Stony Brook University

Diachrony in Synchrony: Korean vowel harmony in verbal conjugation

A Dissertation Presented

by

Hijo Kang

to

The Graduate School

in Partial Fulfillment of the

Requirements

for the Degree of

Doctor of Philosophy

in

Linguistics

Stony Brook University

August 2012

Stony Brook University

The Graduate School

Hijo Kang

We, the dissertation committee for the above candidate for the

Doctor of Philosophy degree, hereby recommend

acceptance of this dissertation.

Ellen I. Broselow – Dissertation Advisor
Professor, Department of Linguistics

Marie K. Huffman - Chairperson of Defense
Associate Professor, Department of Linguistics

Christina Y. Bethin
Professor, Department of Linguistics

Yoonjung Kang
Associate Professor, Department of Linguistics,
University of Toronto

This dissertation is accepted by the Graduate School

Charles Taber
Interim Dean of the Graduate School

Abstract of the Dissertation

Diachrony in Synchrony: Korean vowel harmony in verbal conjugation

by

Hijo Kang

Doctor of Philosophy

in

Linguistics

Stony Brook University

2012

This dissertation deals with a pattern of variation which results from a historical change in progress in Korean. In an earlier stage of the language, there was a consistent process of vowel harmony which resulted in alternations between [a] and [ʌ] in verbal suffixes. In present day Korean, however, the use of suffix forms containing [ʌ] is often generalized to contexts that originally took [a]. I present results from a Google-driven corpus study, a judgment survey, a production experiment, and a spontaneous speech study showing that the likelihood of a disharmonic form is affected by three factors: the morphophonological class of the stem, the identity and position of the suffix, and the quality of the stem vowel. First, *p*-irregular stems generally take [ʌ]-suffix forms irrespective of the stem vowels. Second, a sentence-ending suffix *–a/ʌ*, frequently used in casual speech, is realized as [ʌ] even with stems containing /a/, while other harmonizing suffixes usually surface as [a]-forms in harmony with the stem vowel /a/. Third, of the two kinds of [RTR] stems (/a/-stems and /o/-stems), which originally triggered [a]-forms, /a/-stems are much more likely to allow the variation (Hong 2008).

The dissertation addresses the question of why these factors should be associated with the innovative forms. First, I argue that the extension of the [ʌ]-forms to a class of irregular stems reflects changes in the subgrammar of *p*-irregular stems. Second, I argue that the extension of the disharmonic form to a suffix in sentence-final position is due to the fact that this position imposes more stringent faithfulness requirements. Finally, I argue that the harmony is more likely to be maintained where it facilitates lexical retrieval of the stem. The fact that harmonic suffix forms are more likely to be used with stems containing the vowel [o] than the vowel [a] reflects Korean speakers' ability to correctly identify the two vowels. I present evidence that the perception of [a] is robust, while the perception of [o] is less accurate, arguing that /o/-stems may need harmonized suffixes to enhance their perceptibility (Kaun 1995).

Table of Contents

List of Figures

List of Tables

Acknowledgments

The most important thing I have learned in the Ph.D program is that there is no single player in research. So many people helped me to finish this dissertation. I'd like to thank all the people.

I thank my advisor and mentor, professor Ellen Broselow. She showed what the life of a scholar and teacher should be like. I thank her specifically for her patience and excellent guidance. I have to confess that this dissertation could not have been born to the world without her. I also thank the committee members, professor Christina Bethin, professor Marie Huffman, and Professor Yoonjung Kang. Their encouragement and challenge refined ideas in my dissertation. I thank professors in my department, professor Mark Aronoff, professor John Bailyn, professor Laura Casasanto, professor John Drury, professor Daniel Finer, professor Robert Hoberman, professor Richard Larson, and professor Lori Repetti. Their lectures and comments have always been inspiring and interesting. I thank professor Yangsoo Moon and Juwon Kim in Korea, who motivated and guided me to linguistics.

I thank Yu-an Lu, who has been my best colleague at Stony Brook. She helped me to the final. I have been happy to have Mark Linsay, Jisung Sun, Hisako Takahasi as my colleagues. I thank my senior students, Young-ran An, Andrei Antonenko, Susana Huidobro, Jiwon Hwang, Hyun-ju Kim, Katharian Schumann, Chih-hsiang Shu, and Yunju Suh. I have taken so many lectures with them, which gave me a lot of ideas and motivations. I thank Miran Kim for taking care of my kids and giving a lot of advice for my research.

My life in the US was a challenge to me because I had to live as a husband and daddy, as well as a student. I thank my parents and mother-in-law, who came to the US to take care of my kids. I thank my sons, Wongyu and Hyeonggyu, who are the meaning of my life. Lastly, I thank my wife Soonhui Choi, who is my best friend and supporter.

Hijo Kang

Chapter 1 Empirical and Theoretical Background

1.1 Introduction: diachronic change and synchronic variation in vowel harmony

This dissertation deals with a pattern of variation which results from a historical change in progress in Korean. In an earlier stage of the language, there was a consistent process of vowel harmony which resulted in alternations between [a] and [ʌ] in verbal suffixes. Stems containing ATR (advanced tongue root) vowels (/i/, /ɯ/, /u/, /e/, and /ʌ/) took the suffix vowel [ʌ], while stems containing RTR (retracted tongue root) vowels (/o/ and /a/) took the suffix vowel [a]. In present day Korean, however, the use of suffix forms containing [ʌ] is often generalized to contexts that originally took [a] (namely, stems containing /o/ and /a/). For example, even though [tɕap**a**] 'to catch-DECL', the harmonic form, is regarded as the standard form, both [tɕap**a**] and [tɕap**ʌ**] are used in Contemporary Korean, and [tɕap**ʌ**], the disharmonic form, is probably more common. Thus, the [a]~[ʌ] alternation in verbal suffixes is disappearing and the use of [ʌ]-forms is being extended to contexts that originally took [a]-forms. This change has been recognized by the revision of the prescriptive grammar in 1988.[1] For example, [komaw**a**] 'to thank-DECL' was the standard form before the revision, but it was replaced by [komaw**ʌ**].

Considering that [ʌ]-forms appear in a greater number of contexts due to the greater number of ATR vowels (five ATR vowels vs. two RTR vowels) and the irregularity of seemingly RTR stems,[2] the extension of [ʌ] to the environments where [a] is expected to appear is not very surprising. However, this extension does not occur across the board. Instead, the use of disharmonic forms is more likely in some contexts than in others. As a result, this ongoing historical change has given birth to 'patterned variation' (Hayes and Londe 2006; Hayes et al. 2009). This dissertation investigates the factors that affect the rate of the loss of this harmony process.

1.2 Vowel harmony in Contemporary Korean

Contemporary Korean has seven contrastive monophthongs as shown in Table 1. For the harmonic feature, I adopt [ATR] and [RTR] following J.-S. Lee (1992), Y.-S. Lee (1993), Cho

[1] The prescriptive grammar or the school grammar was enacted and revised by the Ministry of Education before the National Institute of the Korean Language (NIKL) was established in 1991. The prescriptive grammar was published by Daehan textbook publishers and is now found in the website of NIKL (http://www.korean.go.kr/09_new/dic/rule01.jsp).

[2] For example, stems containing *-ha-*, which is an extremely productive verbalizer, take [e]- or [jʌ]-forms (e.g., [ilhe] 'to work-DECL' and [ilha-jʌ] 'to work-CONN') though the last vowel is [a]. Based on type frequency (the frequency data by the National Institute of the Korean Language), only 10.1% of stems (1,006 stems out of 9,955) trigger [a]-forms.

(1994), J.-K. Kim (2000), C.-W. Chung (2000), Ahn (1998), and J.-W. Kim (1988, 2003). Other features such as [high] or [low] (Ahn 1985; Hur 1986; Moon 1974; Sohn 1987 among others) and [back] (K.-M. Lee 1968; S.-O. Lee 1984 among others) have been proposed. I do not adopt these features, above all, because they do not distinguish /o/ and /a/ from /u/ and /ʌ/. Also, it is a matter of dispute whether ATR and RTR are the opposite values of the same feature (i.e., [RTR]=[-ATR], Chomsky and Halle 1968) or two distinct features which involve "two opposing gestures on the same or related articulatory dimensions" (Steriade 1995: 149-52). These topics are beyond the scope of this dissertation.

Table 1. Vowel system in Contemporary Korean

	[ATR]		[RTR]	
[+hi], [-lo]	i	ɯ / u		
[-hi], [-lo]	e	ʌ		o
[-hi], [+lo]				a
	[-bk]	[+bk]	[-bk]	[+bk]

Five vowels behave as ATR vowels, which means that they take [ʌ]-forms of suffixes. The other two vowels (/o/ and /a/) generally take [a]-forms of suffixes.

In Contemporary Korean, the [a]~[ʌ] alternation in verbal suffixes is the only productive alternation that is related to vowel harmony. The stems of verbs and adjectives cannot appear by themselves, but must be combined with at least one verbal suffix. Verbal suffixes in Korean all begin with a consonant, [ɯ], or [a/ʌ]. Only *a*/ʌ-initial suffixes harmonize with stems. The choice of [a] vs. [ʌ] depends on the vowel in the preceding verbal stem:

(1) Trigger and target vowels in Korean verbal conjugation
   a. tɕ**o**p-**a** 'narrow-DECL'
   b. pitɕ**o**p-**a** 'cramped-DECL'
   c. tɕ**o**p-**a**sʌ 'narrow-because'
   d. tɕ**o**p-**a**s'-ʌ 'narrow-PAST-DECL'

In (1a) the vowel /o/ in *tɕop* 'narrow' triggers [a] in the declarative suffix rather than [ʌ]. (1b) shows that when a stem contains more than one vowel the trigger vowel is the last vowel. This is true no matter how long a stem may be. Harmony affects only the first vowel of the suffix, as (1c) shows. When two or more suffixes follow a stem, only the first suffix harmonizes with the stem vowel (1d).

However, vowel harmony is not consistent. As the two words in (2b) show, the two RTR stem vowels show different behaviors.

(2) ATR vowels vs. RTR vowels in Korean verbal conjugation

a. ATR stems

tɕ'**i**k-**ʌ**/*__a__ 'to vote-DECL'

p**e**-**ʌ**/*__a__ 'to cut-DECL'

k**ɯ**s-**ʌ**/*__a__ 'to draw-DECL'

tɕ**u**-**ʌ**/*__a__ 'to give-DECL'

m**ʌ**k-**ʌ**/*__a__ 'to eat-DECL'

b. RTR stems

tɕ**o**p-**a**/*__ʌ__ 'narrow-DECL'

tɕ**a**p-**a**/**ʌ** 'to catch-DECL'

Stems containing [a] as the trigger vowel (2bii) often surface with [ʌ] in the suffix, though [a] is still a possibility for the suffix form. However, stems containing /o/ (2bi) generally do not allow the disharmonic form (*[tɕopʌ]). This is the first factor affecting the likelihood of the extension of [ʌ]-forms to new contexts.

The second factor affecting the acceptance of [ʌ]-forms is the identity of the suffix. Not all suffixes are equally likely to surface with a disharmonic vowel. The National Institute of the Korean Language (NIKL) frequency data contain 16 harmonizing suffixes whose first segment alternates between [a] and [ʌ] depending on the trigger vowel of stem. With three rarely used suffixes excluded, thirteen harmonizing suffixes are listed in (3).

(3) Harmonizing suffixes (*a*- or *ʌ*- initial suffixes) in Contemporary Korean

a.	*-a/ʌ*	declarative, interrogative, or imperative (familiar)
b.	*-a/ʌ*	connective
c.	*-ataka/ʌtaka*	and
d.	*-ato/ʌto*	though, but
e.	*-ara/ʌra*	imperative
f.	*-asʌ/ʌsʌ*	because
g.	*-aja/ʌja*	should
h.	*-ajaman/ʌjaman*	only if, should
i.	*-ajatɕi/ʌjatɕi*	will, should
j.	*-ajatɕi/ʌjatɕi*	only if
k.	*-ajo/ʌjo*	declarative, interrogative, or imperative (honorific)
l.	*-as/ʌs'*	past
m.	*-as'ʌs'/ʌs'ʌs'*	used to

The thirteen harmonizing suffixes presented in (3) include three sentence enders (a familiar suffix *–a/ʌ*, an honorific suffix *-ajo/ʌjo*, and an imperative suffix *-ara/ʌra*) and two non-terminal suffixes (past tense marker *–as'/ʌs'* and past perfect tense marker *-as'ʌs'/ʌs'ʌs'*), which precede the sentence enders and denote tense, aspect, and/or mood. The other eight harmonizing

suffixes are all embedded-clause enders, which link a clause to a clause except for the connective suffix.[3]

The suffix in (3a), which I call the Sentence-Final Monosyllabic (SFM) suffix,[4] is the suffix that shows the greatest variation, being realized not only as [a] but also as [ʌ] even where it is expected to be [a] (generally, where it is preceded by /a/-stems). The SFM suffix serves two functions: to signal a particular level of politeness, and to mark the end of a sentence. The SFM suffix is used when the addressee is a friend, or someone who is younger than the addressor, and is used at the end of declarative, interrogative, and imperative sentences, which are distinguished by their intonation. In contrast to the SFM suffix, the other suffixes in (3) seem to follow the harmonic pattern in general, though disharmonic tokens are occasionally found.

As the term 'sentence-final monosyllabic' indicates, the SFM suffix is located in the sentence-final position as in (4a), in contrast to other harmonizing suffixes, which are followed by another word or clause, as shown in (4c) and (4d). Because the suffix consists only of a vowel, this vowel occurs in sentence-final position. As (4b) illustrates, the SFM suffix may follow another verbal suffix (e.g., tense marker). In this case, the suffix does not harmonize with the stem, as illustrated in (1d) above.

(4) Positions of the SFM suffix vs. other harmonizing suffixes

a.	kojaŋi-ka	tɕwi-rɯl	tɕap-**a/ʌ**.		
	cat-NOM	rat-ACC	catch-**SFM**		
	'A cat catches a rat.'				
b.	kojaŋi-ka	tɕwi-rɯl	tɕap-as'-**ʌ**.		
	cat-NOM	rat-ACC	catch-PAST-**SFM**		
	'A cat caught a rat.'				
c.	kojaŋi-ka	tɕwi-rɯl	tɕap-**a**	mʌk-ʌs'-ta.	
	cat-NOM	rat-ACC	catch-**CONN**	eat-PAST-DECL	
	'A cat caught and ate a rat.'				
d.	kojaŋi-ka	tɕwi-rɯl	tɕap-**asʌ**	tɕwi-ka	ʌps-ta.
	cat-NOM	rat-ACC	catch-**because**	rat-NOM	non_exist-DECL
	'Because the cat catches rats, there is no rat.'				

The third factor affecting the acceptance of disharmonic suffixes is the identity of the stem. One specific group of stems, called *p*-irregular stems, is more likely than other stems to surface with disharmonic [ʌ] suffixes. Let us compare *p*-irregular stems with regular stems that end with *p*.

[3] For the terms of suffix class, I consult H.-M. Sohn (1999). The connective suffix *-a/ʌ* is not classified in H.-M. Sohn (1999).

[4] From now on, I will use 'SFM' for the gloss of the suffix, rather than 'DECL' because (i) it is used in other types of sentences such as interrogative and imperative and (ii) it may cause confusion other declarative suffixes (e.g., *-ta* 'DECL').

(5) Conjugations of regular stems vs. *p*-irregular stems

		suffixes		
		-ko 'and'	*-ɯni* 'as'	*-a/ʌ* 'SFM'
a. Regular stems				
tɕap-	'to catch'	tɕapko	tɕapɯni	tɕapa/ʌ
p'op-	'to elect'	p'opko	p'opɯni	p'opa
tɕʌp-	'to fold'	tɕʌpko	tɕʌpɯni	tɕʌpʌ
b. *P*-irregular stems				
kak'ap-	'close, near'	kak'apko	kak'a**u**ni	kak'a**wʌ**
kwerop-	'painful'	kweropko	kwero**u**ni	kwero**wʌ**
mukʌp-	'heavy'	mukʌpko	mukʌ**u**ni	mukʌ**wʌ**

The *p*-irregular stems in (5b) are not different from those in (5a) when they are followed by consonant-initial suffixes (e.g., *-ko* 'and'). However, when they take vowel-initial suffixes, the stem-final consonant surfaces as [w] or [u]. For example, /kak'ap-ɯni/ 'close-as' is realized as [kak'a**u**ni],[5] while a regular stem /tɕap-ɯni/ 'to catch-as' surfaces as [tɕa**pɯ**ni] without change. When *p*-irregular stems take harmonizing suffixes, the stem final segment is realized as [w] intervocalically. Another difference is that the target vowel in the harmonizing suffix (here, the SFM suffix) is realized most frequently as [ʌ] irrespective of the trigger vowels in the *p*-irregular stems, while the suffix alternates depending on the trigger vowels in the regular stems. With *p*-irregular stems the [ʌ]-forms are regarded as standard. However, monosyllabic *p*-irregular stems containing /o/ trigger vowel are described as exceptions to this 'rule', for example, *top-* 'to help' → [towa], *[towʌ] and *kop-* 'beautiful' → [kowa], *[kowʌ]. It should be noted that the [ʌ]-form suffixes are not triggered by the glide [w] in the surface form. When the glide is derived from /o/, it does not trigger [ʌ]-forms, while it does when it is derived from /u/, as shown in (6).

(6) [w] triggers [a] or [ʌ] in suffixes depending on whether [w] is derived from /o/ or /u/.

a.	o-a/ʌ	'to come-SFM'	[wa], *[wʌ]
b.	po-a/ʌ	'to see-SFM'	[pwa], *[pwʌ]
c.	tu-a/ʌ	'to put-SFM'	[twʌ], *[twa]
d.	tɕu-a/ʌ	'to give-SFM'	[tɕwʌ], *[tɕwa]

So far we have seen that the extension of [ʌ] occurs in some environments in which [a] used to appear or still can appear. As a result, there is variation between harmonic and disharmonic[6] forms in Contemporary Korean. To summarize the patterns, disharmonic forms are found mainly in *p*-irregular stems (7a) or in the combinations of regular /a/-stems (7b) and the SFM suffix (7c).

[5] In the framework of derivational phonology, this is accounted for by the change of *p* between vowels (*p* → *w*) and the merger (*w* and *ɯ* → *u*).

[6] In this dissertation, 'disharmonic' means 'RTR-stem and ATR-suffix' (e.g., *tɕap-ʌ*), but not 'ATR-stem and RTR-suffix' (e.g., **tɕʌp-a*). The latter is not found in Contemporary Korean.

(7) Summary: factors favoring extension of ATR ([ʌ]) suffix
   a. The identity of stem: *p*-irregular stems are more likely than other stems to take [ʌ].
   b. The quality of stem vowel: /a/-stems are more likely than /o/-stems to take [ʌ].
   c. The identity of suffix: the SFM suffix is more likely than other harmonizing suffixes to surface as [ʌ].

The factors (7a) and (7b) were found to be significant in Hong's (2008) data. Using the Sejong Balanced Corpora of Spoken Korean,[7] he calculated the percentages of harmonic and disharmonic forms of [RTR] stems for regular and *p*-irregular stems, respectively. As shown in Table 2, /a/-stems appear with disharmonic suffixes (10.27%) as well as harmonic ones, while /o/-stems appear only with harmonic suffixes.

Table 2. Disharmonic and harmonic[8] forms after [RTR] 'regular' stems (Hong 2008:412)

Stem-final vowel	# of stems	# of disharmonic forms	# of harmonic forms	% of disharmonic forms	% of harmonic forms
a	102	1097	9582	**10.27**	**89.73**
o	41	0	1467	**0**	**100**

However, the numbers for *p*-irregular stems are very different. Disharmonic forms are much more frequent than harmonic forms, except for monosyllabic /o/-stems, as shown in Table 3. These numbers will be compared with the results of the experiments conducted for this dissertation.

Table 3. Disharmonic and harmonic forms after [RTR] '*p*-irregular' stems (Hong 2008:413)

Stem-final vowel		# of stems	# of disharmonic forms	# of harmonic forms	% of disharmonic forms	% of harmonic forms
a		10	229	31	**88.08**	**11.9**
o	σ=1	2	0	204	**0**	**100**
	σ>1	6	51	15	**77.27**	**22.73**

From the perspective of historical linguistics, the extension of ATR suffix forms with [ʌ] to stems containing RTR vowels indicates movement toward the loss of vowel harmony in Korean. I consider the historical context to understand why this is happening in Contemporary Korean.

1.3 Historical background

In this section, I introduce the development of the vowel system and the vowel harmony process since the 14th century, when Hangeul (the Korean writing system) was invented.[9] This

[7] The corpora were produced by the 21st Sejong Project Team and distributed by NIKL. The corpora contain 1,929,040 tokens, which are morphologically analyzed.
[8] [ə]-form and [a]-forms in the original
[9] Before Hangeul was invented, Chinese letters were borrowed to write the Korean language.

will show that vowel harmony was relatively robust and productive in Middle Korean, informing the direction of change and the status of vowel harmony in Contemporary Korean.

1.3.1 Vowel harmony in Middle Korean

The vowel system of Middle Korean was balanced with regard to the number of vowels in either harmony group. In contrast, as shown in the previous section, the vowel system in Contemporary Korean is not balanced in this respect. Researchers generally agree on the number of monophthongs in Middle Korean, though the quality of the vowels is a matter of dispute. The seven monophthongs were represented by ㅣ, ㅜ, ㅡ, ㅓ, ㅗ, ㆍ, and ㅏ. I use the IPA symbols /i/, /u/, /ɯ/, /ʌ/, /o/, /ə/, and /a/ to represent the vowels based on the current qualities of the vowels corresponding to these orthographic symbols, except for ㆍ, which does not exist in Contemporary Korean. According to *Hunminjeongeum Haerye*,[10] the vowels were divided into neutral (/i/), class A (/u/, /ɯ/, and /ʌ/), and class B (/o/, /ə/, and /a/) vowels.[11]

(8) Vowel classification in Middle Korean
   a. Class A (ATR vowels in Contemporary Korean): /u/ /ɯ/ /ʌ/
   b. Class B (RTR vowels in Contemporary Korean): /o/ /ə/ /a/
   c. Neutral: /i/

The class A and class B vowels made up three pairs of vowels ([u]~[o], [ɯ]~[ə], and [ʌ]~[a]), each of which was found in the alternations of suffixes (see (10)). The vowel system of (early) Middle Korean has been reconstructed as shown in (9a) and (9b), based on different interpretations of the features distinguishing the two classes of vowels:

(9) Reconstructed vowel systems of Middle Korean and Contemporary Korean
(Two vowels alternating in suffixes are paired in an oval.)

a. Lee (1972)

i	u	o
ʌ	ɯ	ə
	a	

b. Kim (1993)

i	ɯ	u
ʌ	ə	o
	a	

c. Contemporary Korean

i		ɯ u
e		o
	a	ʌ

Lee (1968) claims that the relevant harmonic feature is [back] in Middle Korean. In his vowel system, the vowels in class A are more front than those in class B. In contrast, Kim (2003) sees the harmonic feature as RTR (Retracted Tongue Root), with the vowels in class A both more front *and* higher than those in class B.

[10] This means "Explanations and Examples of the Correct/Proper Sounds for the Instruction of the People."

[11] These were represented in *Hunminjeongeum Haerye* as 舌不縮 'non-tongue-retracted', 舌小縮 'slightly-tongue-retracted', and 舌縮 '(fully-)tongue-retracted'.

Although in Contemporary Korean, vowel harmony is found only in the verbal conjugation,[12] vowel harmony was pervasive throughout the lexicon in Middle Korean. Harmony patterns were found in both nouns and verbs (excluding Sino-Korean words).

(10) Vowel harmony in Middle Korean (E.-J. Baek 1999: 112-13)[13]

a. Within words

kəməls	'drought'
tasəs	'five'
toskapi	'monster'

b. Nominal declension

sarəm-əl	'person-ACC'	sɯsɯ-ɯl	'teacher-ACC'
sarəm-əi	'person-GEN'	sɯsɯ-ɯi	'teacher-GEN'
sarəm-ən	'person-TOPIC'	sɯsɯ-nɯn	'teacher-TOPIC'

c. Verbal conjugation

na-a	'go out-CONN'	pʌs-ʌ	'take off-CONN'
məiŋkər-a	'make-CONN'	mʌk-ʌ	'eat-CONN'
ar-o	'tell-will'	ʌt-u	'take-will'
kərətɕʰi-o	'teach-will'	tɯri-u	'give-will'

The words in (10a) contain only /o/, /ə/, and /a/, which belong to class B. The counterparts of these words in Contemporary Korean are *kamul*, *tasʌs*, and *tok'epi*, which contain vowels from both classes. This shows that vowel harmony existed as a phonotactic constraint on stems in Middle Korean, while Contemporary Korean stems may be disharmonic. The alternation [ə]~[ɯ] in (10b) shows that nominal suffixes also changed their forms depending on the vowel quality of the preceding noun. In Contemporary Korean, the nominal suffixes have been regularized to [ɯ]-forms. In the verbal conjugation, the [a]~[ʌ] alternation is still found in Contemporary Korean but the [o]~[u] alternation is not. These examples show that the domain of vowel harmony has been reduced over the past centuries.

1.3.2 Changes in the vowel system

The breakdown in vowel harmony is related to diachronic changes in the vowel system. Three changes took place: (i) the loss of /ə/; (ii) the appearance of /e/; and (iii) the change of vowel

[12] Harmony patterns in Korean ideophones have been also studied by many researchers (Cho 1984; C.-W. Chung 2000; I.-H. Kim 1995; J.-S. Lee 1992; Y.-S. Lee 1993, among others). In Korean, some words representing sounds or manners have ATR-RTR pairs (e.g., *sukunsukun* & *sokonsokon* 'in whispers' and *tʌlkʰʌŋtʌlkʰʌŋ* & *talkʰaŋtalkʰaŋ* 'brattle' from Cho 1994). In general, ATR counterparts are perceived as 'heavy' or 'deep' while RTR ones as 'light' or 'bright'. This dissertation does not include ideophones for the following reasons: First, the harmony patterns in ideophones are different from those in verbal conjugation. For example, [i] and [ɯ] are neutral vowels in ideophones but ATR vowels in verbal conjugation (e.g., *tʌlk**ɯ**rʌk* & *talk**ɯ**rak* 'rattling' and *hʌp**i**tɛʌk* & *hap**i**tɛak* 'dig out with a fingernail'); Second, the vowel harmony in ideophones are not productive. That is to say, an ATR ideophone does not imply the existence of an RTR counterpart (e.g., *ultʰuŋpultʰuŋ* 'bumpy' does not imply the existence of **oltʰoŋpoltʰoŋ*).

[13] All the examples are from *Seokbosangjeol*, published in 1447.

quality, particularly of /ʌ/ (compare (9a) & (9b) with (9c) above). These are important with regard to vowel harmony because they broke the 'balance' and changed the 'characteristics' of vowel harmony.

The loss of /ə/ is assumed to have happened in the 18th century (K.-M. Lee 1972) or later (E.-J. Baek 1999). This vowel was replaced mainly by /a/ in word-initial position. This change was not problematic for vowel harmony because /ə/ and /a/ belonged to the same class. However, in non-initial position /ə/ changed to /ɯ/. This change resulted in words which had originally contained only class B vowels becoming disharmonic. Also, the loss of /ə/ was followed by the loss of the [ɯ]~[ə] alternation in nominal suffixes (see 10b).

The appearance of /e/ also played a role in changing the balance. The mid front vowel is represented by two symbols ㅔ and ㅖ in the Korean writing system. These two symbols are assumed to have represented two diphthongs (/əj/ and /aj/) in Middle Korean. Then the two vowels are assumed to have monophthongized into /e/ and /ɛ/. According to the phonetic studies of Korean vowels (I.-J. Chung 1997; Silva and Jin 2008), the two vowels seem to have merged recently, although older Korean speakers have been reported to distinguish the two vowels in their productions (Yang 1996). Though the two mid front vowels (/e/ and /ɛ/) behaved differently in terms of vowel harmony before the merger, now /e/, the only mid front vowel, behaves only as an ATR vowel. This is assumed to have accelerated the inclination toward the ATR series.

Lastly, change in the vowel quality of /ʌ/ is assumed to have played a role in the loss of the phonetic grounding of vowel harmony. Regardless of whether the harmonic feature was [back] or [RTR], vowels in class A are assumed to have been more front than their counterparts in class B in Middle Korean. However, in Contemporary Korean, /ʌ/ (which belonged to class A) became farther back than /a/. As a result, it became hard to find a single harmonic feature which would distinguish vowels in class A from those in class B.

Another factor leading to the breakdown of vowel harmony was the influx of Sino-Korean words over several centuries (E.-J. Baek 1999; Han 1996, among others).[14] As Sino-Korean words are composed of monosyllabic morphemes, they do not follow harmony patterns and the pronunciations of Sino-Korean words were not adjusted to fit the harmony pattern in

[14] There are two types of Sino-Korean words. Some Sino-Korean words were borrowed from China and others were made up of (already-borrowed) Chinese letters in Korean. Neither type follows the harmony patterns of Korean. Sino-Korean words are found even in the literature of the Silla dynasty (B.C. 57 ~ A.D. 935, Park 1995) and they took a considerable proportion of the Korean lexicon in Middle Korean (18.7% to 31.5%, M.-S. Kim 2007). In nominal declension, the last vowel of Sino-Korean words worked as a trigger vowel (E.-J.Baek 1999:117). For example, in *t'aŋs'ju-nɯn* 'longevity-TOP' and *tɕʰʌnrjaŋ-əl* 'thousand-ACC', each noun has two vowels belonging to different series and the nominal suffixes harmonize with the last vowels of the preceding nouns.

Middle Korean. Furthermore, even pure Korean words did not always obey vowel harmony. Even though vowel harmony was very productive both in the lexicon and in morphological processes, the literature of the 15th century shows that it was not exceptionless.

(11) Exceptions to vowel harmony in Middle Korean (E.-J. Baek 1999: 115)

	observed	expected	gloss
a.	*mʌri-rəl*	(*mʌri-rɯl*)	'head-ACC'
b.	*mjʌnɯri-rəl*	(*mjʌnɯri-rɯl*)	'daughter_in_law-ACC'
c.	*nʌhɯi-rəl*	(*nʌhɯi-rɯl*)	'you(PL)-ACC'

In the three nouns above, the last vowel /i/, which is a neutral vowel, is preceded by class A vowels, so if vowel harmony applies, the accusative marker should be [rɯl]. However, the 'illegal' form [rəl] is found instead. This pattern, in which a class A stem vowel is followed by a class B suffix vowel, is the 'typical' exceptional pattern in Middle Korean (let us call this 'old' disharmonic form).[15] Interestingly, the pattern is the opposite of the disharmonic forms in Contemporary Korean, where the Contemporary Korean ATR (Class A) alternate [ʌ] appears when [a] is expected.

Han (1994, 1996) investigates how the patterns of exceptions to vowel harmony changed from the early 15th century to the late 16th century, focusing on the nominal declension. During this period, both the earlier type of disharmonic form (i.e., extension of RTR suffixes to ATR stems), as in Figure 1, and the current disharmonic forms (i.e., extension of ATR suffixes to RTR stems) are found. By and large, the overuse of ATR suffixes (i.e., [ɯ]-forms) increased during this period, while the overuse of RTR suffixes (i.e., [ə]-forms) fluctuated.

[15] This pattern was reported to appear in certain dialects in Contemporary Korean (e.g., *p*-irregular stems in Jangheung dialect, H.-S. Kang 1996).

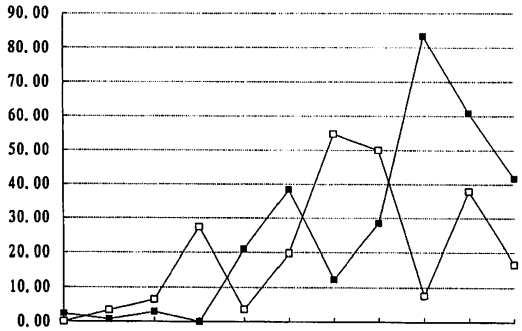
Figure 1. Percentages of exceptional patterns of nominal suffixes during the 15th and 16th centuries (Han 1994: 144-54)

-■-: extension of ATR suffixes ([ɯ]-forms, current disharmonic forms)

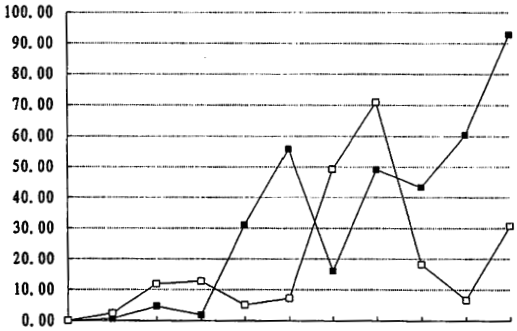
-□-: extension of RTR suffixes ([ə]-forms, old disharmonic forms)

x-axis: time from the early 15th century to the late 16th century[16]

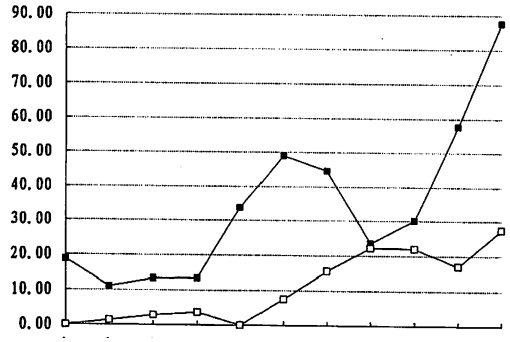
a. Topic marker (*ən ~ ɯn*)



b. Accusative marker (*əl ~ ɯl*)



c. Genitive marker (*əj ~ ɯj*)



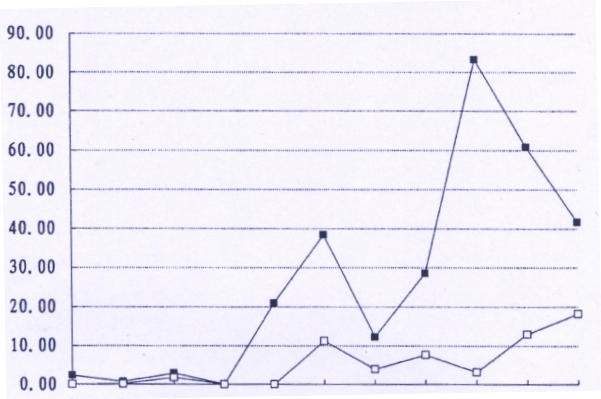
These figures show that (i) the breakdown of vowel harmony in the nominal declension already had begun in the 15th century or earlier; and (ii) disharmonic forms prevailed in nominal declension in the 16th century. In particular, [ɯ]-forms continuously increased until the regularization to [ɯ]-forms was completed after the 16th century. This shows that the disharmonic forms of nominal suffixes has gradually increased and suggests what vowel harmony in the verbal conjugation will be like in the future. In contrast, vowel harmony in the verbal conjugation was relatively robust in the 15 and 16 centuries. Figure 2 shows that the proportion of disharmonic forms of the topic marker (*ən ~ ɯn*, nominal declension) was almost always higher than that of disharmonic forms of the adjectival suffix (*ən ~ ɯn*, verbal conjugation), though the use of both consistently increased during this period.

[16] In his study, he classified the literature published in the 15th and 16th centuries into eleven groups depending on the time when each book published. The average interval is 20 years but the intervals are not regular.

Figure 2. Comparison of the proportions of exceptional patterns of nominal and verbal suffixes during the 15th and 16th centuries (Han 1994: 147)

-▉-: extension of ATR suffixes ([ɯ]-forms) in topic marker

-□-: extension of ATR suffixes ([ɯ]-forms) in adjectival suffix



In summary, in the 15th century, the vowel system was relatively balanced between ATR and RTR vowels and vowel harmony was robust and productive, though both types of disharmonic forms (ATR-RTR and RTR-ATR) were found. But the vowel system changed and many alternations in suffixes have disappeared. As a result, the only surviving vowel harmony process is the [a]~[ʌ] alternation in verbal suffixes, and this process is not fully productive. These facts all show that vowel harmony is disappearing in Korean, and should be taken into account in explaining the patterns of present-day variation in verbal suffixes.

1.4 Motivation for vowel harmony

The variation in Korean vowel harmony provides dynamic data that show which patterns are dying out soonest and which are surviving longest in the domain of vowel harmony. In the Korean case, vowel harmony appears to be still 'alive' with /o/-stems while vowel harmony is 'dying' in /a/-stems. Why are /o/-stems more likely to trigger harmony than /a/-stems? This section presents a perception-based approach to the motivation for vowel harmony.[17]

According to the perception-based approach, vowel harmony is highly motivated when the trigger vowel (or the harmonic feature in the trigger vowel) is perceptually weak. Kaun (1995) elaborates Suomi's (1983) proposal that "harmony is a means to facilitate the perception of weak vowels in positions lacking prominence by rendering the occurrence of such vowels predictable." Based on the investigation of the typology of rounding harmony, mainly in the

[17] In this section (and also, in the dissertation), I focus on the perception-based approach to vowel harmony because the articulation-based approach (Lindblom 1983; Ohala 1994), which sees vowel harmony as the phonologized vowel-to-vowel coarticulation that is motivated by articulatory economy, predicts that /a/ will be the stronger trigger than /o/ in Korean, which is the opposite to what is observed.

Altaic language family, Kaun reaches the generalization that (i) rounding harmony is favored when the trigger and target agree in height; and (ii) if the trigger and target do not agree in height, rounding harmony is favored when the target is high and/or when the trigger is non-high. Yakut, a Northern Turkic language spoken mainly in Yakutia in the Russian Federation, exemplifies generalization (ii) by showing that when the target (suffix) vowel is high, rounding harmony applies irrespective of the height of the trigger (stem) vowel (12a and b), but when the target vowel is not high, rounding harmony applies only with rounded non-high trigger vowels (12c, d, and e).

(12) Yakut vowel harmony (Kaun 1995: 22, 23)

a. High vowel suffixes with unrounded root vowels

aɣa-nɨ	'father-ACC'
pa:rta-nɨ	'desk-ACC'
kinige-ni	'book-PL'
kihi-li:n	'man-SOC'

b. High vowel suffixes with rounded root vowels

oɣo-nu	'child-ACC'
oɣo-lu:n	'child-SOC'
börö-nü	'wolf-ACC'
kötör-dün	'bird-SOC'

c. Non-high vowel suffixes with unrounded root vowels

aɣa-lar	'horse-PL'
aɣa-ɣa	'father-DAT'
et-ter	'meat-PL'
kini-ler	'he-PL'

d. Non-high vowel suffixes with rounded non-high root vowels

öttöχ-tor	'farm-PL'
börö-ttön	'wolf-ABL'

e. Non-high vowel suffixes with rounded high root vowels

tünnük-ter	'window-PL'
tobuk-ka	'knee-DAT'

Supported by acoustic and perceptual studies of round vowels (Linker 1982; Terbeek 1977), Kaun argues that the degree of rounding is greater in high vowels than in non-high vowels. Therefore, she concludes, the feature [round] in a non-high trigger vowel is extended to a high target vowel, where the feature is salient, in order to enhance the perceptibility of the trigger vowel's [round] feature.

Walker (2005) provides another piece of evidence for the perception-based account of vowel harmony. In Veneto Italian, only high vowels trigger vowel harmony and the target of the [+high] feature is a preceding stressed vowel. High vowels are intrinsically weak in terms of duration (and amplitude) so they raise their perceptibility by spreading the [+high] feature to a stressed vowel, which is the most prominent vowel in a word. This is another case where vowel

harmony is a means to enhance the perceptibility of the triggering element (Kaun 1995: 73) by spreading the harmonic feature over some domain.

Assuming that vowel harmony is highly motivated when the trigger vowel (or the harmonic feature in the trigger vowel) is perceptually weak, and that functionally motivated processes are less susceptible to change (cf. teleological mechanism in language change, McMahon 1994, Croft 2000), the last trigger to survive in a decaying vowel harmony process should be the perceptually weakest vowel. I will show this prediction is correct in the Korean case.

1.5 Factors to investigate

So far we have seen what has been observed in terms of Korean vowel harmony in verbal conjugation and what has been proposed for vowel harmony in general. These observations and proposals provide empirical and theoretical grounding for the hypotheses which will be tested by a series of experiments presented in the following chapters. First, three hypotheses based on observation need to be confirmed by experiments.

(13) Hypotheses based on observation and the previous studies

a. Stem vowel quality: Stems with trigger vowel /a/ are more likely to appear with either *a*-initial or ʌ-initial suffix forms while those with /o/ will only appear with *a*-initial suffix forms (Hong 2008)
b. Suffix type: The SFM (Sentence-Final Monosyllabic) suffixes are more likely than other suffixes to appear as either *a*-initial or ʌ-initial forms.
c. Regularity of stem: *P*-irregular stems are more likely to appear with ʌ-initial suffix forms than other stems (Hong 2008).

In addition, I consider several other linguistic factors. The first of these is stem length. Stem length is an important factor in vowel harmony in Hungarian (Hayes and Londe 2006; Ürögdi 2000) and Finnish (Ringen and Heinämäki 1999), where harmony is less likely as the distance between the target vowel and the trigger vowel increases. In both languages, the likelihood of harmony is directly related to the number of neutral vowels which intervene between trigger and target vowels. From the perspective of perception, longer stems are more likely to be identified easily because they will have fewer neighbors than shorter stems, in general. I investigate whether stem length is a factor in Korean vowel harmony. An additional linguistic factor to be investigated is morphological relatedness - whether stems that share a root show similar patterns in terms of harmony (Benua 1997, 2004).

In addition to linguistic factors, I also investigate sociolinguistic factors of age, gender, and dialect. Since the variation is assumed to reflect an ongoing historical change, the ATR suffix forms ([ʌ]-forms) are expected to extend to more environments in younger speakers than in older speakers. Gender is also considered, following the general findings in sociolinguistic studies. Labov (1990: 205-06) has argued that in stable sociolinguistic situations, men use a higher frequency of nonstandard forms than women, but that in most cases of linguistic

change, women tend to use innovative forms with higher frequency than men do. If the extended [ʌ]-form is regarded as an incoming form, women are expected to accept [ʌ]-forms in more environments than men. Furthermore, because the previous literature shows that the vowel harmony in verbal conjugation varies from dialect to dialect (H.-S. Kang 1996 for Jeonnam dialect; Ko 1997 for Jeju dialect; J.-H. Park 2003 and So 1988 for Jeonbuk dialect),[18] dialect is also included as a potential factor.

Another factor that has been shown to be relevant to sound change, the frequency of existing forms, is also investigated. Bybee (2001a) argues that, as a result of repetition, high frequency accelerates articulatorily motivated changes, which enable the quick articulation of the item. In contrast, for morphosyntactic changes, high frequency helps words to resist the change.[19] Considering that Korean vowel harmony is a morphophonological process, high-frequency stems are expected to be less likely to accept the extension of [ʌ]-forms.

Finally, I compare Korean speakers' behavior with respect to existing words vs. nonce forms. Hayes and Londe (2006) and Hayes et al. (2009) show that the aforementioned variation in Hungarian vowel harmony can be modeled with a stochastic grammar which accounts for Hungarian speakers' production of both real and nonce words. They argue that the stochastic grammar is acquired even though it includes seemingly unnatural constraints; however, the unnatural constraints were relatively underlearned compared to natural constraints. Following their argument, I test whether the same linguistic factors affect the likelihood of vowel harmony in nonce stems as in real stems.

The remainder of this dissertation is organized as follows. Chapter 2 introduces a Google-driven corpus study and a judgment survey to show which factors actually affect the likelihood of disharmonic forms in Korean verbal conjugation. Chapter 3 reports on a production experiment and a spontaneous speech study which were used to test same factors in production data. In Chapter 4, the perception-based account of vowel harmony is tested in the perception experiment. In these three chapters, the synchronic patterns made by the significant linguistic factors (*p*-irregularity, the SFM suffix, and the stem vowel) are analyzed briefly. In Chapter 5, I introduce alternative accounts of the factors. In addition I discuss other linguistic factors and sociolinguistic factors, and the role of frequency in historical change. The

[18] These studies are done with speakers over age 60 except for Ko 1997, which includes younger speakers as well as older ones.

[19] An examples of change motivated by articulatory considerations offered by Bybee is the loss of 'syllabicity of unstressed schwa + resonant' in American English, where the middle syllable tends to lose its syllabicity in high frequency words like *every*, *camera*, *memory*, and *family* but to be maintained in low frequency words like *mammary*, *artillery*, and *homily*. For an example of the resistance of high frequency words to morphosyntactic change, she mentions the English past tense formation in verbs, where low-frequency verbs (e.g., *dreamt* > *dreamed*) have been regularized while high-frequency verbs (e.g., *came*) still resist the regularization.

dissertation concludes with implications for the typology of vowel harmony and the relation between synchrony and diachrony in phonology.

Chapter 2 Google-driven Corpus Study and Judgment Survey

2.1 Introduction

This chapter investigates the variation between harmonizing and non-harmonizing vowels in Korean verbal conjugation suffixes using two methods: (i) a Google-driven corpus study; and (ii) a judgment survey in which participants were asked to rate the acceptability of forms containing harmonic and disharmonic suffixes. The goal of these studies was to determine which factors correlated with speakers' use of and preference for harmonic vs. disharmonic forms.

Based on the results of these studies, I argue that the variation in suffix vowels is not random, but instead is 'patterned' (Hayes and Londe 2006). Specifically, three factors are found to affect the choice of harmonic vs. disharmonic forms: disharmonic forms were mainly found when the trigger vowel in the stem was /a/ and the suffix was *–a*/ʌ 'SFM', called the sentence-final monosyllabic[20] suffix. In addition, disharmonic forms were strongly preferred with the class of stems called *p*-irregular stems irrespective of the trigger vowels in stems and the identity of the following suffixes. In contrast, the length and the frequency of the stem were not found to be significant. The judgment survey revealed that younger speakers were more likely to accept disharmonic forms than older speakers and that speakers who came to the US earlier in their lives and/or had been in residence longer (for more than six years) were more likely to accept disharmonic forms. The results of the Google-driven corpus study are presented in section 2.2; section 2.3 presents the results of the judgment survey. Section 2.4 provides a discussion of the findings.

2.2 Google-driven corpus study

While 'Googling' has been recognized as an effective method in phonological variation studies (Berkson 2010; Hayes and Londe 2006; Hayes et al. 2009; Shaw and Balusu 2010, among others), this method is not without problems, chiefly the fact that there is no effective way to filter out homonyms (e.g., *galla*, which can mean either 'to split-SFM' or 'gala') or to distinguish morphemes from identical sequences which are found inside larger morphemes (e.g., *malla* 'to dry-SFM' vs. *mallaria* 'malaria'). However, a Google search can provide a basic idea of the frequency of occurrence of different forms. The Google study was designed to investigate the following hypotheses:

[20] As discussed in Chapter 1, the function of this suffix is twofold. First, the suffix ends a sentence. Second, the suffix determines the level of politeness and is used in casual speech, for example, between friends. For discussion of this suffix, see section 1.2.

(14) Hypotheses tested in the Google-driven corpus study

a. Stem vowel quality: Stems with trigger vowel /a/ are more likely to appear with either *a*-initial or ʌ-initial suffix forms while those with /o/ will only appear with *a*-initial suffix forms.
b. Regularity of stem: *P*-irregular stems are more likely to appear with ʌ-initial suffix forms than other stems.

2.2.1 Method

Selection of the stems for the Google search began with the frequency data created by the National Institute of the Korean Language (NIKL). Of the 13,639 verbal stems (10,918 verbs and 2,721 adjectives), stems longer than three syllables (3,672 stems) were excluded because they only have low frequencies. Vowel-ending stems were excluded because no variation was observed in them. Of these consonant-ending shorter stems, 154 contained trigger vowel /o/ and 541 contained trigger vowel /a/[21] (where the trigger vowel is in general the last vowel of the stem). In the selection of stems, the first criterion was that the conjugated form with the SFM suffix ([a] or [ʌ]) should not have homonyms.[22] After the stems with homonym problems were excluded, the target stems were selected considering the potential factors of trigger vowel (/a/ vs./o/), regularity (*p*-irregular vs. regular), and stem length. As there are a very small number of *p*-irregular stems in verbs, all 24 *p*-irregular stems were selected in adjectives, considering the trigger vowel (/o/ vs. /a/) and stem length (monosyllabic vs. bisyllabic). Of the regular verbs and adjectives, 60 verbal stems and 29 adjectival stems were selected with the same factors (trigger vowel and stem length) considered. In addition, 10 /u/-stems and 10 /ʌ/-stems, which were not expected to show variation, were selected as a control set. In the course of the search, 12 stems (8 verbs and 4 adjectives) turned up unexpected homonym problems and were discarded.[23] As a result, 101 stems were used for the Google-driven corpus study, as shown in (15). The list of all the stimuli is in Appendix I.

(15) Distribution of tokens with regard to category, regularity, trigger vowel, and stem length

Targets			
Category	Regularity	Trigger vowel	Stem length
52 verbs	52 regulars	21 /o/-stems	8 monosyllabic
			8 bisyllabic
			5 trisyllabic
		31 /a/-stems	8 monosyllabic
			14 bisyllabic
			9 trisyllabic
49 adjectives	25 regulars	8 /o/-stems	3 monosyllabic

[21] This does not include stems derived from *–ha-*, which attaches to a noun to make a verb or an adjective, because *-ha-* verbs are irregular in that (i) [j] is inserted between the trigger vowel and the target vowel and (ii) not [a], but [ʌ] is always selected. E.g. /koŋpuha-a/ʌ/ 'to study-CONN' → [koŋpuha**jʌ**]

[22] For example, a disharmonic form of *tɕap-* 'to catch' is *tɕapʌ*, which means '(various) small fish' as a noun.

[23] Most of the unexpected homonyms were foreign words that were used as proper nouns. e.g. *olla* 'to rise-SFM' and *olla* (names for restaurants, Spanish language institutes, and so on).

			3 bisyllabic
			2 trisyllabic
		17 /a/-stems	6 monosyllabic
			5 bisyllabic
			6 trisyllabic
	24 *p*-irregulars	12 /o/-stems	5 bisyllabic
			7 trisyllabic
		12 /a/-stems	7 bisyllabic
			5 trisyllabic
Controls			
Category	Regularity	Trigger vowel	Stem length
10 verbs	10 regulars	6 /u/-stems	2 monosyllabic
			2 bisyllabic
			2 trisyllabic
		4 /ʌ/-stems	1 monosyllabic
			2 bisyllabic
			1 trisyllabic
10 adjectives	10 regulars	4 /u/-stems	2 monosyllabic
			2 bisyllabic
		6 /ʌ/-stems	2 monosyllabic
			2 bisyllabic
			2 trisyllabic

Each stem was searched in two different forms.[24] First, each stem plus the harmonic vowel ([a] for [RTR] stems or [ʌ] for [ATR] stems) was searched. This returned the total number of harmonic forms of a stem+suffix, including not only stem+SFM, but stem+other harmonizing suffixes as well (e.g., [pata] for *pat-* 'to receive' is found in *pat-a* 'to receive-SFM', *pat-asʌ* 'to receive-because', *pat-ato* 'to receive-though', and so on). The number was reported as 'total-harmonic'. Likewise, the combination of each stem plus disharmonic vowel ([ʌ] for [RTR] stems or [a] for [ATR] stems) was searched, resulting in a 'total-disharmonic' number. These two numbers gave birth to the overall proportion of disharmonic forms of each stem in the Google-driven corpus, which was used to test the effects of trigger vowel and *p*-irregularity.

The Google hits were arranged in a Microsoft Excel file and then the proportions of disharmonic forms were calculated. The next step was to transfer the proportions to their logarithmic values, which were subjected to correlation tests with the factors of regularity, trigger vowel, and stem length. In order to find the effect of frequency, two sets of frequency data were subjected to regression tests with the logarithmic values of disharmonic proportions: the frequency data from the NIKL and the frequency data from the Google search (the sum of total harmonic and disharmonic hits). The frequency data were also used after being transformed to logarithmic values. Table 4 shows part of the data arranged in an Excel file.

[24] The quotation mark ("") was applied to get the number of exact matches.

Table 4. Data subjected to statistical analysis

stem	gloss	vowel	length	Irreg.	NIKL	Cat.	sum	log(sum)
olm-	to move	1	1	1	6	1	1650627	6.2176
kolm-	to fester	1	1	1	5	1	1260623	6.1006
sok'-	to weed out	1	1	1	7	1	2422000	6.3842
tot-	to rise	1	1	1	22	1	11308850	7.0534
sos-	to rise up	1	1	1	63	1	25100840	7.3997

total-har	total-dis	total-pro	log(total-pro)
1650000	627	0.0003798	-3.4204
1260000	623	0.0004942	-3.3061
2420000	2000	0.0008257	-3.0831
11300000	8850	0.0007825	-3.1065
25100000	840	0.0000334	-4.4754

Correlation tests were performed to test the effect of stem vowel quality and *p*-irregularity. I did not test both factors on the complete set of data because the effect *p*-irregular stems was so great that it masked the effect of stem vowel quality. For this reason, *p*-irregular stems were taken out in the test of stem vowel quality. The following section presents the results.

2.2.2 Results

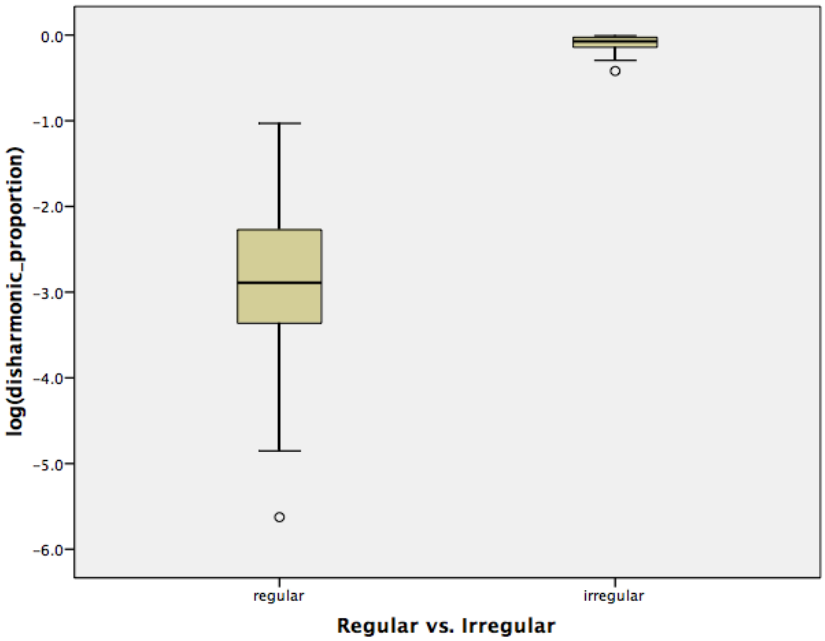
As Table 5 shows below, the overall percentage of disharmonic forms was very low in regular stems, while it was very high in *p*-irregular stems, consistent with Hypothesis (14b). In terms of trigger vowel, the percentage of disharmonic suffixes was higher with /a/-stems than /o/-stems, whether the stem was regular or *p*-irregular, as predicted by Hypothesis (14a). In fact, the percentage of disharmonic suffixes was even lower with /o/-stems than control stems (/u/- or /ʌ/-stems), which are generally assumed not to allow variation. Compared to the results in Hong (2008), who calculated the percentages of harmonic vs. disharmonic forms using Sejong Balanced Corpora of Spoken Korean, the results for *p*-irregular stems are very similar. However, for regular /a/-stems, the percentage of disharmonic forms is much lower here than in Hong's results, which suggests that the change is slower in written Korean than in spoken Korean, presumably due to the effect of prescriptive grammar. With the overall picture in mind, let us consider the statistical results for each factor.

Table 5. The average percentages of disharmonic forms in two studies

	regular		*p*-irregular		control
	/o/	/a/	/o/	/a/	/u/ or /ʌ/
Google-driven corpus (% disharmonic)	0.09	1.27	71.30	87.82	0.12
Hong (2008, % disharmonic)	0	10.27	77.27	88.08	N/A

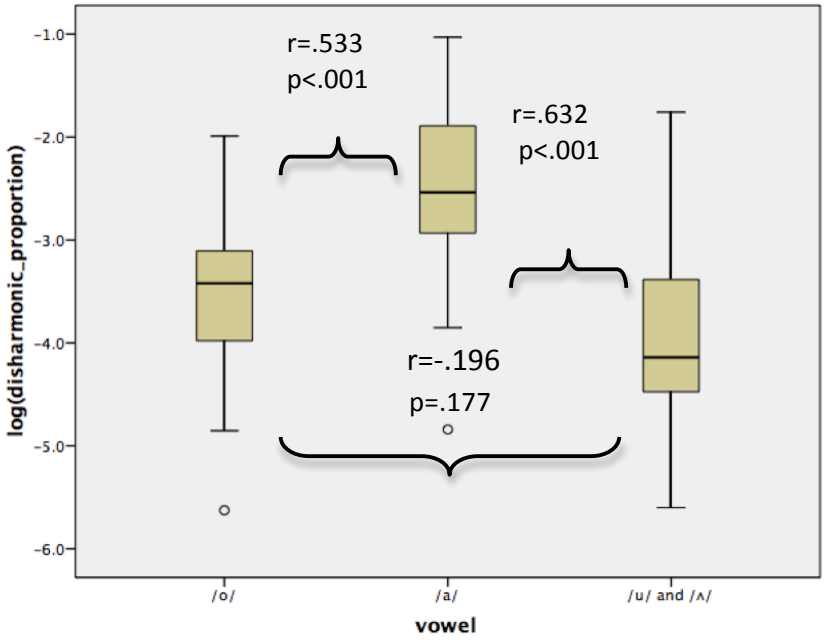
The biggest effect was found in the comparison of regular vs. *p*-irregular stems（r =.818, p <.001, n =101). Figure 3 demonstrates that the percentage of disharmonic forms was overwhelmingly high in *p*-irregular stems, but not in regular stems. This shows that *p*-irregular stems rarely follow the harmony patterns in verbal conjugation but that other stems generally do, with a broad distribution of variation.

Figure 3. Logarithmic values of disharmonic proportions for regular vs. *p*-irregular stems in the Google-driven corpus



After excluding *p*-irregular forms, the effect of stem vowel quality was considered. The comparisons within each pair (i.e., /o/ vs. /a/, /o/ vs. /u/ & /ʌ/, and /a/ vs. /u/ & /ʌ/) revealed that /a/-stems were significantly different from the others (the average values were -3.58 (/o/-stems, SD=0.78) vs. -2.45(/a/-stems, SD=0.78) vs. -3.93(/u/- and /ʌ/-stems, SD=0.96)). As Figure 4 shows, stems whose trigger vowel is /a/ appeared with disharmonic suffixes more often than the other two groups, which were not different from each other. This demonstrates that the disharmonic forms of /a/-stems were not brought about by mistakes such as typos, but instead reflected actual linguistic tendencies. In contrast, the disharmonic forms of the other stems do not seem to be due to systematic variation.

Figure 4. Logarithmic values of disharmonic proportions for /o/-stems vs. /a/-stems vs. /u/- & /ʌ/-stems in the Google-driven corpus



Among /a/-stems, stem length (*r* =-.016, *p* =.911, n =48) and stem frequency (*r* =.021, *p* =.886, n =48) did not affect the proportion of disharmonic forms. The logarithmic values of disharmonic proportions were subjected to regression tests with two types of stem frequency (the logarithmic values of 'number of occurrence' in the NIKL frequency data and the logarithmic values of total hits for each stem in the Google-driven corpus), yielding no significant relationships ($F(1,46)=0.116$, $p=.735$ for NIKL data and $F(1,46)=0.013$, $p=.887$ for Google hits).

In summary, *p*-irregular stems were inclined to take disharmonic (or regularized) forms. For regular stems, harmonic forms were still dominant. Within the regular stems, only stems containing /a/ showed a meaningful amount of variation. Even though the proportion of disharmonic forms was very small (1.27%), it was significantly higher than that of /o/-stems (0.09%), which was not different from that of the non-variant [ATR] stems (0.08%, /u/-stems and /ʌ/-stems). Other factors (stem length, stem frequency) did not make a significant difference. Though the predictions of the two hypotheses in (14) were borne out by the statistically different results, it should be noted that the percentage of disharmonic forms was very low (e.g., 1.27% for regular /a/-stems), which appeared different from my observation.

Although the Google hits provided a large set of data, they did not allow us to look into the data in detail. For example, I was not able to test the effect of the SFM suffix because there was no way to distinguish this suffix from others in the Google-driven corpus. In addition, the Google hits are based only on written data, which might be strongly affected by prescriptive

grammar. Therefore, an elaborated judgment survey was done to control for speaker background and to investigate not only the use of disharmonic forms but also the degree of acceptability of these forms. The results of this survey are presented in the next section.

2.3 Judgment survey

This survey was conducted to look for patterned variation in Korean speakers' judgment on the conjugated forms of verbal stems. The participants were requested to evaluate the acceptability of the harmonic vs. disharmonic forms of various combinations of stem plus suffix, selected to test the same factors already tested in the Google-driven corpus study (*p*-irregularity and the quality of stem vowel) as well as additional factors such as the identity of the suffix, stem length, and the frequency of the stem.

As mentioned in Chapter 1, the extension of [ʌ]-forms does not seem to take place in all the harmonizing suffixes. Most disharmonic forms belong to the sentence-ender (SFM), which alternates between [a] and [ʌ]. Morphosyntactically, there are three types of verbal suffixes in Korean: sentence-ender, embedded-clause ender, and non-terminal suffix. The sentence-enders are located at the end of sentence, playing these two roles: (i) to indicate the type of sentence (declarative, interrogative, imperative, and so on); (ii) to indicate the level of politeness relative to the addressee.

(16) Sentence enders in Korean categorized by level of politeness and type of sentence

		sentence type		
	level of politeness	declarative	interrogative	imperative
least polite	1	*-ta*	*-nja*	*-ara/ʌra*
↕	2	*-ne*	*-nka*	*-ke*
	3	*-a/ʌ*	*-a/ʌ*	*-a/ʌ*
	4	*-ajo/ʌjo*	*-ajo/ʌjo*	*-ajo/ʌjo*
	5	*-o*	*-o*	*-o*
most polite	6	*-pnita*	*-pnik'a*	*-psio*

As discussed in Chapter 1, the suffix in question, which I call the SFM (sentence-final monosyllabic) suffix, is used at the ends of sentences in casual speech. As a result, it is one of the most frequently used verbal suffixes.[25] The judgment survey tested the effect of the identity of suffix by comparing the SFM suffix and two embedded-clause enders.

Another factor is stem length. Assuming that vowel harmony is motivated by the weak perceptibility of the triggering element (Kaun 1995), trisyllabic stems are expected to be less likely to trigger vowel harmony than monosyllabic stems. Longer stems are relatively easy to identify, due to plentiful phonological information and their low neighborhood density. This may result in the loss of harmony.

[25] In the frequency data of NIKL, it is ranked at the third out of all the verbal suffixes based on frequency in the 'spoken' category.

Lastly, frequency was added as a potential factor, following Bybee's (2001a) argument that low frequency words are more subject to morphosyntactic changes. The following three hypotheses, as well as the two hypotheses in (14), were tested in the survey.

(17) Additional hypotheses tested in the judgment survey

a. Suffix type: The SFM (Sentence-Final Monosyllabic) suffixes appear as either *a*-initial or ʌ-initial forms with /a/-stems, while other suffixes appear only as *a*-initial forms with /a/-stems.
b. Stem length: Longer RTR-stems are more likely to take ʌ-initial suffix forms than shorter RTR-stems.
c. Frequency of stem: Low frequency RTR-stems are more likely to take ʌ-initial suffix forms than high frequency RTR-stems.

This survey was designed to test not only the linguistic factors, but the sociolinguistic factors that have been shown to play a role in other cases of language change.

2.3.1 Participants

47 Korean speakers, Stony Brook University students or members of their families, voluntarily participated in the experiment. The following demographic factors were considered in the analysis:

Age (year of birth) – Because the emergence of disharmonic forms reflects a change that is in progress, it is reasonable to expect that age would be an important factor, with younger speakers more likely to accept disharmonic forms than older speakers. However, as the survey was done in the US, it was hard to get a wide age range of Korean speakers.[26] Consequently, the participants were all 'young adult' Korean speakers. The oldest was 39 years old and the youngest was 20, and the average age at the time of the survey was 26.6 years. For the analysis, the participants were divided into three groups depending on their ages: (i) those born after 1985 (17 participants); (ii) those born between 1980 and 1985 (15 participants); and (iii) those born before 1980 (15 participants). Even though the age gap was small, the youngest group was expected to choose more disharmonic forms than the older participants.

Gender – 18 male and 29 female speakers participated in the survey. Previous research suggests that in historical change, women "use more of the incoming forms than men" in general (Labov 1990: 205-06). Thus, women were expected to be more accepting of disharmonic (regularized) forms than men.

Dialectal background –The participants' dialects were determined by where they were raised and educated. Based on this criterion, they were classified as speakers of one of three regional dialects: Seoul/Gyeonggi (32); Chungcheong (8); and Gyeongsang (6). There was one speaker of the Jeolla dialect, making this fourth dialect group too small to include in the

[26] For example, most of the children in the community are bilingual and older adults (over 50) have been in the US for more than 20 years.

comparison. It is commonly believed that Chungcheong speakers use more disharmonic forms than others,[27] which leads us to the prediction that Chungcheong speakers should be more accepting of disharmonic forms than other speakers.

Age of arrival in the US and *length of stay in the US* – There were six participants who came to the US between 10 and 19 years of age and three participants who came between age 30 and 39. The others (38) came in their twenties. The group with the earliest age of arrival was predicted to be more accepting of disharmonic forms than the other groups on the basis of Labov's (1982: 46-47) finding that adolescents as well as pre-adolescents are the agents of transmission of change. I also assumed that Korean speakers in the US would have less exposure to Korean than those in Korea, so the length of stay was included in the factors to test the effect of decreased exposure. The participants were classified into three groups: 0-to-3-year group (27); 4-to-6-year group (13); and longer-than-6-year group (7). The last group was predicted to be more accepting of disharmonic forms than the others on the grounds that their overall exposure to Korean forms would be lower, and that lower frequency correlates with greater likelihood of morphosyntactic changes (Bybee 2001a).

2.3.2 Stimuli

In the judgment survey, 98 tokens[28] were selected to test the hypotheses presented above. The selection of stems began with the frequency data created by the NIKL. The pool for stimuli was restricted to 695 stems which satisfied these three conditions: (i) trigger vowel /o/ or /a/; (ii) length shorter than four syllables; and (iii) ending with one or more consonants.

First, 22 /a/-stems and the same number of /o/-stems were selected to test the effect of stem vowels. Hypothesis (14a), borne out in the Google-driven corpus study, predicted that words with /a/-stems would be more likely to tolerate disharmonic suffixes. The 44 stems were combined with the SFM suffix. It was expected that speakers would judge words containing disharmonic forms of the suffix more positively with /a/-stems than with /o/-stems. Second, for either trigger vowel, 9 monosyllabic, 9 bisyllabic, and 4 trisyllabic stems were selected to test the effect of stem length (Hypothesis 17b).[29] Third, to test the effect of stem frequency (Hypothesis 17c), the selected 44 stems were divided into three groups, depending on the

[27] This belief might be due to the fact that many sentences end with /ʌ/ in Chungcheong dialect, even though the same sentences do not end with /ʌ/ in other dialect. For example, *hjʌ* (Chungcheong) vs. *he* (Seoul) 'do!' and *kɯrjʌ* (Chungcheong) vs. *kɯre* (Seoul) 'yes' Some Koreans also believe that the regularization of harmonizing suffixes started from Chungcheong dialect and then spread to others.

[28] This includes 29 tokens included to test the morphological relatedness of stems, as well as the 69 tokens described in this section. On the effect of morphological relatedness, see section 5.2.1.

[29] Because most trisyllabic verbal stems are derived with *–ha*, which attaches to a noun to make a verb, they are irregular with regard to the vowel harmony process in verbal conjugation. In addition, it is difficult to find trisyllabic stems that are very frequently used. For these reasons, fewer trisyllabic stems were included.

logarithmic value of occurrence in the NIKL frequency data: (i) low frequency group with fewer than 10 occurrences; (ii) mid frequency group with 10 to 99 occurrences; (iii) high frequency group with more than 100 occurrences.[30] Fourth, to compare the SFM suffix with other suffixes, 16 stems were selected, balanced with other factors already described (Hypothesis 17a). The 16 stems were conjugated with the connective suffix *–a/ʌ*, which linked a verb to a verb (word-final) or with an embedded-clause ender, which linked a clause to a clause (clause-final), resulting in the addition of 16 tokens to the stimulus set. The 60 tokens are listed in Appendix II. Lastly, nine *p*-irregular stems were added to see whether they behaved differently from others in the variation (Hypothesis 14b). The nine *p*-irregular stems and other stems included to test morphological relatedness[31] are in Appendix III.

2.3.3 Design

As described in the previous section, 98 stem + suffix combinations were selected as stimuli. These stimuli were presented to Korean speakers in context sentences, which were found by Googling. For each stimulus, the context (sentence) was given with both harmonic and disharmonic forms. The contexts and the target words were presented in Hangeul, the Korean writing system. Participants were asked to rate each stimulus on the seven-degree scale in (18).

(18) An example of the questionnaire and the meaning of each choice

저기 도둑이 도망간다! _____!
tɕʌki totuk-i tomaŋkanta! _____!
there thief-Nom runs away! _____!

잡어	잡아
tɕap-ʌ	tɕap-a
to catch-IMP (disharmonic)	to catch-IMP (harmonic)

◦	◦	◦	◦	◦	◦	◦
a	b	c	d	e	f	g

a. Only the form on the left (**disharmonic**) is possible. (-3)
b. Both are possible, but the lefthand form is highly preferred. (-2)
c. Both are possible, but the lefthand form is slightly preferred. (-1)
d. Both forms are equally good. (0)
e. Both are possible, but the righthand form is slightly preferred. (1)
f. Both are possible, but the righthand form is highly preferred. (2)
g. Only the form on the right (**harmonic**) is possible. (3)

2.3.4 Procedure

The survey was done in a Korean church and at Stony Brook University. To familiarize participants with the procedure, each participant was trained with five questions which contained stems other than the stimuli. The participants were requested to read the context

[30] Trisyllabic stems included only low and mid frequency ones, see footnote 28.
[31] For this factor, see section 5.2.1.

sentence and the target word and then to give their judgment on the basis of their intuition. Their judgment was marked on the survey and the choices for each question were converted to numbers from -3 (only disharmonic form possible) to 3 (only harmonic form possible). These numbers were stored with all the linguistic and sociolinguistic information in an Excel file, as seen in Table 6. In total, 4,606 responses (47 participants * 98 responses) were collected. Chi square tests were performed to test linguistic and sociolinguistic factors.

Table 6. An example of data which were subjected to chi-square tests

Parti.	Gender	Age	Dialect	USstay	USenter	token No.	stem	Trigger
SHC1	2	2	3	1	2	A15	*ɯilop-*	1
SHC1	2	2	3	1	2	A19	*kwelop-*	1
SHC1	2	2	3	1	2	A23	*selop-*	1
SHC1	2	2	3	1	2	A27	*anik'op-*	1

StemLength	Suf.Type	LogFreq.	Reg.Irreg.	Category	rop	Judgment
2	3	1	2	2	1	-3
2	3	2	2	2	1	-3
2	3	3	2	2	1	0
3	3	1	2	2	2	2

2.3.5 Results

Before the results are presented, let us review what results were predicted. Three linguistic factors (trigger vowel, suffix type, and irregularity) were predicted to have relatively categorical effects (i.e., variation appears in category A but not in category B, marked by '>>' in Table 7) while the other factors (stem length, frequency, morphological relatedness, and morphological category), as well as sociolinguistic factors, were predicted to have gradient effects (marked by '>' in the table). The predictions are arranged in Table 7.

Table 7. Predictions on Korean speakers' judgments regarding the linguistic and sociolinguistic factors

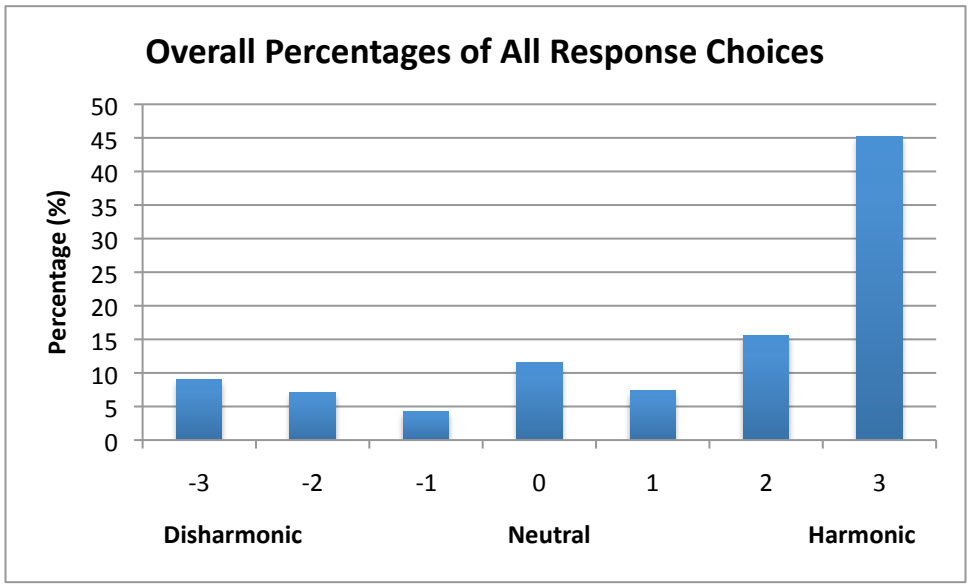
factor	more harmonic		more disharmonic
trigger vowel	/o/	>>	/a/
suffix type	other suffix	>>	SFM suffixes
stem length	shorter stems	>	longer stems
irregularity	other stems	>>	*p*-irregular
frequency	high frequency stems	>	low frequency stems
age	older speakers	>	younger speakers
gender	male speakers	>	female speakers
dialect	other speakers	>	Chungcheong speakers
length of stay	shorter stay	>	longer stay
age of arrival	later arrival	>	earlier arrival

I first consider the overall results, which will show how speakers' judgments differ from the written corpus. Also, this is compared with their productions in an experimental situation and in a normal situation (Chapter 3).

2.3.5.1 Overall results

The survey results revealed a general preference for harmonic forms over disharmonic forms. About 45% of the responses were 'only harmonic form is possible'. The next most frequent response was 'Both are possible, but the harmonic form is highly preferred' (15.6%), as in Figure 5.

Figure 5. Overall results from judgment survey

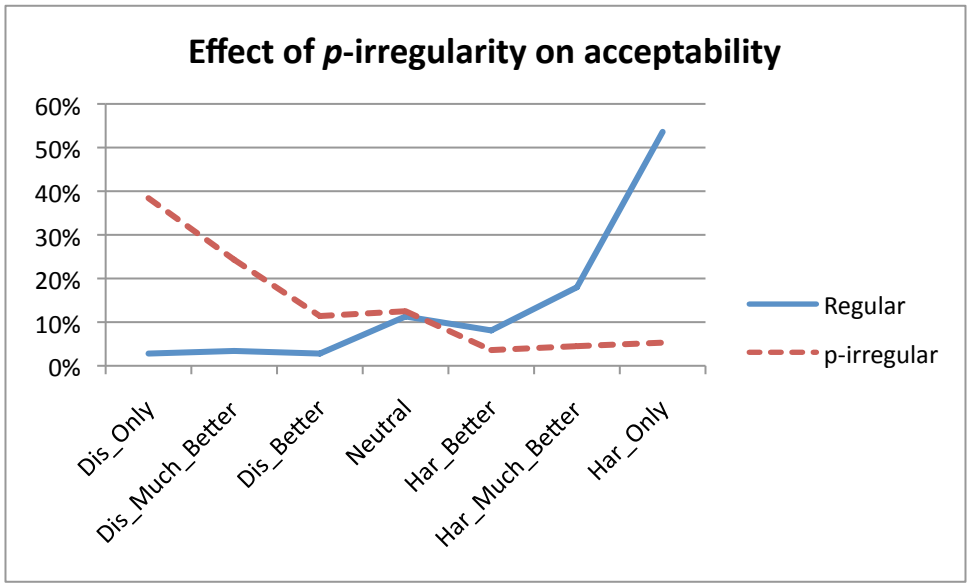


In line with the findings in the Google-driven corpus study, speakers' judgments on harmonic vs. disharmonic forms were significantly affected by trigger vowel and irregularity of the stem. The result of each factor is presented below, beginning with the factor that showed the greatest effect.

2.3.5.2 *P*-irregularity (X^2=1,888, df=6, p<.001)

As expected, *p*-irregular stems were totally different from the others. As Figure 6 shows, about three out of four responses for *p*-irregular stems fell on the disharmonic-preference side (74.1%), while other (regular) stems showed the opposite pattern (79.7% on the harmonic-preference side).

Figure 6. Effect of *p*-irregularity on acceptability (regular vs. *p*-irregular stems)



Within *p*-irregular stems, trigger vowel (X^2=14.0, df=6, p=.03)[32] and suffix type (X^2=40.8, df=12, p<.001)[33] also proved to be significant. The responses on the disharmonic side were more frequent with stems containing /a/ than stems containing /o/ and in the SFM suffix than in other suffixes, consistent with the regular stems. But in spite of the statistical significance, the effects of these other factors were small compared to their effects in regular stems.

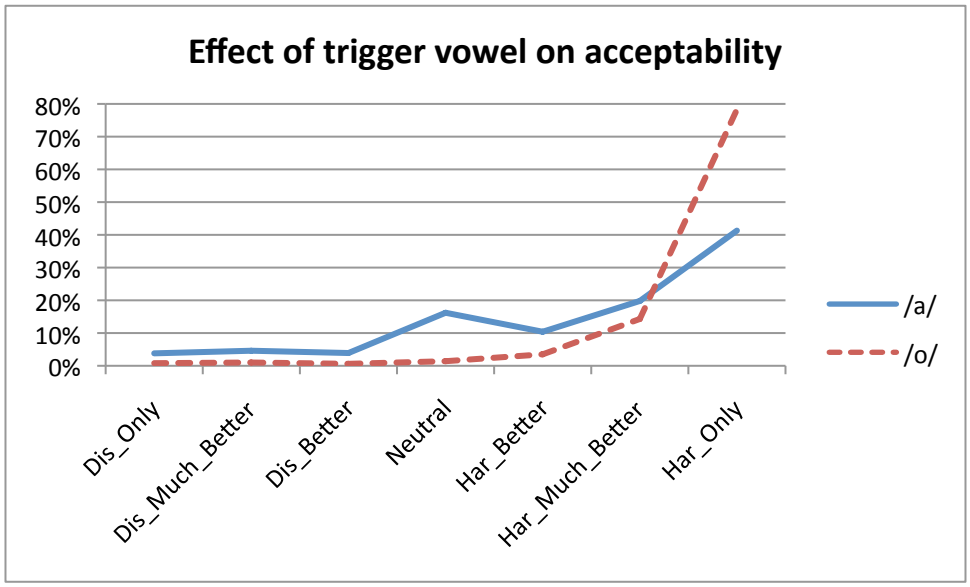
2.3.5.3 Trigger vowel (X^2=534.2, df=6, p<.001)

Excluding *p*-irregularity, the quality of the trigger vowel made the biggest difference in the responses. For an /o/ trigger vowel, only 2.4% of responses rated disharmonic forms as better than harmonic forms, in contrast to 12.3% for /a/. Moreover, 78.3% of responses were 'harmonic only' for /o/, as compared to only 41.3% for /a/, as in Figure 7. In spite of the extreme bias toward harmonic suffixes with /o/-stems, it should be noted that Korean speakers' judgments were not 100% categorical.

[32] The percentages of responses on the disharmonic side were 70.0% (/o/-stems) vs. 79.9% (/a/-stems) on average.

[33] The percentages of responses on the disharmonic side were 79.6% (the SFM suffix) vs. 70.0% (clause-final suffixes) vs. 65.6% (word-final suffixes).

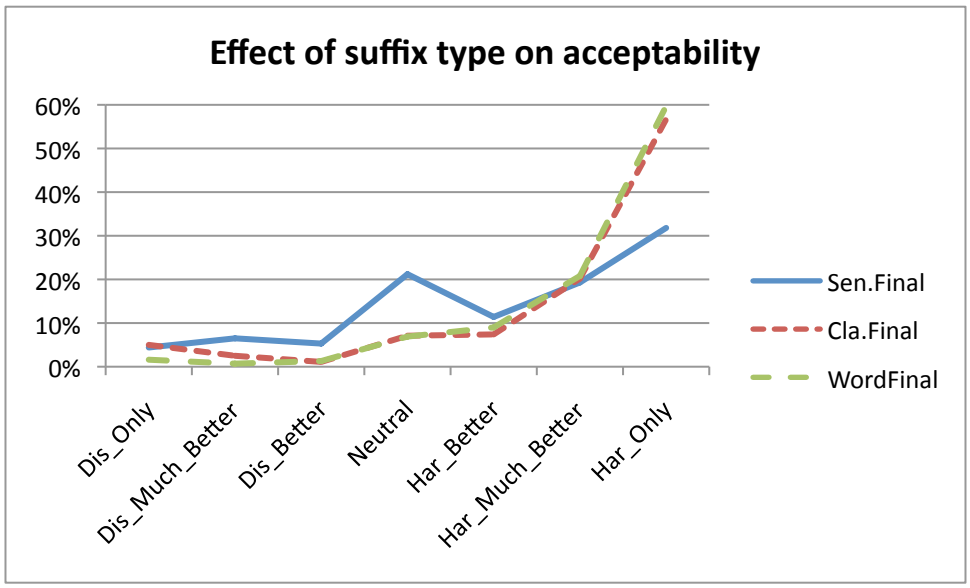
Figure 7. Effect of trigger vowel on acceptability (/a/ vs. /o/)



2.3.5.4 Suffix type (X^2=252.3, df=12, p<.001)

To test linguistic factors other than *p*-irregularity and trigger vowel, *p*-irregular stems and /o/-stems were excluded from the pool, leaving the set of regular /a/-stems. The biggest effect in these stems was due to suffix type. For word-final and clause-final suffixes, more than half the responses were 'harmonic-only' (59.7% and 56.7%), and disharmonic forms were preferred in only 3.6% and 8.6% of responses, respectively. This pattern contrasts with the SFM suffix, which had 16.2% of the responses on the disharmonic side and only 31.8% of the responses on the 'harmonic-only' choice, as shown in Figure 8.

Figure 8. Effect of suffix type on acceptability (sentence final vs. clause final vs. word final)



2.3.5.5 Other factors

The other two factors (stem length and stem frequency) were tested only on the regular /a/-stems with the SFM suffix because this set showed the greatest variation. None of these three linguistic factors had a significant effect on ratings (for stem length, X^2=4.405, df=12, p=.354 and for stem frequency, X^2=6.593, df=12, p=.159), as represented in Figures 9 & 10.

Figure 9. Effect of stem length on acceptability (monosyllabic vs. bisyllabic vs. trisyllabic)

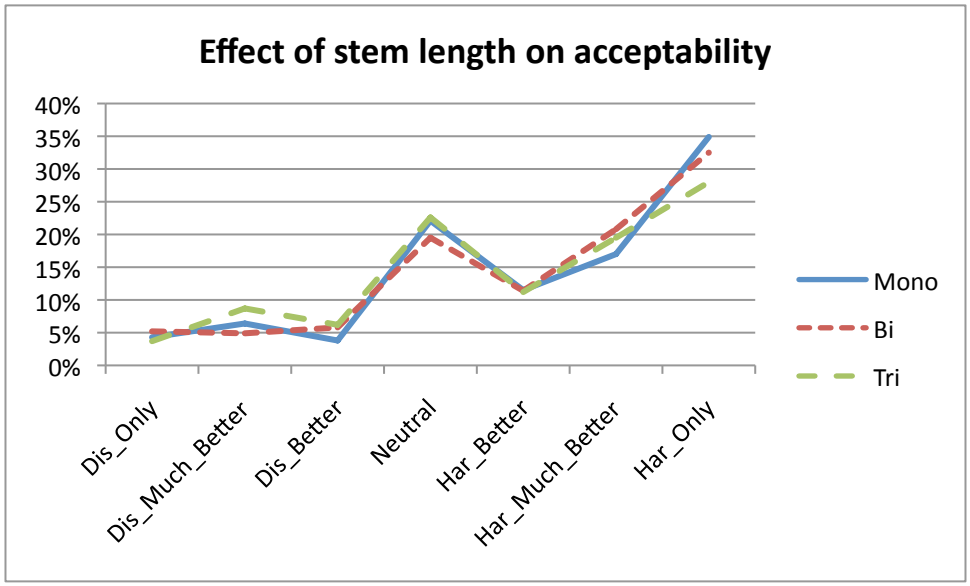
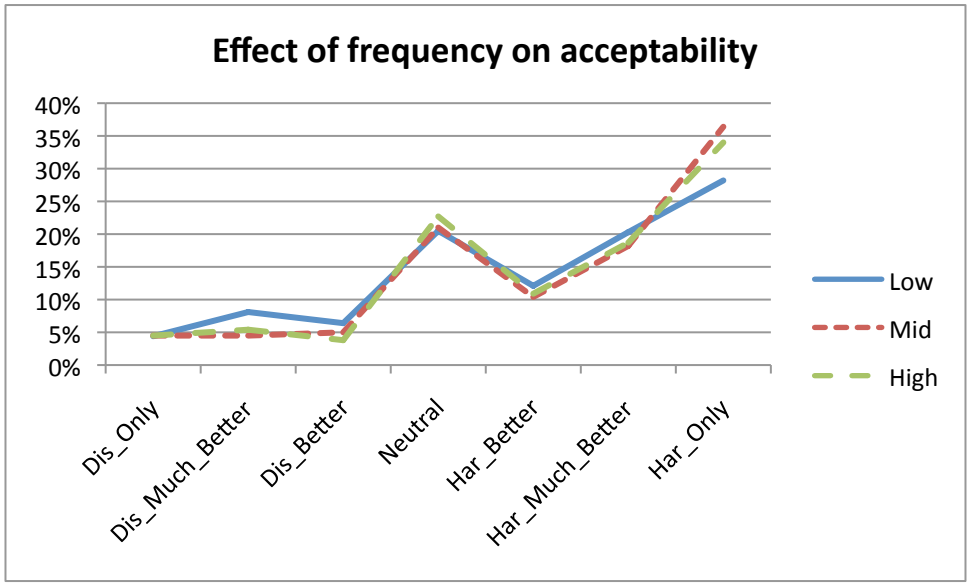


Figure 10. Effect of frequency on acceptability (low vs. mid vs. high frequency)



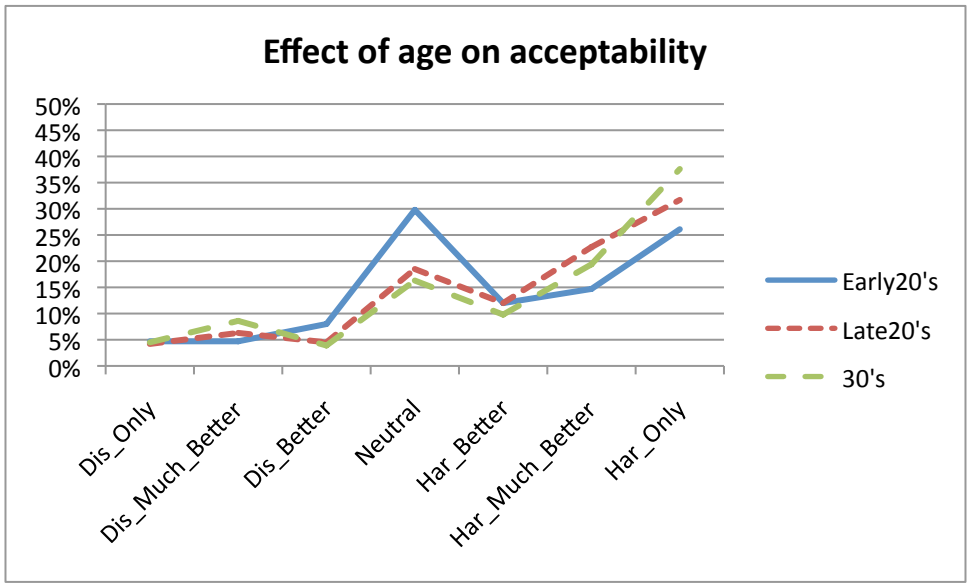
2.3.5.7 Sociolinguistic factors

Before I deal with the results concerning sociolinguistic factors, it should be noted that the set (regular /a/-stems with the SFM suffix) that was used for the last three linguistic factors was

also used to test sociolinguistic factors,[34] because this set (regular /a/-stems) reflected subtle phonological factors in the clearest way. Sociolinguistic factors affected the acceptance of disharmonic forms, as predicted in Table 7.

Age - As expected, the oldest group was relatively conservative in that older speakers preferred harmonic forms more often than younger speakers (X^2=60.77, df=12, p<.001). For example, 37.6% of the responses were on the 'harmonic-only' for the oldest group and the percentages for younger groups were 31.7% and 26.1%. Interestingly, the percentages on the disharmonic side were not that different. So the results are interpreted as follows: harmonic forms are still preferred through all the age groups but younger speakers are more flexible than older speakers in that they allow more variation (e.g., they chose 'neutral' more often than older groups), as Figure 11 shows.

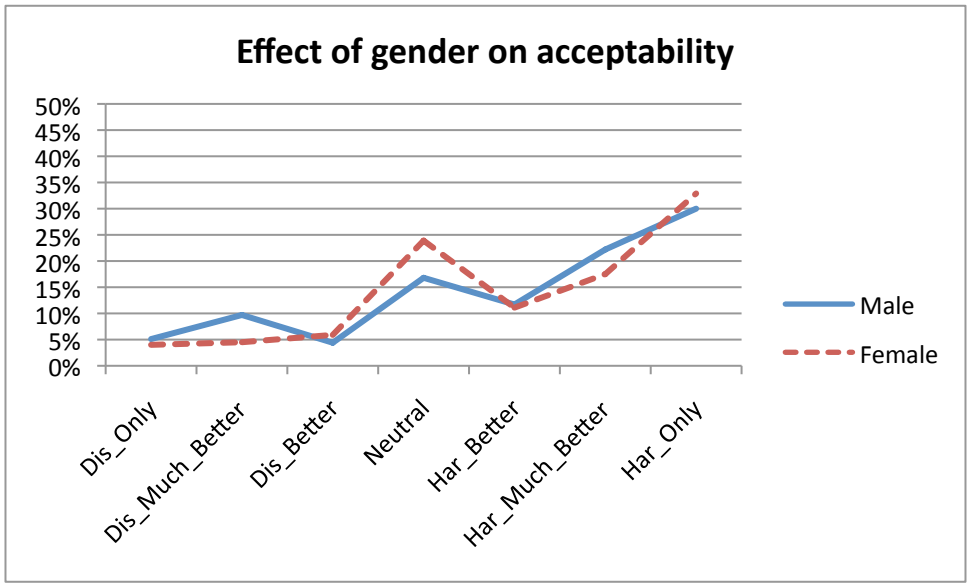
Figure 11. Effect of age on acceptability (early 20's vs. late 20's vs. 30's)



Gender - On the harmonic and disharmonic forms of verbal suffixes, the judgments of male and female speakers were similar in terms of the proportions of responses on either the harmonic or the disharmonic side. The most noticeable distinction between the two groups was that female speakers chose 'neutral' more often than male speakers (X^2=32.22, df=6, p<.001, 23.9% vs. 16.8%), as in Figure 12.

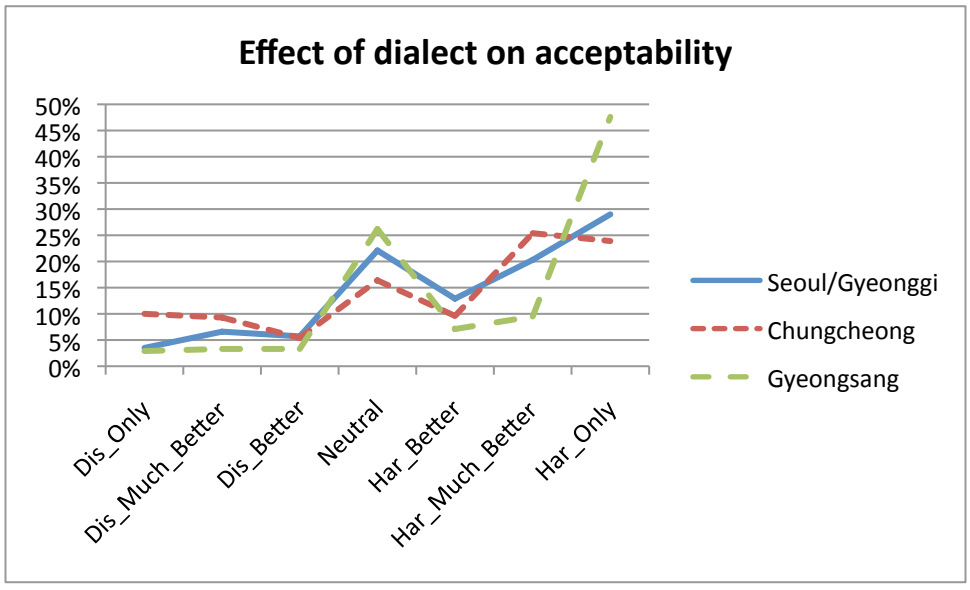
[34] Though the sociolinguistic factors were tested based on other sets, the results are not presented, mainly because they are not very different from those presented here.

Figure 12. Effect of gender on acceptability (male vs. female)



Dialect - Even though the participants were young adults who had all been educated in so-called 'standard' Korean, there were slight differences among the three dialectal groups (X^2=13.83, df=12, p<.001). Figure 13 shows that Gyeongsang speakers were the most conservative in that only 8.5% of their responses fell on the disharmonic side (compared to Seoul/Gyeonggi 15.8% and Chungcheong 24.7%) and 47.6% of their responses were 'harmonic-only' (compared to Seoul/Gyeonggi 29% and Chungcheong 23.9%). On the opposite, Chungcheong speakers were the most accepting of disharmonic forms.

Figure 13. Effect of dialect on acceptability (Seoul/Gyeonggi vs. Chungcheong vs. Gyeongsang)



Length of stay & age of arrival - The speakers who had been in the US for more than six years chose disharmonic forms far more often than other speakers (X^2=131.1, df=12, p<.001, 37.2% vs. 10.3% or 13.8%). This is consistent with the finding that the speakers who had come to the US in their teens chose disharmonic forms more often than more recent arrivals (X^2=95.7, df=12, p<.001, 23.7% vs. 11.4% or 12.4%). Another thing to note is that the youngest arrivals chose 'neutral' about twice as often as the others (38.1% vs. 18.6% or 20.0%). Figures 14 & 15 show the results.

Figure 14. Effect of length of stay on acceptability (shorter than 3 year vs. 3 to 6 years vs. longer than 6 years)

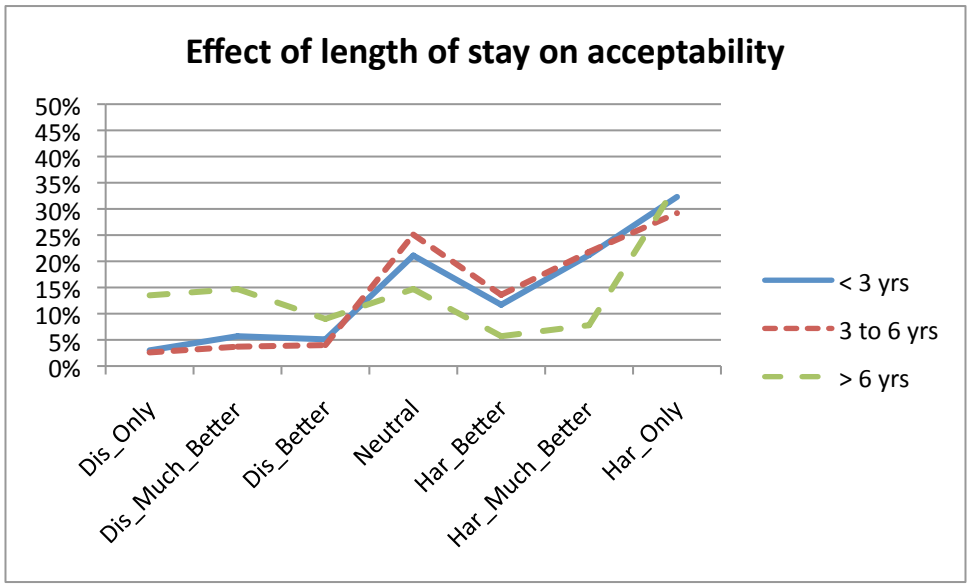
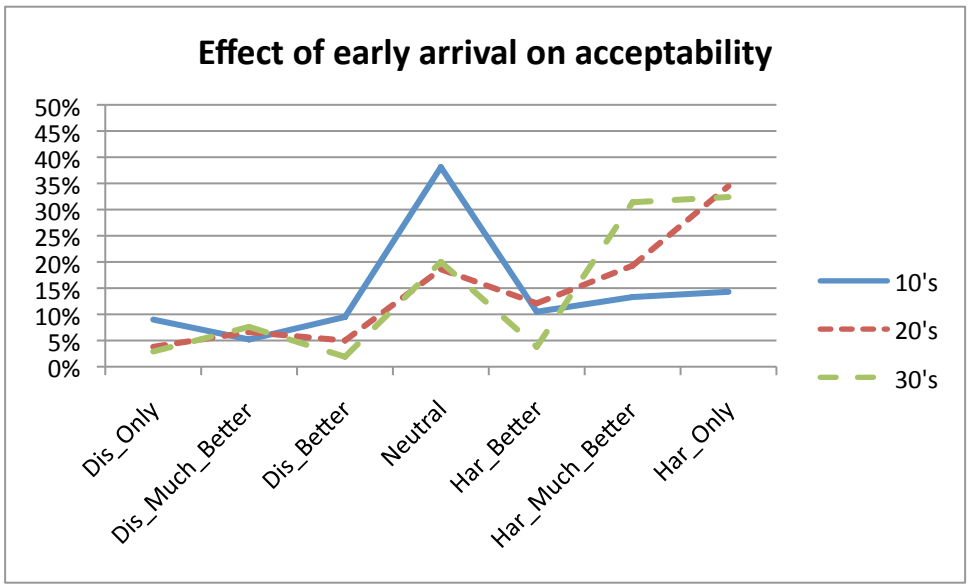


Figure 15. Effect of early arrival on acceptability (10's vs. 20's vs. 30's)



In sum, female speakers were different from male speakers in that they showed more tolerance of the disharmonic forms, selecting 'neutral' more frequently than male speakers for these forms. As with other historical changes, younger speakers accepted the innovative (disharmonic) forms more frequently than older speakers. Chungcheong dialect speakers were in advance regarding this change. It was also found that Korean speakers who had left Korea early in their lives and who had spent more time in the US were more accepting of the innovative forms.

2.4 Discussion

To summarize the results of the judgment survey, *p*-irregular stems are overwhelmingly in the lead in the move toward disharmonic suffixes. For other stems, speakers were more likely to accept disharmonic suffixes with stems containing /a/ but were still reluctant to accept disharmonic forms containing /o/. Among harmonizing suffixes, the SFM suffix was more actively regularized than others. The length of stem and the stem frequency did not make any difference with respect to the acceptance of disharmonic forms.

These results, by and large, show the same trends as the Google-driven corpus study presented in section 2.2. The most apparent difference was the overall percentage of disharmonic forms. While only 1.27% of the forms found in the Google-driven corpus contained disharmonic suffixes, 12.3% of the responses in the judgment task rated disharmonic forms as 'only possible' or 'preferred' forms. I speculate that the low percentage of disharmonic forms in the Google-driven corpus can be attributed, above all, to the fact that the 'total' result in the Google-driven corpus included not only the SFM suffix but also all the harmonizing suffixes that rarely vary. In addition, there might be other reasons: for example, the corpus data were all written and are therefore more likely to be subject to the prescriptive rules; while the judgment was done recently, the corpus included data gathered over a relatively long period; and the judgment was given by a group of young adults but the corpus was generated by speakers of all generations. However, in spite of the difference, it should be emphasized that the two studies revealed similar patterns. That is, for both sets of data, the same sets of factors either showed an effect or not. In the following discussion I focus on the synchronic analysis of the factor of *p*-irregularity.

To account for the data of the vowel harmony of *p*-irregular stems, the grammar should be able to deal with (i) probabilistic variation and (ii) phonologically exceptional patterns specific to a group of lexical items. In Optimality Theory (Prince and Smolensky 1993, 2004), partially ordered ranking (Anttila 1997, 2002) and stochastic constraint rankings (Boersma 1998; Boersma and Hayes 2001) have been proposed as a way to model variation. In addition, Cophonology Theory (Anttila 1997, 2002; Inkelas 1998; Inkelas and Zoll 2005; Itô and Mester 1997) and Indexed Constraint Theory (Pater 2010; Smith 1997) have been proposed for lexically specified phonological processes. I adopt Stochastic Optimality Theory and Cophonology Theory

to account for the synchronic variation of [a]-form and [ʌ]-form suffixes appearing with *p*-irregular stems.

In Stochastic Optimality Theory, constraints are endowed with 'ranking values', which determine the position of each constraint on a continuous ranking scale. In contrast to classical Optimality Theory, the order does not imply 'strict domination' (Kager 1999: 22), because each constraint is assumed to have its own range based on standard deviations. As a result, even if constraint A is ranked higher than constraint B in terms of its mean (or ranking value), it is still probabilistically possible to produce an output that satisfies constraint B but not A, under the condition that the ranges of the two constraints overlap, though the probability is low. This theory can model how a grammar is learned and how a change occurs gradually, since the constraints move on a continuous scale. Also, it can predict percentages of variants. For these reasons I adopt Stochastic Optimality Theory over Partially Ordered Ranking Theory.

The behavior of *p*-irregular stems is different from other stems in two ways. First, the stem-final /p/ becomes [w] between vowels and second, *p*-irregular stems generally take [ʌ]-form suffixes even when the trigger vowel is /o/ or /a/. For the first difference, H.-J. Kang (2011) presents the following constraint rankings based in Cophonology Theory.

(19) Cophonology approach to *p*-irregularity in Korean (H.-J. Kang 2011: 173)

a. Regular stem : IDENT [stop] > *V*p*V
b. *P*-irregular stem : *V*p*V > IDENT [stop]

As in (19), the Cophonology approach allows subgrammars with different constraint rankings, which apply to different groups of words (here, *p*-irregular stems vs. others). The rankings above are categorical (represented by '>'). The realization of /p/ does not vary in either group. The second difference, which is related to vowel harmony, is accounted for by the following rankings:

(20) Cophonology approach to the vowel harmony of *p*-irregularity in Korean (H.-J. Kang 2011:173)

a. Regular stem : AGREE [RTR] ≥ IDENT-V
b. *P*-irregular stem : IDENT-V ≥ AGREE [RTR]

In the subgrammar of regular stems, the markedness constraint AGREE [RTR] is still higher than the faithfulness constraint IDENT-V, while the ranking is reversed in the subgrammar of *p*-irregular stems. Variation is found in both groups, which is reflected in the overlap of the ranges of two constraints (represented by '≥'). From the perspective of historical change, the promotion of IDENT-V (or the demotion of AGREE [RTR]) took place earlier and/or faster in *p*-irregular stems than in regular stems.

The constraint rankings in (19) and (20) briefly show how the different patterns are produced with regard to *p*-irregularity, though the pattern is not so simple. For example, the effect of stem vowel was found even in *p*-irregular stems. The percentages of disharmonic

forms were 71.3% (/o/-stems) vs. 87.82% (/a/-stems) in the Google-driven corpus and 70.0% vs. 79.9% in the judgment survey data. This is discussed in Chapter 4. Moreover, these accounts do not explain why the reranking of constraints took place earlier and/or faster for *p*-irregular stems (cf. the actuation problem, Weinrich et al. 1968). I discuss this problem in Chapter 5 and provide an alternative account.

2.5 Summary

I examined linguistic and sociolinguistic factors in the variation of vowel harmony in Korean, based on two types of data: a Google-driven corpus and Korean speakers' judgments of harmonic and disharmonic forms. It was found that disharmonic (or regularized) suffixes appear with *p*-irregular stems irrespective of the trigger vowels of the stems. Among regular stems, disharmonic forms were mostly found under the following two conditions: (i) stems containing /a/ and (ii) the SFM suffix. I argued that the disharmonic-preference of *p*-irregular stems is accounted for by different rankings in the subgrammars, adopting Cophonology Theory. Sociolinguistic factors also made meaningful differences in the variation. Younger male speakers were more likely to accept disharmonic forms than others. In addition, participants who came to the US early in their lives and had resided longer in the US were more inclined to accept disharmonic forms.

Chapter 3 Production

3.1 Introduction

The previous chapter reported on a Google-driven corpus study and a judgment survey designed to investigate the factors that correlate with the extension of the [ATR] suffix vowel to stems containing [RTR] vowels. The results of the two studies showed that *p*-irregular stems led other stems in the change from the earlier harmony system to a system in which a single form of the suffix is used regardless of the vowel in the stem. In other stems, the use of disharmonic suffixes was most frequent with the SFM suffix and with stems containing the trigger vowel /a/.

The corpus study and the judgment survey both involved written data, which means that the results might reflect a strong influence of prescriptive grammar. This chapter reports on two studies investigating whether similar patterns appear in speech: (i) a production experiment in which participants produced specific stem-suffix combinations (where stems included both real and nonce forms); and (ii) a study of spontaneous speech from two TV reality programs. The results show that the effects of trigger vowel and suffix type appeared even more clearly in spoken Korean than in written forms. Moreover, the production experiment revealed the effects of some factors that did not emerge in the judgment survey. For instance, the honorific *-ajo/ʌjo* was compared with the SFM suffix because the honorific suffix is a sentence ender, which shows the same distribution as the SFM suffix and therefore is expected to show a similar proportion of [ʌ]-forms. It turned out that the honorific suffix is always harmonic, which implies that the disharmony is strongly related not to the proportion of [ʌ]-forms but to the (sentence-final) position of the target vowel (-**a**]$_s$ vs. –**a**jo]$_s$). In addition, an effect of stem length was found in nonce words that did not appear in real words: in nonce words, longer stems were more likely to take disharmonic suffixes than shorter stems.

The spontaneous speech data showed a greater use of disharmonic forms than the production experiment, in which forms were elicited under experimental conditions. This suggests that the loss of vowel harmony is more common than the production experiment and the judgment survey showed. In spontaneous speech, the loss of harmony has already begun to spread to harmonizing suffixes other than the SFM suffix. The following section deals with the production experiment, which is followed by the spontaneous speech study (section 3.3) and discussion (section 3.4).

3.2. Production experiment

This experiment was designed to determine whether the patterns found in the judgment survey and the Google-driven corpus study also appear in production data, where the effects of prescriptive grammar are likely to be weaker. Because it is difficult to collect a meaningful

amount of the relevant types of forms in spontaneous speech, a production experiment was designed to provide sufficient data for the statistical analysis.

The hypotheses tested in the judgment survey were slightly modified and tested in the production experiment. The factor of *p*-irregularity was excluded because its effect was very obvious. The quality of the stem vowel (/o/ vs. /a/) was tested by focusing on /a/-stems because /o/-stems showed little variation in the Google-driven corpus and the judgment survey.[35] The effect of suffix type (the SFM suffix vs. others) was tested in a more elaborate way by adding an honorific suffix (e.g., *tɕap-a* 'to catch-SFM' vs. *tɕap-ajo* 'to catch-HON'). If the peculiar behavior of the SFM suffix is due to the fact that the suffix generally appears in contexts in which harmony does not apply, we should expect a similar percentage of disharmonic forms for the honorific suffix *-ajo/ʌjo*, as the honorific suffix appears in the same contexts as the SFM suffix does. However, if the extension of [ʌ] is related to the sentence-final position of the target vowel, we should get different results for the two suffixes. The factors of stem length and stem frequency were also tested in production. Even though they did not yield significant differences, the results showed slight tendencies toward the predictions of the hypotheses.

(21) Hypotheses tested in the production experiment

a. Stem vowel quality: Stems with trigger vowel /a/ are more likely to appear with either *a*-initial or *ʌ*-initial suffix forms while those with /o/ will only appear with *a*-initial suffix forms.
b. Stem length: Longer stems are more likely to appear with *ʌ*-initial suffix forms than shorter stems.
c. Suffix type: The SFM (Sentence-Final Monosyllabic) suffixes are more likely than other suffixes to appear as either *a*-initial or *ʌ*-initial forms.
d. Frequency of stem: Low frequency stems are more likely to take *a*-initial suffix forms than high frequency stems.

3.2.1 Participants

Thirty Korean speakers took part in this experiment. All the participants were recruited at Stony Brook University and paid for their participation. Twenty of the participants had also participated in the judgment task. The same sociolinguistic factors as in the judgment survey (age, gender, dialect, length of stay, and age of arrival) were considered in the production experiment. The oldest participant was 35 years old and the youngest was 20. The average age was 26.5 at the time of participation. Twelve participants were male and eighteen were female. As in the judgment survey, more than half the participants were from the Seoul/Gyeonggi area (19). Four participants were from Chungcheong and six from Gyeongsang. The Jeolla dialect had

[35] While there were the same (or similar) number of /o/-stems as /a/-stems in the Google-driven corpus study and the judgment survey, /o/-stems were fewer than /a/-stems in the production experiment (10 vs. 40).

only one speaker. 20 had left Korea between age 20-29, four between age 30-39, and six in their teens. The participants had resided in the US from one month to nine years.

3.2.2 Stimuli

The stimuli were composed of three sets: real verbal stems, nonce verbal stems, and nouns. The real stems were included as the main stimuli to test both linguistic and sociolinguistic factors. The reason that nonce stems were included in the experiment was to reveal how the vowel harmony process works at an abstract level without the effects of morphologically related words. The last set, nouns, was added as a control set for an acoustic analysis.

Because stimuli were presented as pictures rather than as written language, which might remind participants of the prescriptive rules of vowel harmony, the major criterion for real words was whether the stem could be represented in a picture. Written forms were avoided lest the participants be influenced by prescriptive grammar. Because vowel-final stems are not expected to allow variation, only consonant-final stems were used as in the judgment survey. Based on the results of the Google-driven corpus and the judgment survey, in which only /a/-stems showed variation, 40 /a/-stems were selected as target stems, controlled for stem length and frequency. For a control set, ten /o/-stems, ten /ʌ/-stems, and ten /u/-stems were added. Lastly, fifteen stems with /i/, /ɯ/, or /e/ were included as fillers. Among the forty /a/-stems, thirty stems were monosyllabic and the other ten stems were longer (eight bisyllabic and two trisyllabic stems). The thirty monosyllabic /a/-stems were divided into three groups on the basis of stem frequency, based on the NIKL data: low (the logarithmic value < 1, eight stems), mid (1 ≤ the value <2, fifteen stems), and high (2 ≤ the value, seven stems). Three different suffixes were combined with each stem: *-ta* (non-harmonizing declarative, infinitive form), *-a*/ʌ (the SFM), and *–ajo*/ʌ*jo* (the honorific). The 85 stems are listed in Appendix IV.

In total, 30 nonce stems were created. Half the stems had /a/ as the trigger vowel and the other half had /ʌ/, /o/, or /u/. Of the fifteen /a/-stems, five stems were bisyllabic and the other ten were monosyllabic. The factors investigated were: (i) the overall proportion of disharmonic form in real words vs. nonce words; (ii) the effect of stem vowel (/a/-stems vs. /o/-stems); and (iii) the effect of stem length. The 30 nonce stems are in Appendix V.

Because nouns were included as a control set for an acoustic analysis, they were designed to have the same vowel patterns and syllable structure (CV.CV) as the verbal stem-suffix combinations. For each of the five vowel patterns (four trigger vowels and their harmonic pairs in verbal conjugation: *o*~*a*; *a*~*a*; *u*~ʌ; ʌ~ʌ and one disharmonic pair: *a*~ʌ), three nouns were selected and 12 fillers were added. The full list is in Appendix VI.

3.2.3 Design

For the selected 90 real stems (85 target stems and 5 stems for training) and 30 nouns (27 target nouns and 3 nouns for training), appropriate pictures were found on the web. Every

participant took part in five cycles, each of which included a training block which contained five verbal stems or three nouns other than targets, before the main block.

In the first cycle, the participant was presented with a picture and asked to produce the target stem with a non-harmonizing declarative suffix *–ta.* This cycle was designed to familiarize participants with the target stems. In the second cycle, half the participants (Group 1) were asked to produce the stems with the SFM suffix (*-a/ʌ*) and the other half (Group 2) with the honorific declarative suffix (*–ajo/ʌjo*).[36] This was reversed in cycle 4, where Group 1 produced the stems with the *–ajo/ʌjo* suffix and Group 2 produced the stems with the SFM suffix. The stimuli for the third cycle were nouns, which were included as a control set for an acoustic analysis. In the first four cycles, the order of presentation of the pictures was randomized for each participant. In the fifth cycle, the stimuli were presented auditorily because nonce stems could not be represented by means of pictures. The stimuli were presented in the form of 'stem plus non-harmonizing (consonant-initial or *ɯ*-initial) suffix', as exemplified in (22).

(22) Stimuli for nonce stems
   a. target form: *pʰʌl-ʌ*
   b. stimuli: *pʰʌl-ta, pʰʌl-ɯni, pʰʌl-ko, pʰʌl-mjʌn*

The structure of the experiment is presented below.

Table 8. Structure of the experiment: type of stimulus, target form for each cycle, and order of cycles for each group

Cycle	Stimuli	Targets	
		Group 1	Group 2
1	visual	real stem-*ta* (infinitive form)	real stem-*ta* (infinitive form)
2	visual	**real stem-*a/ʌ*** (the SFM)	**real stem-*ajo/ʌjo*** (the honorific)
3	visual	Nouns	Nouns
4	visual	**real stem-*ajo/ʌjo*** (the honorific)	**real stem-*a/ʌ*** (the SFM)
5	auditory	Nonce stems-*a/ʌ* (the SFM)	Nonce stems-*a/ʌ* (the SFM)

3.2.4 Procedure

All the sessions were recorded using a Zoom H4n recorder and Shure WH30 microphone. All the recordings were transcribed categorically (i.e., harmonic vs. disharmonic) by the experimenter.[37] This way, 6,000 tokens were obtained ((85 real stems * 2 suffixes + 30 nonce stems) * 30 speakers). Whether a stem was a real or a nonce stem, *ʌ*-initial suffix forms were always chosen for the trigger vowels /i/, /e/, /ɯ/, /u/, and /ʌ/, as expected, so stems with these

[36] The two groups were balanced in terms of other demographic factors such as gender, age, dialect, and length of stay.

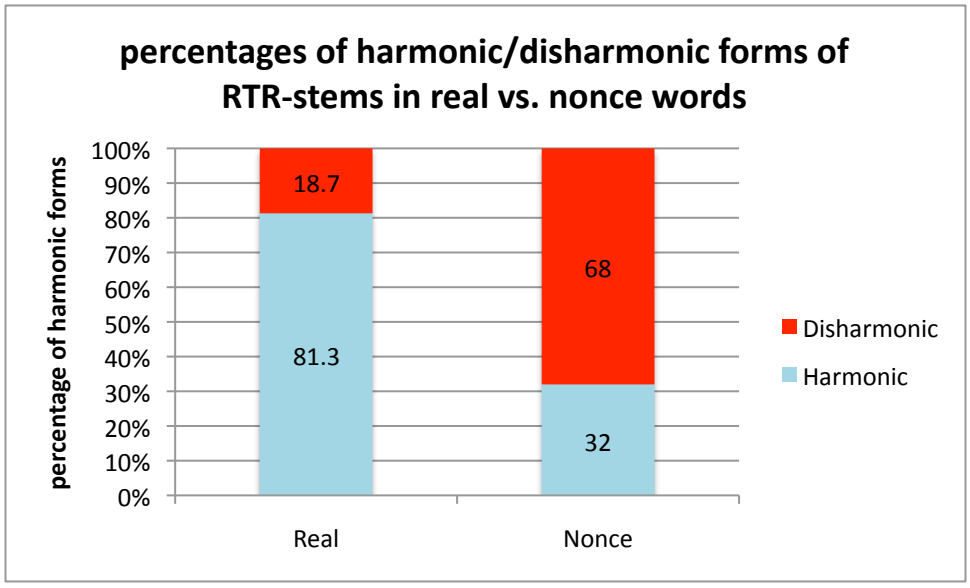
[37] For seven tokens which were slightly confusing to the experimenter, two more Korean speakers were asked to identify the vowels. As their perceptions were not different for each token, all seven tokens were included.

trigger vowels were excluded before the statistical analyses were carried out. Therefore only 3,600 tokens ((50 real stems * 2 suffixes + 20 nonce stems) * 30 speakers) were subjected to chi-square tests. Out of 30 speakers, six male speakers were selected for the acoustic analysis.

3.2.5 Results

In contrast with the results of a similar study on Hungarian vowel harmony (Hayes and Londe 2006, Hayes et al. 2009), where speakers showed similar judgment patterns for real and nonce words, Korean speakers showed very different patterns in real words vs. nonce words (X^2=471.9, df=1, p<.001). In the production of real words (specifically, stems containing /o/ or /a/), harmonic forms were still strongly preferred, in accordance with the results of the judgment survey (81.3% for harmonic vs. 18.7% for disharmonic). However, the tendency was reversed in nonce words (32% for harmonic vs. 68% for disharmonic), as Figure 16 shows. Stems containing ATR vowels were always harmonic whether the stem was real or nonce. The effects of different factors in real and nonce words are considered below.

Figure 16. The percentages of harmonic/disharmonic forms of RTR-stems in the production of real vs. nonce words



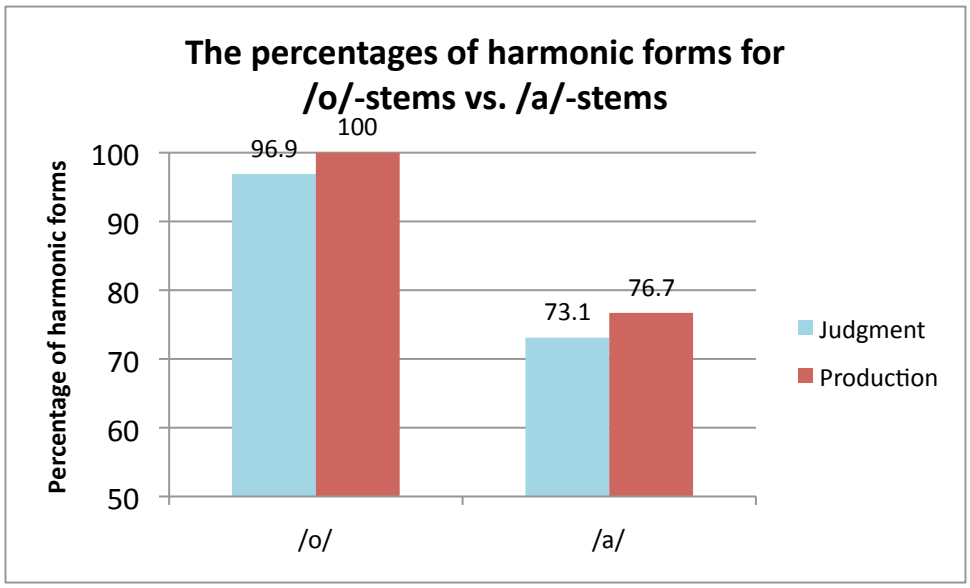
3.2.5.1 Real words

For real words, the effects of the two main factors of stem vowel and suffix type found in the judgment survey were replicated, and were even clearer. No disharmonic form was produced for /o/-stems or the honorific suffix.

The first factor considered is the effect of the trigger vowel. As predicted, only /a/-stems showed variation in the conjugated forms with potentially harmonizing suffixes. There were no

disharmonic tokens containing an /o/-stem,[38] which is the same as in Hong's (2008) results. In contrast, 23.3% of /a/-stem suffixes were disharmonic, which is higher than that in Hong (2008, 10.27%).

Figure 17. The percentages of harmonic forms for /o/-stems vs. /a/-stems in judgment and production[39]

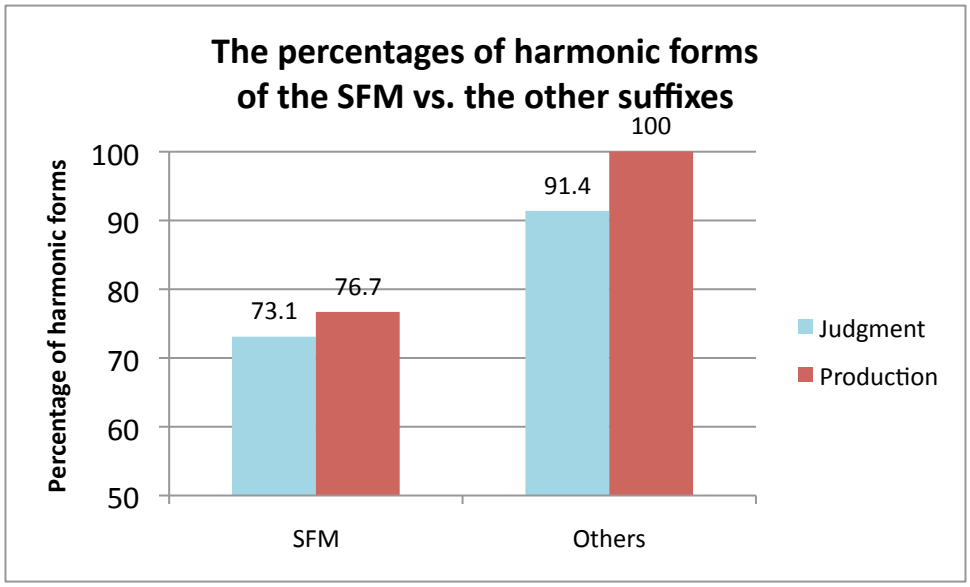


The next factor investigated was the identity of the suffix. As Figure 18 shows, no disharmonic form of the honorific suffix [ʌjo] was produced with stems containing [RTR] vowels (/o/ or /a/), whether a speaker belonged to Group 1 or Group 2 (in other words, whether s/he produced the forms containing the honorific suffix before or after the forms containing the SFM suffix). This result supports the claim that the extension of [ʌ]-forms is related to the sentence-final position.

[38] There was one disharmonic token containing an /o/-stem which did not count because the speaker corrected himself. 3.1% of the responses for /o/-stems were on the disharmonic side in the judgment survey.

[39] For comparison, the result of the judgment survey was categorized to harmonic vs. disharmonic responses. The percentage of harmonic forms was calculated based on 'responses on harmonic side (response 1 to 3)/responses on harmonic and disharmonic sides (excluding neutral responses)'.

Figure 18. The percentages of harmonic forms of the SFM vs. the other suffixes in judgment and production



In order to examine the real variation, I excluded /o/-stems and the honorific suffix from the set and tested other factors. Different orders of the two suffixes (SFM then honorific and vice versa) affected the proportion of harmonic vs. disharmonic forms but factors of stem frequency and stem length did not.

It turned out that the participants in Group 1 produced more disharmonic forms than those in Group 2 (31.2% vs. 15.5%, X^2=41.16, df=1, p<.001). Group1 participants produced the SFM suffix first, which showed variation, while Group 2 participants produced the honorific first, which was realized in only harmonic forms. This suggests that the harmonizing tendency of the honorific suffix lead the participants in Group 2 to produce harmonic forms more frequently than usual. As in the judgment survey, frequency and stem length made no significant difference (X^2=1.837, df=2, p=.399 for frequency and X^2=0.224, df=1, p<.636 for stem length).

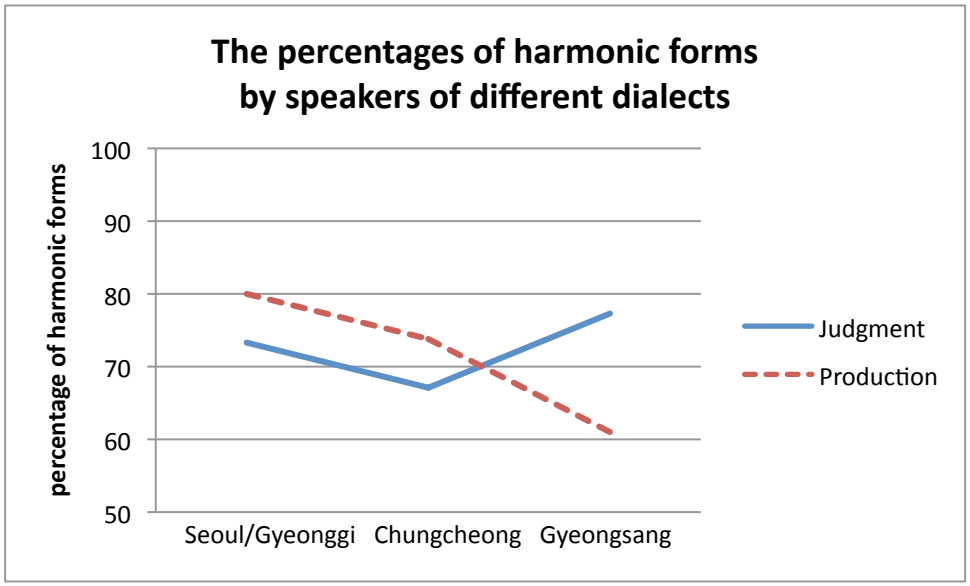
3.2.5.2 Nonce words

As shown in Figure 16 above, nonce words did not display the same patterns as real words. Disharmonic forms were in the majority in nonce words as opposed to real words, and the quality of the trigger vowel did not have an effect in nonce words (/o/ vs. /a/, 68.7% vs. 67.8%, X^2=0.41, df=1, p=.840). However, the production of nonce words was affected by stem length, which was not a factor in real words: longer stems (bi- or tri-syllabic stems) were more disharmonic than monosyllabic stems (74.8% vs. 64.4%, X^2=6.789, df=1, p<.01). Suffix type was not tested in nonce words. The effect of stem length is discussed in section 5.2.1, in relation to morphological relatedness across words.

3.2.5.3 Sociolinguistic factors

To test sociolinguistic factors, the set of real /a/-stems with the SFM suffix was used for chi-square tests. By and large, the results were not consistent with those of the judgment survey except for gender. The effect of gender was cleare in the production study, where males produced more disharmonic forms than females by a greater margin (35.4% vs. 15.3%, X^2=65.3, df=1, p<.001)[40] than in the judgment survey. As in the judgment survey, Gyeongsang speakers were distinguished from others in the production experiment (X^2=45.34, df=2, p<.001). However, Gyeongsang speakers were more conservative in the judgment study, but more innovative in the production study, where their proportion of disharmonic forms was the highest (39%). Chungcheong speakers produced disharmonic forms more often than Seoul/Gyeonggi speakers (26.2% vs. 20%), consistent with the results of the judgment survey. The effect of dialect is represented in Figure 19.

Figure 19. The percentages of harmonic forms by speakers of different dialects in judgment and production



The proportion of disharmonic forms was not very different through the three age groups (23.8%, 24.4%, and 21.7%, X^2=0.854, df=2, p=.652). Length of stay and age of arrival (in the US) each made a significant difference, but not in a consistent way in that the groups in the middle were different from the others. For instance, the proportion of disharmonic forms was higher in those who arrived in their mid and late twenties than those who arrived in their early twenties and thirties. However, when the Gyeongsang speakers, who were totally different from others, were taken out of the data set, the patterns for the other groups was consistent with the results of the judgment survey. The longer a Korean speaker had been in the US, the more

[40] The percentages were 23.2% (male) vs. 14.4% (female) in the judgment survey.

disharmonic forms s/he produced (15.4% vs. 29.5% vs. 31.7%) and participants who had left Korea before age 20 produced disharmonic forms more often than others (40% vs. 15.4% and 20.6%).

Before we look into the correlation of judgment and production in the next section, let us recapitulate the results presented so far. They are arranged in Table 9.

Table 9. Results of judgment and production

Factors	Judgment	Production		Note
		Real	Nonce	('>>' means 'more *disharmonic* than')
Trigger vowel	✔	✔	✘	/a/-stems >> /o/-stems
Stem length	✘	✘	✔	longer stems >> shorter stems
Suffix type	✔	✔	N.A.	sentence-final suffix >> non-final suffix
Frequency	✘	✘	N.A.	
P-irregularity	✔	N.A.	N.A.	*p*-irregular stems >> regular stems
Group (order)	N.A.	✔	✘	sentence-final-first >> sentence-final-last
Gender	✔	✔	N.A.	male >> female
Age	✔	✘	N.A.	younger speakers >> older speakers
Dialect	✔	✔	N.A.	Gyeongsang << others in judgment Gyeongsang >> others in production
US stay	✔	✔*	N.A.	longer stay >> shorter stay
US arrival	✔	✔*	N.A.	early arrival >> late arrival
*: Gyeongsang speakers excluded				

3.3 Production in spontaneous speech

The production experiment confirmed that the linguistic factors that affected Korean speakers' judgments, such as trigger vowel and suffix type, also affected the choice of harmonic vs. disharmonic forms in elicited production. However, even in the absence of influence from orthography, experimental conditions in the production experiment may have influenced speakers to use more formal speech than usual. Moreover, in the experiments, only two harmonizing suffixes (the SFM and the honorific) were compared. I expected to observe the behaviors of harmonizing suffixes other than these two suffixes in spontaneous speech. I therefore carried out an observation of spontaneous speech.[41] Two reality TV programs were selected and monitored for 10 months. Even though this did not produce a set of data that was large enough for statistical analysis, it will be useful to compare the harmony patterns in spontaneous speech with the patterns found in the production experiment.

[41] I thank Robert Hoberman for suggesting this study.

3.3.1 Method

In order to get as many tokens as possible, the following criteria were used in selecting the two programs. First of all, the programs chosen were unscripted, since a written script would most likely follow prescriptive grammar norms. For example, there would be no possibility to hear a disharmonic form on TV news because news programs are required to comply with the prescriptive grammar. The two programs selected were 'real' reality programs, which did not have scripts except for the opening and closing remarks. Second, the programs involved speech that did not include honorific forms. The SFM suffix, which shows the variation most clearly, is used in familiar and close relationships such as 'between friends'.[42] In both programs selected, the actors had participated in the programs for longer than three years and consequently they were familiar enough with one another to adopt casual speech. The two programs were *One Night and Two Days* on KBS (Korean Broadcasting System) and *Infinite Challenge* on MBC (Munhwa Broadcasting Corporation). The programs were telecast once a week for about 80 minutes and seven actors appeared on each program. The monitoring was done from February to November in 2011 and 40 episodes were monitored for each program.

While monitoring the programs, focus was on the /a/-stems with the SFM suffix, noting whether they were harmonic or disharmonic. So every token noticed was recorded in an Excel file. For other suffixes, only disharmonic tokens were recorded. Attention was also paid to /o/-stems, which turned out to be all harmonic.

3.3.2 Results

A total of 277 tokens of /a/-stems+SFM suffix combinations were collected from the 80 episodes. The overall percentage of harmonic forms was 43.3%, which was much lower than the 76.7% in the production experiment. As mentioned above, no disharmonic forms were found with /o/-stems. Eight disharmonic tokens of /a/-stems plus a suffix other than the SFM suffix combinations were collected.[43] Among the 277 tokens, 35 different /a/-stems were observed. Nine stems turned up more than ten times and the percentages of harmonic forms ranged from 20% to 83.3% for the ten frequent stems. Due to the small number of tokens and the absence of control sets, no further statistical analysis was attempted.

In comparison with the production experiment, the following points should be noted: (i) For the '/a/-stem plus SFM suffix' combination, Korean speakers used more disharmonic forms in spontaneous speech than in the production experiment; (ii) Disharmonic forms appeared in suffixes other than the SFM suffix in spontaneous speech; (iii) /o/-stems were not produced with disharmonic suffixes.

---

[42] Fundamentally, it is not recommended to use non-honorific (i.e., familiar or informal) forms on public TV programs.

[43] These were *mak-ʌjo* 'to block-HON', *sak-ʌ-katɕiko* 'to decay-CONN-as', *antɕ-ʌ-pwa* 'to sit-CONN-to try', *antɕ-ʌ-is'ʌ* 'to sit-CONN-to stay', *matɕ-ʌjatɕi* 'to be beaten-should', etc.

3.4 Discussion

So far, we have investigated variation in Korean vowel harmony through the production experiment and the observation of spontaneous speech on TV, as well as the corpus study and the judgment survey in Chapter 2. The results of all these studies confirm that the extension of [ʌ]-forms started from the SFM suffix and is spreading to other harmonizing suffixes. However, of the two [RTR] stem types (/o/ and /a/), only stems containing /a/ are taking the extended [ʌ]-forms of suffixes. In this section, I discuss the effect of the suffix, focusing on the new findings of the production studies.

3.4.1 Identity of suffix

The SFM suffix is the only suffix that shows notable variation when it is attached to /a/-stems. Other harmonizing suffixes predominantly take *ɑ*-initial forms when they combine with /a/-stems, so only the SFM suffix shows a significant tolerance for variation. What characteristics of the suffix are related to the change towards disharmonic forms? In this section, I present two characteristics of the suffix, which might be responsible for the change.

First, the distribution of the suffix must be taken into account, because it results in the overwhelming dominance of [ʌ]-forms in the SFM suffix. As introduced in section 1.2, there are morphosyntactically three types of verbal suffixes in Korean. The sentence below represents how the three types of suffixes differ in terms of position and function. The first verbal suffix – *asʌ*/*ʌsʌ* 'because' is located between the subordinate clause and the main clause, to connect them with a specific meaning. The second verbal suffix denotes the tense of the whole sentence. It is attached to the stem and is followed by a sentence ender, which is the third verbal suffix located at the end of sentence. The sentence ender represents the type of sentence (declarative, interrogative, imperative, and so on) and the level of politeness.

(23) Three types of verbal suffixes

	Embedded-clause ender			Non-terminal suffix	Sentence-ender
Cheolsu-nɯn	mʌri-ka	tɕoh-**asʌ**	kɯ	muntɕe-rɯl	pʰul-**ʌs'**-**ʌ**.
Cheolsu-TOP	brain-NOM	good-because	that	problem-ACC	to solve-PAST-SFM.

'Because Cheolsu was smart, he solved the problem.'

With regard to distribution, sentence-enders are different from others in that they may follow other suffixes, while the other suffixes directly follow stems in most cases. As in (23), the embedded-clause ender is not preceded by another suffix (e.g., a tense marker), because a subordinate clause generally does not have a tense marker. The tense of a subordinate clause depends on that of the main clause in Korean.

The SFM suffix is one of the sentence-enders. As a result, it may follow another suffix, as shown below. In cases where it follows another suffix, it always surfaces as [ʌ] because only the

first (leftmost) suffix harmonizes with the stem. As a result, the only contexts in which the SFM suffix can surface as [a] is where it directly follows /o/-stems or /a/-stems ((24f, g) in the 'present' column below). As a result, the frequency of [ʌ]-forms is much higher in the SFM suffix than in other suffixes.

(24) The distribution of the SFM suffix: The SFM suffix does not harmonize when it follows another suffix.

	present -∅	past-*a*/*ʌs'*	future-*kes'*
a.	tɕ'ik-**ʌ**	tɕ'ik-ʌs'-**ʌ**	tɕ'ik-kes'-**ʌ**
b.	pe-**ʌ**	pe-ʌs'-**ʌ**	pe-kes'-**ʌ**
c.	kɯs-**ʌ**	kɯs-ʌs'-**ʌ**	kɯs-kes'-**ʌ**
d.	tɕu-**ʌ**	tɕu-ʌs'-**ʌ**	tɕu-kes'-**ʌ**
e.	mʌk-**ʌ**	mʌk-ʌs'-**ʌ**	mʌk-kes'-**ʌ**
f.	top-**a**	top-as'-**ʌ**	top-kes'-**ʌ**
g.	tɕap-**a/ʌ**	tɕap-as'-**ʌ**	tɕap-kes'-**ʌ**

Of the thirteen harmonizing suffixes presented in Chapter 1, there are two other sentence enders in addition to the SFM suffix: the honorific suffix *-ajo*/*ʌjo* and the imperative suffix *-ara*/*ʌra*. The honorific suffix shows exactly the same distribution as the SFM suffix, while the imperative suffix does not follow the tense markers because imperative sentences are always realized in the present form. If the factor favoring the overextension of [ʌ]-forms in the SFM is the greater frequency of these forms, due to the distribution of the suffix, then we would expect the sentence-ending honorific suffix *-ajo*/*ʌjo*, which has a similar distribution, to show a similar pattern in terms of tolerance of disharmonic [ʌ]-forms. However, this was not the case.

Let us turn to the second characteristic of the suffix. The SFM suffix distinguishes itself from others by the position of the target vowel [a] or [ʌ]. As mentioned above, the SFM suffix is a sentence ender. In addition, the suffix consists of only one vowel. This means that the vowel is in the sentence-final syllable, which is the domain of final lengthening in Korean (Jun 1993).[44]

Beckman (1997: 5) argues that segments or syllables in psychologically salient positions (word-initial or stressed and therefore prominent) allow a wider range of contrasts, and are more likely to be faithfully realized than segments or syllables in other positions. Petrova et al. (2006) argue in the case of laryngeal contrasts in Hungarian, that ends of constituents, as well as beginnings, are 'psycholinguistically salient'.[45] Assuming that the lexical representation of the

[44] The acoustic analysis of six speakers' productions in the production experiment showed that the sentence-final vowels were longer than those in other positions by about 60%.

[45] For psychological evidence, see the studies cited in Petrova et al. (2006: 9). Additionally, Hyman (1977) and McGarrity (2003) show that final positions have a demarcative function. Blumenfeld (2006:161) proposed a non-finality constraint, whose rationale is "to protect the final syllable of a word from some prosodic constituent being built over it". These studies show that final position may play an important role in perception and therefore avoid certain phonological processes.

SFM suffix is [ʌ],[46] the positional faithfulness effect would protect the vowel from the application of a morphophonological process of vowel harmony. Furthermore, the lengthening associated with final position might serve to make a vowel in final position more prominent, and hence more salient.

Based on these previous findings, I propose the following constraint ranking:

(25) Constraint ranking including the positional faithfulness constraint

a. Regular stem : $\text{IDENT}_{\Sigma\text{-final}}$-V ≥ AGREE [RTR] ≥ IDENT-V
b. *P*-irregular stem : $\text{IDENT}_{\Sigma\text{-final}}$-V, IDENT-V ≥ AGREE [RTR]

To summarize, the extension of [ʌ]-form in the SFM suffix is accounted for by the tendency for segments in more salient positions or prosodically stronger positions to be realized faithfully.

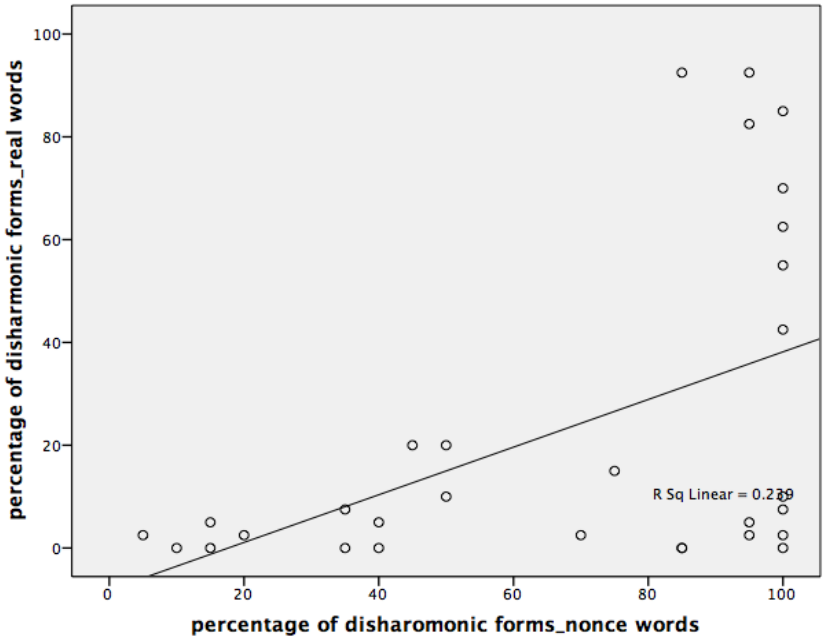
3.4.2 Real vs. nonce words

One of the most surprising findings was that the two [RTR] trigger vowels did not make a difference in the likelihood of disharmonic suffixes in nonce words, in contrast to real words. In addition, the percentage of disharmonic forms was much higher in nonce words than in real words (67.8% vs. 23.3% for /a/-stems).

This might be interpreted as indicating that participants did not understand the experiment and conjugated the nonce words randomly. However, this does not seem correct. The percentages of disharmonic forms in real words and nonce words for each speaker were subjected to a correlation test, which showed a significant correlation between the two values ($F(1,29)=0.489$, $p=.006$). Basically, the percentages of disharmonic forms in real stems were proportional to those in nonce stems, as in Figure 20.

[46] This is supported by the fact that the SFM suffix surface as [ʌ] when it follows another suffix, as in (24).

Figure 20. Correlation between the percentages of disharmonic forms in real and nonce stems for individual participants[47]



What caused the difference between real and nonce words? I speculate that Korean speakers depend not only on the morphophonological process of vowel harmony but also on the concrete tokens of conjugated forms for the production of the 'stem plus harmonizing suffix' combinations. This is related to the robustness or the productivity of the process. As the harmony process is losing its productivity, Korean speakers become more dependent on the lexicon, rather than on phonological rules/constraints. For real words, the harmonic forms of [RTR]-stems might have resulted from the stored forms in the lexicon, as well as from the application of the harmony process. However, the harmonic forms of nonce stems were produced only via the harmony process, which resulted in lower frequency of harmonic forms. I discuss this with regard to morphologization and the frequency effect in Chapter 5.

3.5 Summary

Even though the overall percentages of disharmonic forms fluctuated depending on the type of data, which might be attributed to the effect of prescriptive grammar and/or the formality of speech, the production experiment and the spontaneous speech study showed, basically, the same patterns as the Google-driven corpus and the judgment survey did. This indicates that the change in vowel harmony affects Korean speakers' productions, as well as their writings and judgments. The SFM suffix turned out to be regularized more often than other harmonizing suffixes (particularly, the honorific suffix, which has a similar frequency of [ʌ]-forms) and stems

[47] The eight participants distributed on the upper right side (who produced disharmonic forms for more than 40% of real tokens) were not sociolinguistically homogeneous. For example, five of them were male and their dialectal background was also diverse (Seoul, Chungcheong, and Gyeongsang).

containing /o/ invariably took [a]-forms in contrast with stems containing /a/. Since the position of the vowel is what distinguished the SFM suffix from other harmonizing suffixes, I argued that regularization of the SFM suffix is due to a special faithfulness constraint specified to sentence-final position, which is phonologically and semantically prominent. Another finding was that the variation in the production of nonce words was not affected by the stem vowel, and this is discussed in Chapter 5.

Chapter 4 Perception

4.1 Introduction

The two previous chapters confirmed, on the basis of four different types of data, that the patterned variation in the verbal conjugation is affected by trigger vowel, suffix type, and *p*-irregularity. This chapter deals with a perception experiment which was designed to investigate possible explanations of the trigger vowel effect: that although prescriptive rules require the [a] variant of a suffix following stem trigger vowels [a] and [o], the overextension of the [ʌ] suffix variant is much more likely when the stem vowel is [a] rather than [o].

This chapter presents a perception experiment which tested hypotheses established on the perception-based approach to vowel harmony. As introduced in section 1.4, Kaun (1995) argues that vowel harmony is perceptually motivated in that the shared feature by the target vowel enhances the perceptibility of the feature in the triggering element, which as a result facilitates the perception of the triggering element and therefore the lexical access of word. From the perspective of the perception-based approach, disharmonic forms could occur when the perceptibility of a triggering element is so robust that it can be perceived without the help of a harmonizing suffix. Steriade (1995) introduces a perceptually driven feature [nonperipheral], to account for the height assimilation in Bantu languages. In Lamba and many other Bantu languages, only vowels in the 'maximally dispersed' set {a, i, u} can appear underlyingly in affixes, while other vowels (e.g., /e/ and /o/) appear only in stems. Underlyingly high vowels in suffixes ('neuter' and 'applied' in (26)) assimilate to high (26a) and mid (26b) vowels in stems, respectively, in terms of height. However, the high vowels in suffixes surface as high with the low vowel /a/ in stems (26c).

(26) Lamba height assimilation (Steriade 1995: 156)

		past	neuter	applied	gloss
a.	high stems	*tul-a*	*tul-ika*	*tul-ila*	'dig'
		fiš-a	*fiš-ika*	*fiš-ila*	'hide'
b.	mid stems	*kos-a*	*kos-eka*	*kos-ela*	'be strong'
		sek-a	*sek-eka*	*sek-ela*	'laugh at'
c.	low stems	*pat-a*	*pat-ika*	*pat-ila*	'scold'

Steriade states that mid vowels are perceptually nonoptimal because of poorer discriminability (cf. acoustic stability of peripheral vowels (Perkell & Cohen 1989) in the Quantal Theory of speech (Stevens 1989)). In this respect, Bantu height assimilation is understood as the extension of the perceptually marked property [nonperipheral], to enhance the perceptibility of the mid vowels in stems. In this case, /a/ in stems does not trigger height assimilation presumably because it is perceptually optimal. Interestingly, this is very similar to the Korean

case in question. Focusing on the two vowels /o/ and /a/, /o/ triggers vowel harmony (or assimilation) but /a/ does not, in both sets of data. If Steriade's analysis applies to the Korean case, it is expected that /a/ is perceptually salient but that /o/ is not so salient as /a/.

Based on this assumption, the perceptibility of the vowels and the effect of harmonizing suffixes in the perception of stems were tested in a perception experiment. The results show that /a/ was correctly identified irrespective of short duration, masking, and disharmonic suffixes, while the perception rate of /o/ declined seriously under such conditions. Based on these results, I argue that stems containing /o/ resist the extension of [ʌ] because the maintenance of harmony may facilitate the perception of the stems.

The hypotheses given in (27) are tested by the two experiments. The perception experiment tests two effects in the perception of stem vowels: the effects of the quality of the trigger vowel and the harmonic vs. disharmonic suffixes.

(27) Hypotheses tested in the perception experiment

a. The quality of trigger vowel: The mid-high RTR vowel /o/ is identified less accurately and more slowly than the low RTR vowel /a/.
b. Stems followed by disharmonic suffixes are identified less accurately and more slowly than those followed by harmonic suffixes.

Section 4.2 presents the methods and the results of the perception experiment. Section 4.3 discusses the results.

4.2 Perception experiment

The perception experiment was designed to answer the questions of whether the resistance of stems containing [o] trigger vowels to the overextension of the disharmonic [ʌ] suffix forms is due to the fact that /o/ is harder to identify than /a/. If this is the case, then use of the harmonizing suffixes should enhance the lexical retrieval of stems. The experiment used 'gating' methodology (Grosjean 1980, 1985; Petten et al. 1999), where participants heard small increments of the stimuli and identified the stem vowel (or the first vowel) they heard. The next section describes how the experiment was done, focusing on how the stimuli were created.

4.2.1 Method

4.2.1.1 Stimuli

Every full stimulus was designed to have a structure of CVC-V (stem-suffix). For the stem, 10 CVC formats were selected and the first vowel position was filled by one of the following four vowels: /a/, /ʌ/, /o/, and /u/. Of the 40 stem forms, 18 were real stems and the other 22 were nonce forms. Then each stem was combined with both harmonic and disharmonic suffixes to create 80 conjugated forms (10 CVC formats * 4 vowels * 2 suffixes). The list of the 10 CVC formats is given in Table 10.

Table 10. Ten CVC formats

tɕVp-	kVr-	mVr-	k'Vk'-	nVm-	mVtɕ-	nVt-	p'Vs-	kVs'-	sVtʰ-

The 80 forms were recorded in a carrier sentence three times by a male Korean speaker from Seoul.[48] The recording was done in a sound-attenuated room, using a Marantz PMD 660 portable digital recorder and a Shure SM48 microphone.

All vowels in the 240 tokens (80 forms * 3 repetitions) were segmented and subjected to an acoustic analysis in which duration, intensity, pitch, and the first two formants were measured. Duration was also measured for consonants to get the average duration for each consonant in each position. Because these acoustic features were expected to play crucial roles in the perception of vowels, they were taken into consideration in the selection and the manipulation of the stimuli. The average durations of consonants are presented in Table 11.

Table 11. Duration of consonant (in ms)

Consonant	tɕ	k	k'	l	m	n	p	p'	r	s	s'	t	t'	tʰ
Average	101	101	118	125	108	78	99	80	38	119	157	84	159	150
Manipulated	100	100	120	120	100	80	100	80	40	120	160	80	160	140

The duration of the vowel varied depending on the vowel quality and the morphological status of the morpheme the vowel belonged to. The lower vowels were longer than the higher vowels and the suffix vowels (CVC-**V**) were longer than the stem vowels (C**V**C-V). Based on the average duration, the duration of the stem vowel was scaled to 60ms and that of the suffix vowel was scaled to 80ms. The measurement of intensity gave rise to the same pattern regarding vowel quality. The high back vowel /u/ was weaker than the others, possibly because some tokens of /u/ were devoiced.[49] The overall average intensity of the stem vowels was 63.86dB (with 4.56 SD: Standard Deviation) and the target stimuli were selected within the average ± one half SD of intensity, with the exception of one /u/-stem. The pitch (F0) was higher in the two higher vowels than in the two lower vowels (r=.130, p=.050), but was not different within the two lower and the two higher vowels. The same criterion was applied to the pitch as to the intensity. The average (107.2dB) and the standard deviation (14.1) values were taken into account. The first two formants were checked so that no token was selected if it fell outside the typical range of a vowel in F1-F2 space.

[48] The carrier sentence was '*nanɯn* _____*rako malhet'a*' (I said _____).

[49] If eight devoiced tokens of /u/ are excluded, the average intensity of /u/ vowels was 63.71dB (3.33 SD) and the intensity was not different depending on the vowels (r=-.062, p=.346).

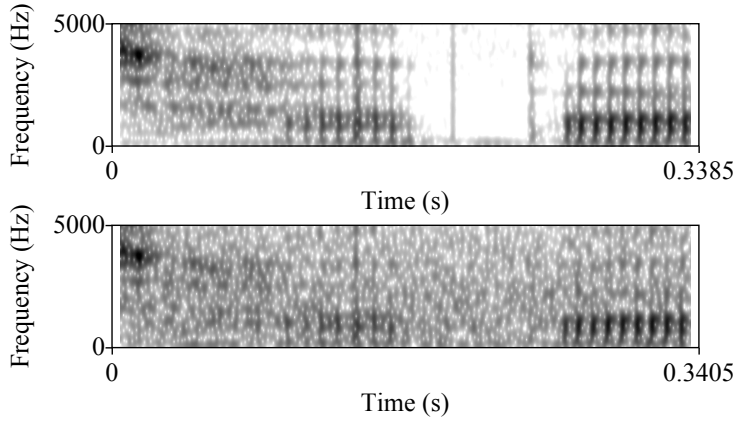
Table 12. The average and standard deviation of acoustic features for the four vowels

Vowel	Stem/ Suffix	Duration		Intensity		F0 (Pitch)		F1		F2	
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
a	Stem	62.72	25.05	64.21	2.40	105.08	15.41	647.50	101.40	1191.88	78.82
	Suffix	81.71	20.89	66.90	2.43	115.59	10.64	604.04	80.63	1199.19	131.77
ʌ	Stem	60.77	23.55	65.25	2.40	106.53	13.91	436.02	56.46	973.08	85.75
	Suffix	71.76	20.37	67.26	2.37	117.19	9.84	456.36	57.72	1034.50	106.09
o	Stem	51.84	19.70	64.89	2.76	109.02	13.96	342.50	35.62	886.73	130.39
u	Stem	40.08	16.54	61.10	7.38	109.66	11.79	298.60	34.13	1016.91	189.67

After all these acoustic features were measured and checked, 80 tokens were selected from the 240 tokens. Duration was manipulated to 60ms for stem vowels and 80ms for suffix vowels. When a vowel was shortened or lengthened, the manipulation took place in the middle of the vowel. The durations of consonants were also adjusted.

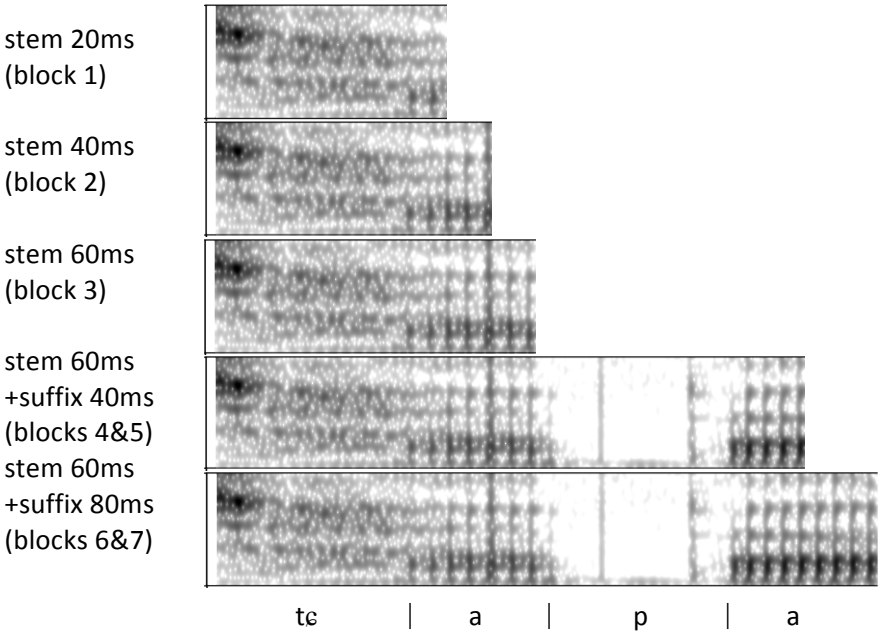
The next step was to create a set of masked stimuli. In order to mask the stimuli, white noise with 60dB, which was created by a fan, was added. The two spectrograms in Figure 21 show how a spectrogram changed after masking. This resulted in 160 tokens (10 CVC formats * 4 vowels * 2 suffixes * 2 presentations (masked or not)).

Figure 21. An unmasked spectrogram and a masked spectrogram (*tɛap-a*)



The full-length stimuli were gated into five durations. First, 'stem' tokens were taken only from harmonic forms (40 unmasked and 40 masked) with a stem vowel of 20ms, 40ms, and 60ms. As a result, 240 stem tokens were created (10 CVC formats * 4 vowels * 2 presentations * 3 durations). Then 'stem+suffix' tokens consisted of a full stem vowel (60ms) and a suffix vowel of 40ms and 80ms, which gave rise to 320 tokens (10 CVC formats * 4 vowels * 2 suffixes * 2 presentations * 2 durations).

Figure 22. Examples of gated stimuli (*tɛap-a*: CV_{20ms}, CV_{40ms}, CV_{60ms}, $CV_{60ms}CV_{40ms}$, and $CV_{60ms}CV_{80ms}$)



The 560 tokens were divided into seven blocks, each of which had 80 tokens. The first block had the shortest stimuli and the last two blocks had the longest ones. The seven main blocks were preceded by a practice block, which was in turn preceded by the instructions. The order of stimuli within each block was random, while the order of blocks was consistent lest participant hear longer stimuli before shorter ones. The experiment was designed and executed using E-Prime on a PC.

4.2.1.2 Procedure

Thirty Korean speakers, all Stony Brook University students, 18 female and 12 male, took part in the experiment. They were all paid for their participation. Their ages ranged from 21 to 34, with one speaker age 45 (the average was 25.2). 17 speakers were from Seoul and Gyeonggi province, and the others from Chungcheong (6), Jeolla (6), and Gyeongsang (1) provinces. At the time of recording, they had resided in the US from 3 months to 9 years, with two exceptions of 12 and 19 years (the average was 3 years). None reported problems with hearing.

Every participant was seated in front of a computer in a sound-attenuated room and given the instructions by the experimenter in Korean. S/he was told that s/he was going to hear non-honorific imperative forms of verbal stems that could be real or invented. After completing the practice block with 40 tokens and being given the opportunity to ask questions, the participants moved on to the main blocks after the experimenter left the room. Stimuli were presented through a headphone (Sony MDR-CD380) and participants were asked to identify the stem or the first vowel of each token by responding with assigned number keys. For half the participants, the four vowels /a/, /ʌ/, /o/, and /u/ were marked on 4, 6, 8, and 2, respectively.

For the other half, the number keys were 8, 2, 4, and 6. The accuracy (1 or 0) and the response time were measured.[50]

Two measures of accuracy were calculated. The accuracy rate by subject was calculated on the basis of the number of correct responses each participant gave to the 10 tokens containing the same variables for all the factors (vowel, duration, masking, and harmony[51]) but different consonants (10 CVC formats presented in Table 10). The accuracy rate by item was calculated on the basis of the number of participants who gave the correct response to each token. These percentages were subjected to ANOVA with the factors of vowel,[52] duration, masking, and harmony. The results are presented in the next section.

4.2.2 Results

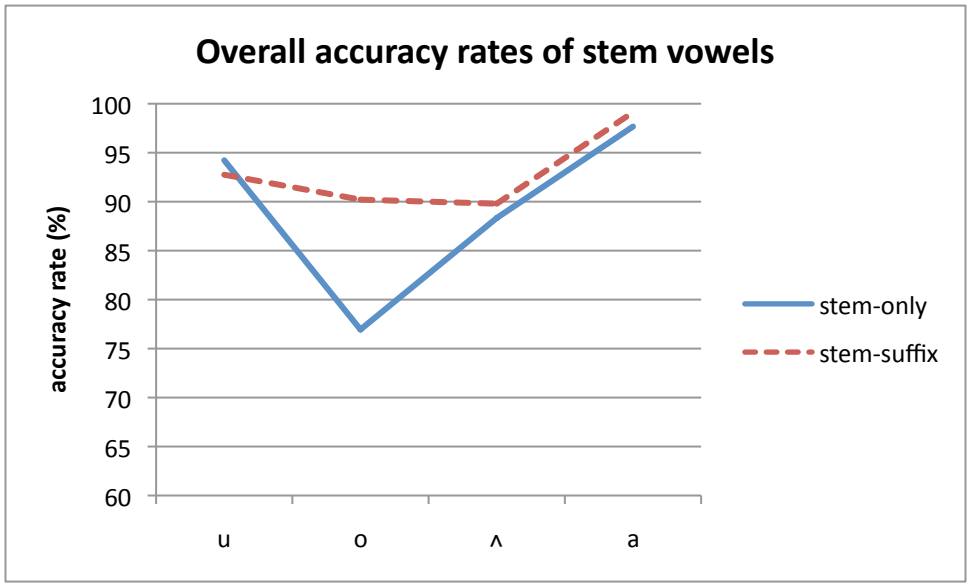
Statistical analyses were performed on accuracy rates arranged by subject and by item, and on response time. The results show that the /o/ (and /ʌ/) were more difficult to identify than /a/ (and /u/) as hypothesized.

4.2.2.1 Accuracy rate by subject

An ANOVA was carried out on the accuracy rates in the 'stem only' set with the factors of vowel (height*ATR), duration, and masking. It turned out that every factor made a significant difference in the accuracy rate. As Figure 23 shows, the overall accuracy rate was the highest for /a/ (97.67%) and the lowest for /o/ (76.94%).[53] Between the two ATR vowels, it was higher for /u/ (94.2%) than /ʌ/ (88.3%). Height ($F(1,29)=40.857$, $p<.001$), ATR ($F(1,29)=10.44$, $p=.003$) and the interaction of height and ATR ($F(1,29)=108.564$, $p<.001$) were all significant.

[50] The response time was measured from the onset of the stimuli because the stem vowel, which was to be identified, was placed at a consistent distance from the onset, but not from the offset.
[51] The harmony factor applies only to the tokens including suffix vowels.
[52] The four vowels were characterized by two features: [high] and [ATR], assuming /a/, /ʌ/, /o/, and /u/ as [-high, -ATR], [-high, +ATR], [+high, -ATR], and [+high, +ATR], respectively.
[53] The overall rate was higher than expected possibly because the volume of the computer that was used for the experiment was set relatively high.

Figure 23. Overall accuracy rates of stem vowels in stem-only and stem+suffix tokens (/u/, /o/, /ʌ/, and /a/)[54]

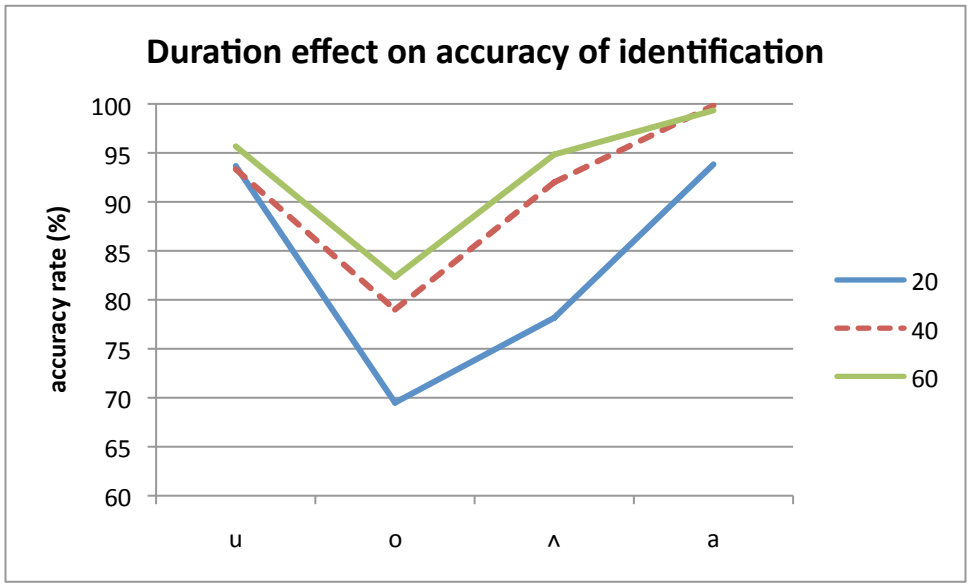


As expected, duration (F(2,58)=58.48, *p*<.001) and masking (F(1,29)=16340, *p*<.001) were also significant. The accuracy rate was lower in shorter tokens and in masked tokens than in longer tokens and unmasked ones, respectively.[55] For the purpose of the experiment, how these factors interacted with the vowels is more important than the factors themselves. The duration factor interacted with the vowel factors (height and ATR, F(2,58)=26.06, *p*<.001). Figure 24 shows that the duration effect was stronger in /o/ and /ʌ/ than the other vowels. Except for /u/, 20ms tokens were identified less accurately than 40ms or 60ms tokens.

[54] The results include all the tokens (i.e., short and long, masked and non-masked, harmonic and disharmonic).

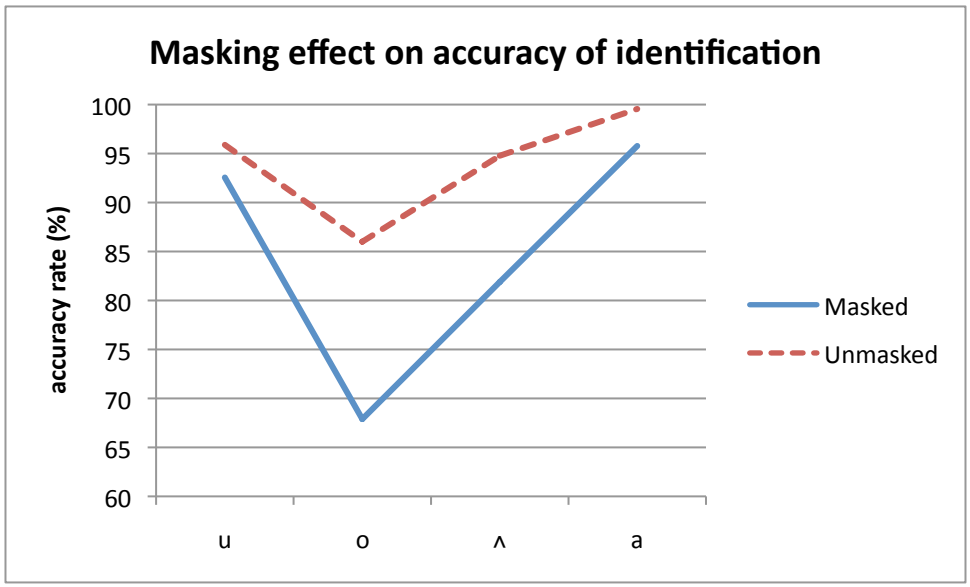
[55] The averages were 83.79 (20ms) vs. 91.04 (40ms) vs. 93.04 (60ms) and 84.52 (masked) vs. 94.06 (unmasked).

Figure 24. Duration effect on accuracy of identification of different vowels (20ms vs. 40ms vs. 60ms)



The masking effect showed a pattern similar to the duration effect. The accuracy rate fell for masked /o/ and /ʌ/, while /u/ and /a/ were not significantly affected by masking ($F(1,29)=25.358$, $p<.001$). Figure 25 shows that the accuracy rate fell when the stimuli were masked.

Figure 25. Masking effect on accuracy of identification of different vowels (masked vs. unmasked)

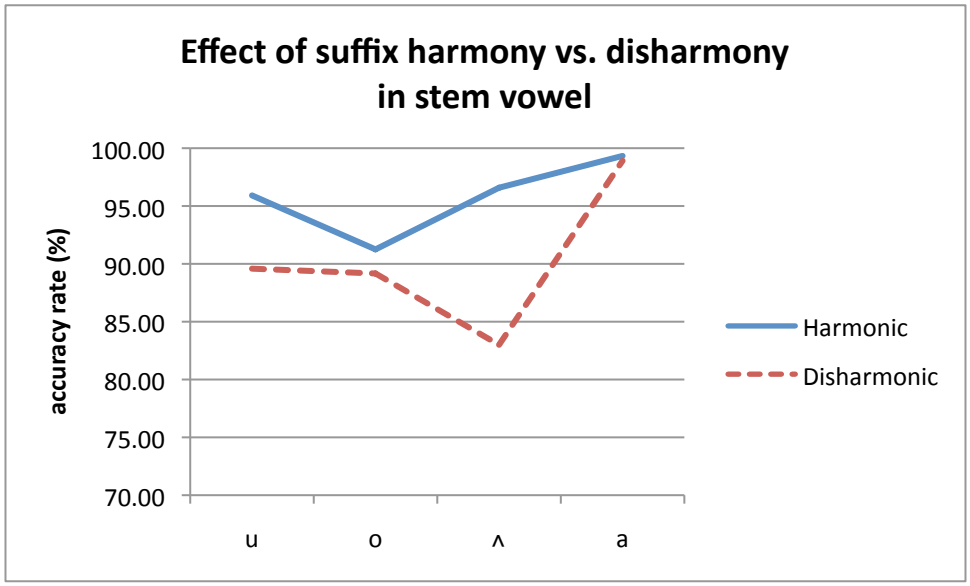


In the set of 'stem+suffix' forms, the accuracy rate was expected to be high because every token in this set had a full stem vowel (60ms). The results were not very different from this expectation. The overall rate was 92.97%, which was higher than that of 'stem-only' set (89.29%). The vowel effect was also found in this set ($F(1,29)=17.08$, $p<.001$ for height,

F(1,29)=18.327, *p*<.001 for ATR, and F(1,29)=55.313, *p*<.001 for the interaction of height and ATR). Even though the gaps between vowels were small compared to the stem-only set, the pattern was similar except that the order of /o/ and /ʌ/ was reversed with a difference of 0.4% as shown in Figure 23 above. The masking effect was replicated in the stem+suffix set. Specifically, the decrease in accuracy when stimuli were masked occurred only with /o/ (93.33% to 87.08%) and /ʌ/ (92.08% to 87.50%) but not with /a/ (99.17% to 99.08%) and /u/ (92.67% to 92.83%). So far the results are not different from the results of the 'stem only' set. So here, the focus is on the harmony factor, that is, whether harmonic and disharmonic suffixes actually affect the perception of stems, particularly stems containing /o/ and /a/.

Even though the overall harmony effect was significant (F(1,29)=83.375, *p*<.001), the significant effects were found in neither of the two RTR vowels (/o/ and /a/, F(1,29)=2.457, *p*=.118 for /o/ and F(1,29)=1.301, *p*=.255 for /a/). Taking into account the fact that all the 'stem+suffix' tokens had the full vowel (60ms) in the stem, which resulted in the overall high accuracy, the harmony effect was tested in the set of masked tokens. It turned out that the perception of /o/ was significantly affected by harmony (91.3% vs, 82.8%, F(1,29)=19.507, *p*<.001), while that of /a/ was not (99.5% vs. 98.7%, F(1,29)=2.513, *p*=.116). Of the four vowels tested, the harmony effect was strongest for /ʌ/, as shown in Figure 26.

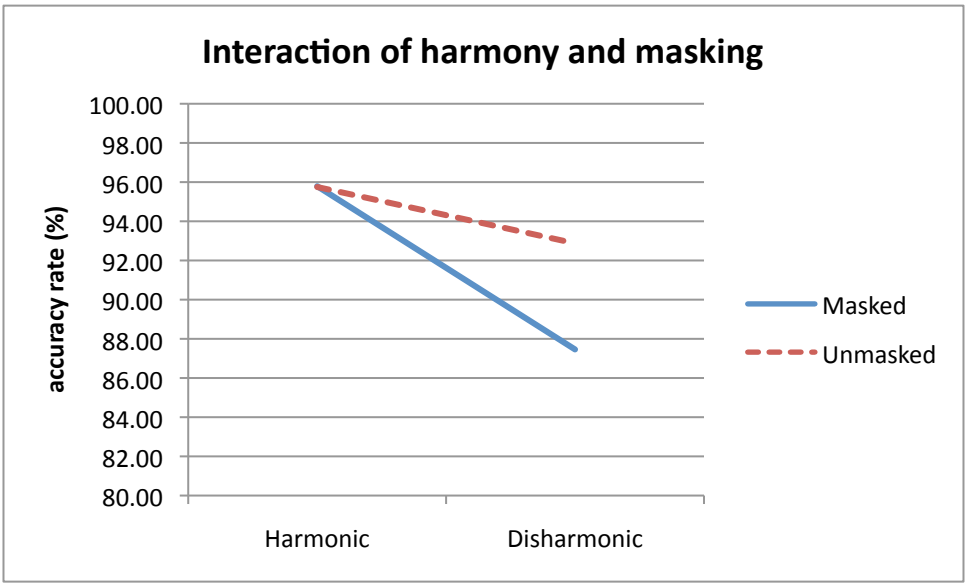
Figure 26. Effect of suffix harmony vs. disharmony of stem vowel on accuracy of identification of different vowels



As pointed out above, the harmony factor also showed a significant interaction with masking (F(1,29)=70.601, *p*<.001). The harmony effect was bigger in masked tokens than in unmasked ones, which indicates that harmonized suffixes facilitate recognition of the stem,

particularly when conditions made perception of the stem vowel more difficult. Figure 27 shows the difference clearly.

Figure 27. Interaction of harmony and masking on accuracy of identification of stem vowel



4.2.2.2 Accuracy rate by item

The accuracy rate by item basically showed patterns similar to those found in accuracy by subject. The effects of the different factors were similar to those in the previous section, but the statistical power was weaker (N=10, 10 CVC frames vs. N=30, 30 subjects). An ANOVA on the accuracy rate of stem vowels revealed that the following factors and interactions were significant: duration ($F(1,9)=30.579$, $p<.001$), masking ($F(1,9)=61.57$, $p<.001$), height*ATR (vowel, $F(1,9)=19.874$, $p=.002$), vowel*duration ($F(2,18)=9.792$, $p=.001$), vowel*masking ($F(1,9)=16.451$, $p=.003$), and duration*masking ($F(1,9)=16.152$, $p<.001$). The patterns in Figure 24 and Figure 25 were replicated, which means that duration and masking effects were strong for /o/ and /ʌ/ but not for /a/ and /u/.

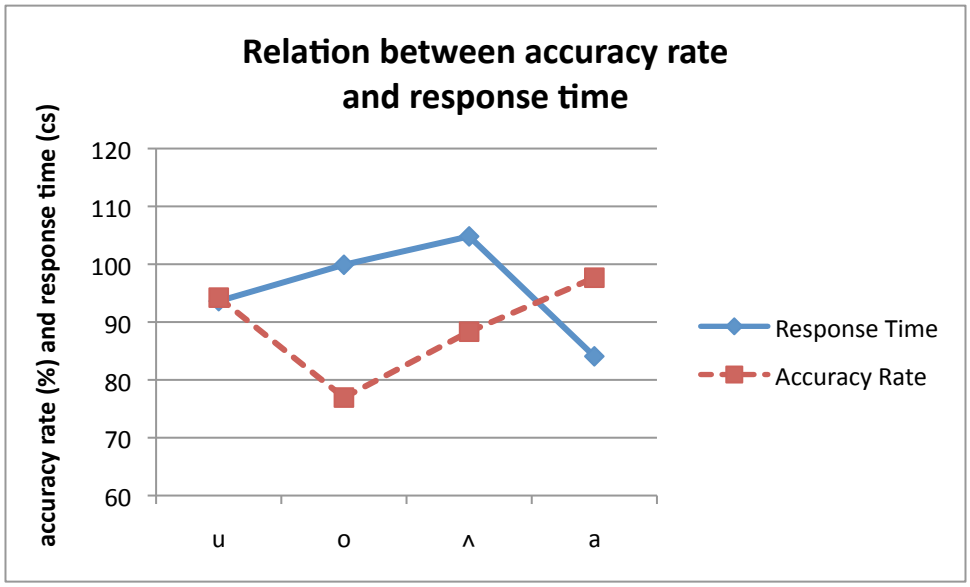
The weak statistical power was obvious in the second set, containing 'stem+suffix' forms. Even though the patterns according to the factors were the same, only three factors or interactions were within the range of significance: masking ($F(1,9)=6.556$, $p=.031$), vowel*masking ($F(1,9)=7.343$, $p=.024$), and masking*harmony ($F(1,9)=11.92$, $p=.007$). The factors and interactions that were significant in the stem set turned out to be marginally significant (e.g., harmony $F(1,9)=3.768$, $p=.084$, and ATR*harmony $F(1,9)=4.323$, $p=.067$).

4.2.2.3 Response time

The results for response time were not very different from those of accuracy rate. In general, the lower the accuracy rate, the longer the response time. For example, different vowels were

associated with different response times, which were nearly inversely related to the accuracy rate. This tendency is represented in Figure 28.

Figure 28. Relation between accuracy rate and response time in identification of different vowels



As in the accuracy rate, masking ($F(1,29)=34.732$, $p<.001$) and duration ($F(1,29)=26.5$, $p<.001$) affected response time. Participants took more time to respond to masked tokens and shorter tokens than to unmasked and longer tokens, respectively.

The effects of masking and duration were replicated in the stem+suffix set ($F(1,29)=28.765$, $p<.001$ for masking and $F(1,29)=9.013$, $p=.005$ for duration). In addition, the harmony factor also played a role ($F(1,29)=14.611$, $p=.001$). The response was a little slower when the participants heard a disharmonic token (957ms vs. 932ms).

In sum, of the four back vowels in Korean, the two vowels in the middle (/o/ and /ʌ/) were less accurately perceived than the high vowel /u/ and the low vowel /a/. Additionally, the inaccurate perception of the two mid vowels was aggravated when the vowels were linguistically weak (e.g., when they were short) and non-linguistically weakened (e.g., when embedded in noise), while the other two vowels were not significantly affected. Moreover, it turned out that harmonizing suffixes had different effects on the two [RTR] stem vowels, when the stem vowels were perceptually weak (in particular, when they were masked). The accuracy in perception of /a/ did not change depending on the harmonic vs. disharmonic suffixes that followed the stems. In contrast, /o/ was perceived significantly more accurately when the stem was followed by a harmonic suffix than by a disharmonic suffix. The results of response time supported those of accuracy rate by showing that the longer a response time, the more inaccurate the response.

4.3 Discussion

So far we have seen results of a perception experiment designed to test the effect of the recoverability of the stem vowel on the persistence of vowel harmony. For the effects of the quality of stem vowel, the hypotheses based on the perception-based account were borne out. Overall, the results showed that the historical change in Korean verbal conjugation is better understood from the perspective of perception. In the phase of decay, vowel harmony survives when it plays a role in the identification of the triggering element.

The experiment showed that (i) the vowel /o/, which generally takes harmonic suffixes, had the lowest rate of accurate perception, while /a/, which is much more likely to allow the extension of the /ʌ/ suffix, had the highest accuracy of perception and the shortest response time; (ii) the harmony effect was the biggest in the two ATR vowels (/ʌ/ and /u/), which allow absolutely no variation, and the smallest in the low vowel /a/, which allows variation. The perception of /o/ was affected by the harmonizing suffixes only when the stimuli were masked; and (iii) the accuracy rate was lower for the two mid vowels (/o/ and /ʌ/) than for the high vowel /i/ and the low vowel /a/, with the duration and the masking effects stronger for the two mid vowels. These results are consistent with Steriade's perceptual claim that nonperipheral vowels show a perceptual disadvantage. They also support Kaun's argument that vowel harmony is strongly motivated when the perception of the triggering element is weak. Here, I discuss possible explanations for the three facts found in the experiment.

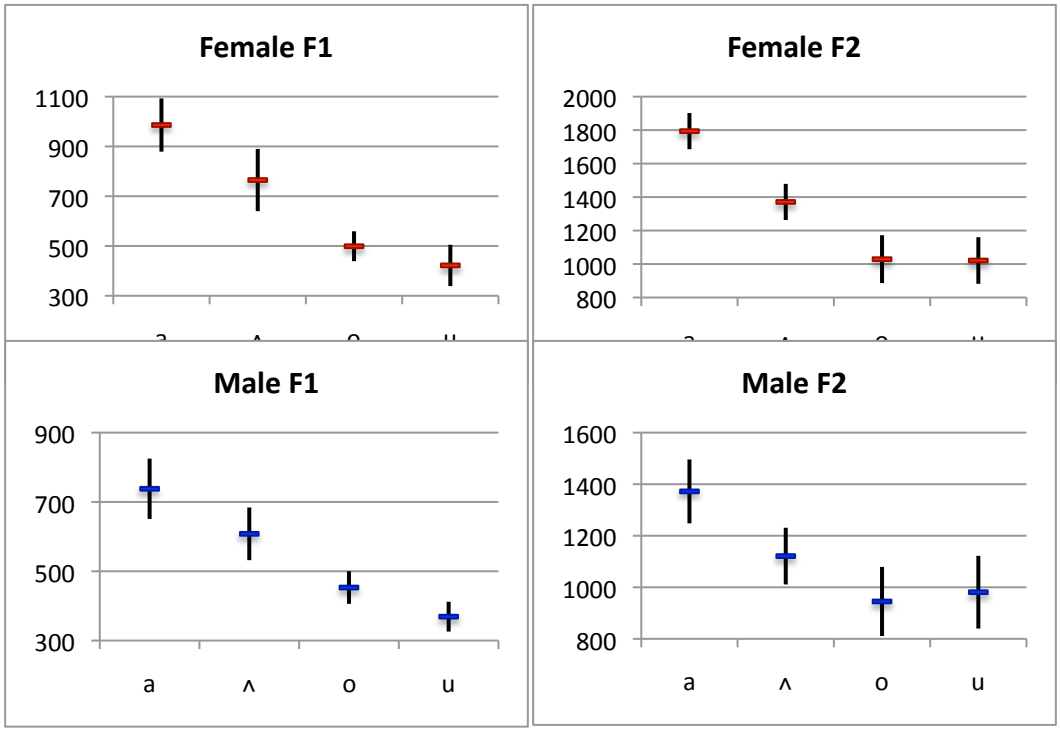
First, /a/ was recognized correctly in any environment but /o/ was the most difficult to identify and vulnerable to internal (e.g., duration) and external (e.g., masking) adverse conditions. The accuracy rate of /a/ was the highest even though duration was manipulated to equalize duration for all four vowels. In actual linguistic data, /a/ is expected to be longer than other vowels, according to Lehiste (1970), who notes that low vowels are longer than high vowels under the same conditions in most (or all) languages. In the acoustic analysis of six participants in the production experiment, /a/ and /ʌ/ were longer than /o/ and /u/ ($F(3,15)=39.362$, $p<.001$), which implies that /a/ was shorter than expected in the perception experiment and that /a/ should have been more difficult to identify.[56] The results are consistent with the conclusion that /a/-stems may be identified even before the following (harmonizing) suffixes are heard but that /o/-stems might not be identified without sufficient top-down information. Consequently, the extension of [ʌ]-forms should have little effect on the recognition of /a/-stems.

Moreover, while the rounding of /o/ might be assumed to be a reliable cue to the presence of this vowel, the vowel system of Contemporary Korean may make it more difficult to distinguish /o/ from the acoustically close /u/. The low vowel /a/ does not seem to experience

[56] I thank Jiwon Hwang for calling this to my attention.

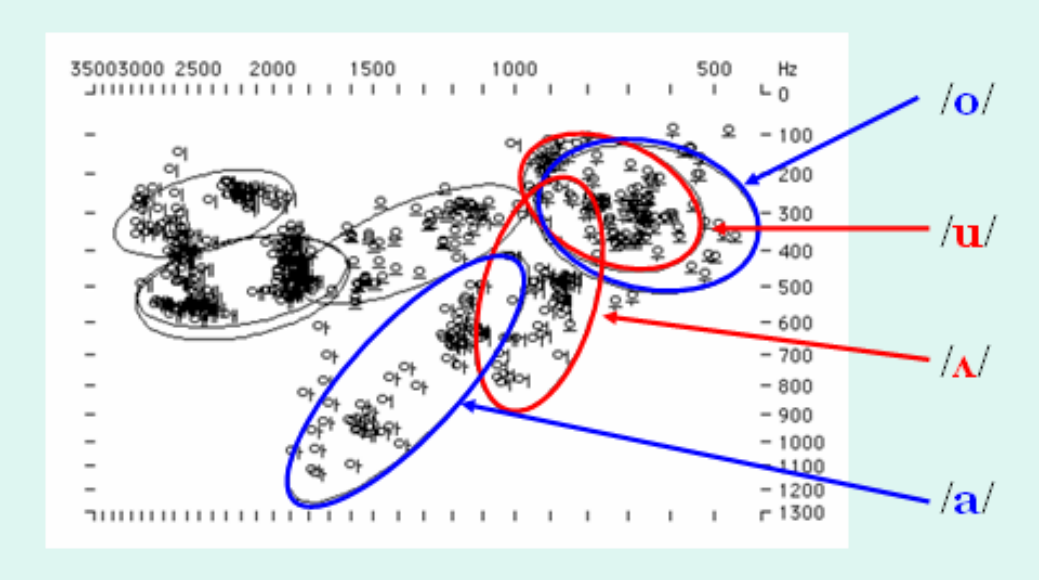
this problem because it is sufficiently far from its counterpart /ʌ/. This is consistent with Yang's (1996) data on the formant values of the Korean vowels represented in Figure 29. The ranges indicate 'mean ± standard deviation' values, calculated based on Yang (1996). For each value and each group (female or male), the range of /a/ rarely overlaps with that of /ʌ/. This means that these two vowels are not likely to be confused. However, except for the F1 values of male speakers, the range of /o/ overlaps almost entirely with that of /u/.

Figure 29. Distribution of F1 and F2 (based on the results in Yang 1996)



This result is replicated in Lee (1998). As seen in Figure 30, /o/ and /u/ show considerable overlap, while /a/ and /ʌ/ have only a small region of overlap.

Figure 30. Distribution of F1 and F2 in vowel space (Lee 1998)

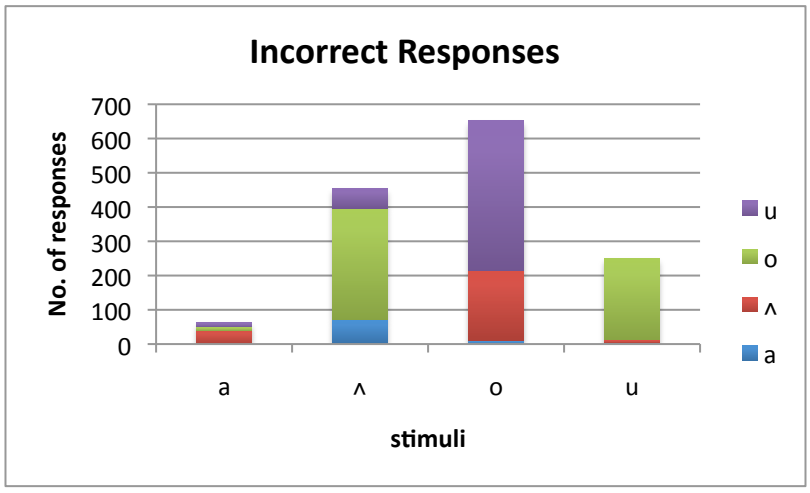


The intrinsic salience of /a/ and its unique position in the vowel system of Korean explain why Korean speakers did not fail to perceive the low vowel /a/ no matter how short and masked it was.

Second, the accuracy rate of stem vowels was lower with disharmonic suffixes than with harmonic suffixes when the tokens were masked. This suggests that Korean speakers may depend, in part, on the suffixes for the identification of stems. Note that the harmony effect was the biggest for the two invariant [ATR] vowels. As participants may never have heard disharmonic forms containing [ATR] stems, this result was not surprising. This also accounts for why /a/-stems were not affected. Korean speakers have been exposed to both harmonic and disharmonic forms of /a/-stems, so they do not rely on the harmonizing suffixes for the identification of /a/-stems. But then, why was the effect of harmony smaller for /o/-stems than for the two [ATR] stems, even though /o/-stems did not allow disharmonic forms? Above all, we should remember that [ʌ] is the dominant form in harmonizing suffixes. In other words, the other suffix form [a] is, in Korean speakers' knowledge, linked to a small group of stems, mainly /o/-stems. So when they hear an [a]-form suffix, it is a strong cue for the presence of either /o/-stems or probably /a/-stems. However, [ʌ] is regarded as a default form, and therefore is not a reliable indicator of stem vowel quality. Moreover, recall that Korean speakers produced disharmonic forms of /o/-stems when the stems were nonce words, even though real /o/-stems did not show any variation in the Google-driven corpus, the production experiment, or the spontaneous speech. I interpret this as indicating that Korean speakers are ready to accept disharmonic /o/-stems even though they still do not actually produce them. This might have weakened the effect of disharmonic suffixes on the perception of /o/-stems.

The last question raised by the results is why /o/ (and /ʌ/) exhibited the lowest accuracy rate. Generally speaking, high vowels are intrinsically weak and /o/ is relatively high compared to /a/. Furthermore, the acoustic analysis showed that /o/ was shorter than /a/. However, the accuracy rate of the highest vowel /u/ was greater than that of /o/, even though /u/ was not only as short as /o/ but also lower in intensity. In contrast, the mid-low vowel /ʌ/ was not recognized as accurately as /u/, even though it was longer and louder than /u/. So this is not merely a matter of intrinsic height and weakness. From the perspective of acoustics, the first two formants of /u/ are concentrated on a specific range of frequency, while those of other vowels are dispersed. The convergence of the first two formants raises the perceptibility of the vowel and makes /u/ more discernible. Another thing to consider is the disadvantage of nonperipherality (Steriade 1995; Crosswhite 1999). Acoustically, this is implicitly shown in Perkell and Cohen (1989), who conclude that peripheral vowels (/i/, /a/, and /u/) are salient because the acoustics of these vowels are stable over a relatively wide range of contraction, based on articulatory (e.g., X-ray tracings) and articulation-and-acoustic-correlated experiments. Peripheral vowels are advantageous from the perspective of competition. In terms of height, /u/ and /a/ are positioned at both margins and accordingly they have only one neighbor vowel each. However, the other two vowels are in the middle and they have their neighbors on both sides, which results in more competition in perception. This is reflected in the incorrect replies in the experiment. The two mid vowels were misperceived as either the higher or the lower neighbors (see Figure 31 below), while most of the incorrect responses for the /u/-stimulus were /o/, its only neighbor.

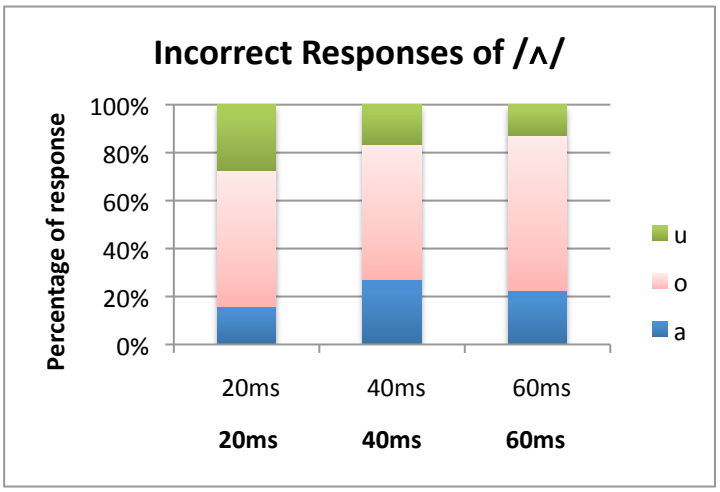
Figure 31. Incorrect responses for different stem vowels



The last thing to note about the high accuracy of /u/ is the intrinsic shortness of the vowel, which might have led participants to misperceive short vowels as /u/ irrespective of the different qualities of the stimuli. For example, Weiss (1972) and Gussenhoven (2004) show that short vowels in German and Dutch, respectively, tend to be perceived as higher than they really

are. This might have affected the results in the perception experiment in this study. This was actually shown in the incorrect responses for /ʌ/. The shorter the stimuli were, the more /u/ responses were given.

Figure 32. Incorrect responses of /ʌ/ depending on the lengths of the stimuli (20ms, 40ms, and 60ms)



If the unrounded high back vowel /ɯ/ is added to the perception experiment, we will be able to get to a narrower conclusion. As /ɯ/ is no longer than and close to /u/ in Korean, this will filter out the contributions of the intrinsic short duration and less competition. I leave this for future research.

For synchronic analysis, I follow Hong's (2008) analysis in which the markedness constraint responsible for the harmony process (AGREE [RTR]) is bifurcated into two separate constraints specified for the two [RTR] vowels.

(28) Trigger-sensitive Agree (Hong 2008: 424)
- a. AGREE(+RTR, *o*): /o/ is followed by a [+RTR] vowel.
- b. AGREE(+RTR, *a*): /a/ is followed by a [+RTR] vowel.

According to his analysis, AGREE-/o/ still dominates the faithfulness constraint (i.e., IDENT-V), while AGREE-/a/ is being demoted, resulting in variation.

(29) Constraint ranking including the trigger vowel-specific constraints
- a. Regular stem : AGREE(+RTR, *o*) > $\text{IDENT}_{\Sigma\text{-final}}$-V ≥ AGREE(+RTR, *a*) ≥ IDENT-V
- b. *P*-irregular stem : $\text{IDENT}_{\Sigma\text{-final}}$-V, IDENT-V ≥ AGREE(+RTR, *o*) ≥ AGREE(+RTR, *a*)

Diachronically, the difference of the perceptibility might have caused the bifurcation of the markedness constraint.

4.4 Summary

The perception experiment, in which Korean speaker heard stimuli of different lengths and under different conditions, and identified the vowels they heard, revealed that /o/ is perceived

less accurately and more slowly than /a/. Moreover, the identification of /o/-stems may be affected by the following harmonic/disharmonic suffixes, while that of /a/-stems is not. These facts support Kaun's (1995) view that harmony may play a role in the enhancement of the perceptibility of stems, in this case, of /o/-stems in Korean. For this reason, vowel harmony is strictly required for /o/-stems.

5 General Discussion and Conclusion

We have seen that vowel harmony in the Korean verbal conjugation is affected by the morphophonological class of the stem (*p*-irregular stems vs. others), the identity of suffix (the SFM suffix vs. others), and the quality of the stem vowel (/o/ vs. /a/). The Google-driven corpus study (Chapter 2) showed that *p*-irregular stems take [ʌ]-form suffixes irrespective of the stem vowels and that in regular stems the proportion of disharmonic forms is significantly higher in /a/-stems than in stems containing /o/, /u/, or /ʌ/. These two results were replicated in the judgment survey (Chapter 2) and the production experiment (Chapter 3). In the judgment survey participants tended to accept forms in which the SFM suffix was realized as either [a] or [ʌ] when the stem contained /a/, while for other harmonizing suffixes, participants generally preferred [a]-forms in the same environment (with /a/-stems). In addition, the production experiment demonstrated that the variation of the SFM suffix is associated with the sentence-final position of the vowel in the suffix. The spontaneous speech study (Chapter 3) confirmed that stems containing /o/ always take [a]-form suffixes, consistent with the results of the production experiment, and that the extension of [ʌ]-forms has begun to spread to potentially harmonizing suffixes other than the SFM suffix. The perception experiment (Chapter 4) supported the view that the effect of the stem vowel quality is perception-oriented by showing that the perception of /o/ is not as robust as that of /a/ and that harmonic suffixes may enhance the perceptibility of /o/ but not of /a/, under suboptimal conditions.

In this chapter, I briefly recapitulate the arguments that were presented for the effect of *p*-irregular stems (Chapter 2), the SFM suffix (Chapter 3), and the stem vowel quality (Chapter 4) with alternative accounts and the implications of the analyses (section 5.1). Other linguistic factors such as stem length, morphological relatedness, and intervening consonant, as well as sociolinguistic factors are discussed in section 5.2. The effect of frequency in language change is discussed in section 5.3. Section 5.4 concludes this dissertation with general discussion and residual issues for future research.

5.1 Phonological rules/constraints and the lexicon

In Chapters 2 to 4, I discussed possible accounts of the synchronic variation patterns in the framework of Optimality Theory, particularly Stochastic Optimality Theory and Cophonology Theory. In this section, I introduce another approach to variation and change with regard to the factors of *p*-irregularity and the SFM suffix. In addition, I discuss how the perception-based account of vowel harmony, which was proposed to account for the effect of stem vowel quality, can be extended to account for other factors.

5.1.1 *p*-irregularity

In Chapter 2, I analyzed the peculiar behavior of *p*-irregular stems in the framework of Optimality Theory, particularly Cophonology Theory. The tendency for *p*-irregular stems containing /a/ or /o/ trigger vowels to take [ʌ]-form suffixes was accounted for by the ranking IDENT-V ≥ AGREE [RTR] in the cophonology of *p*-irregular stems, which is different from the ranking AGREE [RTR] ≥ IDENT-V in the cophonology of other stems. Though this analysis accounts for the synchronic variation neatly, it does not explain how the different rankings arose in the two cophonologies. In this section, I discuss what could be a diachronic account for the vowel harmony of *p*-irregular stems.

To review, verbal suffixes are phonologically classified as consonant-initial, *ɯ*-initial, and *a*/ʌ-initial (harmonizing) suffixes, as given in Chapter 1. Regular verbs do not change their forms at the segmental level, no matter what type of suffix they take. In (30), the regular stem *tɕap-* does not alternate with any of the suffix types. However, in *p*-irregular stems, the stem-final *p* is maintained before consonant-initial suffixes but becomes [u] and [w] before *ɯ*-initial and *a*/ʌ-initial suffixes, respectively.

(30) Verbal conjugation of regular vs. irregular stems

	Regular	Irregular
suffix type	*tɕap-* 'to catch'	*komap-* 'to thank'
C-initial	***tɕap****ko*	***komap****ko*
ɯ-initial	***tɕap****ɯni*	***komau****ni*
a/ʌ-initial	***tɕap****a/ʌ*	***komaw****a/ʌ*

One possible diachronic explanation of the exceptional behavior of *p*-irregular stems appeals to the change of underlying representations (URs) M. Choi (1985) and I.-H. Chung (1997) argue that Korean speakers have multiple URs for *p*-irregular stems, *p*-final UR and *u*-final UR. According to M. Choi (1985), these stems ended in a segment which is reconstructed as /β/ in early Middle Korean. This segment was realized as [β] in intervocalic positions and [p] elsewhere. Then [β] in intervocalic positions was replaced by [w] in the 15th century. M. Choi proposes the following stages:

(31) The change of *p*-irregular stems (a to c from M. Choi 1985: 165-6)

a. Stage 1 /β/ ⇒ [p] / ___]$_{verbal\_stem}$ C
   [β] / ___]$_{verbal\_stem}$ V
b. Stage 2 /β/ ⇒ [p] / ___]$_{verbal\_stem}$ C
   [w] / ___]$_{verbal\_stem}$ V
c. Stage 3 /?/ ⇒ [p] / ___]$_{verbal\_stem}$ C
   [w] / ___]$_{verbal\_stem}$ V
d. Stage 4 /-p/ for C-initial suffixes
   /-u/ for V-initial suffixes

At stage 1, the two surface sounds [p] and [β] were derived from /β/, as exemplified in (32a). The change of /β/ to [p] was not unusual considering that other fricatives or affricates were also realized as stops before another consonant in Middle Korean, as they are in Contemporary Korean. At stage 2, [β] began to be replaced by [w], resulting in [β]~[w] variation. As [β] was still available, it was probably regarded as the underlying form, from which all the surface forms were derived. The derivation (/β/ to [w]) looks feasible, as the sounds ([β] and [w]) are phonetically similar. At stage 3, the bilabial fricative /β/ totally disappeared from surface forms (32b). In the absence of evidence for a regular phonological [p]-[w] alternation, Korean speakers began to posit two allomorphs for *p*-irregular stems as in stage 4. This case can therefore be seen as an example of how a phonological alternation, when it loses phonetic grounding, may be fossilized in the lexicon, in a process called morphologization by Joseph and Janda (1988). As no stem ends with [w] in Korean, speakers assumed underlying [u], a vowel which would normally take [ʌ]-form suffixes.[57] This seems to explain what activated the reranking of constraints in the cophonology of *p*-irregular stems.

(32) Historical change of *p*-irregular stems (M. Choi 1985: 163)

a.	tʌp-ko, tʌβ-ɯmjʌn, tʌβ-ʌ	'hot'	(*Wolinseokbo*, published in 1459)
b.	tʌp-ke, tʌu-mjʌ, tʌw-ʌ	'hot'	(*Beophwagyeong*, published in the 16th century)

However, this predicts that *p*-irregular stems should take [ʌ]-forms only, because /u/ does not fail to trigger [ʌ]-forms in other stems. This was not the case in the Google-driven corpus study and the judgment survey. Though [ʌ]-forms were dominant, [a]-forms were still found and accepted. Moreover, the difference between /o/-stems and /a/-stems also existed among *p*-irregular stems. This explanation can account for the different behavior of *p*-irregular stems with respect to vowel harmony, but it does not show how the present variation is produced.

In sum, the lexicon-based explanation of change shows why *p*-irregular stems are different from other stems with regard to vowel harmony or how the change occurred to *p*-irregular stems much earlier than to other stems, with relation to the morphophonological alternation of *p*-irregular stems. The remaining issue is how to combine this with the synchronic explanation of variation without conflict.

5.1.2 Identity of suffix

The fact that the SFM suffix may be realized as [ʌ] with stems containing /a/ was accounted for in Chapter 3 by appealing to special faithfulness requirements linked to the sentence-final position. The constraint requires the SFM suffix to be identical to the input /ʌ/ (resisting harmony) in the sentence-final syllable. In contrast, the alternating vowel in other harmonizing suffixes is not protected from vowel harmony because it is not in sentence final position. This

[57] Stem-final /u/ becomes [w] before a/ʌ-initial suffixes in Korean. e.g., /s'au-ʌ/ 'to fight-SFM' [s'awʌ] and /pak'u-ʌ/ 'to change-SFM' [pak'wʌ]

positional faithfulness is partially attributed to the prosodic prominence of the position, resulting from final lengthening (Jun 1993). Another factor to take into account is the fact that the proportion of [ʌ] realizations is very high for the SFM suffix compared to other harmonizing suffixes. However, it turned out that the proportion is not a crucial factor, as the honorific suffix *-ajo/ʌjo*, which has a very high proportion of [ʌjo] realizations, was always realized as [ajo] with stems containg /a/ in the production experiment.

For the behavior of the SFM suffix, I consider two possible alternative explanations below. The first alternative account is based on Ohala's (1993) argument that historical change is caused by listeners' reanalysis of phonetically variable (or phonologically ambiguous) sounds. In the Korean case, [a] or [ʌ] is expected to be longer in sentence-final position than in other situations, as a consequence of a final lengthening. This process might affect the articulation and/or perception of the vowels (cf. Becker-Kristal 2007; Lippus 2010). For example, Becker-Kristal (2007) shows that long /a/ is realized as lower than short /a/ in Hebrew. This variation in articulation, if any, might lead to a misperception, which could initiate a historical change.

An acoustic analysis was conducted to determine whether there is variation in vowel quality in sentence-final position, as a possible effect of position on vowel harmony. Of 30 speakers who participated in the production experiment, six male speakers from Seoul were selected.[58] For the purpose of the analysis, the first two formants (F1 and F2) of the two vowels alternating in harmonizing suffixes ([a] and [ʌ]) were measured and compared with the factor of position. The results showed that position (stem vs. suffix) made no significant difference, as shown in Table 13.

Table 13. The first two formants of [a] and [ʌ] in stem and suffix[59]

Vowel	Type	Example	Formant	Mean	Std. Deviation
[a]	stem	*tɕ**a**pa*	F1	653	33.3
[a]	suffix	*tɕap**a***	F1	654	22.27
[a]	stem	*tɕ**a**pa*	F2	1311	53.76
[a]	suffix	*tɕap**a***	F2	1280	102.4
[ʌ]	stem	*tɕ**ʌ**pʌ*	F1	514	35.02
[ʌ]	suffix	*tɕʌp**ʌ***	F1	514	27.38
[ʌ]	stem	*tɕ**ʌ**pʌ*	F2	1017	63.79
[ʌ]	suffix	*tɕʌp**ʌ***	F2	1090	88.73

[58] Three of the speakers were 'conservative' in that they produced nearly all the stems in harmonic forms (95% to 97.5%), while the other three adopted both harmonic and disharmonic forms at similar rates (37.5% to 57.5%).

[59] The position factor was not significant in any pair.

Another possible explanation of the extension of [ʌ]-forms in the SFM suffix appeals to learners' reanalysis of the morphological structure of stem-plus-suffix forms. As the vowel harmony process lost its phonetic grounding and productivity, the alternating vowel might have come to be regarded as a part of the stem rather than the suffix. Since verbal stems cannot appear by themselves in Korean, verbal stems are always followed by one or more verbal suffixes. This means that any word containing a verbal stem is analyzed into a stem and a suffix. For example, forms containing the stem *tɕap* might be reanalyzed as follows:

(33) Reanalysis of harmonizing suffixes

a. original analysis		b. reanlysis
tɕap-asʌ	'because'	tɕapa-sʌ
tɕap-ajatɕi	'only if'	tɕapa-jatɕi
tɕap-ato	'though'	tɕapa-to
tɕap-ajo	'honorific'	tɕapa-jo

However, this reanalysis cannot apply to the SFM suffix, because the suffix contains no segments other than the target vowel. Moreover, the sentence-final position makes the suffix prominent phonologically and semantically.[60] For this reason, the SFM suffix may be perceived as separate from stems. As a result, on this view Korean speakers refer to the input (or UR) form of the suffix (/ʌ/), which may surface either as [ʌ], the overwhelmingly frequent surface form, or as [a], the harmonized form. As the reanalysis of structures removes evidence for the vowel harmony process, the motivation for applying harmony to the SFM disappears. This way, this analysis can account for the overextension of [ʌ] in the SFM.

This account is consistent with the data reported in the studies of the development of Korean verbal conjugation in children (G.-M. Baek 2011; S. Lee et al. 2009). The typical error found in the development of verbal conjugation is that [ɯ] or [a/ʌ], which originally belongs to *ɯ*-initial or *a*/*ʌ*-initial suffixes, appears before consonant-initial suffixes, as shown in (34). This indicates that children regard [ɯ] or [a] as belonging to stem forms at least at some stage of language acquisition.

(34) Incorrect conjugation in child language (G.-M. Baek 2011)

		correct form		incorrect form
a.	*us-ne*	[unne]	'to laugh-DECL'	[us**ɯ**ne]
b.	*nol-mjʌn*	[nolmjʌn]	'to play-if'	[nor**ɯ**mjʌn]
c.	*mandɯl-tɕa*	[mandɯltɕa]	'to make-let's'	[mandɯr**ɯ**tɕa]
d.	*moɯ-nɯn*	[moɯnɯn]	'to collect-adjectival'	[mo**a**nɯn]
e.	*s'o-tɕa*	[s'otɕa]	'to shoot-let's'	[s'w**a**tɕa]

[60] Because in Korean, the sentence final suffixes not only end sentences but determine the type of sentence and the level of politeness.

Some of these 'incorrect' forms are found in the adult language of dialects (Y.-J. Kang 2006 and references therein). These facts are accounted for by the extension of *ɯ*-final or *a*/ʌ-final forms to consonant-initial suffixes.

The problem with this reanalysis account is that it predicts that harmonizing suffixes other than the SFM suffix will always be realized as harmonic. However, the spontaneous speech study showed that they may in fact be disharmonic.

5.1.3 Stem vowel

The perception experiment provided support for the view that the strict application of vowel harmony to stems containing /o/, in contrast to the variability with the stems containing /a/, can be explained by the weak perceptibility of /o/ as compared to /a/, giving rise to different behaviors of the two [RTR] vowels.

The argument that vowel harmony may play a role in facilitating lexical access by facilitating perception of stem vowels, based on the typology of round harmony (Kaun 1995), centralizing harmony in Pasiego dialect of Spanish (Hualde 1989), nonperipheral harmony in Lamba (Steriade 1995), and height harmony in Veneto Italian (Walker 2005), is extended to account for the behavior of Korean vowel harmony. In the perception experiment in Korean, /a/-stems were identified even before the beginning of a suffix attached to the stem. This tells us why /a/-stems were able to be the first to discard the 'old' harmony patterns and to take the regularized suffix form. In addition, Korean speakers tended to pay less attention to the vowel harmony of longer stems, which is not surprising from the perspective of perception and lexical retrieval (see section 5.2.1 below). The longer a stem is, the easier it is to distinguish from other stems. In contrast, short stems (in particular, monosyllabic stems) need to enhance their perceptibility by extending the feature of stem to the following suffix in order to keep them contrastive with other stems in the lexicon. This is evident in the seemingly exceptional cases of *p*-irregular stems (Hong 2008). As we have seen, *p*-irregular stems take [ʌ]-suffixes irrespective of the identity of the trigger vowel. In spite of the fact that almost all *p*-irregular stems have moved to [ʌ]-suffixes, the monosyllabic *p*-irregular stems containing /o/ trigger vowels continue to resist the move toward the [ʌ] suffix form, presumably because the disharmonic forms would give rise to confusion with stems containing /u/ or /ʌ/.

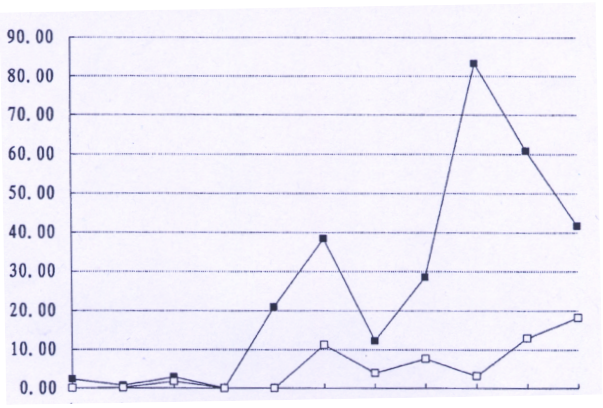
The perception/retrieval-based account of vowel harmony can also explain why vowel harmony disappeared in the nominal declension earlier than in the verbal conjugation. Figure 2 in Chapter 1, replicated below, shows that the decay of vowel harmony in the nominal declension progressed more rapidly than that in the verbal conjugation. In Middle Korean, the topic marker and the adjectival suffix were both realized as *ə n* or *ɯn*, depending on the vowels in the preceding nouns and verbs, respectively. In Korean, nouns can appear by themselves but verbs cannot, which means that nouns must be identifiable even without case markers. In

contrast, as verbal stems always appear with verbal suffixes, listeners are more likely to depend on the suffixes.

Figure 33. Comparison of the proportions of exceptional patterns of nominal and verbal suffixes (Han 1994: 147)

-■-: extension of ATR suffixes ([ɯ]-forms) in topic marker

-□-: extension of ATR suffixes ([ɯ]-forms) in adjectival suffix



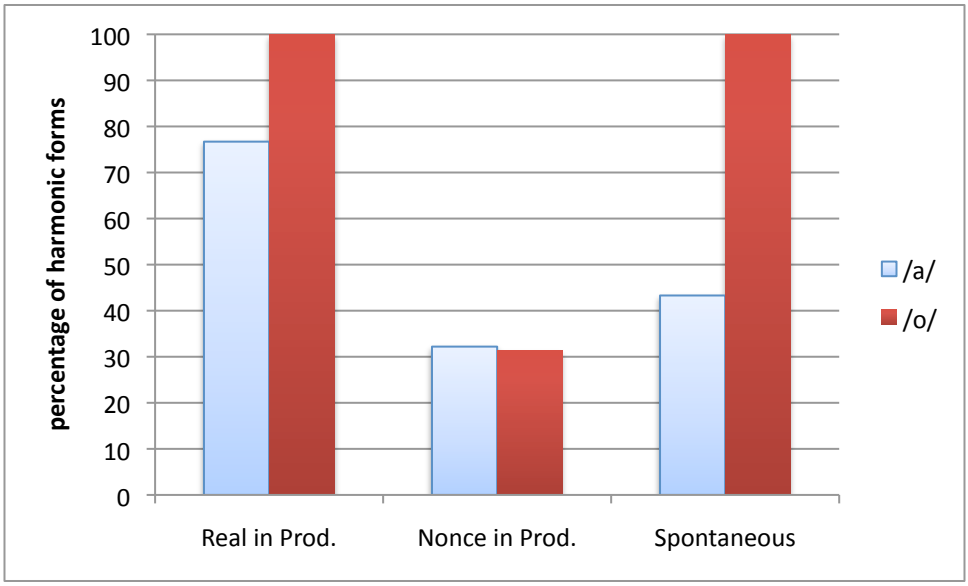
Interestingly, the difference between the two [RTR] vowels has been noticed in vowel harmony in domains other than verbal conjugation in Korean. Hong (2010) examines vowel cooccurrence restrictions in monomorphemic native Korean words. Calculating the O/E ratio (observed frequency divided by expected frequency, Pierrehumbert 1993), he shows a greater than chance frequency of harmonic patterns (ATR vs. RTR) in monomorphemic pure Korean words, as well as in ideophones. When an [RTR] vowel (V_2) follows an [ATR] vowel (V_1) in a word, the O/E value was higher when the [RTR] vowel was /a/ than when it was /o/, which means that /a/ is more likely than /o/ to tolerate disharmonic patterns in monomorphemic pure Korean words. This suggests that /a/ might be losing its status as an [RTR] vowel in the Korean vowel harmony system.

Assuming that mid vowels are more difficult to identify than low or high vowels (Steriade 1995), we can predict that mid vowels will be more likely to trigger vowel harmony crosslinguistically. This is true in the typology of rounding harmony, particularly in Mongolian languages (Kaun 1995). In Kaun's classification, the existence of 'high trigger and non-high target' implies the existence of 'non-high trigger and high target'. The vowel systems of African language with ATR (or RTR) harmony are in line with this prediction (Casali 2008). With a few exceptions (e.g., Kinande), a harmonic pair of low vowels or high vowels implies a harmonic pair of mid vowels. In other words, high and low vowels are more likely to be neutral in ATR languages. A topic for future research is to determine which vowels behave as neutral in these languages, specifically in languages in which vowel harmony is in the phase of decay.

A result concerning the effect of the stem vowel which remains to be explained is the variation in nonce stems containing /o/. In the case of stems containing /a/, the proportion of harmonic vs. disharmonic forms was relatively consistent throughout the three production results. The high proportion of harmonic forms in the production of real words might be attributed to the frequency of the forms (see section 5.3 below) or the style of speech. More problematic is the gap between the real vs. nonce stems containing /o/.

If the production of nonce words reflects the proportion of harmonic vs. disharmonic forms when all the forms are generated from the grammar, how can we interpret the results of real words in the production experiment and the spontaneous speech where no disharmonic token was observed?

Figure 34. The percentage of harmonic forms in different productions (/a/-stems vs. /o/-stems)



This might be the result of morphologization as mentioned in section 5.1.2. That is to say, the forms of (real) /o/-stems plus [a] are not derived but stored, even with the SFM suffix. As the harmonic forms of /o/-stems are taken from the lexicon in which there are no disharmonic counterparts, there should be no room for variation and this was true in the production experiment and the spontaneous speech study as in Figure 34. Then it should be explained why the harmonic pattern of only /o/-stems has begun to be morphologized, while /a/-stems are still derived by a morphophological process. I speculate that the type frequencies of /o/-stems and /a/-stems might contribute to the difference. The number of /o/-stems is much smaller than that of /a/-stems,[61] which might have made it possible for /o/-stems to form an 'irregular'

[61] It was 766 (/a/-stems) vs. 240 (/o/-stems) when only consonant-final stems that are shorter than four syllables are counted in the frequency data of NIKL.

group. If this is on the right track, stems containing /o/ will remain as the only stems taking /a/-form suffixes in Korean, not affected by the language change.[62]

5.2 Other factors

In this section, I discuss the additional factors that played a role in at least one of the experiments: linguistic factors such as stem length and morphological relatedness, as well as sociolinguistic factors. Even though these factors did not always correlate with significant differences in the results, it is worth investigating how these factors interacted with each other.

5.2.1 Stem length & morphological relatedness

The results show that stem length did not have an effect on speakers' judgments and productions and the Google-driven corpus did not show any patterns in terms of different stem lengths. Before rushing to the conclusion that stem length is irrelevant, however, there is one thing to take into account. In the lexicon, longer stems are closely related to shorter stems, particularly monosyllabic stems. This fact may explain why no stem length effect was found. Let us take bisyllabic /a/-verbs as an example set. In the frequency data of the NIKL, there are 217 bisyllabic /a/-verbs. Of these 217 verbs, 114 verbs (52.5%) are derived by the combination of a monosyllabic morpheme plus *–ha*, which usually attaches to a noun to make a verb or an adjective. Among the other 104 verbs, only seven verbs[63] are considered as monomorphemic. The other 97 verbs have monosyllabic roots. For example, 11 verbs share a root, *tɕap-* 'catch', as listed below.

(35) Bisyllabic /a/-verbs with a root *-tɕap.*

a.	kʌt-tɕap-	'to make a rough estimate (surface-catch)'
b.	ta-tɕap-	'to brace oneself up (all-catch)'
c.	tɯt-tɕap-	'to listen (humble expression, listen-catch)'
d.	matɕ-tɕap-	'to hold together (against-catch)'
e.	put^{h}-tɕap-	'to hold (stick-catch)'
f.	son-tɕap-	'to cooperate (hand-catch)'
g.	s'a-tɕap-	'to put together (wrap-catch)'
h.	jat^{h}-tɕap-	'to make a low estimate of (low-catch)'
i.	tɕoŋ-tɕap-	'to get the point (?-catch)'
j.	tɕul-tɕap-	'to estimate (line-catch)'
k.	hɯm-tɕap-	'to find fault with (flaw-catch)'

In the judgment survey, an additional set of stimuli was added to test the effect of output-to-output correspondence among morphologically related stems (Benua 1997, 2004). First, five monosyllabic stems were selected as roots. Each root appears in derived forms which share the

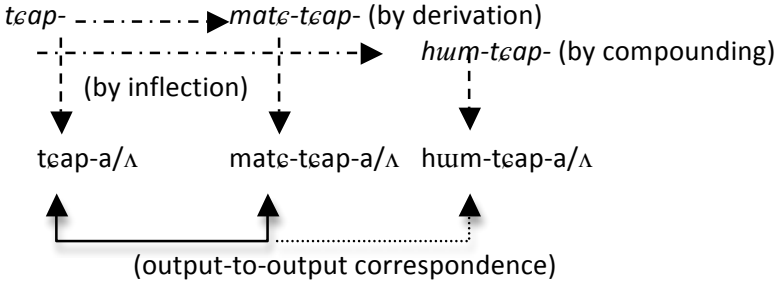
[62] However, considering that the nonce word stimuli were much fewer than real words in the production experiment, a more elaborate experiment needs to be conducted with a larger set of data.

[63] *samka-* 'refrain', *tɕina-* 'pass', *tʌŋtal-* 'do the same as', *kɯra-* 'do so (in Jeolla dialect)', *para-* 'wish', *nolla-* 'be surprised', *tɕara-* 'grow'

root. For example, the root *pat*- 'to receive' is shared by *twɛ**pat*** 'to receive back', *pon**pat*** 'to follow', *koŋkɯp**pat*** 'to be supplied', and *iʌ**pat*** 'to succeed'. Because the root is the final morpheme in the derived words or compounds, it determines the form of a following harmonizing suffix. Thus, a root may affect the conjugation of morphologically related words (e.g., *pat-a* 'to receive-SFM' may lead *twɛ**pat*** 'to receive back' to take [a] 'SFM' rather than [ʌ]). A group of five morphologically unrelated stems was included as a control.

Using a chi-square test, I examined whether morphologically related stems in a group had different responses or similar responses. As expected, all words in a group behave similarly to each other in terms of the acceptance of disharmonic forms.[64] However, interestingly, the responses were significantly different across groups (X^2=39.5, df=24, p=.024). This suggests that morphologically related words behave in a similar way in terms of the vowel harmony variation. This raises the possibility that the longer verbs may be influenced by their root in the verbal conjugation and that they behave similarly to the shorter verbs containing the same root, as shown in (36).

(36) Output-to-output correspondence in Korean verbal stems



This suggests that the effect of stem length may have been obscured by output-to-output correspondence between morphologically related words. This is supported by the results of the production of nonce words. Nonce words, which are free from morphological relatedness, showed the effect of stem length. The proportion of disharmonic forms was higher in bisyllabic stems than in monosyllabic stems (74.8% vs. 64.4%, X^2=6.789, df=1, p<.01).

The effect of stem length is also accounted for by the perception/lexical access-based approach, as pointed out above. The longer a stem is, the more easily it will be identified. In this case, it does not matter whether a suffix is harmonized or not. The neighborhood density, which was calculated based on the NIKL frequency data, supports this claim. The numbers in

[64] Group 1: X^2=22.8, df=18, p=.200
Group 2: X^2=15.8, df=18, p=.605
Group 3: X^2=17.1, df=24, p=.844
Group 4: X^2=21.6, df=24, p=.603
Group 5: X^2=27.2, df=24, p=.296

(37) tell us that bisyllabic and trisyllabic stems do not depend on their trigger vowel for identification, while monosyllabic stems may.

(37) Neighborhood[65] density of /o/- and /a/-stems (total numbers in parenthesis)

		Verbs	Adjectives
a.	Monosyllabic :	**1.416** (89 stems)	**0.5** (26 stems)
b.	Bisyllabic :	0.103 (165 stems)	0 (73 stems)
c.	Trisyllabic :	0 (490 stems)	0 (132 stems)

In summary, I argue that there is a tendency for Korean speakers to pay less attention to the vowel of the suffix with longer stems and that this is accounted for by the perception/lexical retrieval-based account which critically relies on certain assumptions about lexical density. However, the effect is not visible in real words because almost every longer stem is affected by its root, a monosyllabic stem.

5.2.2 Intervening consonant

Even though the effect of intervening consonants was not considered as a factor in the survey, I need to discuss why disharmonic forms are never found when the suffix vowel directly follows the stem vowel, with no intervening consonant. In contrast, when a consonant intervenes between the vowels, both the harmonic and the disharmonic forms are possible (e.g., *t'ʌna-a/*ʌ* 'to leave-SFM' vs. *metal-a/ʌ* 'to hang- SFM') when other conditions are met. The Korean case might be explained by an optional blocking of vowel harmony by an intervening consonant. However, the typological generalization seems to be that harmony is blocked when a consonant is specified for the harmonizing feature. For example, palatalized consonants and /j/ tend to block backness harmony in Turkish (van der Hulst and van der Weijer 1995), where the blocking consonants share the harmonizing feature. However, H.-S. Kang (2002) shows that in Korean no feature (place and/or manner) of an intervening consonant affects the proportion of disharmonic forms, as Table 14 indicates. Let me take two kinds of consonants for examples, nasal and liquid consonants. Consonants containing [nasal] are scattered from 56.7% (*nh*) to 100% (*lm*) and the lateral /l/ from 52.3% to 100%, showing no effect of the features. The place features ([labial], [coronal], and [velar]) are not relevant, either.[66]

Table 14. The proportions of disharmonic forms for each consonant type (H.-S. Kang 2002: 16)

type of C	lk	lm	t^h	k'	lh	n	p	m	nh	t	l	k	tɕ
percentage	100	100	100	91.7	75	71	68.5	58.5	56.7	56.4	52.3	50	47

[65] Here, a neighbor is defined as 'a stem that shares every segment except for the trigger vowel'. The neighborhood density was calculated using '2*(number of neighbor pairs)/(number of stems)'.

[66] The number and the place/manner features of the intervening consonants made no differences in a pilot judgment survey, which was conducted online with 10 participants of Korean speakers. These factors were excluded in the main judgment survey considering on the results of the pilot survey and the number of tokens in the main survey.

The examples in (38) demonstrate why disharmonic forms should be avoided when there is no intervening consonant. When a trigger vowel is *a*, the suffix vowel merges with the trigger vowel (resulting in [a:]) or disappears (resulting in [a]). Sequences of different vowels such as [aʌ] in *[t'ʌnaʌ] are dispreferred in verbal conjugation.[67] In /o/-stems, the trigger vowel becomes [w] before the target vowel, to avoid hiatus. As a result, the disharmonic form *$pw\Lambda$ could not be differentiated from $pw\Lambda$ which is derived from another stem *pus*- 'to pour' through *s*-deletion and glide formation. In this case, the harmonized target vowel plays a crucial role in the identification of the stem.

(38) Vowel-ending stems with harmonizing suffixes

a.	/a/-stem:	*t'ʌna-a/ʌ*	'to leave-SFM'	[t'ʌna(:)], *[t'ʌnaʌ]
b.	/o/-stem:	*po-a/ʌ*	'to see-SFM'	[poa]~[pwa], *[poʌ]~*[pwʌ]
		cf. *pus-a/ʌ*	'to pour-SFM'	[puʌ]~[pwʌ]

As mentioned above, disharmonic vowel patterns are rare in monomorphemic native Korean words (Hong 2010). Moreover, vowel sequences (VV) are not preferred in verbal conjugation, while they are tolerated within morphemes or in nominal declension in Korean (J.-K. Kim 2000; I.-K. Chung 2007; among others). So it is not the case that an intervening consonant plays a role in blocking vowel harmony, but rather that [aʌ] and [oʌ] sequences are not allowed because of a domain-specific phonotactic constraint and the preservation of contrast.

5.2.3 Sociolinguistic factors

The sociolinguistic factors in the judgment survey and the production experiment were not as influential as were linguistic factors.[68] This section discusses the results briefly.

An effect of age was found in the judgment survey but not in the production experiment. As pointed out in Chapter 2, the gap between the different age groups was very small, so this was not unexpected. In terms of gender, male speakers turned out to accept the innovative forms

[67] In Korean, VV sequences are allowed word-internally (e.g., *nui* 'sister', *muʌs* 'what', an so on). But in verbal conjugation, vowel hiatus is resolved by glide formation, glide insertion, or vowel deletion (Kim 2000 and Chung 2007).

[68] Moreover, it should be noted that the group of participants was not a nicely balanced one because they are from a relatively small Korean community. For example, the youngest group (early 20's) consisted of two male and twelve female speakers, while the other groups had relatively similar numbers of male and female speakers (eight vs. 11 in late 20's and eight vs. six in 30's). So the results about sociolinguistic factors will not be interpreted as absolute ones because of the restricted participant set.

more readily than female speakers, consistent with the tendency of female speakers to use prestigious or standard dialect forms more than male speakers (e.g., Trudgill 1972).[69]

The previous literature shows that the vowel harmony in verbal conjugation varies depending on different regional dialects (H.-S. Kang 1996 for Jeonnam dialect, So 1998 and Park 2003 for Jeonbuk dialect, Ko 1997 for Jeju dialect, etc.). The Chungcheong speakers' acceptance of disharmonic forms was expected, though they were not very different from those of Seoul/Gyeonggi speakers. The interesting results were those of Gyeongsang speakers, who were more likely to reject the innovative forms than other speakers in the judgment survey. Considering that all the Gyeongsang speakers were female, the result may be attributed to the gender effect mentioned above. However, in the production experiment, this group produced disharmonic forms more often than other speakers. One Gyeongsang speaker pointed out that the use of the SFM suffix gave an impression of the Seoul dialect and that in their own dialect, they would be more likely to use other sentence enders such as *–ta* 'declarative' and *–na* 'interrogative', rather than the harmonizing SFM suffix. This means that they produce the suffix in question much less frequently than speakers of other dialects, which might be, in part, the reason for the high frequency of disharmonic (or regularized) forms in their production.

Note that participants who had been in the US longer were more likely to choose disharmonic forms both in the judgment survey and in the production experiment. Exposure to relatively fewer stimuli seems to have caused the acceleration of the regularization. Both results showed evidence for the effect of exposure to native language stimuli, as noted above. The participants who had resided in the US for a long time and/or who arrived early in their lives had a relatively smaller number of tokens from which to recover the general patterns of verbal conjugation, and may have had less exposure to the environments in which 'formal' speech is used,[70] as they belong to a Korean community whose members are mostly students. The results might be caused by less exposure to written Korean. A comparison of these results with results from Korean speakers in Korea would shed light on this issue. I leave this for future research.

Let us compare the results with those of Babcock et al. (2012),[71] who tested the effect of gender, length of residence, and age of arrival in adult-learned second language. Their basic assumption is that English irregular verbs that are stored in memory will show frequency effect but that regular verbs that are in general composed will not. Chinese and Spanish speakers who

[69] However, this is not consistent with Labov's (1990: 205-06) finding that in most cases of linguistic change, women tend to use innovative forms with higher frequency than men do. Considering that in stable sociolinguistic situations, men use a higher frequency of nonstandard forms than women (*ibid*), the results showed that female speaker might perceive disharmonic forms not as innovative forms, but as coarse forms and that the variation is relatively stable in Contemporary Korean.

[70] This was suggested by Laura Casasanto (p.c.).

[71] I thank John Drury for introducing this study.

came to the US and began to learn English after puberty, as well as English native speakers, produced the past-tense forms of English verbs based on the present-tense forms in the experiment, where accuracy and response time were measured. The frequency effect was stronger in female L1 speakers than L1 males for regular verbs, which suggests that female speakers are more likely than males to store 'full-forms' even for regular stems in L1. For L2 speakers both female and male speakers showed a frequency effect on regular verbs, which means that they depend on memory. However, females changed their strategies (memory to composition) as time went on, while males rarely did (they adhered to composition and relied on memory only at high length of residence). The younger L2 speaker arrived in the US, the more s/he relied on composition.

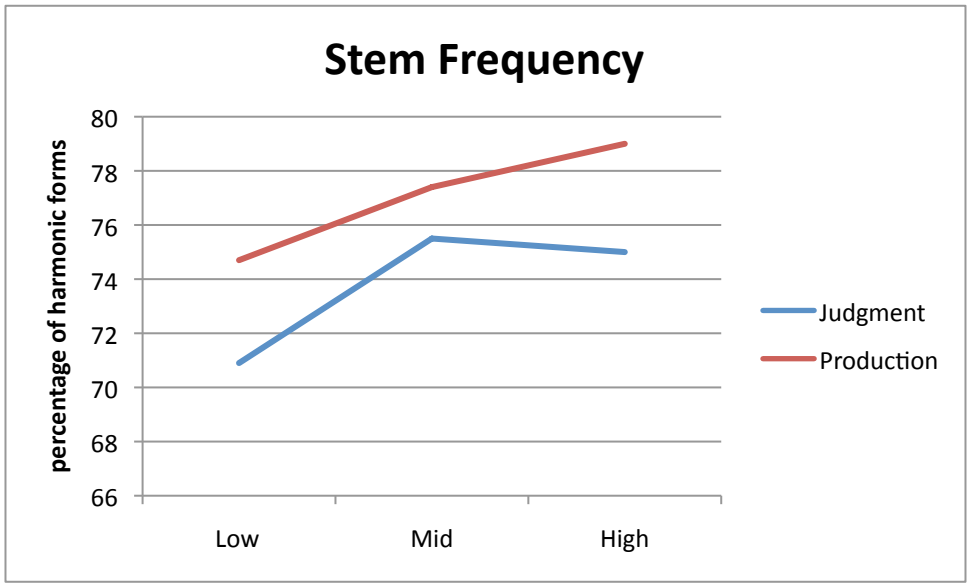
Both Korean vowel harmony and English past tense data suggest that female speakers are more likely to rely on memory. Assuming that Korean vowel harmony in verbal conjugation has begun to be lexicalized, Korean speakers should depend on the storage of full conjugated forms to produce harmonic forms. In the production experiment, female speakers produced harmonic forms more frequently than males, which is consistent with the claim that females relied on memory more than males. In both studies, early arrival in the US resulted in more dependence on composition. The L2 English speaker who arrived in the US in their teens did not show the frequency effect, which suggests that they did not depend on storage for the regular past tense form. In the Korean case, the participants who arrived in their teens accepted and produced disharmonic forms more often than others, which suggests that they did not rely on memory, either.

5.3 Role of frequency in historical change

Frequency has been investigated as an important factor in historical change (Bybee 1995, 2001a, 2001b, 2002, 2006, 2010; Phillips 2006; Pierrehumbert 2001). In particular, Bybee (2001a) argues that, as a result of repetition, high frequency accelerates articulatorily motivated changes, which enables the quick articulation of the item and the easy access to the item. In morphosyntactic changes, high frequency is said to have the opposite effect, with high frequency words more likely to resist the change. In this section, I discuss the role of frequency in the loss of Korean vowel harmony. In addition to the frequency of each stem, the frequency of each suffix alternant and the frequency of forms involving harmony processes are considered.

The judgment and production tasks confirmed that there was no significant effect of stem frequency on the variation in Korean vowel harmony. Nonetheless, there was a tendency for high frequency stems to be more likely to be harmonic than low frequency stems, as Figure 35 shows. Assuming that the vowel harmony in Korean is a morphophonological process which is not motivated by articulation, this result is consistent with Bybee's argument about morphosyntactic changes.

Figure 35. The percentages of harmonic forms of different frequency groups



However, it should be pointed out that the effect of stem frequency is restricted compared to the phonological factors which were associated with categorical differences. For example, stems containing /a/ are more frequent than stems containing /o/ (766[72] vs. 240 in the frequency data of NIKL), which predicts that /a/-stems will be more harmonic than /o/-stems. This prediction is the opposite of what is actually happening. The change was motivated not by frequency, but by perception as demonstrated in Chapter 4. Because of the strong perceptibility of /a/, the harmonic suffixes with /a/-stems are barely motivated, which results in the occurrence of the disharmonic forms of /a/-stems.

Second, the frequency of each alternant ([a]-forms vs. [ʌ]-forms) is also relevant. As introduced in Chapter 1, changes in the vowel system resulted in an imbalance between [ATR] and [RTR] vowels (5 vs. 2). Moreover, almost every newly created verbal stem is derived with -*ha*-, which attaches to a noun to make a verb or an adjective (e.g., *tɕʰetʰiŋ-ha*- 'to chat (on a computer)' and *hepʰi-ha*- 'happy'). The *ha*- stems are irregular in terms of vowel harmony. With harmonizing suffixes, they surface as [he] (e.g., *tɕʰetʰiŋhe* 'to chat-SFM' and *hepʰihe* 'happy-SFM') or as [hajʌ] (e.g., *tɕʰetʰiŋhajʌ* 'to chat-CONN' and *hepʰihajʌ* 'happy-CONN'). With the change of *p*-irregular stems, this must have increased the imbalance toward [ʌ]-forms. The imbalance is maximal in the SFM suffix (and the honorific suffix), due to the fact that these suffixes may follow another suffix and in that situation, they always surface as [ʌ] (and [ʌjo]) irrespective of the stem vowel. However, the role of frequency was also restricted in this case. Even though the overwhelming frequency of [ʌ] determined the direction of the change, the change took place when another condition was satisfied – the positional faithfulness effect.

[72] Stems including –*ha*, which are irregular in terms of vowel harmony, are excluded.

Third, the frequency of forms containing harmonizing suffixes seems to play a role. As discussed above, participants who had less exposure to the Korean language (in particular, participants who left Korea earlier at younger ages and had resided longer in the US) were, by and large, more inclined to the regularized [ʌ]-forms. Furthermore, Gyeongsang speakers, who usually use the SFM suffix less than other speakers, also produced more regularized forms than other speakers. This could be a reason for the discrepancy between the results of the two production studies, the production experiment and the spontaneous speech study. In the spontaneous speech in the television programs, only 277 tokens of '/a/-stems plus the SFM suffix' combinations were found in 80 episodes, each of which was about 80 minutes. In contrast, the participants in the production experiment produced 40 tokens of the same combination, in about 10 minutes, even though 45 stems containing other stem vowels were mixed in the same cycle. The frequent use of harmonizing suffixes might have activated the morphophonological process of harmony, resulting in a higher proportion of harmonic forms.

Because the harmony process ([a]~[ʌ] alternation) is found only in the harmonizing suffixes - in other words, because vowel harmony in Korean is not fully productive - the proportion of harmonic vs. disharmonic forms is affected by the frequency of use. This is, I speculate, one of the reasons for the difference between the variation in Hungarian vowel harmony and in Korean vowel harmony. In Hungarian, vowel harmony is robust as a phonotactic constraint and as a morphophonological process (Ringen and Vago 1998). The high productivity of vowel harmony enabled Hungarian speakers to apply the same constraints even to nonce words. In contrast, the lower productivity is responsible for the poor application of vowel harmony to nonce words in Korean.

In sum, the role of frequency in historical change is obvious. High frequency adds strength to the tokens and the processes which the tokens go through (Bybee 1995, Pierrehumbert 2001). However, it should not be exaggerated. As we have seen, frequency was not a decisive condition.[73] The change in Korean vowel harmony took place only when phonological and/or morphological conditions were met.

5.4 Conclusion

I examined variation in vowel harmony in the Korean verbal conjugation. The empirical data, which were collected from the Google-driven corpus, the judgment survey, the production experiment, and the spontaneous speech, consistently showed that the variation is not random, but patterned. Synchronically, this patterned variation can be accounted for by constraint ranking enriched by the probability distribution of constraint on a continuous ranking scale (Stochastic Optimality Theory). The exceptional behavior of *p*-irregular stems, which belong to a

[73] Albright (2005) provides evidence that not the most 'frequent' form but the most 'informative' form is regarded as the base in analogical changes.

morphophonologically defined set, was explained by establishing a subgrammar which has a different ranking from the main grammar. The disappearance of [a]~[ʌ] alternation in the SFM suffix turned out to be a position-specific phenomenon, which was explained by a positional faithfulness constraint. Lastly, the strict harmonization of /o/-stems in contrast with the variability of /a/-stems was accounted for by distinguishing two AGREE constraints (i.e., AGREE(+RTR, *o*) and AGREE(+RTR, *a*), Hong 2008), associated with the perceptual difference between the two [RTR] vowels.

Diachronically, the patterned variation in Korean vowel harmony shows that language change is slowed when the change may undermine the contrast between or the retrieval of lexical entries. The loss of vowel harmony in verbal conjugation, as well as in the native lexicon (Hong 2010), did not take place with stem trigger vowel /o/ because of the weak perceptibility of this vowel. Monosyllabic stems (particularly of p-irregular stems) are also more likely to resist the change since the change can cause misanalysis of the stems.[74] This study also shows how the synchronic grammar affects language change. The regularization of the SFM suffix did not take place even where the frequency of one alternant is overwhelming but it did where the positional faithfulness effect was relevant. The effect of domain-final position, which is found crosslinguistically (Petrova et al. 2006 and references therein), initiated the change in Korean verbal conjugation.

This study also shows the interaction of morphology and phonology in language change. I argue that the morphological alternation of *p*-irregular stems caused the loss of vowel harmony in this group of stems. In the case of the SFM suffix, the positional faithfulness effect caused the regularization of the suffix, which in turn initiated the loss of vowel harmony in the total verbal conjugation. A phonological change may begin in a morpheme or in a group of lexical items and spread to other members in the lexicon, through gradient change in a (morpho-)phonological rule/constraint. This tells us why 'change in the lexicon', as well as 'change of rules/constraints' should be taken into account in the analysis of language change (Bermúdez-Otero 2006 in Optimality Theory; van der Hulst 1980 in rule-based phonology).

Lastly, the effect of frequency was shown to play a role in the acceleration of language change. In general, the low frequency of use made the regularization of the suffix forms faster. However, in spite of this role of frequency, it was found that frequency is not a decisive condition for the change.

[74] This kind of language change is not unusual. McMahon (1994:332), for example, mentions that the deletion of intervocalic /s/ was blocked in Ancient Greek only when the /s/ distinguished the present tense form of a verb from its future tense form. Such a case is also found in synchronic variation. For example, Synchronically, /t,d/ deletion in English occurs more often when it is a part of a stem (e.g, *mis**t***) than when it is the past tense marker (e.g., *miss-**ed***) (Labov et al. 1968; Guy 1980).

One thing which should be studied in the future is the role of acquisition in the change of Korean vowel harmony – specifically, whether children, at some stage of language development, have different (or 'imperfect', Kiparsky 1965) grammars from adults and the relationship between the children's grammar and the development of the language change. To answer these questions, an experiment should be conducted, including child participants at various developmental stages of language.

This study showed the effect of prescriptive grammar or formal speech by comparing written and spoken data. The effect was maximal in Gyeongsang speakers, who were conservative in the judgment survey but innovative in the production experiment. The role of this 'conscious' grammar is another topic to pursue in the future. Lastly, the decay of vowel harmony in other languages is also worth investigating. Compared to the evolution of vowel harmony (Cole 2009; Harrison et al. 2002; Mailhot 2010 among others), the decay of vowel harmony has rarely been studied (cf. Dombrowski 2010). The disintegration of vowel harmony, as well as the emergence of vowel harmony, will help us to understand the structure of linguistic knowledge.

References

Ahn, Sang-Cheol (1985), 'The Interplay of Phonology and Morphology in Korean', (University of Illinois).

--- (1998), *An Introduction to Korean Phonology* (Seoul: Hanshin).

Albright, Adam (2005), 'The morphological basis of paradigm leveling', in Laura Downing, Tracy Alan Hall, and Renate Raffelsiefen (eds.), *Paradigms in Phonological Theory* (Oxford University Press), 17-43.

Anttila, Arto (1997), 'Deriving variation from grammar', in Frans Hinskens, Roeland Van Hout, and W. Leo Wetzels (eds.), *Variation, change and phonological theory* (Amsterdam: John Benjamins), 35-68.

--- (2002), 'Morphologically conditioned phonological alternations', *Natural Language and Linguistic Theory,* 20, 1-42.

Baek, Eung-Jin (1999), *Hankukeo Yeoksaeumunron (Korean Historical Phonology)* (Seoul: Pakijeong).

Baek, Gyeong mi (2011), 'Yuaui Eoneo Seupdeuk Gwajeonge Natanan Yongeon Hwalyong Oryu (A Study on the acquisition of language through the error of inflection in childhood)', *Hangukeoneomunhwa,* 44, 255-74.

Barnes, Jonathan (2003). 'Positional Neutralization: A Phonologization Approach to Typological Patterns' (University of California, Berkeley)

Becker-Kristal, Roy (2007), 'On quantity and quality of the low vowel in Hebrew', ms. (UCLA).

Beckman, Jill (1997), 'Positional faithfulness, positional neutralization and Shona vowel harmony', *Phonology,* 14, 1-46.

Benua, Laura (1997), 'Transderivational Identity: Phonological relations between words', (University of Massachusetts).

--- (2004), 'Transderivational Identity: Phonological Relations between Words', in John J. McCarthy (ed.), *Optimality Theory in Phonology*, 419-37.

Berkson, Kelly Harper (2010), 'The Nature of Optional Sibilant Harmony in Navajo', (University of Kansas).

Bermúdez-Otero, Ricardo (2006), 'Phonological Change in Optimality Theory', in Keith Brown (ed.), *Encyclopedia of language and linguistics* (Oxford: Elsevier).

Blumenfeld, Lev A. (2006), 'Constraints on phonological interaction', doctoral dissertation (Stanford University).

Boersma, Paul (1998), 'Functional Phonology: Formalizing the interaction between articulatory and perceptual drives', doctoral dissertation (University of Amsterdam).

Boersma, Paul and Hayes, Bruce (2001), 'Empirical tests of the Gradual Learning Algorithm', *Linguistic Inquiry,* 32, 45-86.

Bybee, Joan (1995), 'Regular morphology and the lexicon', *Language and Cognitive Processes,* 10, 425-55.

--- (2001a), 'Frequency effects on French liaison', in Joan L. Bybee and Paul J. Hopper (eds.), *Frequency and the Emergence of Linguistic Structure* (Amsterdam, The Netherlands: John Benjamins), 337-60.

--- (2001b), *Phonology and language use* (Cambridge: Cambridge University Press).

--- (2002), 'Word frequency and context of use in the lexical diffusion of phonetically conditioned sound change', *Language Variation and Change,* 14, 261-90.

--- (2006), 'From usage to grammar: the mind's response to repetition', *Language,* 82, 711-33.

--- (2010), *Language, Usage and Cognition* (Cambridge: Cambridge University Press).

Casali, Roderic F. (2008), 'ATR Harmony in African Languages', *Language and Linguistic Compass,* 2/3, 496-549.

Cho, Mi-Hui (1994), 'Vowel Harmony in Korean: A Grounded Phonology Approach', doctoral dissertation (Indiana University).

Choi, Myung-Ok (1985), 'Byeonchikdongsaui Eumunhyeonsange daehayeo (On the phonological phenomena of irregular verbs)', *Kukeohak,* 14, 149-88.

Chomsky, Noam and Halle, Morris (1968), *The Sound Pattern of English* (New York: Harper & Row).
Chung, Chin-Wan (2000), 'An optimality-theoretic account of vowel harmony in Korean ideophones', *Studies in Phonetics, Phonology and Morphology,* 6 (2), 431-50.
Chung, Il-Jin (1997), 'Pyojun dansun moeumui sedae chaie daehan silheomeumseonghakjeok bunseok yeongu (A experimental study of vowel quality)', *Malsori,* 33, 111-25.
Chung, In-Ho (1997), 'Bieup bulgyuchik yongeon eoganui byeonhwae daehayeo (On the change of *p*-irregular verbal stems)', *Aesanhakpo,* 20, 145-78.
Chung, Inkie (2007), ' Ecology of PF: A Study of Korean Phonology and Morphology in a Derivational Approach' (University of Connecticut).
Cole, Jennifer (2009), 'Emergent feature structures: harmony systems in exemplar models of phonology', *Language Sciences,* 31, 144-60.
Croft, William (2000), *Explaining Language Change: An Evolutionary Approach* (London: Longman).
Crosswhite, Katherine (1999), 'Vowel Reduction in Optimality Theory', (UCLA).
Dombrowski (2010), 'Vowel Harmony Loss in West Rumelian Turkish', a paper presented at *LSA annual meeting* (Chicago).
Grosjean, François (1980), 'Spoken word recognition processes and the gating paradigm', *Perception & Psychophysics,* 28 (4), 267-83.
--- (1985), 'The recognition of words after their acoustic offset: Evidence and implication', *Perception & Psychophysics,* 38 (4), 299-310.
Gussenhoven, Carlos (2004), 'Perceived vowel duration', in H. Quené and V. van Heuven (eds.), *On Speech and Language: Studies for Sieb G. Nooteboom* (Utrecht: LOT), 65-71.
Guy, Gregory R. (1980). 'Variation in the group and the individual: the case of final stop deletion', in William Labov (ed.), *Locating language in time and space* (New York, NY: Academic Press), 1-36.
Han, Yeonggyun (1994), 'Hugi jungsegukeoui moeumjohwa yeongu (A study of vowel harmony in the late Middle Korean) ', (Seoul National University).
--- (1996), 'Moeumjohwaui yeoi chulhyeonbiyule daehan tongsijeok haeseok (A diachronic interpretation of the proportion of exceptions of vowel harmony)', *Gwanakeomunyeongu,* 21, 377-405.
Harrison, David K., Dras, Mark, and Kapicioglu, Berk (2002), 'Agent-Based Modeling of the Evolution of Vowel Harmony' *NELS 32*, 217-236.
Hayes, Bruce and Londe, Zsuzsa Cziraky (2006), 'Stochastic Phonological Knowledge: The Case of Hungarian Vowel Harmony', *Phonology,* 23 (1), 39-104.
Hayes, Bruce, Siptár, Péter, and Zuraw, Kie (2009), 'Natural and Unnatural Constraints in Hungarian Vowel Harmony', *Language,* 85 (4), 822-63.
Hong, Sung-Hoon (2008), 'Variation and Exceptions in the Vowel Harmony of Korean suffixes', *The Journal of Studies in Language,* 24, 405-28.
--- (2010), 'Gradient Vowel Cooccurrence Restrictions in Monomorphemic Native Korean Roots', *Studies in Phonetics, Phonology, and Morphology,* 16, 279-95.
Hualde, José (1989), 'Autosegmental and Metrical Spreading in the Vowel-harmony Systems of Northwestern Spain', *Linguistics,* 27, 773-805.
Hur, Woong (1985), *Gukeoeumunhak (Korean Phonology)* (Seoul: Jeongeumsa).
Hyman, Larry (1977), 'Phonologization', in A. Juilland (ed.), Linguistic studies presented to Joseoph H. Greenberg (Anma Libri), 407-18.
Inkelas, Sharon (1998), 'The theoretical status of morphologically conditioned phonology: a case study from dominance', *Yearbook of Morphology*, 121-55.
Inkelas, Sharon and Zoll, Cheryl (2005), *Reduplication* (Cambridge: Cambridge University Press).
Ito, Junko and Mester, Armin (1997), 'Correspondence and compositionality: the Ga-gyo variation in Japanese phonology', in Iggy Roca (ed.), *Derivations and constraints in phonology* (Oxford: Clarendon Press), 419-62.

Joseph, Brian and Janda, Richard D. (1988), 'The How and Why of Diachronic Morphologization and Demorphologization', in Michael Hammond and Michael Noonan (eds.), *Theoretical Morphology* (San Diego: Academic Press), 193-210.
Jun, Sun-Ah (1993), 'The Phonetics and Phonology of Korean Prosody', doctoral dissertation (The Ohio State University).
Kager, Rene (1999), *Optimality Theory* (Cambridge: Cambridge University Press).
Kang, Hijo (2011), 'What Role Does Morphology Play in Historical Change?', in William McClure and Marcel den Dikken (eds.), *Japanese/Korean Linguistics 18* (18; Cuny Graduate Center: CLSI), 165-76.
Kang, Huisuk (1996), 'Jangheungbangeonui moeumjohwa (Vowel harmony in Jangheung dialect)', *Korean Journal of Linguistics,* 4, 1-24.
--- (2002), 'A Study of Vowel Harmony in the Modern Seoul Dialect', *The Korean Language and Literature,* 26, 1-27.
Kang, Yoonjung (2006), 'Neutralization and variation in Korean verbal paradigms', *Harvard Studies in Korean Linguistics XI* (Hanshin Publishing Company), 183-96.
Kaun, Abigail Rhoades (1995), 'The Typology of Rounding Harmony: The Optimality Theoretic Approach', (University of California).
Kim, Jong-Kyoo (2000), 'Quantity-Sensitivity and Feature-Sensitivity of Vowels: A Constraint-Based Approach to Korean Vowel Phonology', (Indiana University).
Kim, Juwon (1988), 'Moeum chegyewa seolchuk (Vowel system and the feature [retracted tongue root])', *Eoneohak,* 8&9, 28-43.
--- (2003), *Moeumjohwaui yeongu (A study of vowel harmony)* (Daegu: Yeongnam University Press).
Kim, Moosik (2007), 16, 7segi kukeo hanjaeoui bijunggwa geu teukseong (A Study on the Proportion of Loanword from China and its traits in Korean in the 16, 7 centuries), *Eomunronchong*, 47, 1-26.
Kiparsky, Paul (1965), 'Phonological Change', (MIT).
Ko, Dong-ho (1997), 'Jeju bangeonui moeumjohwa yeongu (A study of vowel harmony in Jeju dialect)', *Eoneohak,* 21, 3-48.
Koo, Hahn and Cole, Jennifer (2007), 'Gradient perceptual facilitation from phonotactic knowledge', *The 43rd Annual Meeting of the Chicago Linguistics Society* (Chicago).
Labov, William (1982), 'Building on empirical foundations', in Winfrid P Lehmann and Yakov Malkiel (eds.), *Perspectives on historical linguistics* (Amsterdam: John Benjamins), 17-92.
--- (1990), 'The interaction of sex and social class in the course of linguistic change', *Language Variation and Change,* 2, 205-54.
Labov, William, Paul Cohen, Clarence Robins, and John Lewis (1968), *A study of the nonstandard English of Negro and Puerto Rican speakers of New York City* (Cooperative Research Report, no. 3288) (Washington, DC: U.S. Office of Education).
Lee, Jae-Kang (1998), 'Experimental Phonetic Contrastive Analysis on Korean and Japanese Vowels', *Eoneohak,* 22, 347-69.
Lee, Jin-Seong (1992), 'Phonology and Sound Symbolism of Korean Ideophones', (Indiana University).
Lee, Ki-Moon (1968), 'Moeumchegyewa moeumjohwa (Vowel system and vowel harmony)', *Lee Sung-Nyeong paksa songsuginyeomnonchong*.
--- (1972), *Gukeohakgaeseol* (Seoul: tapchulpansa).
Lee, Samhyung, Kim, Taekyung, and Lim, Jungnam (2009), 'Eogan jaeguseong hyeonsangeul tonghae bon yuaui yongeon hwalyong gyuchik seupdeuk kwajeong (The development of verbal conjugation through the reanalysis of stems in children) ', *Gugeogyoyuk,* 130, 123-46.
Lee, Sang-oak (1984), 'An Overview of Issues in the Vowel System and Vowel Harmony of Korean', *Language Research,* 20, 417-44.

Lee, Yong-Sung (1993), 'Topics in the Vowel Phonology of Korean', doctoral dissertation (Indiana University).
Lehiste, Ilse (1970), *Suprasegmentals* (Cambridge: MIT Press).
Lindblom, Bjorn (1983), 'Economy of speech gestures', in P. MacNeilage (ed.), *Speech Production* (New York: Springer), 217-46.
Linker, Wendy (1982), 'Articulatory and acoustic correlates of labial activity in vowels: A cross-linguistic study', doctoral dissertation (UCLA).
Lippus, Pärtel (2010), 'Variation in Vowel Quality as a Feature of Estonian Quantity', *Speech Prosody 2010* (Chicago).
Mailhot, Frédéric (2010), 'Modelling the Acquisition and Evolution of Vowel Harmony', doctoral dissertation (Carleton University).
McGarrity, Laura W. (2003), 'Constraints on patterns of primary and secondary stress', doctoral dissertation (Indiana University).
McMahon, April (1994), *Understanding Language Change* (Cambridge: Cambridge University Press).
Moon, Yang-soo (1974), 'A Phonological History of Korean', doctoral dissertation (University of Texas).
Ohala, John (1993), 'The phonetics of sound change', in Charles Jones (ed.), *Historical Linguistics: Problems and Perspectives* (London: Longman), 237-78.
--- (1994), 'Toward a universal, phonetically-based theory of vowel harmony', *ICSLP 3* (Yokohama), 491-94.
Park, Jong-hee (2003), 'Jeonbuk bangeon moeum johwaui bultumyeongseong (The opaqueness of vowel harmony in Jeonbuk dialects)', *Korean Linguistics and Language,* 134, 155-80.
Park, Yeongseop (1995), Gukeohanjaeohwiron (Sino-Korean Words in the Lexicon of Korean) (Seoul, Pakijeong).
Pater, Joe (2010), 'Morpheme-Specific Phonology: Constraint Indexation and Inconsistency Resolution', in Steve Parker (ed.), *Phonological Argumentation: Essays on Evidence and Motivation* (London: Equinox), 123-54.
Perkell, Joseph S. and Cohen, Marc H. (1989), 'An indirect test of the quantal nature of speech in the production of the vowels /i/, /a/, and /u/', *Journal of Phonetics,* 17, 123-33.
Petrova, Olga, Plapp, Rosemary, Ringen, Catherine O., and Szentgyörgyi, Szilárd (2006), 'Voice and aspiration: Evidence from Russian, Hungarian, German, Swedish, and Turkish', *The Linguistic Review,* 23 (1), 1-35.
Petten, Cyma Van, et al. (1999), 'Time Course of Word Identification and Semantic Integration in Spoken Language', *Journal of Experimental Psychology,* 25 (2), 394-417.
Phillips, Betty S. (2006), *Word Frequency and Lexical Diffusion* (New York: Palgrave MacMillan).
Pierrehumbert, Janet (1993), 'Dissimilarity in the Arabic verbal roots', *NELS 23*, 367-81.
--- (2001), 'Examplar dynamics: Word frequency, lenition and contrast', in Joan Bybee and Paul Hooper (eds.), *Frequency effects and the emergence of linguistic structure* (Amsterdam: John Benjamins), 255-80.
Prince, Alan and Smolensky, Paul (1993/2004), *Optimality Theory: Constraint Interaction on Generative Grammar* (Oxford: Blackwell).
Ringen, Catherine O. and Heinämäki, Orvokki (1999), 'Variation in Finnish vowel harmony: An OT account', *Natural Language and Linguistic Theory,* 17, 303-37.
Ringen, Catherine O. and Vago, Robert, M (1998), 'Hungarian vowel harmony in Optimality Theory', *Phonology,* 15 (3), 393-416.
Shaw, Jason and Balusu, Rahul (2010), 'Language contact and phonological contrast: the case of coronal affricates in Japanese loans', in Muriel Norde, Bob de Jong, and Cornelius Hasselblastt (eds.), *Language Contact: New perspectives* (Amsterdam: John Benjamins), 155-80.

Silva, David and Jin, Wenhua (2008), 'The merger of non-high front vowels in Korean: mission accomplished', a paper presented at *International Conference on Korean Linguistics* (Cornell University).
So, Kang-chun (1988), 'Jeonbuk bangeonui moeum johwa hyeonsange uihan gongsijeok eoneo bunhwae daehayeo (A study of vowel harmony in Jeonbuk dialects)', *Korean Linguistics and Language,* 99, 279-308.
Sohn, Ho-Min (1999), *The Korean Language* (Cambridge: Cambridge University Press).
Sohn, Hyang-Sook (1987), 'Underspecification in Korean Phonology', (University of Illinois).
Steriade, Donca (1995), 'Underspecification and markedness', in John A. Goldsmith (ed.), *The Handbook of Phonological Theory* (Oxford: Blackwell), 114-74.
Stevens, Ken N. (1989), 'On the quantal nature of speech', *Journal of Phonetics,* 17, 3-45.
Suomi, Kari (1983), 'Palatal harmony: A perceptually motivated phenomenon?', *Nordic Journal of Linguistics,* 6, 1-35.
Terbeek, Dale (1977), 'A cross-language multidimensional scaling study of vowel perception.', doctoral dissertation (UCLA).
Trudgill, Peter (1972), 'Sex, covert prestige, and linguistic change in the urban British English of Norwich', *Language in Society,* 1, 179-96.
Ürögdi, Barbara (2000), 'Gradient Effects and Variation in Hungarian Vowel Harmony', ms., (Stony Brook University).
van der Hulst, Harry and van der Weijer, Jeroen (1995), 'Vowel Harmony', in John A. Goldsmith (ed.), *The Handbook of Phonological Theory* (Oxford: Blackwell).
van der Hulst (1980), ' Towards a lexical theory of phonological change', in W. Zonneveld and F. Weerman (eds.), Linguistics in the Netherlands (Dordrecht, Foris), 170-82.
Walker, Rachel (2005), 'Weak triggers in vowel harmony', *Natural Language and Linguistic Theory,* 23, 917-89.
Weinrich, Uriel, Labov, William, and Herzog, Marvin (1968), 'Empirical foundations for a theory of language change', in Winfrid P Lehmann and Yakov Malkiel (eds.), *Directions for historical linguistics* (Austin: University of Texas Press), 95-198.
Weiss, Rundolf (1972), 'Perceptual parameters of vowel duration and quality in Germen', *The VIIth International Congress of Phonetic Sciences* (Montreal: Mouton & Co.), 633-36.
Yang, Byunggon (1996), 'A comparative study of American English and Korean vowels produced by male and female speakers', *Journal of Phonetics,* 24, 245-61.

Appendix I - Google-driven corpus stimuli

Legends: irregularity. 1-regular, 2-irregular
vowel: 1-/o/, 2-/a/, 3-/u/ or /ʌ/
length: 1-monosyllabic, 2-bisyllabic, 3-trisyllabic
frequency: 1- 1 to 9, 2- 10 to 99, 3- over 100
category: 1-verb, 2-adjective

stem	gloss	irreg.	vowel	length	freq.	NIKL	category
olm-	to move	1	1	1	1	6	1
kolm-	to fester	1	1	1	1	5	1
sok'-	to weed out	1	1	1	1	7	1
tot-	to rise	1	1	1	2	22	1
sos-	to rise up	1	1	1	2	63	1
k'otɛ-	to stick	1	1	1	2	58	1
p'op-	to draw out	1	1	1	3	186	1
nol-	to play	1	1	1	3	480	1
kot-	to be straight	1	1	1	2	28	2
nop^{h}-	to be high	1	1	1	3	691	2
tɛoh-	to be good	1	1	1	3	2661	2
nemol-	to drive out	1	1	2	2	16	1
t^{h}aorɯ-	to burn up	1	1	2	2	34	1
natol-	to wander	1	1	2	2	45	1
nenoh-	to put out	1	1	2	3	211	1
t'ʌolɯ-	to rise up	1	1	2	3	215	1
netɛ'otɛ^{h}-	to drive out	1	1	2	1	8	1
tɯlpok'-	to nag	1	1	2	1	5	1
kʌt^{h}tol-	to feel left out	1	1	2	1	7	1
olkot-	to be straight	1	1	2	1	5	2
pitɛop-	to be narrow	1	1	2	2	13	2
tɯnop^{h}-	to be high	1	1	2	2	13	2
s'akotol-	to protect	1	1	3	1	2	1
kallanoh-	to separate	1	1	3	1	6	1
t'wiʌnol-	to play around	1	1	3	2	15	1
nɯrʌnoh-	to spread	1	1	3	2	43	1
namatol-	to be in excess	1	1	3	2	13	1
murɯnok-	to get fully ripe	1	1	3	1	1	2
saitɛoh-	to get along	1	1	3	2	21	2
salm-	to boil	1	2	1	2	69	1
pat-	to receive	1	2	1	3	2566	1
sal-	to live	1	2	1	3	2297	1
tɛ^{h}atɛ-	to find	1	2	1	3	1006	1
kalk-	to gnaw	1	2	1	1	2	1
k'ak'-	to cut	1	2	1	2	87	1
tak'-	to wipe	1	2	1	3	272	1

tɛarɯ-	to cut	1	2	1	3	197	1
matɛ-	to be right	1	2	1	3	517	2
talm-	to resemble	1	2	1	2	98	2
tɛatɛ-	to be frequent	1	2	1	2	55	2
jalp-	to be thin	1	2	1	2	59	2
manh-	to be much	1	2	1	3	2697	2
tɛ'alp-	to be short	1	2	1	3	260	2
twepat-	to receive back	1	2	2	1	6	1
tɛʰipat-	to butt up	1	2	2	1	2	1
matɛpat-	to crash into	1	2	2	1	3	1
matɛtɛap-	to hold together	1	2	2	1	5	1
motɛsal-	to live humble	1	2	2	1	7	1
ponpat-	to follow	1	2	2	2	34	1
putʰtɛap-	to seize	1	2	2	2	57	1
tɛalsal-	to live wealthy	1	2	2	2	28	1
tɛultat-	to continue	1	2	2	1	1	1
t'ʌan-	to take care of	1	2	2	1	3	1
tɛʰʌparɯ-	to paint, spread	1	2	2	1	1	1
tɛʰitat-	to run up	1	2	2	2	21	1
p'eas-	to deprive	1	2	2	2	55	1
k'etat-	to comprehend	1	2	2	3	200	1
ʌntɛ'anh-	to be unpleasant	1	2	2	2	17	2
hatɛʰanh-	to be worthless	1	2	2	2	25	2
almatɛ-	to fit	1	2	2	3	168	2
kwentɛʰanh-	to be OK	1	2	2	3	271	2
olparɯ-	to be right	1	2	2	3	137	2
koŋŋkɯppat-	to be supplied	1	2	3	1	4	1
tɯripat-	to dash against	1	2	3	1	3	1
pujʌtɛap-	to take hold of	1	2	3	1	7	1
ʌntɛʰʌsal-	to be dependent	1	2	3	1	6	1
k'orapak-	to be punished	1	2	3	1	1	1
iʌpat-	to succeed	1	2	3	2	25	1
sarotɛap-	to catch alive	1	2	3	2	19	1
mʌkkosal-	to survive	1	2	3	2	33	1
malmiam-	to be due to	1	2	3	2	45	1
aŋtɛɯŋmatɛ-	to be tiny	1	2	3	1	7	2
nɯŋkɯlmatɛ-	to be sly	1	2	3	1	2	2
kamtɛ'okkatʰ-	to be as good as	1	2	3	1	4	2
ʌtɛ'uptɛanh-	to be saucy	1	2	3	1	2	2
mʌtɛianh-	to be close	1	2	3	2	26	2
simsimtɛʰanh-	to be often	1	2	3	2	11	2
ɯirop-	to be righteous	2	1	2	1	2	2
kwerop-	to be painful	2	1	2	2	57	2
sanap-	to be fierce	2	1	2	2	26	2

werop-	to be lonely	2	1	2	2	61	2
serop-	to be new	2	1	2	3	1061	2
anik'op-	to be saucy	2	1	3	1	8	2
etɕʰʌrop-	to be pitiful	2	1	3	1	9	2
kasorop-	to be ridiculous	2	1	3	1	1	2
k'atarop-	to be faultfinding	2	1	3	2	43	2
pʌnkʌrop-	to be troublesome	2	1	3	2	27	2
narkʰarop-	to be sharp	2	1	3	2	51	2
tɕajurop-	to be free	2	1	3	3	181	2
salkap-	to be affectionate	2	2	2	1	1	2
tɕʌŋtap-	to be friendly	2	2	2	2	23	2
t'akap-	to be not	2	2	2	2	36	2
ak'ap-	to be regrettable	2	2	2	2	54	2
komap-	to be thankful	2	2	2	3	259	2
pankap-	to be glad	2	2	2	3	118	2
kak'ap-	to be close	2	2	2	3	336	2
k'olsanap-	to be ugly	2	2	3	1	1	2
arit'ap-	to be pretty	2	2	3	1	6	2
potɯrap-	to be soft	2	2	3	1	7	2
antʰak'ap-	to be pitiful	2	2	3	2	84	2
arɯmtap-	to be beautiful	2	2	3	3	586	2
kut-	to harden	1	3	1	2	18	1
mut-	to ask	1	3	1	3	665	1
kʌt-	to walk	1	3	1	3	388	1
mulk-	to be sloppy	1	3	1	2	29	2
kulk-	to be thick	1	3	1	3	113	2
jʌlp-	to be shallow	1	3	1	2	32	2
tɕʌlm-	to be young	1	3	1	3	401	2
k'emul-	to bite	1	3	2	2	20	1
matɕputʰ-	to fight	1	3	2	1	7	1
twisʌk'-	to mix	1	3	2	1	4	1
nekʌl-	to hang	1	3	2	2	43	1
tɕiskutɕ-	to be ill-natured	1	3	2	2	12	2
tɯmul-	to be rare	1	3	2	3	112	2
sirʌps-	to be senseless	1	3	2	1	7	2
pʰoknʌlp-	to be wide	1	3	2	2	59	2
tɯripus-	to pour	1	3	3	1	2	1
tallaputʰ-	to stick	1	3	3	2	25	1
tɕapamʌk-	to slaughter	1	3	3	2	51	1
sojonŋʌps-	to be useless	1	3	3	2	20	2
tɕutɕenʌm-	to be impudent	1	3	3	1	7	2

Appendix II – Judgment survey stimuli (main set)

Legends: vowel: 1-/o/, 2-/a/
length: 1-monosyllabic, 2-bisyllabic, 3-trisyllabic
suffix: 1- the SFM, 2- word-final, 3- clause-final
category: 1-verb, 2-adjective

stem	gloss	vowel	length	suffix	frequency	Category	NIKL
olm-	to move	1	1	1	1	1	6
kolm-	to fester	1	1	1	1	1	5
kolm-	to fester	1	1	3	1	1	5
coleu-	to tease	1	1	1	1	1	4
tot-	to rise	1	1	1	2	1	22
sok-	to be deceived	1	1	1	2	1	25
sok-	to be deceived	1	1	3	2	1	25
koleu-	to be even	1	1	1	2	1	35
p'op-	to draw out	1	1	1	3	1	186
nol-	to play	1	1	1	3	1	480
nol-	to play	1	1	3	3	1	480
oleu-	to rise	1	1	1	3	1	500
olkot-	to be straight	1	2	1	1	2	5
olkot-	to be straight	1	2	2	1	2	5
uilop-	to be righteous	1	2	1	1	2	2
nachmoleu-	not to know (face)	1	2	1	1	1	4
naemol-	to drive out	1	2	1	2	1	16
naemol-	to drive out	1	2	2	2	1	16
koylop-	to be painful	1	2	1	2	2	57
thaoleu-	to burn up	1	2	1	2	1	34
naenoh-	to put out	1	2	1	3	1	211
naenoh-	to put out	1	2	2	3	1	211
saelop-	to be new	1	2	1	3	2	1061
t'eooleu-	to rise up	1	2	1	3	1	215
s'akotol-	to protect	1	3	1	1	1	2
s'akotol-	to protect	1	3	2	1	1	2
anik'op-	to be saucy	1	3	1	1	2	8
t'uyeonol-	to play around	1	3	1	2	1	15
t'uyeonol-	to play around	1	3	3	2	1	15
k'atalop-	to be faultfinding	1	3	1	2	2	43
kalk-	to gnaw	2	1	1	1	1	2
kalk-	to gnaw	2	1	3	1	1	2
as-	to take	2	1	1	1	1	9
saleu-	to burn	2	1	1	1	1	5
k'ak'-	to cut	2	1	1	2	1	87
k'ak'-	to cut	2	1	3	2	1	87
talm-	to resemble	2	1	1	2	2	98

kaleu-	to split	2	1	1	2	1	46
tak'-	to wipe	2	1	1	3	1	272
tak'-	to wipe	2	1	3	3	1	272
nam-	to remain	2	1	1	3	1	652
caleu-	to cut	2	1	1	3	1	197
cultat-	to continue	2	2	1	1	1	1
t'eoan-	to take care of	2	2	1	1	1	3
t'eoan-	to take care of	2	2	3	1	1	3
cheopaleu-	to paint, spread	2	2	1	1	1	1
chitat-	to run up	2	2	1	2	1	21
p'aeas-	to deprive	2	2	1	2	1	55
p'aeas-	to deprive	2	2	3	2	1	55
tataleu-	to arrive	2	2	1	2	1	23
k'aetat-	to comprehend	2	2	1	3	1	200
kwaenchanh-	to be OK	2	2	1	3	2	271
kwaenchanh-	to be OK	2	2	3	3	2	271
olpaleu-	to be right	2	2	1	3	2	137
eoc'upcanh-	to be saucy	2	3	1	1	2	2
eoc'upcanh-	to be saucy	2	3	3	1	2	2
arit'ap-	to be pretty	2	3	1	1	2	6
malmiam-	to be due to	2	3	1	2	2	45
anthak'ap-	to be pitiful	2	3	1	2	2	84
anthak'ap-	to be pitiful	2	3	3	2	2	84

Appendix III – Judgment survey stimuli (minor set)

Legends: group: 1 to 5- morphologically related stems, 6-control,
7-*p*-irregular stems containing /o/, 8-*p*-irregular stems containing /a/,
9-control
length: 1-monosyllabic, 2-bisyllabic, 3-trisyllabic
morph: 0- root, 1- derivational, 2- compounding
frequency: 1- 1 to 9, 2- 10 to 99, 3- over 100

group	stem	gloss	length	suffix	morph	freq.
1	*pat-*	to receive	1	1	0	1
1	*toypat-*	to receive back	2	1	1	1
1	*ponpat-*	to follow	2	1	2	2
1	*kongkeuppat-*	to be supplied	3	1	2	1
1	*iepat-*	to succeed	3	2	2	2
2	*pat-*	to butt	1	1	0	1
2	*chipat-*	to butt up	2	1	1	1
2	*macpat-*	to crash into	2	1	1	1
2	*teulipat-*	to dash against	3	1	2	1
3	*cap-*	to catch	1	1	0	3
3	*maccap-*	to hold together	2	1	1	1
3	*puthcap-*	to seize	2	1	1	2
3	*puyeocap-*	to take hold of	3	1	1	1
3	*salocap-*	to catch alive	3	1	1	2
4	*mac-*	to be right	1	1	0	3
4	*almac-*	to fit	2	1	1	3
4	*keolmac-*	to be well-matched	2	1	1	2
4	*angceungmac-*	to be tiny	3	1	1	1
4	*neunggeulmac-*	to be sly	3	1	1	1
5	*sal-*	to live	1	1	0	3
5	*mocsal-*	to live humble	2	1	2	1
5	*calsal-*	to live wealthy	2	1	2	2
5	*meokkosal-*	to survive	3	1	2	2
5	*eonchyeosal-*	to be dependent on	3	1	2	1
6	*chac-*	to find	1	1	0	3
6	*p'aeas-*	to deprive	2	1	1	2
6	*k'aetat-*	to comprehend	2	1	1	3
6	*k'olapak-*	to	3	1	1	1
6	*kamc'okkath-*	to be as good as	3	1	1	1
7	*koylop-*	to be painful	2	2	1	2
7	*oylop-*	to be lonely	2	1	1	2
7	*aecheolop-*	to be pitiful	3	1	1	1

7	*k'atalop-*	to be faultfinding	3	1	1	2
7	*uilop-*	to be righteous	2	2	2	1
7	*haelop-*	to be harmful	2	1	2	2
7	*kasolop-*	to be ridiculous	3	2	2	1
7	*peonkeolop-*	to be troublesome	3	1	2	2
8	*sanap-*	to be fierce	2	1	0	2
8	*ceongtap-*	to be friendly	2	1	2	2
8	*komap-*	to be thankful	2	1	0	3
8	*anthak'ap-*	to be pitiful	3	1	0	2
8	*k'olsanap-*	to be ugly	3	1	2	1
8	*anik'op-*	to be saucy	3	2	0	1
9	*naec'och-*	to expel	2	1	1	1
9	*naemol-*	to drive out	2	1	1	2
9	*s'akotol-*	to protect	3	1	2	1
9	*mureunok-*	to ripen thoroughly	3	2	1	1

Appendix IV – Production experiment stimuli (real words)

Legends: vowel: 1-/o/, 2-/a/, 3-/u/, 4-/ʌ/, 5-/i/, /ɯ/, or /e/
length: 1-monosyllabic, 2-bisyllabic, 3-trisyllabic

stem	gloss	vowel	logfrequency	length
kal-	to grind	2	1.4	1
kam-	to shampoo	2	1.68	1
k'al-	to spread	2	1.81	1
nal-	to fly	2	1.99	1
nam-	to leave	2	2.81	1
tal-	to differ	2	3.05	1
tak'-	to wash	2	2.43	1
tat-	to be close	2	2.05	1
tal-	to be sweet	2	1.58	1
tam-	to put in	2	2.55	1
mak-	to block	2	2.49	1
manh-	to be much	2	3.43	1
mal-	to roll	2	1.53	1
malk-	to be clear	2	2.32	1
pak-	to bump	2	1.87	1
pat-	to receive	2	3.41	1
palk-	to bright	2	2.24	1
palp-	to step on	2	2.06	1
p'al-	to be fast	2	2.55	1
p'al-	to suck	2	1.54	1
sal-	to live	2	3.36	1
an-	to hug	2	2.38	1
antɕ-	to sit	2	3.01	1
al-	to know	2	3.47	1
tɕak-	to be small	2	2.87	1
tɕap-	to take	2	2.98	1
tɕ'al-	to be short	2	2.41	1
tɕam-	to endure	2	2.33	1
tɕʰaɕ-	to find	2	3	1
pʰal-	to sell	2	2.52	1
karomak-	to obstruct	2	1.61	2
kwentɕʰanh-	to be ok	2	2.43	2
kwitɕʰanh-	to be tiresome	2	1.73	2
k'etal-	to realize	2	2.3	2
metal-	to hang	2	1.38	2
parotɕap-	to be correct	2	1.18	2
ponpat-	to emulate	2	1.53	2
p'eas-	to steal	2	1.74	2
almatɕ-	to be appropriate	2	2.23	2
tɕalsal-	to be rich	2	1.45	2
kol-	to snore	2		

nol-	to play	1		
nop^{h}-	to be high	1		
tol-	to rotate	1		
top-	to help	1		
mol-	to be ignorant	1		
pok'-	to fry	1		
p'op-	to pluck	1		
tɛol-	to doze	1		
tɛop-	to be narrow	1		
kʌl-	to walk	4		
tʌp-	to be hot	4		
tʌp^{h}-	to cover	4		
t'ʌl-	to shake	4		
mʌk-	to eat	4		
mʌl-	to be far	4		
ʌl-	to freeze	4		
ʌps-	not to exist	4		
tɛʌl-	to be young	4		
tɛʌp-	to fold	4		
kulm-	to starve	3		
nup-	to lie	3		
t'ulh-	to bore	3		
mut-	to dig	3		
pul-	to blow	3		
sum-	to hide	3		
ul-	to cry	3		
us-	to laugh	3		
tɛuk-	to die	3		
p^{h}ul-	to untie	3		
kil-	to be long	5		
kip^{h}-	to be deep	5		
k'ɯlh-	to boil	5		
tɯt-	to listen	5		
tɯl-	to lift	5		
masis'-	to be delicious	5		
mep-	to be spicy	5		
pet^{h}-	to spit	5		
p'es-	to take away	5		
sim-	to plant	5		
jep'-	to be pretty	5		
ilk-	to read	5		
ip-	to put on	5		
himtɯl-	to be difficult	5		
kɯri-	to draw	5		

Appendix V – Production experiment stimuli (nonce words)

Legends: vowel: 1-/o/, 2-/a/, 3-/u/, 4-/ʌ/, 5-/i/, /ɯ/, or /e/
length: 1-monosyllabic, 2-bisyllabic, 3-trisyllabic

stem	vowel	length
kak-	2	1
pal-	2	1
akʰ-	2	1
tɕ'ah-	2	1
tʰal-	2	1
hatɕ-	2	1
kʰas-	2	1
s'ak-	2	1
tatɕ-	2	1
satʰ-	2	1
nok'atɕ-	2	2
kɯpatɕʰ-	2	2
tɕʰiatʰ-	2	2
nutɕ'am-	2	2
motʰal-	2	2
tʰol-	1	1
s'ok-	1	1
kʰom-	1	1
kuhok'-	1	2
sibos-	1	2
k'us-	3	1
tup-	3	1
tʰul-	3	1
kiuk-	3	2
mapuk-	3	2
k'ʌl-	4	1
pʰʌt-	4	1
sʌm-	4	1
pitɕʌs-	4	2
emʌp-	4	2

Appendix VI – Production experiment stimuli (nouns)

stem	gloss	in Korean	trigger vowel	target vowel
pata	sea	바다	a	a
kama	palanquin	가마	a	a
nasa	screw	나사	a	a
matʌ	mother	마더	a	ʌ
sasʌ	librarian	사서	a	ʌ
saŋʌ	shark	상어	a	ʌ
sora	top shell	소라	o	a
roma	Rome	로마	o	a
motɕa	hat	모자	o	a
bʌtʰʌ	butter	버터	ʌ	ʌ
bʌnʌ	burner	버너	ʌ	ʌ
tɕʌnʌ	gizzard shad	전어	ʌ	ʌ
sutɕʌ	spoon	수저	u	ʌ
kukʌ	national language	국어	u	ʌ
munʌ	octopus	문어	u	ʌ
pʰato	wave	파도	filler	
siso	seesaw	시소	filler	
imo	aunt	이모	filler	
namu	tree	나무	filler	
tɕiku	earth	지구	filler	
tupu	tofu	두부	filler	
memi	cicada	매미	filler	
hjutɕi	tissue	휴지	filler	
pori	barley	보리	filler	
anke	fog	안개	filler	
tɕoke	shell	조개	filler	
sepe	bowing	세배	filler	