Differences in the Duration of Constriction between Korean and English Glides

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The goal of this study is to investigate the duration of the labio-velar [w] and palatal [j] constriction of glides in English and Korean and attempt to provide an explanation for Koreans' difficulties in learning English glides reported in the literature. Production data from the two languages containing glide-initial words were collected for analysis. The results show that glides in English consistently exhibit a persistent constriction that is markedly prolonged compared to Korean glides that display only a brief constriction. It is suggested that differences in duration of constriction may also explain other linguistic phenomena.

Keywords: glides, constriction, duration, Korean, English

1. Introduction

Studies have shown that native speakers of Korean learning English as second language have difficulties in producing glides in English (T-Y Jang & Y-J Cho 2005; M-H Cho et al. 2001; Jy Lee 2004; Ms Seo et al. 2009). What is common in these studies is that the difficulties are found not in all environments but in some particular ones. For example, Jy Lee (2004) reports that the learners tend to delete labiovelar glide [w] when the following vowel is non-back and when it is not syllable-initial; e.g., [kin] for *queen*, [læŋgidʒ] for *language*, [skiz] for *squeeze*. M-H Cho et al. (2001) found that the [w] in CwV environment is often pronounced as a version of [j] when the vowel is [+back]; e.g., *quarrelling*, *quote*. One important observation that M-H Cho et al. (2001) made was that the learners do not complete "lip-rounding" in making English [w]. Also, T-Y Jang & Y-J Cho (2005) report difficulties in pronouncing a syllable-initial glide followed by a homorganic vowel: [ji] or [wu]. These studies also argue that the difficulties are

caused by the learners' native language (L1) glides [j, w] that have different characteristics from those of English glides. These difficulties in the acquisition of English glides suggest that there are some systematic differences between the glides in English and Korean. The goal of this study is to investigate the durational cue of glides in order to provide an explanation of why such L1 interference occurs in learning English glides. The results of this study do not support Stevens' (2000) hypothesis that there are two different glide types on the phonetic level, but they show that glides in English are, in fact, systematically different from the Korean ones based on the duration of what Espy-Wilson (1992) calls the *voiced steady state*.

2. Glides Cues

Stevens (2000) reports some important cues of glides in English and compare their values with those of vowels. He notes that the narrow vocal track constriction, palatal for [j] and labial for [w], causes reduction of formant amplitudes, and either increase or decrease of formant frequencies. He found that the average reduction of amplitude of the first formant (F1) of glides was 8.3 dB. In addition, the average F1 ranges from 250 to 300 Hz; on the other hand, the average F1 of high vowels ranges from 270 to 370 Hz. As for F2 and higher formants, the palatal constriction of [j] results in higher F2 (2,200~2,800 Hz) *or* higher F3 (2,800~3,300 Hz) than those of [i], and the tongue body retraction and narrow labial opening of [w] contribute to low F2 ranging from 750 to 840 Hz (Stevens 2000; Espy-Wilson 1992).

Nevertheless, it is true that the above information does not sufficiently characterize glides apart from high vowels. As pointed out by Ladefoged (2006), glides share with high vowels the quality of vocoids, whose production involves no central obstruction in the oral cavity. To Ladefoged (2006), glides [w, j] are "movements" away from a version of their homorganic vowels [u, i]. Also, other studies generally agree with the formant values in Stevens (2000) and Espy-Wilson (1992), but they have also shown that these values are subject to individual and regional variations (Bg Yang 1996; 2009a, b). Finally, these frequency values of English glides and high vowels appear to largely overlap with those of Korean glides (M-R Cho & Lotto 2004) and

high vowels (Han 1963; Bg Yang 1996; Igeta & Arai 2011).

However, Stevens (2000) found that native speakers of English have an additional strategy contrasting a glide with the following high vowel; glides before a high vowel are produced with yet tighter constriction, which further influences the amplitude and formants. For glides before a high vowel, the average reduction of F1 amplitude was 10.7 dB, but for glides before a non-high vowel, it was 6 dB. Also, the average F1 of glides before a high vowel was 250 Hz which contrasts with 292 Hz for glides before a non-high vowel. Therefore, although glides preceding non-high vowels may resemble high vowels, they employ further constriction when followed by a high vowel. Stevens (2000) hypothesizes that this is a cue enhancement mechanism maximizing the contrast between the glide and the vowel, and this is unnecessary and not found in glides preceding a non-high vowel.

Based on Stevens (2000) therefore, there are two glide types on the level of phonetics: ones with enhanced cues and ones with normal cues, and the enhancing shift of glide cues is dependent on the phonetic context in which the glide occurs, e.g., homorganic glide-vowel (GV). Such a shift of cues may not at all be part of Korean since there is no such trigger context in the language: *[ji], *[wu]. Among those acquisition studies that have reported difficulties in learning English glides by Korean learners, T-Y Jang & Y-J Cho's (2005) findings receive an explanation on phonetic grounds. That is, the cue enhancement in English ensures the contrast between the glide and its homorganic high-vowel environment, but in the identical environments in T-Y Jang & Y-J Cho's (2005) study, Korean learners fail to do so.

The focus of the current study is on the duration of the voiced steady state (Espy-Wilson 1992:736). Espy-Wilson mentions rather briefly that this steady state is one of the characteristics of glides caused by the slow change of oral constriction. In her example of *you* [ju], she reports that the duration of the constant voicing state that takes place at the initial production of [j] is 130 ms out of 400 ms, the duration of the whole syllable. In the current study, three native English and three native Korean speakers participated as production informants. From their production, the durations of the steady states of initial glides as well as the duration of the movement state from the glide toward the following vowel will be measured. The following section discusses the procedure of data collection.

3. Data Collection

3.1. Materials

Two sets of stimuli, English and Korean are shown in (1) below. Each set repeats the initial-onset glide multiple times before various vowels. The last four lines in both sets compare initial glides and initial vowels; for example, *yes* [jɛ] and *essay* [ɛ] in lines 6 and 7.

(1) The stimuli

a. English

1.	wonder	yard	don't	Yiddish	easy
2.	kind	weep	guy	wound	watch
3.	winner	buyer	won't	yeast	cute
4.	year	wood	think	pipe	yellow
5.	yippee	Yale	whoopee	yield	wasps
6.	yes	yummy	youth	yoke	yard
7.	essay	umpire	oozy	oak	art
8.	windy	weep	Wendy	wonder	what
9.	index	ease	ending	under	arson

b. Korean

1.	jətʃ^{a}	wɛt^{h}u	jasu	wanduk^{h}ong	jəmsot'ɛ
	woman	*coat*	*beast*	*pea*	*goat herd*
2.	jutʃ^{h}i	jori	wənso	witʃaŋ	
	childish	*cooking*	*atom*	*stomach*	
3.	ɛdisɨn	əməni	usan	omitʃa	akut^{h}aŋ
	Edison	*mother*	*umbrella*	*schizandra*	*monkfish soup*
4.	jɛsul	jətʃa	juto	jori	jaku
	art	*woman*	*judo*	*cooking*	*baseball*
5.	imitʃi	ɛtʃɨŋ	ənə	ariraŋ	
	image	*love and hate*	*language*	*Arirang* (a traditional song)	
6.	wiro	wɛkuk	wənp'ul	watʃən	
	condole	*foreign country*	*cone*	*misrepresent*	

3.2. Participants and Procedures

Three native speakers of English and three native Korean speakers participated in this study. All three native English speakers were graduate students at the University of Iowa and native to the upper Midwestern United States. Two of the Korean participants were born and grew up in Seoul and the other one (JMN) in Pusan Korea. They had received five to six years of English instruction in Korea but their oral proficiency and accuracy were low.[1] At the time of recording, they were newly admitted students at the university who were in the university ESL (English as a Second Language) program.

The recording was made in an anechoic speech recording facility located at the University of Iowa linguistics department. Each participant was given a written word-list, and s/he read off the list twice in the anechoic room. A natural reading rate as well as a pause after every word was instructed. The reading speed was found to be approximately 40 words per minute. For recording, the *Audacity*[2] program was used, and the analysis tool was *Praat* software.[3]

4. Results

The findings from the English data are consistent with the report of Espy-Wilson (1992) and the Korean data support the results of T-Y Jang & Y-J Cho (2005) and M-H Cho et al. (2001). Compared to English glides, Korean glides are significantly shorter, and frequently involve a very short and brief lip-rounding. Particularly, the characteristic short constant voicing state (*constriction* henceforth) that is found to be specific to Korean glides could potentially limit the acquisition of English glide in the way observed in T-Y Jang & Y-J Cho (2005) and M-H Cho et al., (2001). The following subsections present the findings.

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1) Their heavy accents as well as the results of this study show that their Korean pronunciation had not been affected by their English.

2) http://audacity.sourceforge.net

3) Paul Boersma and David Weenink. http://www.fon.hum.uva.nl/praat/

4.1. State of Constriction and Movement in English

First, consider the following waveforms and spectrograms in Figure 1 for English words *youth* and *weep* in (a) and (b), and the zoom-in version of youth in (c).

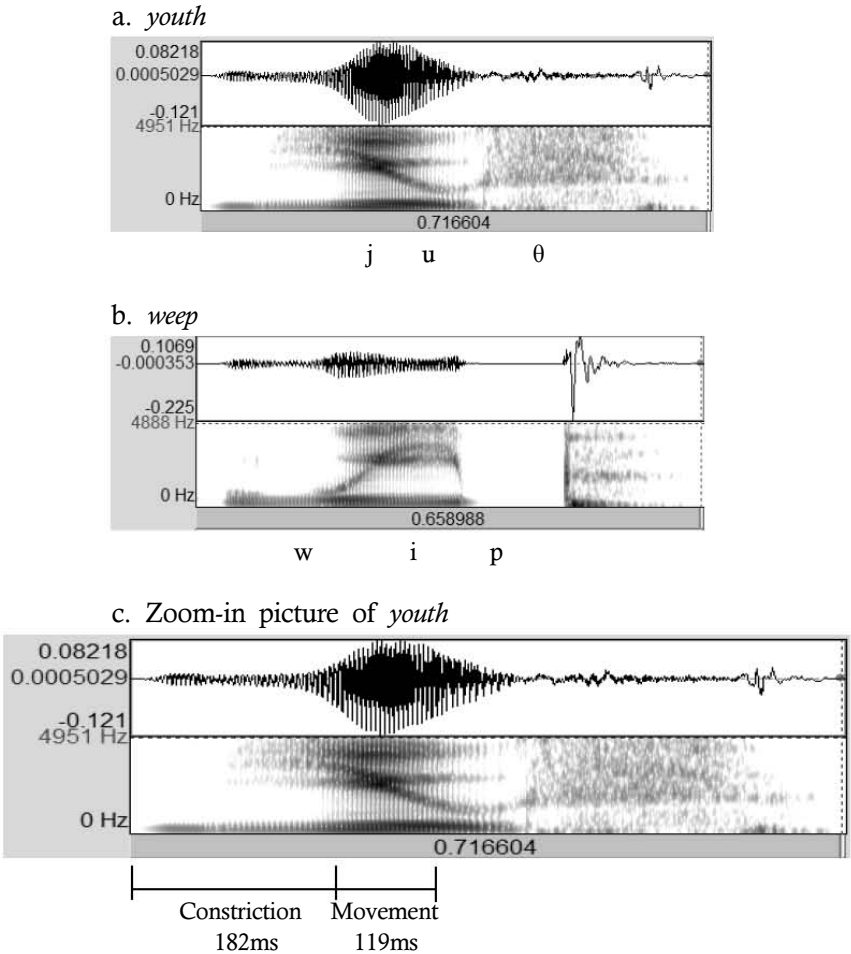


Figure 1. English initial [w, j] samples from speaker JF.

A period of constriction begins the glides, which is followed by the smooth movement toward the vowel. Constriction in English data is shown consistently as a long emission of low-amplitude periodic en-

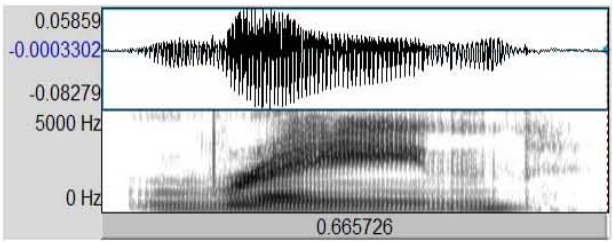
ergy, and the movement typically appears as formant transition from the release of the constriction toward the following vowel. Certainly, the segmentation is often a great challenge particularly in the region where the glides merges into the following vowel. It should be noted that movement (the transition) may be interpreted as a region shared by the glide and the vowel. The two gestures in the waveform and the spectrogram are summarized as the following table.

Table 1. Articulatory Features of Glide and Their Appearances

	Waveform	Spectrogram
Constriction	Low Amplitude	Lighter prints
Movement	Increasing Amplitude	Increasing Darkness Formant Transition

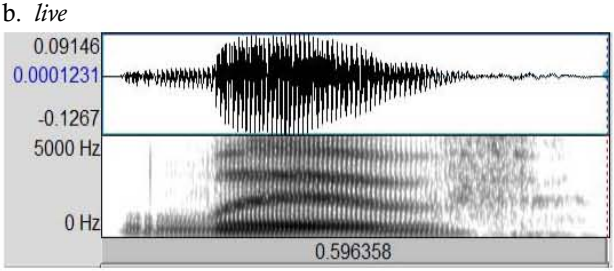
Constriction shows a particularly strong definition in English. In fact, this prolonged emission of low energy, accompanied by the periodicity of the voicing, is not unfamiliar. In fact, the low energy relative to the neighboring vowels during the constriction of glide resembles the syllable-initial liquids and voiced fricatives produced by the same speaker shown in the recordings of [r, l, v, ð] in Figure 2 below.

a. *rain*



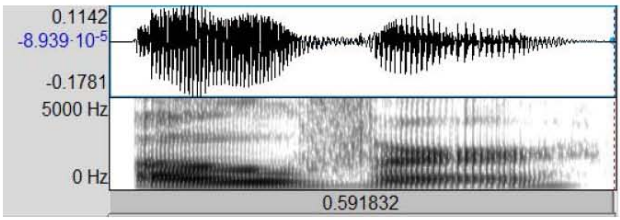
r eɪ n

b. *live*



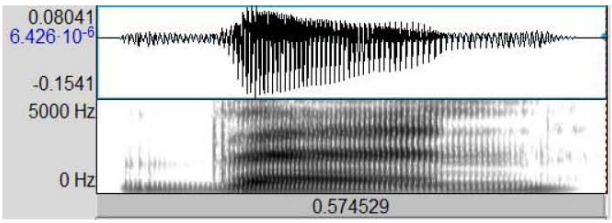
l ɪ v

c. *over*



ʔ oʊ v ə r

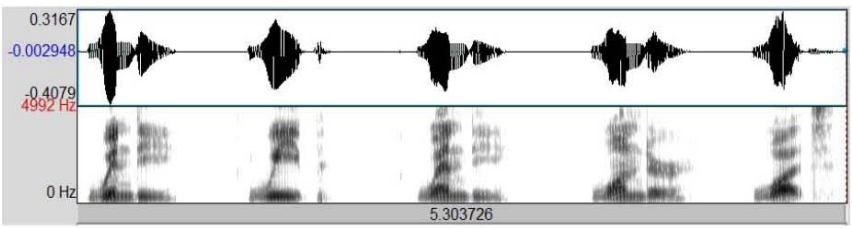
d. *then*



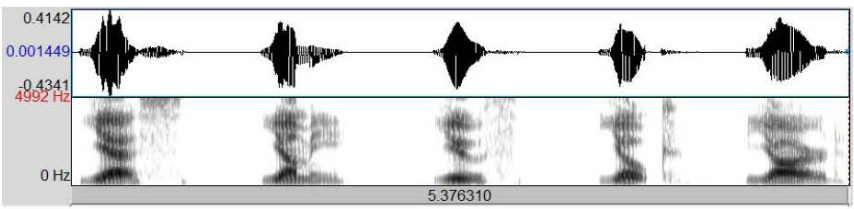
ð ɛ n

Figure 2. English liquids [r, l] and voiced fricatives [v, ð].

This initial constriction is observed in almost all English glide samples recorded in this study. In Figure 3 below, without zooming in, the initial low-amplitude section in the waveform and the spectrogram at the beginning of each word is remarkable.



DC W-12 *windy* *weep* *Wendy* *wonder* *what*



DC W-11 *yes* *yummy* *youth* *yoke* *yard*

Figure 3. Spectrograms glide-initial words by speaker DC.

The duration of the initial glide was substantial. As indicated in Figure 1-c, the constriction of the glide ends where the formants start moving, which is marked as the initiation of the movement. This is also the point where the amplitude increase starts. The endpoint of the movement, to repeat, is where the formant movement gentles to settle for the following vowel. Tables 2 and 3 show the mean durations of constriction and movement of English glides produced by the three native speakers of English.

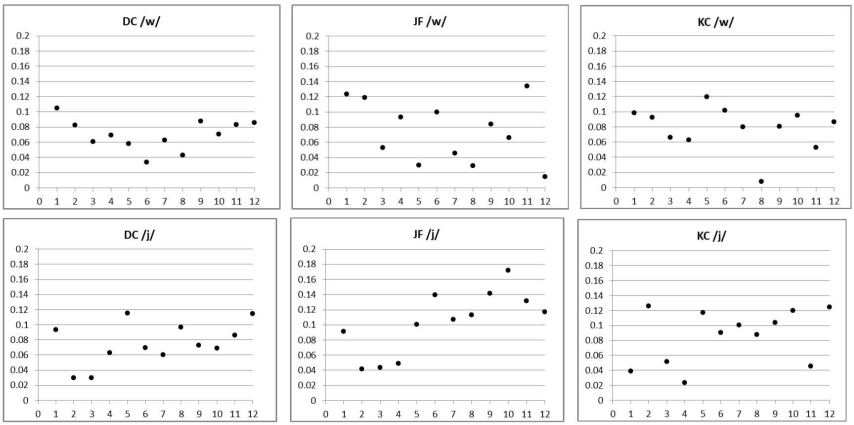
Table 2. Mean Durations of *Constriction* of English [w, j] (ms)

Participant (n=3)	DC		JF		KC	
Segment	[w]	[j]	[w]	[j]	[w]	[j]
Mean Duration	**70**	**74**	**74**	**104**	**79**	**86**
SD	20	28	40	42	29	37

Table 3. Mean Durations of *Movement* of English [w, j] (ms)

Participant (n=3)	DC		JF		KC	
Segment	[w]	[j]	[w]	[j]	[w]	[j]
Mean Duration	**61**	**70**	**64**	**63**	**79**	**75**
SD	14	15	16	30	23	26

The duration of constriction shows greater variation than movement given the larger standard deviations. Different individuals and different following vowels contribute the variation of the duration. Figure 4 below shows the measured values of constriction duration of each occurrence of glide [w] and [j] by the three English native speakers.



Note: The vertical axis represents duration in seconds, and the horizontal axis the glide-initial words in the stimuli:
/w/-initial words: 1. *weep* 2. *wound* 3. *watch* 4. *winner* 5. *won't* 6. *wood* 7. *wasps* 8. *whoopee* 9. *windy* 10. *Wendy* 11. *wonder* 12. *what*
/j/-initial words: 1. *yeast* 2. *year* 3. *yellow* 4. *yippee* 5. *Yiddish* 6. *yield* 7. *Yale* 8. *yes* 9. *yummy* 10. *youth* 11. *yoke* 12. *yard.*

Figure 4. Duration of constriction of individual words by native speakers of English.

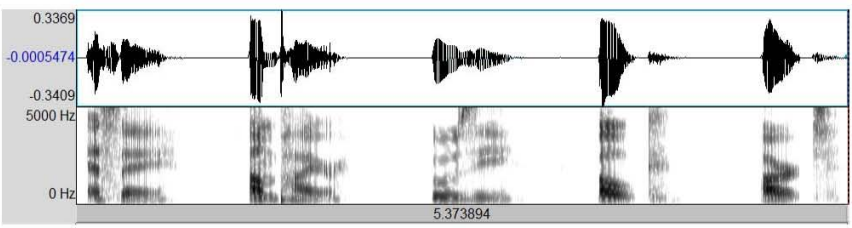
Some of the words, such as *whoopee* and *yippee*, tend to have shorter constriction. This may be because of the exclamatory nature of these words. The speakers pronounced the second syllable considerably longer than the first as if the stress is on the second syllable. For example, first syllable of *whoo-pee* produced by speaker JF was 150 ms while the second syllable was 435 ms long. The same speaker's first and second syllables of *yi-ppee* were 143 and 464 ms, respectively.

Finally, one may expect a pattern that matches the findings in Stevens (2000). For example, the enhancement of the glide cues before a high vowel may entail longer duration of the glide constriction before a high vowel. But no particular correlation has been found between duration and the degree of constriction. For example, the labial constriction of *watch* is consistently shorter than the ones in *weep* and *wound*, but at the same time, the palatal constriction in *yard* averages approximately 120 ms which exceeds the ones in most of the tokens of *yeast* and *year* where the palatal glide is followed by a high vowel. Before turning to the Korean data, the following section compares English initial glides to initial vowels.

4.2. English Initial Glides and Vowels

Glottal stop [ʔ] insertion in English is highly active before initial vowels, and virtually all vowel-initial words begin with the sharp onset of the glottis. This glottal onset of the vowel appears as an abrupt initiation of high-amplitude energy in the spectrogram and waveform. In every word in Figure 5, the articulation of abrupt glottal onset is clear without zooming-in. On the other hand, the initial glides in Figure 3 above begin with a smooth low-amplitude energy which increases gradually. In fact, comparing initial vowels and glides turns out to be comparing between the abrupt onset associated with the vowel and the smooth constriction of the glide.

a. Initial vowels

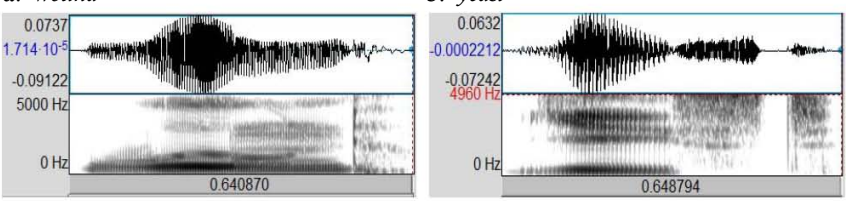


DC W-13 *essay* *umpire* *oozy* *oak* *art*

Figure 5. English vowel-initial words spoken by DC.

Given the definition of glides in Ladefoged (2006) that [w, j] are short movements away from short versions of [u, i] respectively, comparison of [w, j] and their corresponding high vowels [u, i] is in order. Figures (6-a) and (b) show *wound* and *yeast* and Figures (6-c) and (d) show corresponding vowel-initial words. As it will be discussed in the next section, this sharp contrast between initial glides and initial high vowels in English is not seen in Korean.

a. *wound* b. *yeast*



w u n d j i s t

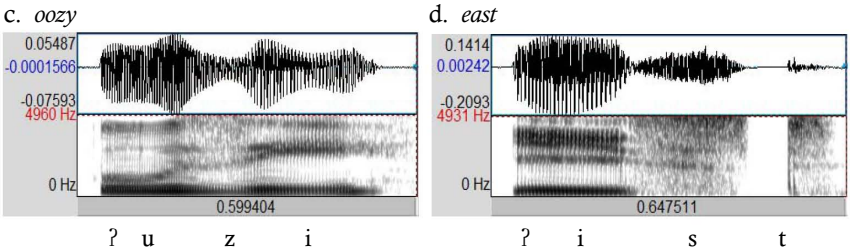
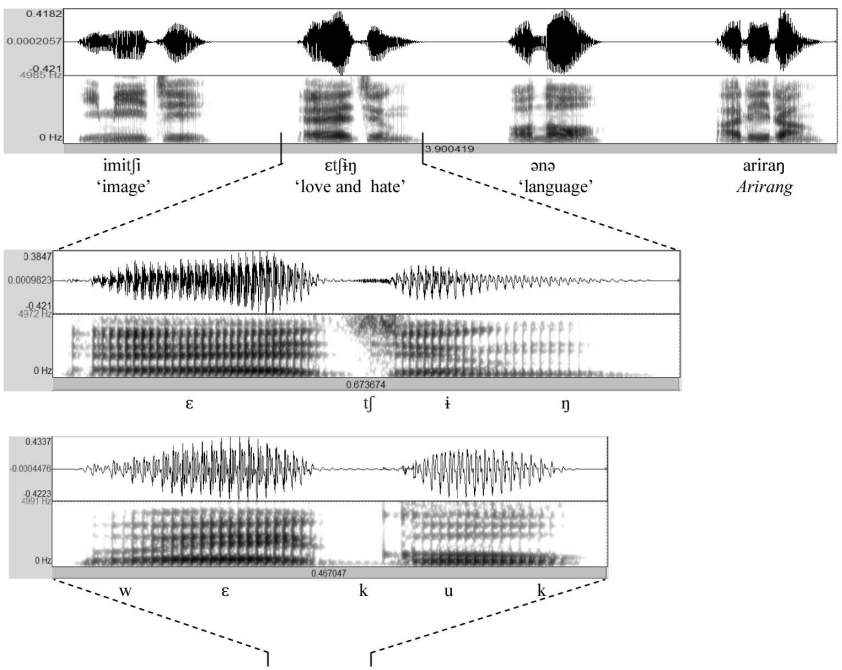


Figure 6. /w, j/ versus /u, i/.

4.3. Glide Gestures in Korean

In order to demonstrate the differences of Korean glides from English ones, it is important to first consider how the initial glides and vowels in Korean are manifested. Consider the pictures in Figure 7 below. The two pictures in the middle are zoomed-in versions of [ɛtʃɨŋ] "love and hate" and [wɛkuk] "foreign country", a vowel-initial and a [w]-initial word respectively.

(CHJH W12, CHJH W13)



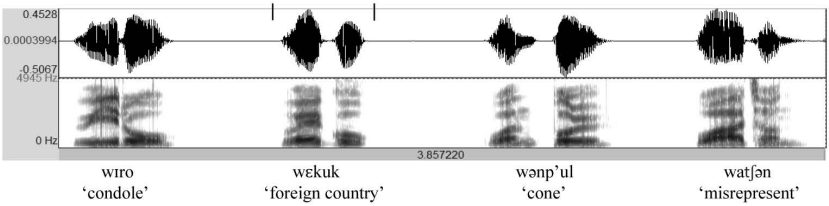


Figure 7. Korean vowel-initial and glide-initial words.

Two things are remarkable in the above figures, and this is because of the combination of the following two elements:

(2) a. absence or a very weak [ʔ] in the production of initial vowels
b. absence or a very brief constriction in the production of the glide

These patterns in (2) are found quite consistent in the data. The vast majority of Korean vowels are produced with very week initial glottal burst, and most of the glides in the data are produced with a very brief constriction. However, as the formant movements can be seen in the spectrograms above, movement gesture in each glide appears clearly. Although it was a very challenging task, the durations of constriction of Korean glides are measured, and the values are presented below in Tables 4 and 5.

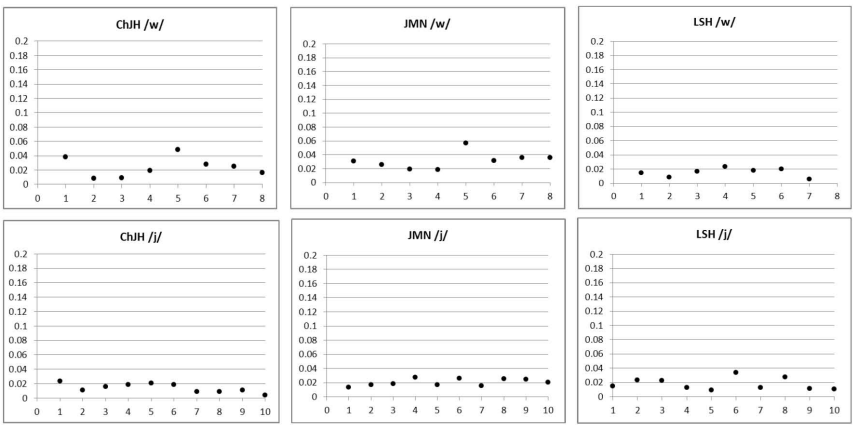
Table 4. Mean Durations of *Constriction* of Korean [w, j] (ms)

Participant (n=3)	DC		JF		KC	
Segment	/w/	/j/	/w/	/j/	/w/	/j/
Mean Duration	**24**	**14**	**32**	**21**	**15**	**18**
SD	14	6	12	5	6	8

Table 5. Mean Durations of *Movement* of Korean [w, j] (ms)

Participant (n=3)	DC		JF		KC	
Segment	/w/	/j/	/w/	/j/	/w/	/j/
Mean Duration	**72**	**73**	**61**	**68**	**76**	**65**
SD	14	21	19	21	25	22

While the movement durations of Korean glides are comparable to those of English glides, the constriction durations of Korean glides are significantly shorter. Figure 8 shows the constriction duration of each glide stimuli by three Korean speakers.



Note: The vertical axis represents duration in seconds, and the horizontal axis the glide-initial words in the stimuli:
/w/-initial words: 1. wɛt^{h}u 'coat' 2. wənso 'atom' 3. witʃaŋ 'stomach' 4. wanduk^{h}ong 'pea' 5. wiro 'condole' 6. wɛkuk 'foreign country' 7. wənp'ul 'cone' 8. watʃən 'misrepresent'
/j/-initial words: 1. jətʃa 'woman' 2. jasu 'beast' 3. jori 'cooking' 4. ja-ku 'childish' 5. jəmsot'ɛ 'goat herd' 6. jɛsul 'art' 7. jətʃa 'woman' 8. juto 'judo' 9. jori 'cooking' 10. jutʃ^{h}i 'baseball'

Figure 8. Duration of individual constriction in Korean.

Given these findings, the following hypotheses may be drawn. First, movement is an essential element in glides. Second, constriction varies significantly; it appears to be an important element in English glides but it seems trivial in Korean glides. The suggestion is that glides in languages exist in two types (or more); those that employ extensive constriction like English glides and those that employ a brief constriction like Korean glides. Furthermore, one may argue that English-type glides appear to be more consonantal than Korean glides that seem to be more vocalic. Based on the findings thus far, movement is more important but more general cue for glides. In fact, regarding the higher amplitude of movement than constriction, movement is certainly more audible and thus, better as a cue than cons-

triction. Certainly, however, this is a topic for research on cue perception. In the following section, some phonological phenomena will be discussed for further research. These phenomena seem to be related to glides with weak constriction.

5. Some Related Phenomena

5.1. Glide Onset Gaps

As the above results suggest, Korean glides appear to be more vocalic than English glides. In fact, Korean glides may resemble the high vowels to an extent that some logically possible GV pairs are blocked from occurring, and H-s Sohn (1987), Ys Lee (1994), and S-C Ahn (1998) argue that such glide-high vowel sequences are subject to what is referred to Obligatory Contour Principle (OCP: Leben 1973; Goldsmith 1976). Unlike Korean, English glides sufficiently differ from the vowels that all logically possible GV pairs occur in the language. Table 6 gives an example word for each one of the twenty four logically possible English GV pairs, and Table 7 shows the 5 GV gaps marked with an asterisk that are disallowed in Korean among fourteen logically possible pairs.

Table 6. English GV pairs – ***No Gaps***

Vowels	i	ɪ	e	ɛ	æ	ʌ/ə	u	ʊ	o	ɔ	a
/j/+ ___	yeast	year	Yale	yes	yam	yummy	youth	*you*	yoke	york	yard
/w/+ ___	weed	win	wane	when	wax	wonder	wound	would	woe	war	wand

Table 7. Korean GV pairs – ***Gaps***

Vowels	i	e	ʌ	ɨ	u	o	a
/j/+ ___	*	je	jʌ	*	ju	jo	ja
/w/+ ___	wi	we	wʌ	*	*	*	wa

The glide and the vowel in the non-occurring GV pairs in Korean share two or three of the features among Height, Backness, and Roundedness as shown in Table 8 and visually illustrated in Figure 9. It

has been argued that the disallowed GV sequences are due to the articulatory similarity between the glide and the vowel (H-s Sohn 1987; D-Y Lee 1998 among others).

Table 8. The Features of Non-Occurring GV's

Sequences	Shared Features
wu	[+high, +back, +round]
wɨ	[+high, +back]
wo	[+back, +round]
ji	[+high, −back]
jɨ	[+high, −round]

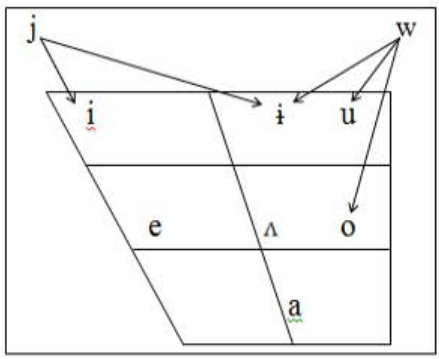


Figure 9. The disallowed GVs.

Ohala and Kawasaki (1984) point out that many languages ban [ji] and [wu] because the two segments create only minimal differences in acoustic parameters such as formant frequency, amplitude, and periodicity. Regarding the weak constriction of its glides, Korean is one such language where the homorganic glide and vowel would fail to make sufficient acoustic contrasts. On the other hand, homorganic GV pairs in English (wu, wʊ, wo, ji, jɪ) are not banned, and one possible explanation obtained from the data in the current study is that the extensive constriction of the glides in English makes the homorganic glide and vowel adequately contrastive.

5.2. Demotion of Glides

In Korean, glides are frequent targets for mutation. Particularly, non-initial glides are often affected by the process of degemination or deletion (H-s Sohn 1987; Ys Lee 1994; Smith 2010; Silva 1991; H-S Kang 1996). Some examples are in (3). These processes are systematic and wide-spread in many varieties of Korean.

(3) a. Degemination (Ys Lee 1994)

p'jam	~ p'em	'cheek'
pjə	~ pe	'rice (the plant)'
kjə	~ ke	'chaff'
pinjə	~ pine	'stick hairpin'
mjənɨli	~ menɨli	'daughter-in-law'

b. Deletion

sakwa	~ saka	'apple'
kwaca	~ kaca	'snack'
pwa	~ pa	'see'
kyecwa	~ keca	'bank account'
kwisin	~ kisin	'ghost'
penkwin	~ penkin	'penguin'

These demotion processes are not found in English. For example, pronouncing *penguin* as [pɛŋgin] and *language* as [læŋgidʒ] would simply be errors rather than social or regional variations. Compared to Korean ones that are more susceptible to phonological changes, English glides are more preserved, and this could also be due to this markedly long constriction.

5.3. Cross-Linguistic Evidence

The findings of this study make some predictions, and among them one is that languages with GV gaps would have more vocalic glides (with a brief constriction); and possibly *vice versa* that languages with such vocalic glides would exhibit GV gaps. I have learned that Spanish, Chinese, and Japanese have such GV gaps. In Japanese, for example, there are five vowels /a, i, u, e, o/ and two glides /w, j/. Quite sur-

prisingly, among the ten logically possible GV pairs, only four occur: /wa, ja, ju, jo/. I recorded some Japanese words produced by two native speakers of Japanese. The stimuli are in (4); lines 1 and 3 are vowel-initial words, and lines 2 and 4 are glide-initial words.

(4) Japanese stimuli

1.	ana	isu	uma	ebi	oni
	hole	*chair*	*horse*	*shrimp*	*ghost*
2.	jaki	juka	joko	wani	
	goat	*floor*	*side*	*crocodile*	
3.	ane	ika	unaki	esa	oto
	older sister	*squid*	*eel*	*prey*	*sound*
4.	waki	jane	jume	joso	
	armpit	*roof*	*dream*	*different place*	

The recorded data confirmed the expectation. In Figure 10 below, the

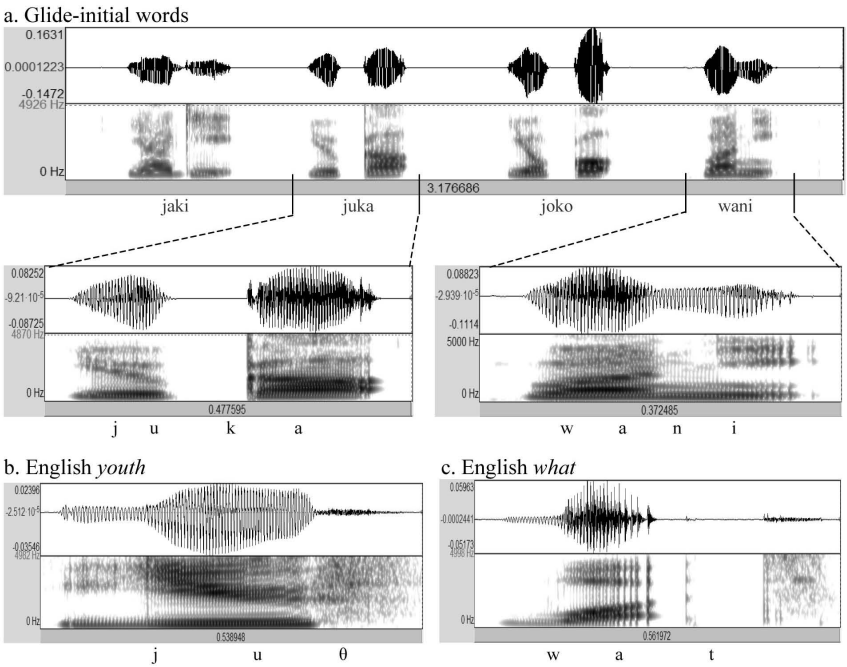


Figure 10. Japanese vowel-initial and glide-initial words and English glides-initial words.

production of line 2 of the stimuli by one of the speakers of Japanese is in the first picture, and two of the words *juka* and *wani* are zoomed in. The two bottom pictures are English *youth* and *what* for comparison.

As it is expected, Japanese glides are produced with a short and brief constriction. Among all sixteen recorded glide-initial words, only one show relatively clear, but still very short constriction. Given this piece of evidence from the Japanese data, it is predicted that Chinese and Spanish glides also exhibit short and brief constriction compared to English glides, and that speakers of these languages will have difficulties in performing English glides particularly when the glide is followed by vowel that is homorganic with the glide.

6. Conclusion

In this study, a series of Korean and English production data containing glide-initial words are analyzed in terms of the parameter of constriction duration of glides. Constriction is often found as a prolonged steady voicing state in English glides (Espy-Wilson 1992), but this pattern is missing in the glides in Korean and also in Japanese. It is suggested that differences in duration and degrees of constriction in glides of a language may explain a number of linguistic phenomena including difficulties in learning second language glides.

Together with the hypothesis in Stevens (2000), what these findings suggest is a possible subdivision of the natural class of glides. As obstruents are grouped in terms of the degrees of oral obstruction or the degrees of aspiration (Lisker & Abramson 1964), glides may be divided into two or more subclasses based on their phonetic manifestation; the ones like English glides that involve an extensive constriction, and the ones like Korean glides with only a marginal constriction. As indicative as it may be, this may only show some subdivision on the phonetic level. Finally, it is also possible that the phonetic manifestation of glides may reflect the phonemic status of glides discussed in Levi (2004). Future research needs to investigate the possible relation between them.

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