were employed to discourage awareness of the target language.

[16] English speakers will be called *talkers* to disambiguate them from Korean speakers who participate in the production experiment.

(7) Target stimuli for perception test

Initial position (CV)		Final position (VC)	
[θi]	[ði]	[iθ]	[ið]
[θə]	[ðə]	[əθ]	[əð]
[θa]	[ða]	[aθ]	[að]
[θo]	[ðo]	[oθ]	[oð]
[θu]	[ðu]	[uθ]	[uð]

One repetition of the 20 target stimuli by each English talker was selected (2 talkers x 20 target stimuli = 40 target words). 30 filler words by each talker were randomly selected (2 talkers x 30 fillers = 60 filler words). 60 filler stimuli comprised recordings of other English consonants (e.g., [d], [f]) in initial and final position, as well as a few Korean[17] (e.g., [t̚]) and French[18] consonants (e.g., [ʁ]) so that the listeners would not be able to make generalizations about the stimuli language. A total of 100 words (40 target, 60 filler) were thus selected for the experiment; all target and filler words were monosyllabic.

3.1.3 Stimuli Selection

As previously mentioned, each stimulus word was repeated three times by each talker. All productions containing the English interdentals were screened prior to selection in order to ensure that the best representation of each stimulus was

[17] Talkers had resided in Korea for 2 years at the time of the recording and were able to produce the filler consonants.

[18] Talkers were intermediate speakers of French.

selected. This was necessary because the talkers sometimes made common errors in production, although training was received before the recording. Both voiced and voiceless interdentals were produced as stops in some of the recordings, and the voiced interdental was devoiced on a few occasions. Once such errors were confirmed by an acoustic or auditory analysis, these erroneous recordings were eliminated from the test set. The talkers were also instructed to fully articulate all consonants during production. Recordings containing little to no frication noise were therefore also excluded. All target stimuli words were examined spectrographically for the existence of frication noise.

Following the initial screening, the remaining recordings were presented to two monolingual English speakers. Neither of the English speakers reported speech or hearing impairments. The speakers were required to identify the consonant in each recording as the closest-sounding English phoneme and goodness scores were given on a five-point scale (1: Poor; 5: Very good). The judges listened to randomly ordered recordings once over headphones in a sound-attenuated room. The recording that had the highest identification rate was selected for each stimulus type. When recordings of the same stimulus type had the same identification rate (e.g., 100% accuracy by both judges), the recording with the highest average goodness rating was selected.

3.1.4 Subjects

Forty seven native speakers of Korean (21 male, 26 female) from the Seoul and Kyeonggi-do district were recruited. Listeners ranged in age from 18 to 38 (M

= 23.7 years). Length of residence in an English-speaking community[19] ranged from 0 to 8 months (M = 1.32 months). Participants had studied English in a classroom environment but all listeners reported having very little interaction with native speakers of English; all participants reported themselves to be low proficient learners of English. A short questionnaire was administered prior to the experiment to ensure that participants did not have extensive linguistic experience with other second languages. None of the listeners reported speech or hearing impairments. All participants were compensated for their participation.

3.1.5 Procedure

The Korean subjects listened to 100 randomly ordered CV and VC sequences, one at a time, over Sennheiser HD 600 headphones in a sound-attenuated booth at the Seoul National University Phonetics Lab. They were required to choose the Korean phoneme that sounded closest to the stimuli consonant in a multiple forced choice listening experiment using Praat (Boersma & Weenink 2008); a relevant script was devised for the experiment. All 18 Korean consonant phonemes were available for selection on a PC computer screen (see (8)).

[19] Includes the US, Canada, Australia, UK, New Zealand, and South Africa

(8) Available selections for the perception experiment

ㅂ	ㅍ	ㅃ	ㄷ	ㅌ	ㄸ	ㄱ	ㅋ	ㄲ	
/b̥/	/pʰ/	/p͈/	/d̥/	/tʰ/	/t͈/	/g̊/	/kʰ/	/k͈/	
			ㅈ	ㅊ	ㅉ				
			/ʤ̊/[20]	/ʧʰ/	/ʧ͈/				
			ㅅ		ㅆ				ㅎ
			/s/		/s͈/				/h/
ㅁ			ㄴ						
/m/			/n/						
			ㄹ						
			/ɾ-l/						

The listeners also rated how similar each stimulus consonant was to the chosen phoneme, using a scale from 1 to 5. ‘‘5’’ was selected when the stimulus consonant was perceived to be exactly like the selected Korean sound (i.e., native-like) and ‘‘1’’ was selected when it was very different (i.e., non-native). The remaining numbers were chosen for sounds that were rated to be in between the two extremes. Response times were also collected, but they are not included in the current study because they did not turn out to be significantly meaningful.

Each token word could be repeated twice after the initial playback if the participants wished to listen to it again (i.e., the participants were allowed to hear each token word up to 3 times). Subjects were given 3 practice trials prior to the actual perception experiment to familiarize themselves with the task.

[20] There is a considerable amount of debate regarding the exact place of the Korean affricates ([ʧ] vs. [ʦ] vs. [ʧ]). They are represented as /ʤ̊ ʧʰ ʧ͈/ in this paper following Lee’s conventions (1996), but this should not be viewed as supporting one argument over another.

3.1.6 Results

The results of the perception test are given in (9), (10), (11) and (12). The probability of an interdental being perceptually mapped to a particular Korean phoneme is given as a decimal to the left of the parentheses (1.0 = 100%); the mean goodness ratings are shown inside the parentheses. Blanks in the tables indicate zero probability. As an example, the probability of /θ/ being heard as /s̪/ in /θa/ is 0.172 (17.2%), and its average goodness score is 1.7 (see (9)).

(9) Korean labels and goodness ratings given to English /θ/ in initial position (CV) across 5 vowel contexts

Korean	English				
	/θa/	/θə/	/θi/	/θo/	/θu/
/b̥/	.043 (1.5)				
/pʰ/	.043 (2.0)	.032 (2.7)	.032 (2.7)	.011 (1.0)	.032 (1.3)
/p̪/		.011 (2.0)			.032 (2.0)
/d̥/	.085 (2.5)	.021 (2.5)	.053 (2.2)	.011 (1.0)	.043 (3.0)
/tʰ/	.043 (2.0)	.053 (2.2)	.064 (2.7)	.064 (2.2)	.032 (1.3)
/t̪/	.606 (2.5)	.617 (2.7)	.755 (2.6)	.574 (2.2)	.585 (2.3)
/s/	.011 (1.0)	.021 (2.5)		.011 (4.0)	.021 (2.0)
/s̪/	.172 (1.7)	.245 (2.0)	.096 (1.9)	.330 (2.0)	.245 (2.7)
/tɕ̪/					.011 (2.0)

In initial position, the voiceless interdental fricative is most often mapped to /t̪/, followed by /s̪/. Goodness ratings are also slightly higher with the /t̪/ mapping than with /s̪/, which suggests that /t̪/ is a better fit for /θ/ than /s̪/.

(10) Korean labels and goodness ratings given to English /θ/ in final position (VC) across 5 vowel contexts

Korean	English				
	/aθ/	/əθ/	/iθ/	/oθ/	/uθ/
/b̥/		.043 (1.5)			
/pʰ/	.085 (1.9)	.170 (1.8)	.085 (1.1)		
/p̚/		.043 (1.5)	.011 (2.0)	.011 (3.0)	
/d̥/	.032 (1.7)	.011 (1.0)	.011 (1.0)	.011 (1.0)	.011 (1.0)
/tʰ/	.096 (1.9)	.043 (2.0)	.117 (1.9)	.096 (2.7)	.043 (2.3)
/t̚/	.160 (1.9)	.170 (1.8)	.223 (1.5)	.223 (2.1)	.202 (1.7)
/s/	.128 (1.8)	.064 (2.2)	.032 (3.3)	.149 (1.7)	.160 (2.5)
/s̚/	.447 (2.1)	.447 (2.3)	.521 (2.4)	.489 (2.5)	.564 (2.6)
/tɕʰ/	.011 (2.0)				.011 (1.0)
/h/	.043 (2.5)	.021 (2.3)		.011 (1.0)	
/kʰ/					.011 (2.0)
/m/				.011 (1.0)	

In contrast, voiceless interdentals are most often mapped to /s̚/ in final position, followed by /t̚/ then /s/. Goodness ratings are also higher for the more probable mapping, namely /s̚/, than with the secondary mapping, /t̚/.

(11) Korean labels and goodness ratings given to English /ð/ in initial position (CV) across 5 vowel contexts

Korean	English				
	/ða/	/ðə/	/ði/	/ðo/	/ðu/
/b̥/	.106 (2.9)	.021 (2.5)	.085 (2.1)		.053 (2.0)
/d̥/	.670 (2.8)	.872 (2.5)	.830 (2.9)	.915 (2.6)	.851 (2.1)
/tʰ/			.011 (1.0)	.011 (2.0)	
/t̚/	.043 (2.0)	.085 (2.0)	.032 (2.7)	.074 (2.9)	.053 (2.8)
/n/	.181 (3.1)		.011 (1.0)		
/dʑ̥/					.021 (3.0)
/h/		.011 (2.0)			
/ɾ-l/		.011 (2.0)	.032 (3.0)		.021 (2.0)

A mapping from /ð/ to /d̥/ is most probable in initial position; there are no mapping probabilities that are high enough to assume a secondary categorization.

(12) Korean labels and goodness ratings given to English /ð/ in final position (VC) across 5 vowel contexts

Korean	English				
	/að/	/əð/	/ið/	/oð/	/uð/
/b̥/	.277 (2.0)	.404 (1.9)	.426 (2.0)	.160 (2.1)	.319 (2.1)
/pʰ/			.021 (2.0)	.011 (1.0)	
/p̚/	.021 (1.5)		.021 (2.0)		.011 (2.0)
/d̥/	.628 (1.9)	.521 (2.1)	.479 (1.7)	.691 (2.0)	.521 (2.1)
/tʰ/				.011 (3.0)	
/t̚/	.032 (1.7)	.011 (1.0)	.011 (1.0)	.011 (1.0)	.043 (1.5)
/s/	.011 (1.0)	.032 (1.3)	.011 (1.0)	.021 (1.0)	.053 (1.4)
/s̚/		.011 (1.0)		.011 (1.0)	.032 (2.0)
/d̥ʒ/	.011 (1.0)	.011 (1.0)	.011 (2.0)	.064 (1.5)	.032 (2.0)
/tɕ̚/				.021 (1.5)	
/h/	.011 (3.0)	.011 (4.0)			
/n/	.011 (3.0)		.011 (2.0)		
/ɾ-l/			.011 (2.0)		

In final position, voiced interdentals are mapped most frequently to /d̥/, followed by /b̥/. Goodness ratings for voiced interdentals in final position are not much different for both prominent perception mappings, namely /d̥/ and /b̥/.

3.1.7 Discussion

While there seems to be small differences in mapping probabilities based on vowel context in all 4 conditions (voiceless-initial, voiceless-final, voiced-

initial and voiced-final), vowel-based differences are not found to be significant ($p > 0.05$)[21].

Therefore, perception mapping probabilities summed up across the 5 vowel contexts are presented in (13).

(13) Korean labels and goodness ratings given to English interdentals across prosodic positions (accumulated across vowel contexts)

Korean	English			
	/θV/	/Vθ/	/ðV/	/Vð/
/b̥/	.009 (1.5)	.009 (1.5)	.053 (2.5)	.317 (2.0)
/pʰ/	.030 (2.2)	.068 (2.2)		.006 (1.7)
/p̚/	.009 (2.8)	.013 (1.8)		.011 (1.8)
/d̥/	.043 (2.4)	.015 (1.3)	.828 (2.6)	.568 (2.0)
/tʰ/	.051 (2.2)	.078 (2.1)	.004 (1.5)	.002 (3.0)
/t̚/	.627 (2.4)	.196 (1.8)	.057 (2.6)	.021 (1.4)
/s/	.013 (2.3)	.101 (2.3)		.026 (1.3)
/s̚/	.217 (1.9)	.494 (2.4)		.011 (1.6)
/d̥z/			.004 (3.0)	.023 (1.6)
/tɕʰ/	.002 (2.0)	.004 (1.5)		
/tɕ̚/				.004 (1.5)
/kʰ/		.002 (2.0)		
/h/		.015 (2.3)	.002 (2.0)	.004 (3.5)
/m/		.002 (1.0)		
/n/			.038 (2.9)	.004 (2.0)
/ɾ-l/			.013 (2.5)	.002 (1.0)

There is, however, a significant effect of prosodic position for both voiceless and voiced interdentals. When the probabilities of perception mappings in initial position are regressed against the probabilities of final mappings using a

[21] Between-groups significance was calculated using Fisher's exact test.

logistic fit, the r-squared values are not large (voiceless, $r^2 = 0.297$; voiced, $r^2 = 0.325$), which indicates that the probabilities in the two prosodic positions are not highly correlated. Likewise, the p-value from the logistic regression is large for both voiced and voiceless interdentals ($p > 0.05$), which suggests that the proportions of perceptual maps in initial and final position do not significantly correspond.

A closer look into the mapping data of the current study reveals some tendencies that are found to be different in the perception of segments in initial and final position. In the voiceless-initial condition, the probability of the target sound being heard as a plosive is approximately 80%. In the voiceless-final condition, the target sound is heard as a fricative in about 60% of the trials. The main difference between voiced-initial and voiced-final conditions is that while mapping to fricatives is uncommon in both voiced contexts, place mismatches are much more common in the voiced-final condition.

Furthermore, the perception results of this study are quite different from those of previously mentioned works. First, unlike Schmidt's study, the percentage of place mismatches is not abnormally high in consonants preceding [u]. Place mismatches are relatively low in all vowel contexts (<11%) for both voiced and voiceless forms in initial position. In addition, place mismatches are also less frequent than in De Jong and Cho's study, in which 23.2% of voiceless interdentals and 28% of voiced interdentals in initial position (i.e., target sounds in /θa/ and /ða/) were heard as /b̥/, /p^h/ or /$p^=$/.

A possible reason for the relatively low probabilities of place confusion in the current study may be in part due to the stimuli creation and selection process. As described in 3.1.3, stimuli recordings were screened on two occasions in an attempt to select the best exemplar of each target word. During

the stimuli creation process, talkers were instructed to clearly articulate each word. Therefore, the perception test stimuli used in this study represent clearly spoken English fricatives. According to Maniwa et al. (2009), clearly spoken fricatives have energy distributions in higher frequency regions, more amplified frication noise relative to the neighboring vowels and longer durations than naturally spoken fricatives. Such differences in the quality of the frication noise may have had positive effects on place disambiguation if the talkers in the current study produced the target stimuli with more emphasis than did the talkers of the previous studies. This suggestion is somewhat plausible since great benefits have been observed in fricative intelligibility with productions involving a relatively large energy increase at higher frequencies (Maniwa et al. 2008).

Place misperception occurrences are also less probable with final consonants in this study (10.9% with voiceless interdentals, 33.8% with voiced interdentals) than in De Jong and Cho's study (52.5% with voiceless interdentals, 55.1% with voiced interdentals). If word-final English consonants were not clearly articulated or not fully released during the stimuli creation process of De Jong and Cho's perception test, the over-representation of bilabial place perception with final consonants that is found in their study might be due to the high frequency of labial codas in Korean. According to Kim, Lee and Yu (1993: 1141), bilabial codas are much more frequent than coronal codas in Korean. Therefore, listeners may have labeled interdental codas as bilabial based on their linguistic experience with Korean in instances when they had trouble identifying the exact place of a final consonant. In a similar sense, the higher percentage of accurate place perception with final consonants in the current study might be related to the clear articulation of stimuli consonants,

which would have given listeners access to more place-or-articulation cues (Jongman et al. 2000, Lawrence 2005).

Second, while voiceless interdentals in initial position were found to be perceived mostly as /s̪/ in previous studies, the current study finds that in initial position, voiceless interdentals are labeled most frequently as /t̪/ (62.7%), although /s̪/ perception is still highly probable (21.7%). While the cause of this dissimilarity is unclear at this point, a combination of factors could have affected the outcome (e.g., listening environment (headphones vs. loud speakers), linguistic experience differences between subject groups, differences in the selected stimuli, etc.). One factor that might have had more influence on the results than others is listeners' knowledge of the source language. In De Jong and Cho's study, it is very likely that the listeners knew that they were hearing English segments (2012: 346-347)[22]. This awareness could have encouraged /s̪/ labels in the perception test because voiceless interdentals are adapted most commonly as /s̪/ in loanwords.

[22] Schmidt's study does not specify whether or not their subjects were aware of the stimuli language.

3.2 Production Experiment

The experiment described in this section is performed to explore the extent of vowel-based effects and the influence of word positions on Koreans' production of the English interdental fricatives.

3.2.1 Method

The production test was conducted after the perception test. The production experiment required Korean participants to produce stimuli words with the interdentals in varying vowel environments and word positions. Both audio and text input were provided because the presence of the two input types has been linked to better L2 production performance than in audio-only conditions (Davidson 2010). Text-only conditions were avoided because it was found that a high percentage of mispronunciations arose when only a word list was given in a pilot test that was conducted.

3.2.2 Stimuli

The auditory stimuli for the production test were recorded by a male speaker of North American English[23]. He did not exhibit obvious speech production problems or strong regional dialects, and he did not report hearing impairments. The talker produced 66 English words (16 target, 50 filler). The list of stimuli

[23] The same male talker from the perception test

words was produced three times and the best exemplar of each stimulus was selected. The recordings were made in the same manner and with the same equipment as the perception test stimuli, with all audible clicks removed and normalized for peak amplitude. The stimuli selection process also consisted of the same procedures as the perception test; two screening tests were involved.

Target stimuli included voiced and voiceless interdentals in word-initial and word-final position across four vowel contexts (see (14)). Altering vowel contexts were given to observe the influence of neighboring vowels on interdental production.

(14) Target stimuli for production test

Word-initial position			Word-final position		
#_iː	*theme*	*thee*	iː_#:	*teeth*	*breathe*
#_ɛː	*theft*	*them*	eɪ_#:	*faith*	*bathe*
#_aɪː	*thigh*	*thine*	o_#:	*both*	*clothe*
#_ʌː	*thug*	*thus*	u_#:	*truth*	*smooth*

3.2.3 Subjects

The same group of participants from the perception test participated in the production experiment.

3.2.4 Procedure

Participants were asked to produce 66 English words (16 target, 50 filler).

Both auditory and orthographic representations of the stimuli were presented to facilitate subjects' knowledge of target pronunciations. Participants' productions were recorded in a sound-attenuated booth at the Seoul National University Phonetics Lab, using a Shure Beta 87A vocal microphone and a Sound Devices USBPre 2 portable high-resolution audio interface hooked up to a laptop computer. Orthographic stimuli were presented in a random order on a tablet PC screen. Auditory stimuli were presented when the participant clicked on an orthographic representation of a stimulus word on the tablet PC touch screen. Participants listened to each stimulus at least once over AKG-66 headphones and then repeated it into the microphone. An additional playback of the auditory stimulus was allowed (i.e., the recording of a stimulus word could be played up to 2 times). The words were produced in isolation because the manner in which words are produced, whether they are produced in isolation or embedded in a native language sentence, has been found to be relatively unimportant for L2 production accuracy (Davidson et al. 2004).

3.2.5 Results

Participants' productions were analyzed by repeatedly listening to the sound files and examining their spectrograms in Praat. The productions were transcribed in IPA (International Phonetic Alphabet) symbols by a bilingual speaker of English and Korean, experienced in phonetic transcription. 15% of the data were randomly selected and transcribed by two additional bilingual phoneticians for reliability. Inter-rater reliability among the three raters was 95.3%. Absolute phoneme-by-phoneme inter-rater agreement for the target

segments was 91.5% (between rater 1 and 2), 89.4% (between rater 1 and 3), and 88.6% (between rater 2 and 3).

The results of the production experiment are given in (15), (16), (17) and (18). The probability of an interdental being produced as a certain phoneme is given as a decimal (1.0 = 100%). Blanks in the table indicate zero probability. For example, the probability of /θ/ being produced as /s̪/ in the target word *theme* (context: #_i) is 27.7% (see (15)).

(15) Koreans' production of English /θ/ in word-initial position

productions	Target: /θ/			
	#_i	#_ɛ	#_aɪ	#_ʌ
/θ/	.447	.489	.383	.532
/ð/		.021		
/s̪/	.277	.149	.319	.234
/d̥/		.021		
/t̪/	.277	.319	.298	.234

In the voiceless-initial condition, correct productions (i.e., /θ/ produced as /θ/) are most frequent. The probabilities of /θ/ being substituted as /t̪/ or /s̪/ are also quite prominent. The probabilities of /t̪/ and /s̪/ productions are almost equally as likely, which is different from both the loanword and L2 perception data since /s̪/ mappings are more likely than /t̪/ mappings in loanwords (as seen in (3)) and /t̪/ labels are much more frequent than /s̪/ labels in the perception data (as seen in (9)).

(16) Koreans' production of English /θ/ in word-final position

productions	Target: /θ/			
	i_#	eɪ_#	o_#	u_#
/θ/	.638	.468	.532	.489
/s̪/	.319	.425	.383	.447
/t̪/	.043	.043	.043	.064
/tʰ/		.064	.021	
/tɕʰ/			.021	

Once again, in the voiceless-final condition, /θ/ is most commonly produced as /θ/. Compared to the voiceless-initial condition, however, substitutions to /s̪/ are much more probable than substitutions to /t̪/. This tendency is similar to the perception results (as seen in (10)) although perception demonstrates more variability with its categorizations. These production results are different with loanword mappings (as seen in (3)) since /s/, /t̄/ and /d̥/ substitutions, which arise in loanwords, are not found in production.

(17) Koreans' production of English /ð/ in word-initial position

productions	Target: /ð/			
	#_i	#_ɛ	#_aɪ	#_ʌ
/θ/	.021	.021	.064	.064
/ð/	.362	.213	.298	.255
/s̪/	.021		.021	
/f/			.021	
/d̥/	.191	.255	.149	.191
/t̪/	.255	.319	.340	.319
/d/	.149	.191	.106	.170

In word-initial position, voiced interdentals are most commonly produced as /t̪/, followed by /ð/, /d̥/ and /d/. These results are different from both the L2 perception and loanword data because /ð/ → /t̪/ mappings in initial position only appear in approximately 6% of the L2 perception data and never appear in loanwords.

(18) Koreans' production of English /ð/ in word-final position

productions	Target: /ð/			
	i_#	eɪ_#	o_#	u_#
/θ/	.085	.191	.128	.234
/ð/	.383	.191	.298	.340
/s̪/	.064	.149	.085	.149
/z/	.064	.149	.128	.106
/d̥/	.319	.191	.319	.128
/tʰ/	.043	.021		.021
/t̪/	.021	.021	.021	
/t̚/		.064	.021	
/d̥z̥/				.021
/tɕʰ/	.021	.021		

In the voiced-final condition, commonly produced segments include /ð/, /d̥/, /θ/, /s̪/ and /z/. The proportions of substitutions to native segments (i.e., probabilities of /ð/ → /d̥/, /s̪/) are somewhat similar to those found in loanwords (as seen in (3)), except that /s/ substitutions are not found in L2 production but very likely in loanwords. Also, /b̥/ substitutions are never found in L2 speech, yet they are commonly found in the perception of voiced interdentals in final position (as seen in (12)).

3.2.6 Discussion

Similar to the findings of the perception experiment, the differences in L2 production probabilities between various vowel contexts are not found to be significant ($p > 0.05$)[24]. This indicates that vowel-based differences are not great and that the general tendencies across different vowel environments are alike.

L2 production mapping probabilities collapsed across vowel conditions are presented in (19).

(19) Koreans' production of the English interdental fricatives

Productions	Target			
	/θV/	/Vθ/	/ðV/	/Vð/
/θ/	.463	.532	.043	.160
/ð/	.005		.282	.303
/f/			.005	
/s̪/	.239	.394	.011	.112
/z/				.096
/d̥/	.005		.179	.239
/t̪/	.283	.048	.309	.011
/tʰ/		.021		.027
/t̚/				.021
/d/			.154	
/d̥z/				.005
/tɕʰ/		.005		.011

While vowel influences are small, word position turns out to be significant for L2 production proportions. Production probabilities between word positions are

[24] Between-groups significance was calculated using Fisher's exact test.

not highly correlated (voiced: $r^2 = 0.231$, $p > 0.05$; voiceless: $r^2 = 0.464$, $p > 0.05$).

In addition, the L2 production results demonstrate some peculiar characteristics. First, there seems to be an increase in the proportion of fricatives when target segments of the source language are in final position. When summed up across vowel contexts, the percentage of fricative mappings is 70.7% in initial position and 92.6% in final position for voiceless interdentals. For voiced interdentals, the likelihood of fricative productions jumps from 34.1% in initial position to 67.1% in final position. Secondly, interdental productions are strikingly different from the loanword and perception data because mappings to non-native segments occur (e.g., /ð/ → /z/, /d/).

3.3 Correspondences

Based on the results collected in the experiments, correspondences between loanword, L2 perception and L2 production maps were calculated. The probabilities of one map were regressed against the probabilities of another map, using a logistic fit to calculate the r-squared value. The calculations are given in (20), (21) and (22).

(20) R^2 values from regressing the probability of loanword maps (from de Jong & Cho 2012) against the probability of perception maps

Context	R^2
Voiceless-Initial	0.196
Voiceless-Final	0.206
Voiced-Initial	0.992
Voiced-Final	0.167

(21) R^2 values from regressing the probability of production maps against the probability of perception maps

Context	R^2
Voiceless-Initial	0.279
Voiceless-Final	0.296
Voiced-Initial	0.124
Voiced-Final	0.013

(22) R^2 values from regressing the probability of loanword maps (from de Jong & Cho 2012) against the probability of production maps

Context	R^2
Voiceless-Initial	0.196
Voiceless-Final	0.028
Voiced-Initial	0.114
Voiced-Final	0.348

When the probabilities of L2 perception maps are regressed against the probabilities of loanword maps (20), the correspondences between the two are found to be very low, except for in the voiced-initial condition. Since perception data accumulated across vowel contexts does not reduce the discrepancy found between the L2 perception and loanword data, the low correspondences found between interdental loanword-perception maps in De Jong and Cho's study cannot be attributed to vowel condition differences between their perception test stimuli and loanword corpus. Low correspondences are also found between perception-production and loanword-production comparisons, as can be seen in (21) and (22). This indicates that the perceptual categorizations of L2 sounds do not successfully predict Korean loanword or production probabilities for the English interdentals, and that loanwords and L2 production do not resemble each other to a high extent.

One objection to this quantification, however, is that the mappings that are only found in the L2 production data, namely those mappings to non-native segments (e.g., /ð/ → /z/, accurate production of target sounds), may be responsible for the very low correspondence rates found between other maps and L2 production probabilities. This can be seen as an unfair comparison since

subjects did not have the option of selecting non-native segments as a match for the target sounds in the perception test. On the basis of such reasoning, a recalculation of the correspondences was carried out, in which production mappings to non-native segments, including correct productions, were excluded. All mappings with a probability below 3% were also eliminated from the both the L2 perception and L2 production data, under the assumption that such exceptions can easily be traced to random noise in the perception test or idiosyncratic characteristics of a particular speaker in the production test. Production and perception probabilities were accordingly adjusted[25] and compared with loanword probabilities. The recalculated correlation values are given in (23), (24) and (25).

(23) R^2 values from regressing the probability of loanword maps (from de Jong & Cho 2012) against the probability of perception maps, excluding perception mappings < 0.03

Context	R^2
Voiceless-Initial	0.214
Voiceless-Final	0.235
Voiced-Initial	0.999
Voiced-Final	0.173

[25] The elimination of correct productions, mappings to non-native segments, and low probability mappings (<0.03) increased the probabilities of existing mappings (i.e., mappings to native segments).

(24) R^2 values from regressing the probability of production maps against the probability of perception maps, excluding production mapping probabilities to non-native segments and mappings < 0.03

Context	R^2
Voiceless-Initial	0.725
Voiceless-Final	0.593
Voiced-Initial	0.321
Voiced-Final	0.073

(25) R^2 values from regressing the probability of loanword maps (from de Jong & Cho 2012) against the probability of production maps, excluding production mapping probabilities to non-native segments and mappings < 0.03

Context	R^2
Voiceless-Initial	0.094
Voiceless-Final	0.099
Voiced-Initial	0.308
Voiced-Final	0.205

As it can be seen in (23), excluding the perception mappings that fall below 3% does not significantly improve correspondences between loanword and perception maps. The increases in r^2 values are very modest, and except in the voiced-initial condition, the correspondences between the two maps remain low. In (24), r-squared values between L2 productions and perceptual responses increase substantially with the recalculation (e.g., in the voiceless-initial

condition, the r-squared value increases from 0.279 to 0.725), indicating that the poor fit for the logistic regression between the two proportions is indeed in part due to uncommonly realized mappings, mappings to non-native segments, and correct productions. It is undeniable, however, that these increased values are still not large enough to support a strong relationship between L2 perception and L2 production maps. Similar to (23), it can be seen in (25) that the recalculation does not improve r^2 values between loanword and L2 production probabilities, leaving behind a very weak logistic relationship between the proportions of the two mappings.

On an additional note, it should be mentioned that the extremely low correspondences found between the maps of L2 perception and others (i.e., L2 production, loanwords) might have been motivated by the nature of the perception test stimuli. As previously mentioned, the auditory stimuli in this study represent clearly articulated speech. It is possible, however, that the perceptual categorization of naturally produced speech more closely approximates loanword and L2 production mappings. If this is the case, then the dominant influence of perception over loanwords and L2 production may be better supported. Unfortunately, it is largely unknown at this point whether the perceptual categorization of natural or conversational speech better predicts loanwords and L2 production.

4 Discussion

This study finds that loanwords, L2 perception and L2 production do not highly conform in the case of Korean contact with the English interdental fricatives. The current results, then, provide insightful information on the ways the three processes in investigation diverge. By carefully observing the data obtained, we can postulate that the variances in the proportions of the three processes arise because loanwords and L2 production do not extensively rely on perceptual categorization nor go through the same derivation process (as hypothesized in 1d). This idea will be supported in the following paragraphs.

4.1 Loanwords vs. Perception

First, the findings of this study illustrate that the loanword-perception differences found in De Jong and Cho's study (2012) cannot be attributed to vowel influences on perception. Similar to the previous findings, this study finds that Koreans' perceptual categorization of English consonants do not successfully predict loanword adaptation mappings in the case of voiceless interdental fricatives and for segments in final position. If phonetic approximation is truly the driving force behind loanword adaptation, /t̪/ adaptations should be found as a majority in loanwords with voiceless interdentals in initial position, as predicted by the perception results. Also, even when the dominant mapping tendencies are similar (the high probabilities of /s̪/ mappings in the perception and adaptation of voiceless interdental codas),

the differences in the proportions of other mappings (e.g., /θ/ → /s/ mappings are more likely in loanwords than in L2 perception) yield low correspondences between the two maps. Therefore, the data in this study reveals an important aspect of the perception-loanword relationship, one which the phonetic approach (as suggested by Peperkamp and her colleagues) cannot account for. One generalization that can also be made from the data is that divergences in loanword mappings and perceptual categorization seem to arise when there is no single prominent perceptual mapping. As it can be seen with voiced interdentals in initial position, when there exists only one dominant perceptual categorization tendency (e.g., /ð/ → /d̥/ mapping is found in 82.8% of the voiced-initial data), the two maps exhibit high correspondence.

An explanation that satisfies the divergences found in this study can thus be attained if we accept that loanword adaptation is not equivalent to L2 speech perception. This argument is justified if we assume the following descriptions to be true. Loanword phonology is much more regular than perception and it functions on the basis of established borrowing patterns (e.g., English /θ/ → Korean /s̄/, /s/; English /ð/ → Korean /d̥/). In the initial stages, borrowings originate from perceptual mapping tendencies; the multiple mappings found with voiceless interdentals in Korean, therefore, reflect the variation in loanword adaptations before the fixation of a dominant borrowing pattern or older perception tendencies[26]. A single segmental pattern, however, becomes standardized and fixed in the recipient language[27]. This explains the high

[26] /θ/ → /t^h/ mappings are mostly found with words of Greek or Hebrew origin (e.g., *pythagoras* [p^hit^ha$\mathring{g}$oras̄ɨ] that were loaned into Korean a long time ago (De Jong & Cho 2012: 353)

[27] Similar conclusions have also been reached by others (Haugen 1950/1953, Kang 2010 and De Jong & Cho 2012).

degree of similarity found between Korean perception and loanword maps for most English consonants. The borrowing patterns are initially driven by perceptual similarities; therefore, if there is only one prominent perceptual mapping, then loanwords will resemble perception to a great extent (e.g., the prominence of English /z/ → Korean /d͡ʑ/ in both perception and loanwords). Accordingly, deviances in the two maps occur when there is more than one likely candidate in the perceptual mapping of a non-native segment.

The one-to-multiple mapping that is found in the perception of voiceless interdentals, therefore, is the motivation for the low perception-loanword correspondence. Moreover, the results of the perception experiment reveal a new pattern in the Korean perception of interdentals. While previous perception studies find that /θ/ is predominantly mapped to /s̪/ by Korean listeners, this study shows that perception responses are largely dependent on prosodic position; /t̪/ mappings are most probable in initial position and /s̪/ mappings are more common in final position. While other studies report a change in the proportion of perception probabilities with prosodic positions, this study reports a change in the most likely candidate.

Such a pattern seems to be rooted in a more general tendency: perceptual asymmetries found with segments in initial and final position. Online perception is highly complex, and mapping discrepancies that are found in initial and final position may stem from perceptual sensitivities toward acoustic information. For example, it is possible that interdentals in initial and final position have different physical manifestations. If they happen to differ in terms of amplitudinal or durational qualities, such contrasts can give rise to different perceptual categorizations. In fact, amplitude rise slope and frication duration has been argued to be an important cue in distinguishing affricates and plosives

from fricatives (Gerstman 1956, Mitani et al. 2006).

Place-of-articulation mismatches are also characteristic of perception responses, and they are more common with segments in final position. Interdentals in VC sequences are often perceived as bilabial by Korean listeners, and the probabilities of these places switches are very high in some vowel contexts (e.g., the probability of /ð/ → /b̥/ in the perception of /ið/ is 42.6%). Different from loanword adaptation, perception is highly conscious of acoustic properties. Since codas are known to be less salient than onsets, containing fewer acoustic cues (Steriade 2008), it is plausible that when listeners hear the interdental codas, they confuse the interdental place as bilabial because they perceive them to be less salient than interdental onsets. In fact, bilabial noise creates lower-amplitude noise than coronals (Stevens 2000, De Jong & Park 2012). Another possibility is that listeners have access to fewer acoustic cues with coda consonants, especially those that are important for disambiguating place-of-articulation. This inherent sensitivity to prosodic position in perception, however, does not translate into loanwords, thereby producing low perception-loanword correspondences in final position.

The reasons for why place confusions from coronal to bilabial are more likely in voiced interdentals are still unclear (probability of bilabial mappings: voiceless-initial (4.8%); voiceless-final (9.0%); voiced-initial (5.3%); voiced-final (33.4%)). Normalized frication duration, however, is typically shorter in voiced interdentals than in voiceless forms; in an empirical study by Jongman and his colleagues (2000), it was found that /θ/ takes up 41.5% of the entire word duration in a naturally produced CVC word with the target segment in initial position, while /ð/ only takes up 26.4% (2000: 1260). In addition, voiceless fricatives in clear speech increase more in length than voiced

fricatives in conversational speech (Maniwa et al. 2009). If voiced interdentals in final position are also significantly shorter than voiceless interdentals, the combination of the shorter duration and the relatively weak salience of codas may be responsible for the substantial increase of place switches from the voiced-initial to the voiced-final context.

4.2 Production vs. Perception

The current data also shed light on the interaction between L2 production and L2 perception. The exact link between second language perception and production is unclear, but many researchers have argued for the primacy of perception in second language. Previous studies have mostly focused on the consequences of perceptual accuracy on L2 production. The extent to which perceptual categorizations align with L2 production tendencies has been largely unstudied. This study finds low correspondences between L2 production and L2 perception data in a straightforward comparison of their mappings. This suggests that Koreans' perception of English segments does not successfully predict Koreans' production of English. This goes against the results of Hancin-Bhatt's studies (1994a/b), where the misperception of the interdentals as /s/ and /z/ is argued to be the driving force behind Japanese speakers' erroneous interdental productions. Likewise, if L2 production is based solely on perception, place mismatches should commonly arise.

Moreover, this study finds that correspondences between L2 production and L2 perception are low regardless of a prevailing perception tendency. For example, a mapping from /ð/ to /d̥/ in initial position is dominant in perception,

while a mapping from /ð/ to /t̪/ is unlikely. The prevalence of the /ð/ → /d̥/ perception mapping, however, is not carried over to production, and substitution patterns that have little perceptual motivation (e.g., /ð/ → /t̪/) occur frequently in the L2 production data.

The most notable finding of the production experiment is the occurrence of mappings to non-native segments. These findings also provide insight on the innate tendencies of production, which can partially account for the perception-production deviances. An observation of the data shows us that mappings such as /ð/ → /d/ and /ð/ → /z/ arise in production. This is surprising since Korean does not have a voicing contrast. On the basis of these productions, it is logical to assume that production is susceptible to articulatory limitations and influences. The reasons for this supposition are outlined below.

Based on the findings, it seems that L2 speakers are able to access phonetic information, regardless of its phonological status in the L1. If L2 speakers are unable to process sub-phonemic information, all productions should essentially involve substitutions to L1 segments. The assumption is that errors arise from attempts to reproduce target sounds. For example, the substitution of /ð/ to /z/ demonstrates that some speakers are able to mimic the voicing and manner of the target sound but unable to master the exact place. Therefore, L2 speakers are susceptible to phonetic details but they are simply unable to articulate them.

Another pattern that highlights L2 production deviances from L2 perception is found with Korean speakers' preference for fricatives in final position. The results of the production study show that Koreans prefer the production of fricatives when the target interdental is in word-final position. While a preference for fricatives in the production of target voiceless interdentals in final position may be rooted in perception mapping tendencies

(/s̪/ mappings are dominant in both production and perception maps), fricative substitutions for word-final voiced interdentals (e.g., /ð/ → /s̪/, /z/) have very little perceptual motivation. This preference for word-final fricatives, however, is reported to be common among non-native learners of English (Cruttenden 1976: 26). This suggests that learners are influenced by certain universal tendencies, which may be irrelevant to perception.

In addition, Korean learners' ability to attend to features such as voicing has important theoretical implications; it challenges Brown's hypothesis that assumes second language learners are unable to acquire new phonological features that do not function contrastively in their native language (Brown 1997/1998).

Finally, while correspondences between L2 perception and L2 production are found to be low, there are moderate increases in the recalculated r-squared values when mapping to non-native segments (including correct productions) and other exceptions are excluded. This indicates that the perceptual categorization of L2 sounds is a better predictor of L2 substitutions to native segments than it is a predictor of all productions patterns that are found in L2 speech.

4.3 Loanwords vs. Production

In regards to the production-loanword interaction, it is shown that the two maps do not extensively match up. Low correspondences are found across all observed conditions, and there is no significant increase in r-squared values when the recalculation is carried out. Furthermore, a closer look into the two

maps reveals the high variability found in the L2 production process and the relative regularity of loanword adaptations. These results, therefore, differ from Major's claim that views loanword phonology as mirroring the primitive stages of second language phonology. We can conclude that loanwords and second language meaningfully deviate from each other, at least in the case of Korean contact with English interdental fricatives.

Lastly, the high rate of variability found in L2 production makes it difficult for existing OT analyses that assume a single segmental mapping for interdental fricatives in second language acquisition[28] (e.g., Lombardi 2003) and for the theory of "differential substitution" (Weinberger 1998: 118), which also predicts that interdental substitution patterns vary across languages but not within one language.

[28] The author recognizes that there are versions of OT (e.g., stochastic versions of OT (Boersma & Hayes 2001)) that yield variable outputs.

5 Conclusion

The present study investigated the degree of correspondence between loanword, L2 perception and L2 production probabilities through a quantificational observation of their maps. This involved comparing a loanword corpus obtained in a previous study to perception and production mappings that were collected in the current study.

In the perception experiment, the effect of vowel context on English interdental perception was observed because it was assumed to be an influential factor for divergences found in the Korean loanword-perception interaction. The current study found a poor logistic relationship between L2 perception and loanword maps, which was not resolved by vowel-based differences. By doing so, the findings of this study challenged an approach in which the borrowing process is simply viewed as a case of perceptual processing.

The results of the production test provided ample evidence in support of second language irregularities. A mismatch was found with L2 perception and L2 production maps, suggesting a non-direct relationship between the two. Dissimilarities were also found with L2 production and loanwords, and this result consequently dismissed previous claims that assumed the two to be parallel.

The low correspondences found between the three processes in investigation highlight the ways in which they diverge. In this paper, the discrepancy in the three mappings is claimed to arise due to the intrinsically different qualities of the processes: the systematic nature of loanword adaptation, perceptual sensitivities toward acoustic information, and the high degree of variability found in second language production.

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국문초록

차용어, 제2 언어 인지 그리고 제2 언어 발음 사이의 상관관계

제2 언어의 인지가 차용어 및 제2 언어 발음에 미치는 영향은 오랫동안 논의되어 왔다. 일부 연구는 차용어와 제2 언어의 발음 양상이 제2 언어에 대한 인지적 범주화를 통해 예상될 수 있다고 보았다. 이러한 관점은 제2 언어 학습자가 대상 외국어를 어떤 음소로 듣는가에 따라 차용어와 제2 언어의 발음이 결정된다고 주장한다. 그러나 제2 언어의 인지가 차용어 및 제2 언어 발음에 직접적으로 영향을 주지 않는다는 지적도 있다. 이러한 연구는 차용어 및 제2 언어 발음이 음운론적 규칙, 철자법, 발음의 제약 그리고 사회적 관습과 같은 요소들에 더 큰 영향을 받는다고 본다.

이 같은 논의를 바탕으로 본 연구는 차용어와 제2 언어의 발음 그리고 제2 언어 인지의 관계를 실험에 기반하여 구체적으로 밝히고자 했다. 영어의 치간 마찰음이 한국어에서 다양하게 실현된다는 점을 살피고, 47명의 한국인 화자를 대상으로 인지 실험과 발화 실험을 하였다. 화자들의 응답과 기존 연구의 차용어 코퍼스를 바탕으로 차용어, 제2 언어 발음 그리고 제2 언어의 인지적 맵핑의 확률을 비교하고

이들의 대응도를 검토하였다. 그 결과, 제2 언어 인지, 차용어 그리고 제2 언어 발음 사이의 낮은 대응도를 밝혔다.

본 연구의 의의는 제2 언어 인지가 차용어와 제2 언어 발음을 부분적으로만 예측한다는 점을 보인 것이다. 이러한 결과는 일부 기존 연구에서 주장해 왔던 예측과는 달리 세 과정의 관계가 간접적이라는 것을 의미한다.

주요어: 제2 언어 인지, 차용어, 제2 언어 발음, 치간 마찰음

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