Revisiting the Variable Deletion of Labiovelar Glide (w) in Seoul Korean

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1 Introduction

In understanding synchronic variation in language, one needs to consider a wide range of factors lying beyond what we observe on the surface, whether they are grammatical, social, psychological, physiological, etc. Some constraints that had been overlooked previously often turn out to yield significant refinements to the explanation of variation as well as the diachronic trajectory of change. In this proposal, I attempt to show how we can account for linguistic variation from a wide range of perspectives that will eventually allow us to see the phenomena more accurately. The linguistic variable chosen to achieve this goal is the variable deletion of the labiovelar glide (w) in Seoul Korean. Using three different approaches, I show that the synchronic variation in (w)-deletion can be understood as diachronic accumulations of variable patterns according to a number of factors.

In Seoul Korean, the labiovelar (w) in five rising diphthongs[1] (wi, we, wɛ, wə, wa) is variably deleted after a consonant.

(1) The variable rule of (w)-deletion in Korean

w → ø / C ___ V

[1] Seoul Korean has seven monophthongs and the labiovelar glide (w) co-occurs with five of them as shown below. Note that /e/ and /æ/ have merged into /e/.

- Co-occurrence restrictions on glide+vowel sequences (Kang 1997)

wi	*wɨ	*wu
we	wə	*wo
wa		

The sequence CwV can either be underived or derived. First, it can be underlyingly present in morphological structures. It can be within a single morpheme as in /swip.ta/ 'to be easy' and /hak.kwa/ 'department, major' or across morphemes as in /sam.wəl/ 'March' (literally 'third month'). Second, it can be derived as the output of phonological processes. One of the processes is an obligatory glide formation process shown in (2).

(2) Obligatory glide formation process in Korean

/o/ → [w]/ ____+/a/
/u/ → [w]/V____+/ə/
/p/ → [w]/u ____+/ə/

In the glide formation process, the monophthongs /o/ and /u/ become [w], forming a rising diphthong when the structural conditions are met as in /po+ayo/→[pwa.yo] 'see'[2] (informal impolite), /o+ayo/→[wa.yo] 'come' (informal impolite), /pe.u+ə/→[pe.wə] 'to learn', /s'a.u+ə/→ [s'a.wə] 'to fight', etc. A labial consonant /p/ becomes [w] when it is preceded by /u/ and followed by /ə/ as in /nup+ə/→[nuwə] 'lie down', /kup+ə/→[kuwə] 'bake' (cf. /kup+ko/→ [kup. ko] 'to bake and'). Another phonological process in which (w) can be derived is an optional contraction process shown in (3). When /u/ is preceded by a consonant and followed by a vowel, it changes to [w], forming a diphthong in one syllable rather than maintaining vowel hiatus as in /mu.əs/→[mwət] 'what'.

(3) Optional contraction process

/u/ → [w]/ C__+V

The variable deletion rule in (1) has been observed from early on. Martin (1954:10) notes that "the phoneme (w) drops after p, ph, pp, m, wu([u]), or o… in sloppy speech." (w)-deletion is genuinely optional in the sense of being variable at an intraspeaker level. Two previous studies, however, demonstrate that this deletion is not a random process but shows systematic patterns.

Based on data from 17 participants' read speech, Silva (1991) shows that variation in (w)-deletion is conditioned by internal and external constraints. The strongest constraint on deletion in Silva's (1991) findings is the place of the preceding segment: deletion is significantly favored after nondorsal consonants, while it is disfavored after dorsal segments. Other than the place of the preceding segment, speech style, the manner of the preceding segment, speakers' fathers' occupational prestige, following vowel, and gender of the speaker are also found to be significant conditioning factors on (w)-deletion as shown in the GoldVarb output in Table 1.[3]

[2] It is noteworthy that Korean has a morpheme structure constraint that disallows a sequence of a labial consonant followed by a labiovelar glide: */pw-, phw-, p'w, mw-/.

[3] In the output from GoldVarb analysis, each factor influencing the dependent variable is given a weight indicating the relative strength of each factor group on (w)-deletion. Factors with a weight above 0.5

Paying special attention to the fact that the place of articulation strongly conditions (w)-deletion, Silva puts forward an articulatory account of (w)-deletion in Korean, claiming that it is an articulation of the CwV sequence with reduction of the number of gestures performed by the body of the tongue. He predicts that when a nondorsal (labial or coronal) segment precedes (w), speakers are more likely to delete (w) in the CwV sequence because the tongue body needs to retract and re-front. The deletion of (w) in this case has advantages in articulatory economy. By contrast, when a dorsal segment precedes (w), he predicts that speakers are less likely to delete (w) because the tongue needs to be retracted for the preceding [+back] segment and then fronted for the following vowel, with no advantage to deleting the glide.

Factor groups	Factors	Weight	% Applications	Total *N*
1. Preceding C—place	dorsal	0.274	23	744
	nondorsal	0.678	63	970
2. Speech style	minimal pairs	0.093	13	136
	word list	0.358	34	782
	sentences/text	0.650	49	1234
3. Preceding C—manner	reinforced	0.294	19	104
	lax	0.486	29	657
	aspirated	0.716	48	137
4. Father's occupational prestige	higher	0.434	36	1261
	lower	0.592	49	891
5. Following vowel	nonfront	0.437	35	1109
	front	0.567	48	1043
6. Gender	female	0.452	38	1160
	male	0.556	46	992

[a]Number of cells = 136; fit: χ^2 (128) = 287.485; $p < .0001$; log likelihood = −1086.199.
[b]Input probability = 0.304.

Table 1. GoldVarb probabilities for factors for the (w)-deletion in Silva (1991).

Kang (1997) also showed that, based on data from the sociolinguistic interviews as well as reading tasks with 63 speakers, the (w)-deletion is a variable deletion rule systematically conditioned by various grammatical and social factors. He also found the place of the preceding segment to be the strongest conditioning factor. There were more refined categories of five places (bilabial, alveolar, palatal, velar and glottal) in Kang (ibid.) than Silva's two categories (dorsal, nondorsal). In Kang's (ibid.) data, a bilabial preceding consonant highly favored deletion. The weight factor for bilabial preceding segments was 0.955 while all the others fell below 0.5. The second significant factor was the manner of the preceding segment: lax (lenis) segments favor deletion, while aspirated and reinforced (fortis) segments disfavor deletion of

favor the application of the rule, those with a weight below 0.5 disfavor the rule, and factors with the value 0.5 had no effect on the rule (Tagliamonte 2006).

(w). The following vowel also had an impact on deletion. There was more deletion when a front vowel follows (w) and less deletion when a central vowel does. The next significant constraint was prosodic position. (w) was less likely to be deleted when it was in the domain-initial syllable, while (w) was more likely to be deleted when it was in non-initial position. Speakers deleted (w) significantly more in the interview than in the reading task. He found that the variable deletion of (w) was structured according to the social stratification of the speech community as well. Female speakers were more likely to delete compared to their male counterparts. The lower the social class of the speakers, the more deletion of (w). Last but not least, the younger generation was more likely to delete (w) than the older generation.

Factor groups	Factors	Weight	% Applications	Total N
*Preceding C (place)	bilabial	0.955	81	886
	alveolar	0.454	23	1860
	palatal	0.298	11	836
	velar	0.354	16	1774
	glottal	0.346	12	894
*Preceding C (manner)	lax	0.509	30	2718
	aspirated	0.475	14	600
	reinforced	0.488	19	810
*Following vowel	[-bk]	0.531	22	3205
	[+bk]	0.468	31	3045
*Syllable position	initial	0.421	24	3721
	noninitial	0.615	29	2529
Morph. boundary	zero	0.504	25	5661
	present	0.459	38	589
*Presence of coda	zero	0.522	26	4049
	present	0.459	27	2201
*Speech Style	ingroup	0.667	39	850
	interview	0.631	30	1421
	sentence R	0.427	22	2230
	word R	0.402	21	1749
*Gender	male	0.476	24	3188
	female	0.525	28	3062
*Social Status	upper	0.414	22	2103
	middle	0.498	25	2087
	lower	0.590	32	2060
*Age	16-25	0.545	30	2111
	26-45	0.524	27	2099
	46+	0.429	21	2040

number of cells: 2585 total chi-square = 3004.0572
chi-square/cell = 1.1621 loglikelihood = – 2654.210 Input = 0.235
overall deletion rate = 26.1%

Table 2. GoldVarb probabilities for factors for the (w)-deletion in Kang (1997).

Another notable finding in Kang's (1997) study was that (w) could also be deleted even when there was no preceding consonant. Although the rate of deletion was less than 10 percent in all age groups (7% for the youngest speakers aged 16-25, 4% for speakers aged 26-45 and 3% for speakers older than 45), it was the first documentation that (w)-deletion without

conditioning of the preceding consonant had initiated. For this non-postconsonantal (w)-deletion, prosodic position (non-initial position favoring the deletion), preceding vowel (rounded vowel favoring deletion), social class (lower class favoring deletion), and gender (women favoring deletion) were found to be significant conditioning factors.

Kang (1997) also paid special attention to the strong conditioning of preceding bilabial consonant on (w)-deletion. Unlike Silva, he focused on the perceptual motivation for (w)-deletion. When (w) is preceded by a labial consonant, the acoustic cue for the presence of (w) is obscured because both a labial consonant and (w) provide essentially the same acoustic cue. It is therefore difficult for listeners to parse the cue for (w). In contrast, when a nonlabial consonant precedes (w), listeners do not have such difficulties. This acoustic ambiguity between the 'labial consonant+w+V' sequence and the 'labial consonant+V' sequence results in perceptual confusion for listeners. This consequently leads them to attribute the acoustic cue of (w) to the preceding labial consonant. Kang (ibid.) further suggests that (w)-deletion is one instance of "sound change by listeners" as proposed by Ohala (1981:187) where listeners fail to recognize the phonetic environment causing perturbations on a neighboring segment and misinterpret the sequence of sounds.

Even though Silva (1991) put forward an articulatory account for the motivation for (w)-deletion and Kang (1997) accounted for the deletion as a perceptually motivated sound change, both Silva (1991) and Kang (1997) concluded that the preceding phonological environment was overwhelmingly the most influential factor on the deletion of (w) in Seoul Korean.

This proposal revisits the (w)-deletion in Seoul Korean, following Silva (1991) and Kang (1997) some 20 years later, but with different approaches. I address three major goals in the exploration of the variable deletion rule of (w) in Seoul Korean. In the first part of the proposed dissertation, I revisit the variable (w)-deletion rule in Seoul Korean almost 20 years later, using a trend study in which the speech community that had been studied previously is resampled. I examine what trajectory the (w)-deletion has taken over the past twenty years in naturally occurring languages from sociolinguistic interviews as well as speech from a reading task. I also examine whether the ranking and strength of internal and external constraints have remained the same over the past 20 years or not, testing the Constant Rate Hypothesis (Kroch 1998). Second, I attempt to account for the variable deletion rule of (w) in Seoul Korean based on formal architecture assuming the repeated application of phonological rules combined with a variable rule framework. Lastly, I aim to show whether the variation in how speakers physically articulate speech can reveal a more comprehensive picture of the variable deletion of (w) in Seoul Korean, using naturalistic articulatory data gathered with Ultrasound Tongue Imaging (UTI).

2 Real-time investigation of (w)-deletion in Seoul Korean

2.1 Design and methodology

In studying language change at the community level, the most reliable method has been considered that of the trend study (Trudgill 1988, Labov 1994, Sankoff and Blondeau 2007). In trend studies, followup studies resample the community, using the same sampling criteria as the first study they are making a comparison with. In this study, I draw on such trend comparisons to shed light on the change in the use of the labiovelar glide (w) in Seoul Korean.

2.1.1 Participants and data collection

In order to construct matched samples with those of Kang's (1997) study, efforts were made to include speakers across a range of age, gender and social class groups for the 2014 data.[4] In recruiting interviewees, I mainly employed the network procedure (Horvath 1985), in which speakers are selected within the fieldworkers' network first, and then asked to introduce someone who is within their networks. For older speakers, I visited a nursing home in *Chungwoon-dong* in Seoul and interviewed two female speakers in their 80s who are native to Seoul, since it was extremely difficult to locate willing older participants native to Seoul[5].

The data collection consisted of two parts. In sociolinguistic interviews, participants were asked to talk about topics that they feel comfortable with, and it was immediately followed by the reading task. After a reading task, demographic information of participants was collected through a questionnaire.

[4] The 1997 sociolinguistic study of Seoul Korean consisted of a sample of 63 speakers, stratified by age, gender, and social class. There was a balanced number of speakers in different groups according to their age, gender and social class.

[5] Seoul is the capital and largest metropolis of South Korea. It has a population of more than 10 million, around 20% of the total population of South Korea. The population of Seoul has skyrocketed throughout the second half of the twentieth century as the Figure below displays. Following the Korean war (1950-1953), there was a great influx of people from the countryside to Seoul in search of greater economic and educational opportunities. Thus it was more difficult to locate native Seoul speakers born before 1940 compared to their younger counterparts.

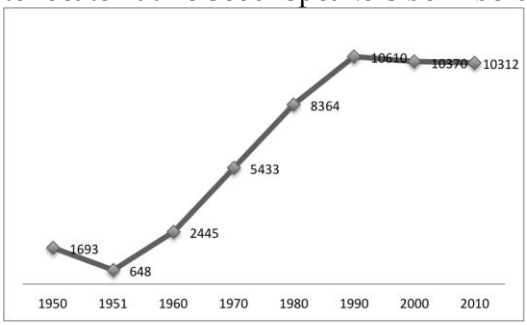


Figure 1. Change in the Population of Seoul (unit:K)

Speaker ID	Age	Gender	Social Class	Proj.Educ[6]	Occupation
GH	15	M	Working	High school	Student
KH	15	M	Middle	Nationally-oriented U	Student
DS	18	F	Working	Comm. College	Student
HK	21	M	Working	Nationally-oriented U	Student
YJ	22	F	Middle	Nationally-oriented U	Student
Min	22	F	Working	Community college	Student
YR	26	F	Middle	Nationally-oriented U.	Student
HJ	26	F	Middle	Nationally-oriented U.	Student
Joon	26	M	Working	Community college	Bartender
JW	36	M	Middle	Nationally-oriented U.	Works for IT company
HS	41	F	Middle	Community college	Nurse
YS	50	M	Middle	Regional U.	Professor
EB	82	F	Middle	High school	
SH	85	F	Working	No schooling	

Table 3. Demographic information of participants.

The preliminary data include 852 tokens from 14 native Seoul Koreans, born between 1930 and 2000, stratified by age, gender and social class (see Table 3 for the demographic information of the participants). Although we made the best efforts to select the most closely matched sample, there is smaller number of older speakers whose ages are above 40 as can be seen in Table 4. These speakers are initially divided into five age groups, based on different lifestages that may bring a dramatic change in their language (Eckert 1997, Cheshire 2005): teenagers (15-19), college years (20-25), early career (26-40), later career (41-65) and after retirement (66+).

[6] For the youngest speakers in our dataset, the education level they have attained thus far does not represent their education level accurately; one of the two 15-year-old male speakers had an aspiration to go on to a prestigious university and he was doing very well in school, while the other 15-year-old had no such aspiration and wanted to be a carpenter right after he graduated from a vocational high school. For speakers such as these, the projected education level was used.

Overall, however, we can say the speakers in the preliminary data collection are comparable to Kang's samples according to their relevant social characteristics, with an equal number of speakers in different social class and gender groups.

Age	Middle Class		Working Class		Total
Gender	F	M	F	M	
15-19	0	1	1	1	3
20-25	0	1	1	1	3
26-40	2	1	0	1	4
41-65	0	1	1	0	2
66+	1	0	1	0	2
Total	7		7		14

Table 4. Composition of the 2014 trend sample by age, sex and social class.

2.1.2 Data coding and analysis

For each speaker, we coded the dependent variable as a binary choice between presence (1) or absence (0), beginning about five minutes into the interview and continuing to code each (w) that occurred. Two coders listened to the sound files and noted codes on separate spreadsheets, after which comparison of the codes was made. If the coding was different, the two coders listened to the sound files again and reconciled the differences. Intercoder reliability checks were conducted on a sample of 300 tokens and 90% consensus was attained.

There were some problem cases, however. Tokens with a very weak lip protrusion and dorsum backing and raising, especially in very fast speech, might be heard as ambiguous or 'indistinct'. We resolved these cases by relistening to the tokens, but the tokens we could not agree on were discarded. (w) is known to lower F2 and F3 of adjacent vowels (Lieberman et al. 1956, Kent and Read 1992), but spectrographic examination with Praat was not effective in identifying (w) since such acoustic correlates of (w) were not consistently displayed or salient in the spectrogram. The number of instances of (w) and deleted (w) were noted and the percentage was calculated as follows:

(w)-deletion rate=(Number of deleted tokens/All tokens) *100

Each token was coded along with linguistic and external constraints. Linguistic constraints include the place and manner of the preceding segment, the following vowel and the prosodic position. The external constraints include speech style, gender, social class, education and age. Table 5 lists all the factor groups and levels within each factor group.

Factor group	Levels
Place of the preceding consonant	Bilabial, Alveolar, Palatal, Velar, Glottal
Manner of the preceding consonant	Stop, Fricative, Liquid, Nasal, Vowel
The following vowel	Front, Central
Prosodic position	Initial, Non-initial
Speech style	Reading, Interview
Gender	Male, Female
Social class	Middle, Working
Education	Higher education, No higher education
Age	(Continuous)

Table 5. Factor groups considered in the analysis of (w)-deletion in Seoul Korean

2.2 The change of (w)-deletion in apparent and real time constructs: diachronic change

In this section, we are going to see what patterns are found with regard to the variable deletion rule of (w) in the apparent time approach (the comparison of older and younger speakers at the same time point, in the year 2014 in this study) as well as in the real time approach (the comparison of the same age groups at two different points in time, in the years 1997 and 2014).

First, let us see how our 2014 speakers vary in the (w)-deletion rate by age. Figure 2 shows the (w)-deletion rate by speaker age in two different styles (spontaneous speech and reading). There is a gradual decrease in the (w)-deletion rate in spontaneous speech: the speakers age 46 and older show a mean (w)-deletion rate considerably higher than that of the speakers age 15 to 20. In reading, deletion rates are consistently lower than those in spontaneous speech for every age group but no dramatic difference among age groups is found.

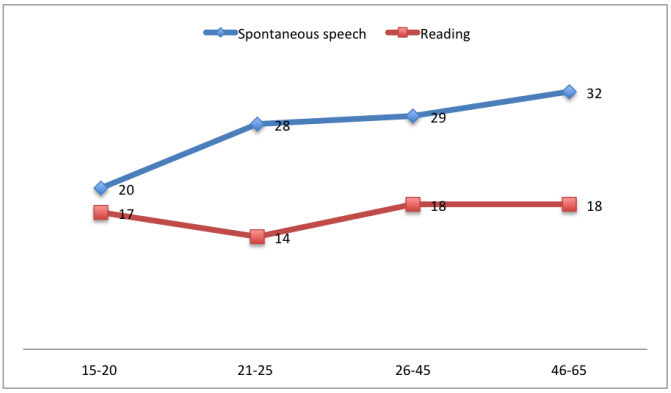


Figure 2. The (w)-deletion rate by speaker age in two different styles

The lower (w)-deletion rate in younger speakers in spontaneous speech is somewhat unexpected given Kang's (1997) finding that the deletion rate was the highest among younger speakers while older speakers showed the lowest deletion rate.

Let us now turn to the real time construct and compare the 2014 deletion rates with Kang's (1997). For the purpose of comparison, a slight adjustment is made to the division of age groups into three age groups (grouping the teenagers and speakers in their early 20s together) in order to make an identical age grouping to Kang's whose age ranges are provided in Tables 7 and 8. For spontaneous speech, compared to the deletion rates in 1997, speakers age 45 and under show a significant decrease in the deletion rate in 2014: 1) For speakers age 15 to 25, the mean deletion rates dropped by seven percentage points (39% in 1997 and 32% in 2014); 2) for speakers age between 26 and 45, the mean deletion rates are four percentage points apart (33% in 1997 and 29% in 2014); 3) for oldest speakers, there is no significant difference between the 1997 and 2014 sample.

Age/Year of recording	1997	2014	Change in the rate of deletion
15-25	39	32	Significant drop ($p<0.0001$)
26-45	33	29	Significant drop ($p<0.001$)
46-65	29	32	No significant change ($p=0.7094$)

Table 7. Change in post-consonantal (w)-deletion rate in spontaneous speech

There is a significant decrease in the deletion rate for speakers age 45 and under in read speech as well: 1) For speakers age 15 to 25, the mean deletion rates dropped by nine percentage points (25% in 1997 and 16% in 2014); 2) for speakers age 26 to 45, the mean deletion rates are six percentage points apart (24% in 1997 and 18% in 2014); 3) for the oldest speakers, there is no significant difference between the 1997 and 2014 samples.

Age/Year of recording	1997	2014	Change in the rate of deletion
15-25	25	16	Significant drop ($p<0.0001$)
26-45	24	18	Significant drop ($p<0.0001$)
46-65	17	18	No significant change ($p=0.8876$)

Table 8. Change in post-consonantal (w)-deletion rate in the reading task

These trend comparisons, representing a real-time reassessment of the community after a 17-year interval, are the basis for assessing real-time change. The significant drop in the (w)-

deletion rate from 1997 to 2014 among speakers age 45 and under appears to represent a nontrivial real-time change in the community and, this coincides with the apparent time pattern that younger speakers delete (w) less. These results allow me to proceed with confidence in pursuing the account of the reversal of (w)-deletion.

2.3 Synchronic variation in the use of (w) in Seoul Korean in 2014

We have seen that the change in the community mean indicates a significant shift toward retention of (w) rather than deletion over the past 17 years. In this section, we will see how synchronic variation in the use of (w) in Seoul Korean is constrained by various internal and external factors. I will begin with the statistically significant constraints. [7]

First, there is a significant gender difference in the use of (w)-deletion. Women are less likely to delete (w) than men, as can be seen in Figure 3. It is interesting to note that women favored the deletion of (w) in Kang's study 17 years ago, and it is again female speakers that favor the retention of (w). This suggests women lead the deletion of (w) as well as the reversal.

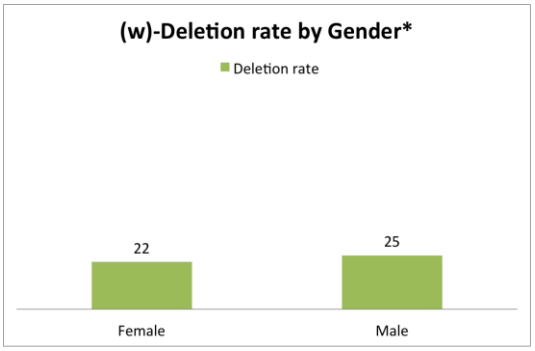


Figure 3. (w)-deletion rate by gender

Style was another highly significant factor constraining (w)-deletion. There was significantly less deletion in reading compared to spontaneous speech in interviews, as can be seen in Figure 4. This pattern is consistent with Kang's (1997) finding.

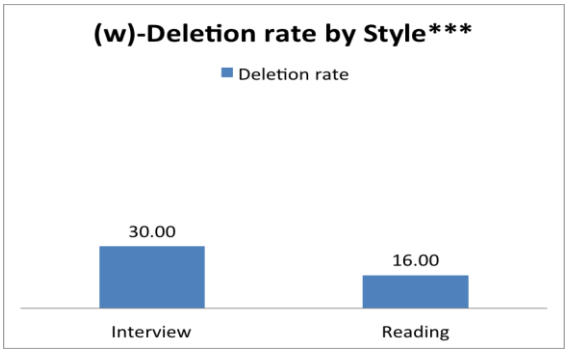


Figure 4. (w)-deletion rate by style

[7] In the following figures, the factors with asterisk(s) next to them are statistically significant factors while those without them fail to reach significance.

Prosodic position is another significant factor: deletion in a domain-initial position is disfavored while that in a non-initial position is favored as in Figure 5. This is also consistent with Kang's (1997) finding.

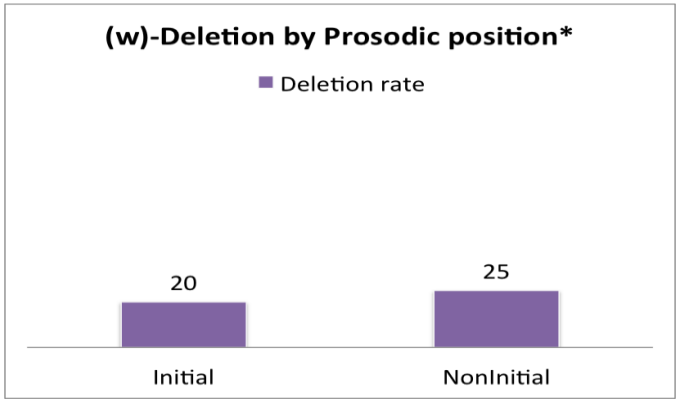
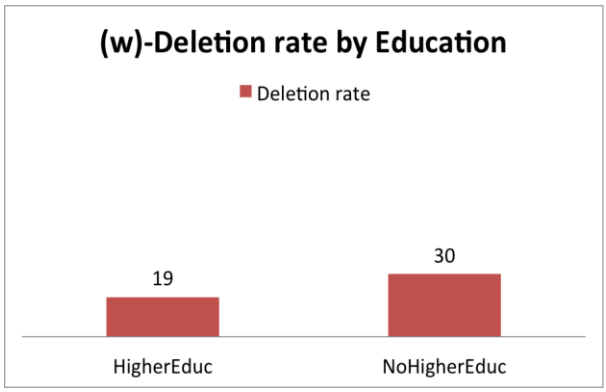


Figure 5. (w)-deletion rate by prosodic position

So far, we have seen the constraints that prove significant in the logistic regression that will be shortly discussed in Section 2.3. Below, I show the factors that fail to reach the significance but still reveal meaningful patterns. [8]



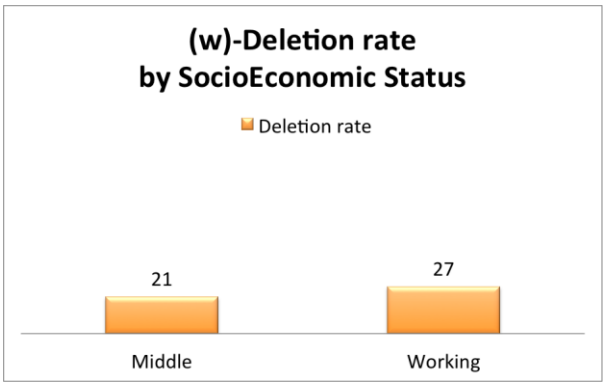


Figure 6. (w)-deletion rate by education and socioeconomic status

Two constraints concerning the social standing of speakers show that working class speakers are more likely to delete, and those with no higher education delete more. Results for social class are also consistent with Kang's (1997).

Two internal constraints that fail to reach significance require further discussion since these two were the most important conditioning factors both in Silva's (1991) and Kang's (1997)

[8] These constraints that fail to reach significance in the logistic regression may be due to the relatively small number of tokens. With more data added, these factors could turn out to be statistically significant constraints.

findings. In the current data, neither the place nor the manner of preceding segment is selected as a significant factor, and the deletion rate is similar across different places and the manners of the preceding segment except for a few categories (e.g. liquids), as Figure 7 shows. The lack of significance of the place of the preceding segment is especially puzzling because this finding is in stark contrast with what both Silva and Kang found. They found a sizeable favoring effect of nondorsal or labial consonants on (w)-deletion: the percent application (the deletion rate) was nondorsal (63%)> dorsal (23%) in Silva (1991) and labial (81%)> alveolar (23%)> velar (16%)> glottal (12%)> palatal (11%) in Kang (1997). Given that both studies found considerable effects of the place of the preceding segment, we may well expect to find the same pattern even after 17 years on the basis of the Constant Rate Hypothesis (Kroch 1989). Kroch (1989) demonstrated that when a new syntactic variant begins to enter the grammar, its use may be more or less favored in different contexts, but it increases in frequency in every context at the same rate over time. Fruehwald et al. (2009) showed the Constant Rate Effect holds in phonology as well, demonstrating that the different contexts for final fortition express a change in a single underlying rule in the grammars of German speakers.

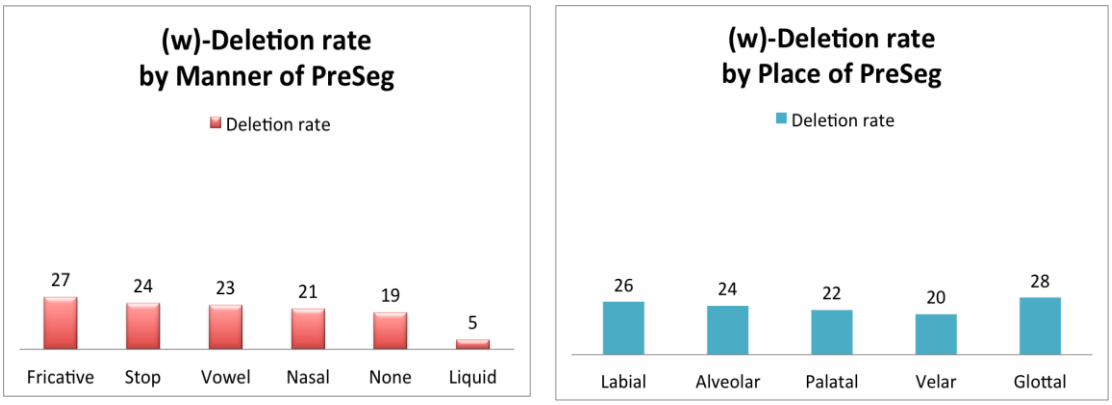


Figure 7. (w)-deletion rate by the manner and place of the preceding segment

Let us look at the data more closely, by dividing them into two different age groups on the grounds that speakers age 45 and under have been reversing the change. This reveals strikingly differing patterns for two age groups. As Figure 8 displays, speakers age 45 and under do not show any effect of the place of the preceding consonant. By contrast, speakers age 46 and older show the same strong conditioning of labial preceding segments as in Kang (1997). This finding suggests that (w)-deletion not only began to retreat at around 1970 but also that it may have been reanalyzed as a general deletion rule insensitive to the preceding consonant.

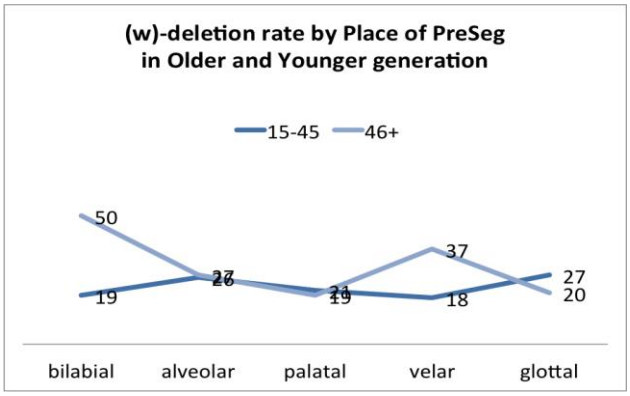


Figure 8. Differing effects of the place of preceding segment in two age groups

The apparent and real time data for non-post consonantal (w)-deletion provide another piece of evidence supporting this. As found in Kang (1997), the deletion of (w) in non-post consonantal environments was initiated decades ago, and this innovation appears to have been on the increase, as Kang's and my data show in Figure 9. This corroborates my proposal that post-consonantal (w)-deletion has been reanalyzed as a general deletion rule.

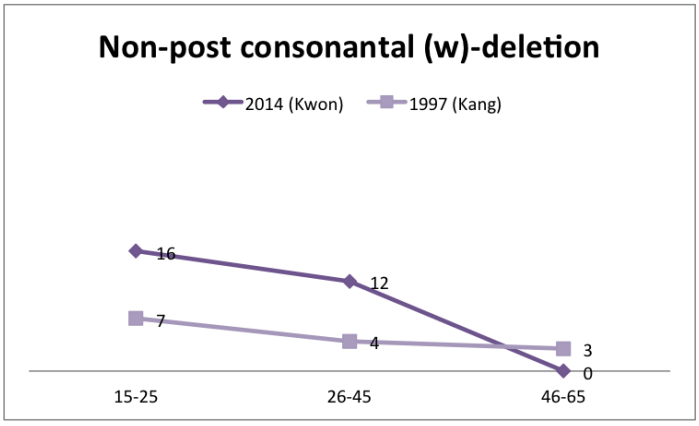


Figure 9. Deletion rate of non-post consonantal (w) in 1997 and 2014

2.4 Logistic mixed model results

Table 9 shows the results from a logistic mixed model where all the internal and external predictors were submitted to regression analysis with the random effects of speaker and word (lemma). Only the coefficients and p-values of significant factors are displayed. As we have seen in the previous section (2.3), style was highly significant: in reading, speakers are significantly less likely to delete (w) than in spontaneous speech. Men delete significantly more than women, which suggests that women are leading the reversal of (w)-deletion. Age is also a significant predictor, confirming that older speakers are more likely to delete and the younger generation is going in the opposite direction. Non-initial position is a significantly more favorable environment for (w)-deletion compared to initial prosodic position.

	Estimate	SE	z value	Pr(>|z|)
(Intercept)	2.68127	0.56487	4.747	0.0000
Style:Reading	0.92875	0.2182	4.256	0.0000
Gender:M	-0.41746	0.19047	-2.192	0.0284
Age	-0.02961	0.01124	-2.635	0.0084
Position:NonInitial	-0.7084	0.21221	-3.338	0.0008

Table 9. (w)-deletion regression coefficients

2.5 Discussion

We have seen that the deletion of (w) has been retreating in favor of the retention of (w), and this reversal is presumed to have been initiated some time around 1970. The younger speakers born after 1970 not only decreased the rate of deletion but also appear to have learned a grammar different from that of the older generation. What has brought about the actuation of this innovation? How did this unexpected reversal of direction come about?

There are some important historical and social contexts worth considering when looking into change in the Korean language in the twentieth century. In the first half of the twentieth century, the Korean language faced a crisis since Korea was colonized by Japan between 1910 and 1945, and the use of Korean was strictly prohibited in public. Korean people had to change their names to Japanese names and they were taught in Japanese in school. It was only at home or in confidential gatherings among Koreans that they could talk to each other in Korean. Children acquired their mother tongue, Korean, from their primary caretaker, usually their mother, at home. Still, many were deprived of the opportunities to learn to read and write in Korean. Also, educational opportunities were limited. Elementary schools, for example, accommodated only 30 percent of all school-age children; only one out of 20 or so enrolled in secondary schools, and very few Koreans attended college. The adult literacy rate in 1945 was only 22 percent.[9] Not long after the Japanese colonial occupation of Korea ended, the Korean war broke out in 1950 and lasted for three years. Given these historical facts, it is not hard to imagine how seriously the development of modern education was disrupted in the first half of the twentieth century in Korea (Kim 2005, Hwang 2010, Hulbert 2014).

In the second half of the twentieth century, however, Korea has gone through spectacular progress in modernization and economic growth since the Korean War. An ensuing change was a great amount of investment in the education system. The percentage of students going on to optional middle school[10] in 1985 was more than 99 percent. Approximately 34 percent of high school graduates attended institutions of higher education in 1987, and this was one of the world's highest rates. By 1970 adult literacy had reached 87.6 percent and by the late 1980s it

[9] Two speakers older than 80 in my preliminary data were not able to participate in the reading task because they were not able to read Korean. Still, they spoke fluent Korean.

[10] Only primary school was compulsory education at the time.

increased to 93 percent. As of 2002, Korea's literacy rate had reached 99.9 percent.

I propose that the reversal of (w)-deletion might have been precipitated by substantial social changes in the speech community whereby there was dramatic increase in literacy and, therefore, more exposure to orthography. The crucial role of orthography in constraining speech production has been extensively acknowledged in a number of psycholinguistic studies (Seidenberg and Tanenhaus 1979, Donnenwerth-Nolan, Tanenhaus, and Seidenberg 1981, Dijkstra, Roelofs, and Fieuws 1995, Halle, Chereau, and Segui 2000, Damian and Bowers 2003, *inter alia*). These studies show that our speech perception and production as well as phonological system are heavily influenced by orthographic codes. Dijkstra, Roelofs, and Fieuws (1995) show that not only phonemic and phonological codes, but also orthographic codes, exert an influence on our perception of phonemes. Halle, Chereau, and Segui (2000) demonstrate that subjects tended to choose the correct orthography even if what they heard was phonetically different from the phoneme typically represented in the orthography. This suggests a robust influence of orthographic codes on phonetic perception. Damian and Bowers (2003) show that orthographic information influences performance in tasks even without visual orthographic codes. These findings raise the possibility that orthographic codes can be activated in speech production even without visual cues.

Given these findings, it seems plausible that a dramatic increase in the literacy rate in a short period of time and the resultant exposure to orthography might have made the restructuring of the (w)-deletion rule possible. If I verify this proposal with more extensive data from speakers from a wide range of age, social class and gender groups, this will provide an interesting case showing how sound change can be reversed and reanalyzed by substantial changes in a society. This will also provide important implications on how successive generations of children advance the change beyond the level of their caretakers over many generations (Labov 1994: Ch. 14).

3 The retreat of a rule from the narrower domain in the retrograde change

3.1 Introduction

In formal architectures from lexical phonology (Kiparsky, 1982; Mohanan, 1986) and Stratal Optimality Theory (Bermúdez-Otero 1999, Kiparsky 2000, Bermúdez-Otero 2011), words are differentiated by derivational history. Some studies have attempted to combine this notion and the variable rule framework to explain the variations in synchronic phonology. One well-known example can be found in a model where Guy (1991a, b) explains the phonological variation in –t/d deletion. He differentiates three different classes of words, monomorphemic forms, semiweak past tense forms and regular past tense verbs since they acquire its final segment at a different derivational level. Monomorphemic forms such as *mist, old*, are underived, maintaining their phonological shape throughout the derivational processes and therefore it is

predicted that it will show highest rate of the final –t/d deletion since it is subject to deletion at all levels. In semiweak past tense forms, such as *left, told*, the affixation of the final stop, irregular internal vowel change, regressive voicing assimilation take place at level one. The prediction is that semiweak past tense forms will display lower deletion rate than the monomorphemic forms because they have chances to undergo the deletion only at two levels. In regular past tense verbs such as *walked, missed*, the final affix is acquired at level two of the lexicon. It is predicted that they will show lowest rate of deletion because they are subject to the deletion rule only once. The basic premise of this model is that variable rules could potentially have multiple opportunities to apply to the forms that meet their structural description at different strata.

Parallel application of the idea can be found in the (w)-deletion in Seoul Korean. There are two different classes of words with (w) that differ in their derivational history. Words that belong to Class A (underived words) are those that have (w) underlyingly so that (w) is subject to deletion process throughout the derivational process. Class B (Derived words) words are those with (w) formed as the output of the phonological processes such as glide formation or contraction processes later in the derivation and have less opportunities to undergo the deletion.

Previous studies on (w)-deletion have considered the possibility that some morphological constraints may have impact on the probability of (w)-deletion. Silva (1991) and Kang (1997) included morpheme boundary [11] in their regression analysis but both studies found no significant effect.[12] Upon further reflection on the different derivational history of words with (w), however, the categorization of words simply based on the presence/absence of the morpheme boundary is not accurate enough to capture the potentially different rate of deletion depending on their derivational history. For example, both *chamwe* (/cham+we/)[13] 'melon' and *pwayo* (/po+ayo/→/p+w+ayo/) 'see (informal polite)' have a morpheme boundary preceding (w), the former is a word where (w) is underlyingly present throughout the derivational processes while the latter is a word containing (w) formed through the glide formation process somewhere between the stem and word level, therefore (w) in *p.w.ayo* 'see (informal polite)' cannot be subject to deletion at the stem level. The prior practice of putting these two types of words together as sharing a common level was mistaken. Therefore, it seems more promising to look into the different behaviors of classes of words differentiated by derivational history rather than the mere presence/absence of a morpheme boundary.

In this proposal, I attempt to examine whether the rate of (w)-deletion is conditioned by differing derivational history of words and, if so, see if the findings can tell us about the diachronic change of the (w)-deletion rule.

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[11] There were 3 factors within the factor group, morpheme boundary: i) no boundary, ii) a boundary in Native Korean and iii) a boundary in Sino Korean.

[12] The morpheme boundary had no significant effect in the logistic mixed model in the current study.

[13] The '+' indicates the morphological breakdown.

3.2 Two different classes of words and quantitative predictions

There are two different classes of words containing (w) in a surface form based on their derivational history. A class of words that satisfies the structural description of a variable rule at an early lexical level of derivation will undergo multiple operations of the rule and, a class of forms that only satisfies the structural description of the rule later in the derivation will be subject to its operation less.

Words that belong to Class A (underived words) are those that have (w) underlyingly so that (w) is subject to the deletion process throughout the derivational process. For instance, *swip.ta* 'to be easy' has (w) underlyingly, therefore (w) in *swip.ta* 'to be easy' is subject to the (w)-deletion at all levels: the stem, word and phrase level.

Class B (Derived words) words are those with (w) formed as the output of the phonological processes such as glide formation or contraction processes later in the derivation and have less opportunities to undergo the deletion. For instance, when the vowel *o* is followed by an ending suffix *ayo,* as in /s'o+ayo/-> [s+w+ayo] (*s'o* 'shoot', *ayo* a suffix meaning 'informal polite'), [w] which did not exist at the stem level appears at the word level. Since this (w) is generated later in the process, it is exposed to the deletion at the word and phrase level only.

Post-consonantal (w)-deletion	Class A: $[[[swip]_{s}\ ta]_{w}\ ]_{p}$ 'easy'	Class B: $[[[[s']_{s}\ wayo]_{w}\ ]_{p}$ 'shoot, fire'
Stem	Yes	No
Word	Yes	Yes
Phrase	Yes	Yes

Table 10. The exposure to the (w)-deletion rule at different strata

It follows that there will be higher rates of application for words in Class A (underived words) than those in Class B (derived words) that have fewer exposure and lower cumulative deletion.

Post-consonantal (w)-deletion	Class A: Underived (Underlying)	Class B: Derived
	$[[[swip]_{s}ta]_{w}]_{p}$ 'easy' (3 cycles:SWP)	$[[[s']_{s}wayo]_{w}]_{p}$ 'shoot, fire' (2 cycles: WP)
The surface deletion rate	Higher rate of deletion	Lower rate of deletion

Table 11. Quantitative predictions about the (w)-deletion rate in Class A (underived) and Class B (derived) words

3.3 Results

Let us now see whether this prediction is borne out in the current data. Recall that there was a divide between the older and younger generation that older speakers born before 1970 (age 46+) showed similar deletion rate of (w) as compared to speakers of the same age group twenty years ago while the (w)-deletion rate dropped significantly among the younger speakers born after 1970. Based on this, two different classes of words (Class A and Class B) will be compared separately in these two age groups.

The older speaker group (born before 1970) shows the expected pattern. They show the higher rate of deletion for Class A than Class B. Surprisingly, however, the younger speaker group (born after 1970) shows the opposite pattern: the deletion rate of Class B is higher than that of Class A. Table 12 illustrates different quantitative patterns in different age groups.

Age	Class A	Class B	Expected results?
	$[[[swip]_s ta]_w]_p$ 'easy'	$[[[s']_s wayo]_w]_p$ 'shoot, fire'	
15-25	0.82	0.73	No
26-45	0.73	0.70	No
46+	0.58	0.77	Yes

Table 12. The (w)-retention rate by different age groups

Let us look into the data more closely by looking at the individual data. The pattern again is clear that in older generation the expected pattern appears. A majority of speakers aged between 20 and 40 show the opposite pattern: more deletion in Class B words than in Class A words although some speakers show similar deletion rates between Class A and Class B. It appears that the teenagers have very similar deletion rate in Class A and B.

Age	Speaker	Stem	Word
15	GH	0.80	0.75
15	KH	0.85	0.82
18	DS	0.86	0.83
21	HK	0.75	0.57
22	YJ	0.91	0.77
22	Min	0.76	0.63
26	HJ	0.71	0.65

26	YR	0.78	0.79
26	Joon	0.81	0.71
36	JW	0.83	0.65
41	HS	0.52	0.73
50	YS	0.63	0.73
82	EB	0.50	0.78
85	SH	0.60	0.80

Table 13. The (w)-retention rate by individuals

Table 14 summarizes the patterns we find in different age groups. In the oldest generation, the deletion rate is higher for Class A words than Class B words. Among the middle age speakers, the pattern is reversed: the greater deletion in Class B than in Class A. The youngest speakers show almost the identical deletion rates for Class A and B words.

Age	Class A: Underlying	Class B: Derived	Expected results?
	$[[[swip]_{s}ta]_{w}]_{p}$ 'easy'	$[[[s']_{s}wayo]_{w}]_{p}$ 'shoot, fire'	
Youngest (15-20)	A=B		No
Middle (21-45)	A<B		No
Older (46+)	A>B		Yes

Table 14. Different quantitative patterns of (w)-deletion in different age groups

3.4 A proposed analysis: retreat of a rule from a narrower domain

Let us speculate on what could have motivated such an unexpected pattern among younger speakers. We begin from the following observation: the fact that the rate of deletion is higher in Class B than Class A among speakers aged between 20s and 40s indicates that the assumption that Class B words have less opportunities to be exposed to the deletion than Class A words may not be valid. Rather, it implies that Class B words may have had more opportunities to undergo the (w)-deletion than Class A words. The fact that there is no significant difference in the rate of deletion in Class A and B among youngest speakers suggests that (w)-deletion rule may have operated at the stratum where Class A and Class B words were treated equally.

I propose one possible scenario how these quantitative patterns were obtained. I propose that, as a rule retreats, a rule may recede from the narrowest morphosyntactic domain to the wider ones, from the stem level to word and then to phrase level. The (w)-deletion rule, in this

case, may have lost the rule at the stem level first by the speakers who were born between 1970 and 1995. Again, the rule may have been lost at the word level by the speakers who were born after 1995. Table 15 illustrates how the deletion rule may recede from the stem level and then to the word level.

Strata	Older (b. before 1970)	Middle age (b.1970-1995)	Youngest (b. after 1995)
Stem	Yes	No	No
Word	Yes	Yes	No
Phrase	Yes	Yes	Yes

Table 15. Retreat of a rule from a narrower domain

Let us now see how this scenario accounts for the quantitative patterns we saw in Section 3.4 by simulating the deletion rate of Class A and Class B in older, middle age and younger speakers. In making quantitative estimation, we may need to make a number of assumptions about the rate of deletion at each cycle. As a rough approximation and for simplicity, let us assume the rate of deletion is equal at all levels as 0.5.

Table 16 shows the simulation of the operation of the (w)-deletion for the older speakers maintaining the deletion rule at all levels. For a Class A word, /swip.ta/, (w) is underlying from the stem level, thus it will get a chance to be deleted at the stem level, 50% of the time. At the word level, (w) can again be deleted if it was retained in the previous cycle. The resultant deletion rate at word level is at 75% (50% at stem level and 25% at word level). At phrase level, (w) is again subject to deletion and the final deletion rate appearing on the surface is 88%. For a Class B word, /s'o+a+yo/-> [s'wayo], there is no chance of deletion at the stem level. (w) gets the first chance of deletion at the word level and it is deleted 50% of the time. At the next cycle, the phrase level, (w) which was retained at the word level is subject to deletion again and the final delete rate on the surface for the Class B words would be 75%. This correctly predicts the higher rate of deletion at 88% in Class A compared to 75% among older generation.

	Class A: Underlying (w)			Class B: Derived (w)		
	$[[[swip]_{s}ta]_{w}]_{p}$'easy'			$[[[s']_{s}wayo]_{w}]_{p}$'shoot, fire'		
Stem	(w)-deleted at S	sip	1/2	(w)-deleted at S	s'wayo	0
	(w)-retained at S	swip	1/2			
Word	(w)-deleted at S	sip	3/4	(w)-deleted at W	s'ayo	1/2

	(w)-deleted at W	sip				
	(w)-retained at W	swip	1/4	(w)-retained at W	s'wayo	1/2
Phrase	(w)-deleted at S	sip	3/4	(w)-deleted at W	s'ayo	1/2
	(w)-deleted at W	sip				
	(w)-deleted at P	sip	1/8	(w)-deleted at P	s'ayo	1/4
	(w)-retained at P	swip	1/8	(w)-retained at P	s'wayo	1/4
Rate of Deletion	7/8 (88%)			3/4(75%)		

Table 16. The Simulation of (w)-deletion rate in older speakers born before 1970

Table 17 shows the simulation of the repeated (w)-deletion for the middle age speakers aged between 20 and 45 that lost the deletion rule at the stem level[14]. The deletion rate at the stem level is the same for Class A and Class B because they lost the rule at the stem level. A Class A word, /swip.ta/ where (w) is underlying from the stem level, thus gets the first chance to be deleted at the word level. Note, however, that their rate of deletion is lowered or degraded to 25% due to the variable cyclic degrading[15]. This is based on the idea of the strict cyclicity first proposed in Chomsky 1971 for major syntactic transformations but later applied to phonological processes as well (Mascaró 1976, Halle 1978, Kiparsky 1985, Rubach 1984, Kenstowicz 1994). By strict cyclicity, a rule crucially must refer to information supplied in the current cycle and will be blocked if its application would be solely within the domain of the previous cycle. Therefore, cyclic rules cannot operate on underived lexical items. Rather than the categorical blocking of classic strict cyclicity, I propose that the output of a variable rule applying in the same situation is degraded (i.e., the rate of application is lowered). Thus, in the example in Table 17, the output from the previous cycle, the stem level, [swip.ta], is the same as the input of the subsequent cycle, the word level, [swip.ta] because the deletion rule at the stem level has been lost for the middle age speakers. For this reason, the deletion rate at the word level is degraded and lowered to, say, 25% compared to 50%, the rate of deletion before degradation. At the word level, therefore, (w) in Class A words is deleted 25% of the time (the degraded deletion rate) while that in Class B is deleted 50% of the time. At the phrase level, (w) that was not affected by the deletion rule at the word level undergoes the deletion again. The resultant rate of deletion is 63% for Class A words and 75% for Class B.

[14] Non-derived environment blocking (NDEB) may be responsible for the loss of the deletion rule at stem level. It might have been possible if speakers are exposed to ambiguity as to whether they should delete (w) or not in non-derived environment, it is possible that speakers might have failed to acquire the exact rule and concluded that the rule does not apply in the non-derived environment.

[15] Each domain is subject to its own stratum-specific grammar.

	Class A: Underlying (w)			Class B: Derived (w)		
	[[[swip]$_{s}$ta]$_{w}$]$_{p}$'easy'			[[[s']$_{s}$wayo]$_{w}$]$_{p}$'shoot, fire'		
Stem NDEB	(w)-retained at S	swip	0	(w)-retained at S	s'wayo	0
Word Cyclic degrading	(w)-deleted at W	sip	1/4	(w)-deleted at W	s'ayo	1/2
	(w)-retained at W	swip	3/4	(w)-retained at W	s'wayo	1/2
Phrase	(w)-deleted at W	sip	1/4	(w)-deleted at W	s'ayo	1/2
	(w)-deleted at P	sip	3/8	(w)-deleted at P	s'ayo	1/4
	(w)-retained at P	swip	3/8	(w)-retained at P	s'wayo	1/4
Rate of Deletion	5/8 (63%)			6/8 (75%)		

Table 17. The Simulation of (w)-deletion rate
in middle age speakers born between 1970 and 1995

Table 18 shows the simulation of the (w)-deletion operation for the youngest speakers born after 1995 who have the deletion rule at phrase level only. Because the deletion process is not subject to any morphological considerations, the deletion rate for Class A and Class B is identical, 50% of the time.

	Class A: Underlying (w)			Class B: Derived (w)		
	[[[swip]$_{s}$ta]$_{w}$]$_{p}$'easy'			[[[s']$_{s}$wayo]$_{w}$]$_{p}$'shoot, fire'		
Stem	(w)-retained at S	swip	0	(w)-retained at S	s'wayo	0
Word	(w)-retained at W	swip	0	(w)-retained at W	s'wayo	0

Phrase	(w)-deleted at P	sip	1/2	(w)-deleted at P	s'ayo	1/2
	(w)-retained at P	swip	1/2	(w)-retained at P	s'wayo	1/2
Rate of Deletion	1/2			1/2		

Table 18. The Simulation of (w)-deletion rate in youngest speakers born after 1995

We have seen that the model I proposed successively derives three different patterns that match the direction of the actual data I obtained for each group. The Table 19 reiterates the three different patterns.

Age	Class A: Underlying	Class B: Derived	Expected results?
	$[[[swip]_s ta]_w]_p$ 'easy'	$[[[s']_s wayo]_w]_p$ 'shoot, fire'	
Youngest (15-20)	A=B		No
Middle (21-45)	A<B		No
Older (46+)	A>B		Yes

3.6 Discussion

We have seen that combining the formal architecture assuming the repeated application of the phonological rules at different strata and the variable rule framework provide more precise quantitative explanation about the operation of variable (w)-deletion rule on words of differing derivational histories. Also, I proposed that the different quantitative patterns found in the oldest, middle age and youngest age groups suggest a possible route of the retreat of a rule: a rule may recede from the narrowest morphosyntactic domain (i.e. the stem level) to wider morphosyntactic ones (i.e. the word and the phrase level).

If we are to picture the life cycle of the (w)-deletion rule based on the findings here following Bermudez-Otero (2005), the following is one possible scenario: the deletion of (w) might have originated due to some phonetic motivations. As Silva (1991) argued, the articulatory ease in deleting (w), when (w) is preceded by nondorsal segment, may have triggered the deletion in the beginning. Or, as Kang (1997) argued, perceptual difficulties in correctly recognizing (w) after a labial segment may have contributed to "the sound change by

listeners" (Ohala 1981). Whether the motivation was articulatory or perceptual, or both, this new phonetic implementation, at some point, should have been phonologized (Hyman 1976) as a variable deletion rule when the successive generation perceived this as a categorical deletion of (w) rather than a gradient reduction of (w) in some environment. Over time, the deletion rules became sensitive to morphosyntactic structure, advancing to the narrower domain of application. Later, the (w)-deletion rule strongly conditioned by the preceding segment was reanalyzed as a general deletion rule insensitive to any phonological conditioning. In this process, some external triggering event might have played a role: the increasing influence of the orthography. Also, the post-consonantal deletion rule itself may retreat from a narrower morphosyntactic domain to larger ones.

The loss of phonological rules from the smaller morphosyntactic domain to larger domains, however, may not be what we generally find in studies of the diachronic trajectories of sound change. It has been argued that when a rule is lost, it is generally lost from the larger morphosyntactic domain (i.e. the phrase level) to the narrower ones (i.e. the word and stem level). The life cycle of sound change (Bermudez-Otero 2007) predicts that young rules initially apply at the largest morphosyntactic domain (i.e. the phrase level) but may advance to the smaller domains (i.e. the word level and the stem level). Given the rule loss operates the same way, the loss of the (w)-deletion should also begin from the phrase level, and then advance to the narrower domains, the word and stem level.

Note, however, that the sound change in question here, the retrograde change of (w)-deletion, may take a different route from the complete loss of the rule. The (w)-deletion rule may retreat or slow down due to extragrammatical factors or the reanalysis of the rule as a more general deletion rule, losing the rule in the narrower domains, but it is very unlikely that the (w)-deletion rule will completely be lost. Although this hypothesis should further be verified with additional data from larger number of speakers, the quantitative patterns shown in this proposal may provide the evidence of a possible route of the rule retreat. The crucial role of morphological structure in constraining variable phonological rule application has not been addressed in any of the previous accounts of the (w)-deletion in Seoul Korean. By examining the effects of morphological structure in different age groups, I will be able to verify what role this morphological constraint has played on the diachronic change of (w)-deletion and perhaps predict what trajectory the (w)-deletion rule will take.

4 Articulatory insights into variations in (w)-deletion

In the third part of the proposed dissertation, I aim to address the relationship that exists between the sounds of speech and the vocal tract configurations that generate them. Recently, an increasing number of researchers have paid attention to the fact that variation or change in sound is largely covert and have argued to take account of sociolinguistic variation from the articulatory perspective (Davidson 2006, Mielke 2007, Scobbie et al. 2008, *inter alia*). In this study, I conduct an articulatory study using Ultrasound Tongue Imaging (UTI) to answer various

questions that will reveal a more nuanced picture of variation and change in (w)-deletion in Seoul Korean.

4. 1 Variable (w)-production in Seoul Korean

Let me begin with my own experience in impressionistic coding of (w). As a native speaker of Korean, I was confident at first that I would easily distinguish the deleted and retained tokens. Not surprisingly, however, a number of tokens sounded extremely ambiguous and some seemed to have only partial gestures. I had to listen to some tokens several times and most of those tokens were excluded from analysis. It was reassuring to have the second coder confirm that my coding was not substantially mistaken, but I still wondered if it would be legitimate to rule out the ambiguous tokens if I wished to draw as complete a picture of the nature of the variable (w)-deletion process in Seoul Korean as possible. Spurred by this thought, I laid out a project looking at the (w)-deletion process from a somewhat different angle from previous studies on (w)-deletion in Seoul Korean.

Previous studies, including my analysis in previous sections, have mainly employed auditory and acoustic methods in analyzing the variable (w)-deletion rule. For instance, tokens of (w) were classified as retained or deleted according to whether they contained an audible (w) or visible acoustic correlates in the spectrogram. Although auditory and acoustic analyses are very useful, they can only hint at what articulatory gestures are made in the vocal tract. In addition, the acoustic correlates of (w) were found to be extremely inconsistent and barely useful in the current study as briefly discussed in 2.1.2. In this light, a direct articulatory study is motivated.

4.2 Ultrasound Tongue Imaging (UTI) in studies of language variation and change

Since the 1970s, advances in technology have made ultrasound an increasingly useful tool for speech research (Gick 2002). A number of researchers have used ultrasound to measure tongue shapes and movements with increasing effectiveness since the 1980s (Sonies et al. 1981, Keller and Ostry 1983, Munhall and Ostry 1985, Stone 1990, Stone et al. 1988, 1992, Stone and Lundberg 1996). Ultrasound Tongue Imaging (UTI) is becoming increasingly popular since it is the only tool for safe, non-invasive imaging of the movement of the whole tongue, both in the field and the laboratory.

Compared to EMMA (electromagnetic midsagittal articulatography, in which pellets are placed on the tongue and their positions measured) in which the information about tongue shape and motion is observed only for the points where pellets are placed on the tongue, Ultrasound Tongue Imaging (UTI) shows the whole midsagittal or coronal contour of the tongue (Davidson 2006). Ultrasound Tongue Imaging (UTI) is adequate for real-time visualizations of tongue motion during the production of vowels and most consonants.

Scobbie et al. (2008) convincingly showed the value of using UTI for vernacular articulatory research by demonstrating that it can be exploited as a tool capable of eliciting relatively relaxed and vernacular speech. They attempted to show the potential psychosocial impact of ultrasound

recording by comparing how subjects behave differently than they would in the presence of a microphone for audio-only recording. They found the use of UTI imaging equipment, including a stabilizing headset, did not cause a large or consistent style shift in speech (two informants talking to each other in Scobbie et al.(2008) are seen in Figure 10). A comparison was made of socially salient variables (TH-fronting, T-glottalling, and L-vocalisation) and there was no clear pattern of variation between the control group (audio-recording only) and the group recorded under UTI conditions. Although there were individual variations, there was no overall average decrease in vernacular variables in UTI condition.

Figure 10. Two informants wearing a stabilizing headset for UTI during spontaneous discourse (from Scobbie et al. 2008).

In this regard, UTI may be particularly useful in our study of the Korean glide (w) not only because it is a safe and invaluable tool in measuring elusive tongue movement but because it also enables us to see the dynamic image of the tongue from root to tip while speakers are involved in spontaneous conversation. I will now present the questions I will particularly focus on about the glide (w) in Korean and what the answers to these questions may reveal about variation in (w)-deletion process in Seoul Korean.

4. 3 Research Questions

4. 3. 1 Question 1: What is (w)-deletion in Korean?

Before delving into various interesting questions about variation and change of the (w)-deletion process, we need to define what (w)-deletion in Seoul Korean means in an articulatory perspective. The articulatory properties of glides have received little attention while vowels and consonants (especially liquids) have been relatively well studied (Gick 2003, Sproat and Fujimura 1993, *inter alia*). Even though lip protrusion as well as dorsum raising and backing have generally been considered the major articulatory features of (w), this has not been without controversy. Anderson (1976) reports cross-linguistic evidence that, in some languages, the 'primary' articulation of labiovelars, including (w), is labial, while in other languages it is velar. Lisker (1995) shows that the primary articulation of (w) in American English is the lip gesture.

A question remains, therefore, as to what articulatory gestures the Korean labiovelar glide (w) involves.

Halle et al. (2000) and Halle (2005) claim that the crucial distinction between vowel and glide is one of Place of Articulation (PoA). That is, the designated articulator of all vowels is [Dorsal] therefore there should be no dorsal glide. Nevins and Chitoran (2008) argue against this claim, saying that glides have two Designated Articulator (DA) features and (w) is both [Dorsal] and [Labial]. This poses a challenge for the feature geometry model in which glides have only one designated articulator. Nevins and Chitoran (ibid.) further argue that glides are mentally represented as neither vowels nor consonants and glides are distinguished from vowels in having their own constriction degree. Thus, they argue for reintroduction of a major class feature [+/-vocalic] in addition to [+/- consonantal].[16] Their prediction about featural specification of the glide and vowel, according to these theories, are summarized as below:

- One Designated Articulator hypothesis
  w: [Labial][-vocalic]
  u: [Dorsal, Labial][+vocalic]

- Two Designated Articulator hypothesis
  w:[Dorsal, Labial][-vocalic]
  u: [Dorsal, Labial][+vocalic]

By answering this question, I aim to resolve the indeterminacy between these two hypotheses by measuring the degree of lip-aperture/protrusion and tongue dorsum backing in the production of the Korean labiovelar glide (w) occurring in various phonological environments.

4. 3. 2 Question 2: Testing the articulatory account of (w)-deletion

Silva (1991) regards (w)-deletion as a process that simplifies articulation of the CwV sequence by reducing the number of gestures performed by the body of the tongue. He predicts that when the nondorsal (labial and coronal) segment precedes (w), speakers are more likely to delete (w) in the CwV sequence because the tongue body needs to retract and re-front. The deletion of (w) in this case has advantages in articulatory economy. By contrast, when the back (velar) segment precedes (w), he predicts that speakers are less likely to delete (w) because the tongue needs to be retracted for the preceding [+back] segment and then fronted for the following vowel anyway, thus there is no advantage to deleting the glide.

With this question, I seek to find out if any evidence of deletion based on such articulatory advantages is found. More specifically, it will be examined whether two age groups, the speakers age 45 and older and the speakers age 45 and under, show different articulatory patterns in (w)-deletion. The expectation is that older generations will show deletion sensitive

[16] Nevins and Chitoran (2008) provide the following definitions of [+consonantal] and [+vocalic]:
[+consonantal]: Presence of an occlusion of the free passage of air in the supralaryngeal vocal tract
[+vocalic]: Absence of a narrow constriction among the articulators

to preceding segment while younger speakers will not show such an articulatory pattern since their deletion rule is not sensitive to the phonetic properties of the preceding segment. If we obtain such evidence, it will corroborate my proposal that the (w)-deletion rule has been reanalyzed as a general deletion rule.

4. 3. 3 Question 3: Gradient vs. categorical deletion of (w)

My last question concerns gradiency. What contributes to 'ambiguous' or 'partial' variants of (w)? If it is a covert gesture, what influences the degree of covertness? One might also ask, when there is no audible (w), is it truly deleted, or is it produced but not heard because it is obscured by the adjacent consonants? If there is much articulatory undershoot, what phonological and morphological environments favor such partial gestures?

UTI will be able to show whether (w)-deletion in Seoul Korean is categorical or gradient. The prediction is that older generations might show more gradient deletion of (w) due to the phonetic pressure exerted by the preceding segment while the younger generation will show more categorical deletion insensitive to any phonetic force. The distinction between categorical and gradient rules, however, cannot be reliably drawn on the basis of impressionistic data and will greatly benefit from the articulatory data.

4.4 Methodology

To address the questions above, I will conduct an experiment using ultrasound technology. In the experiment, midsagittal images will be recorded from a portable ultrasound machine using a transducer. The video frame will be at least 30 frames/sec.[17] In UTI, it is essential to make sure that neither the transducer nor the speakers' heads move or shake during the experiment. The participants will be seated in a chair and wear a headset made from lightweight aluminum in order to hold the probe in a fixed position under the chin (See Figure 11). This ensures that there will be little lateral movement of the probe and no probe rotation. It will also allow the participants to move freely while they talk. Once the subjects are seated in the chair, a microphone will be attached to the chair. Also, a closed-circuit TV camera will be used to capture side-view video of the participant's face to videotape the lip rounding/protrusion. An audio signal from a microphone and the incoming video signal from the ultrasound machine will be synchronized and captured directly to a Mac.

[17] The frame rate of 30 frames/sec has shown itself to be adequate for capturing most articulatory movements (Gick 2002).

Figure 11. Headset to hold probe steady and allow natural head movement during speech. (from Scobbie et al. 2008)

Tokens of (w) will be elicited from four speakers, all of whom are native speakers of Seoul Korean. Two are younger speakers born after 1970 while the other two are speakers born before 1970. First, the speakers will participate in sociolinguistic interviews for about half an hour. Second, they will participate in a reading task. Recordings will be made inside a sound-proof booth using clip-on microphones and a digital sound recorder. Participants will be encouraged to drink juice while they speak because swallowing liquid is a good means of obtaining a palate trace on the UTI image (Gick 2002).

A list of words put in the carrier sentence *iken taneo* _____ *imnita* 'This is _____ word' will be used. Items consist of 1) monosyllabic words, 2) nonce words with (w) in non-initial position, 3) minimal pairs and 4) existing Korean words with (w) in various prosodic positions. In all these words, (w) is preceded by a labial (p, p', p^h), alveolar (t, t', t^h) or dorsal (k, k', k^h) segment and followed by four different vowels that co-occur with (w) in Korean. These words were chosen to yield tokens of (w) produced in a number of contexts. Twelve additional filler words will also be presented in this carrier phrase. The order of sentences will be randomized. Stimuli items are listed in the appendix.

5 Implications and directions for future work

While the preliminary results in this proposal look promising, they call for further efforts to verify their significance and generality. The following points to the implications the three different studies proposed here have and the directions for future investigation.

The first part of the proposed dissertation shows the longitudinal trajectory of (w)-deletion in Seoul Korean using the real time construct. I propose that (w)-deletion rule has been reanalyzed as a general deletion rule at around 1970 and I attribute this to the different environment where older and younger generations have learned the language due to dramatic social change in the speech community. This shows how the phonological structure is molded by external forces and how incrementation can be largely externally motivated. It also shows an interesting case of the actuation of the reversal of sound change rooted in grand social change. To reinforce my proposal, however, more extensive data from speakers from a wide range of social classes and ages should be added to make a more robust comparison with Kang's (1997) findings. The current corpus includes only a few speakers from each age group.

The second part of the proposed dissertation attempts to give a more precise explanation – in the form of a quantitative theoretical prediction – on the (w)-deletion rule in Seoul Korean. We have seen that classifying words based on their derivational histories rather than the presence of morpheme boundaries lends more explanatory power. Also, it proposes a new explanation of the diachronic evolution of phonological processes. To validate the model as well as to confirm that individual speakers are conforming to the model, it is essential to get enough data from a number of speakers as well as each individual.

The third part of the proposed dissertation demonstrates a new avenue of sociolinguistic research in studying variation and change in languages. In order to present a more complete picture of variability found in phonological processes, the investigation of how speakers physically articulate speech may reveal what we have been missing in looking at variation and change. Also, articulatory data have great potential to answer the questions that we are not able to definitively answer with acoustic and auditory studies in the first and second part of the proposed dissertation. Careful design and implementation of the experiment will address these questions. Furthermore, the first question I proposed has profound implications for the nature of phonological representations and the architecture of phonological grammar.

I believe our understanding of phonological variation and change will be enhanced as a result of this work and it is my hope that this work provides new insight to understanding the (w)-deletion rule in Seoul Korean.

6 Timeline

The following is my projected timeline for completion of the dissertation. Since I am not very sure if I need to take a leave after giving birth to a baby this November, for now I am being a bit ambitious and planning to finish by next year as I originally planned. I will focus on collecting enough data before my belly gets too big and then spend most of my time coding and analyzing data before the delivery. I will come back for the UTI experiment next February and write up the UTI part after discussing the results fully with Jianjing. In the meantime, I will meet with my advisor and committee members to discuss the final results I'll have obtained by this fall and then finish the write-up of the discussion part. After all the other parts get in shape, I will

write up the introduction and the conclusion of the dissertation and then prepare to defend my dissertation in May 2015.

June-August 2014

- Seek extra interviews with at least 15 speakers
- Code for the existing 11 interviews
- Write up the methodology section

August-October 2014

- Code for the additional 15 interviews
- Analyze all the interviews
- Write up the result section of Part I and II

November-December 2014

- Give a birth to a baby ☺ and recover

January 2015

- Write up the discussion section of Part I and II

February-Mar 2015

- Conduct the UTI experiments
- Write up the Part III

April 2015

- Write up the introduction and conclusion

May 2015

- Put together defense
- Defend (early May)
- Revise as recommended
- Submit (mid May)

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Appendix A – List of sentences

1. 예컨대, 왜구가 대나무로 공격한 것을 의미해.
2. 시간 외 근무수당이 늦게 지급되어 진희를 애태웠었어.
3. 외숙모댁에 데릴사위가 와 있더라구.
4. 그는 해괴망측한 점괘로 속임수를 쓰고 있었어.
5. 아무리 더 의뢰해보아도 더 이상의 에누리는 없대.
6. 땔감과 부스러기를 바구니에 넣었어.
7. 게딱지를 집게로 들어봐.
8. 카메라와 렌즈를 네모진 가방안에 넣어 놔.
9. 모레 재환이와 태권도 시합이 예정되어 있대.
10. 계속 꾀병을 부리면 팀에서 제외될 위기에 처한 거지.
11. 빨간펜으로 내천 위치와 배의 궤적을 표시해봐.
12. 일례로, 파리채를 가위로 잘라버린 사건이 있지.
13. 의사선생님과 약속이 있대.
14. 진화와 석원이는 동의서를 받았어.
15. 주희는 의상학과에 원서를 넣었대
16. 수연이는 부모님과 상의하지 않았대.
17. 나는 민진이의 가방을 보지 못했어.
18. 주연이는 시냇가에 앉아있는 까치를 보았대.

19. 보원이는 사과를 들고 있었어.
20. 형의 소원은 그곳에 가보는 것이다
21. 새로 산 바지를 입고 바다에 갔어요.
22. 파란 이 잎과 예쁜 꽃이 어울려요.
23. 아버지와 형을 학교 입구에서 봤어요.
24. 집에 가고 싶고 피곤했어요.
25. 사과가 잘 익고 있어요.
26. 어제 이익과 손실을 계산해 봤어요.
27. 밥과 국이 식고 있어요.
28. 진원이 회사는 한화 그룹의 자회사니까.
29. 삼월에는 뭔가를 해 보겠어.
30. 그의 계산은 아주 정확했다.
31. 참외를 먹고 아버님을 뵙다가 야단 맞았다.
32. 관둬라. 그냥 둬
33. 지원이는 의예과에 다니고 있어.
34. 그 마을은 이제 폐허가 됐다
35. 폐기가 된 것들은 여기다 버려
36. 뒷산에 귀신이 나타났다는 소문이 퍼졌다.
37. 튀는 공을 꼭 잡기는 힘들다.
38. 그 죄수는 족쇄를 찬 기분으로 쉬어도 쉰 것 같지 않았다.
39. 내 실수를 넓은 마음과 이해로 예쁘게 봐 줘.
40. 석좌교수님은 좌석에서 일어났다.
41. 위험하게 추월하려 하지마
42. 그 해에 도량형 통일과 화폐개혁이 있었다.
43. 그는 죄인의 수의를 입고 있었다.
44. 저 기와집을 계단에서 촬영해 보자.
45. 간통죄는 존폐 위기에 몰려 있어.
46. 좌석버스에서 사과를 먹었다.
47. 기왕 관광왔는데 영화를 볼 수는 없지.
48. 의심하지 말고 믿어줘.
49. 자연분만과 재왕절개 사이에서 고민중이야.
50. 거지도 요즘은 십원은 안 받아.
51. 잘 모르는 사람에게 결례를 하면 안 돼
52. 청와대 경호실의 호위를 받을 때 그는 굉장한 성취감을 느꼈다.

53. 그 동사의 변형규칙과 용례를 잘 공부해 봐
54. 그것 봐, 내가 뭐랬어.
55. 그는 죽는 그 순간에도 괜찮다고 이야기했다.
56. 재권이가 화분과 편지를 보내오다니 이거 웬일이야.
57. 위문가는 것은 항상 유쾌한 일은 아니야.
58. 문화부장관은 자원봉사자와 군인을 대거 동원했다.
59. 이 곳이 옛날 혜화문 자리야.
60. 음악회에서 기획부 차관과 사모님을 뵈었다.

Appendix B – Stimuli for the UTI experiment

Preceding segment & Following vowel	Labial	Alveolar	Dorsal (velar)
/i/	pwi p'wi p^hwi	twi t'wi' t^hwi	kwi k'wi' k^hwi
/e/	pwe p'we p^hwe	twe t'we t^hwe	kwe k'we k^hwe
/a/	pwa p'wa p^hwa	twa t'wa t^hwa	kwa k'wa k^hwa
/ə/	pwə p'wə p^hwə	twə t'wə t^hwə	kwə k'wə k^hwə
Nonce words with /w/ in non-	ka.ta.pwi.ta ka.ta.p^hwe.ta ka.ta.p'wa.ta ka.ta.p'wə.ta	ka.pa.twi.pa k a.pa.t^hwe.pa ka.pa.t'wa.pa ka.pa.t'wə.pa	pa.ta.kwi.ta pa.ta.kwe.ta pa.ta.kwa.ta pa.ta.kwə.ta

initial position			
Minimal pairs	i) **pwe**.eoss.neun.te 'greet (honorific)' **pe**.eoss.neun.te 'be cut' ii) seon.**pwe**.ta 'display' seon.**pe**.ta 'is a senior'	i) **twe**.ge 'very' **te**.ge 'usually' ii) **twe**ss. ta 'became' **te**ss.ta 'put, approach'	i) **kwi.**in 'important person' **ki.**in 'eccentric person' ii) **kwa**.chang 'exaggeration' **ka.**chang 'the most'
Real words with /w/ in various prosodic position	▪ te.**pwi** 'debut' ▪ **pwi**.p^{h}e 'buffet' ▪ keu. keos. **pwa** 'look at that' ▪ **pwa**t.seum.ni.ta 'saw' ▪ ceo.eum. **pwe**ss. eul.t'ae 'when first met'	▪ **twi**t.san 'the mountain in the back' ▪ hak.kyo.**twi** 'the back of the school' ▪ **twə**t. ta 'put' ▪ jal.**twə**n. il. i.ta 'it is good'	▪ **kwi**.yeop. ta 'cute' ▪ sa.**kwi**.ta 'date with' ▪ **kwi**.han.a.teul 'a precious son' ▪ hak.**kwa** 'department' ▪ **kwə**n.wi 'authority' ▪ cham.jeong.**kwə**n 'suffrage' ▪ kwe.han 'suspicious man'