Effects of Word Frequency on a Lenition Process: Evidence from Stop Voicing and /h/ Reduction in Korean*

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ABSTRACT

The present study examined whether words with higher frequency have more exposure to the lenition process such as intervocalic stop voicing or /h/ reduction in the production of the Korean speakers. Experiment 1 and Experiment 2 tested if word-internal intervocalic voicing and /h/ reduction occur more often in the words with higher frequency than less frequent words respectively. Results showed that the rate of voicing was not significantly different between the high frequency group and the low frequency group; rather both high and low frequency words were shown to be fully voiced in this prosodic position. However, intervocalic /h/s were deleted more in high frequency words than in low frequency words. Low frequency words showed that other phonetic variants such as [h] and [w] were found more often than in high frequency group. Thus the results of the present study are indefinitive as to the relationship between the word frequency and lenition with the data at hand.

Keywords: stop voicing, /h/ reduction, Korean, lexical frequency

1. Introduction

The realization of optional variability as a function of word frequency has been thought to be problematic in traditional models of grammar. Traditional models of grammar posit that phonological knowledge is instantiated in the form of rules or constraints operating on mental representation of words. A fundamental assumption of these models is that phonological rules or constraints exist in a module of grammar that is quite separated from the words in use (Halle, 1985 among others). Phonological rules are assumed to be abstracted away from the lexicon, forming a separate component, and necessarily operate when the surrounding conditions are met. In the traditional model of phonology, any given sequence is either well-formed or completely impossible. Thus it cannot account for optional variability in the operation of phonological rules as a function of lexical frequency. The effects of lexical frequency in word

processing are assumed to be related to performance factors and therefore they are treated to be beyond the scope of a linguistic theory.

Outside linguistics, however, it has been already widely held that cognitive representations are greatly affected by experience (Johnson & Mullennix, 1997). Even within linguistics, certain usage-based effects were attested in various places (Greenberg, 1966; Hopper, 1979 among others). Recently, these usage-based approaches have gained currency, shifting the mechanics of formal linguistic theories as above (See Barlow & Kemmer, 2000 for a review). A usage-based model is one in which the speaker's linguistic system is fundamentally grounded in 'usage events', or instances of a speaker's producing and understanding language. The linguistic system is built up from lexically specific instances, only gradually abstracting more general representations from the repetition of similar instances of use. Units of language (from phonemes to constructions) are not fixed but dynamic, and they're subject to creative extension and reshaping with use. Namely, usage events are crucial to the ongoing structuring and operation of the linguistic system.

In the usage-based model, frequency of instances is a prime factor in its structure and operation. Frequency plays an important role in the formation of lexical representation. A way of accounting for the role of frequency is to assume that sound changes affect words each time they are used. This is because high frequency words have more exposure to the pronunciation pattern, whereas low frequency ones occur less often in casual speech and thus have even less exposure to the reductive processes. If the effects of the sound change are cycled back into the lexicon, the lexical representations for the words gradually adjust to the new productions. The idea that frequency has an indispensable role in the formation of the lexical representation can be found in several studies (Beckman & Edwards, 2000; Bybee, 2000; Bush, 2001; Patterson & Connine, 2001 among others).

Patterson and Connine (2001) examined the effects of frequency on American English flap production. They focused the distribution of optional variants [t], [ʔ], or [ɾ] of word-medial /t/. Utilizing a large conversational speech corpus, they found that /t/s in high frequency words were produced predominantly as flaps whereas low frequency words exhibited a greater variability with fewer flaps. Bybee (2000) examined the frequency effects on French liaison, arguing that the syntactic cohesion is a result of frequency of co-occurrence: words that are used together more often tend to seem more fused and also tend to have more liaison. Bush (2001) found frequency effects on an optional rule, word-boundary palatalization. He found that word-boundary palatalization was more likely to take place if those words occur together with high frequency (e.g., *did you, would you, don't you*).

These studies reveal that frequency plays a major role not only in the formation of the lexical representation but also in the account of an optional lenition of sounds such as the flap production and palatalization. Lenition refers to some reduction in constriction degree or

duration, and as applied to consonants, it includes many phonological processes such as degemination, flapping, spirantization, debuccalization, voicing, and other reduction or deletion processes (Kirchner, 1998). In usage-based theory, the word frequency is closely tied to the lenition process in that high frequency words occur more often in casual speech and thus have even more exposure to the reductive processes. But traditional theory in phonology has not been able to explain the realization of optional variants. In generative phonology, for example, a sound change necessarily takes place when the conditions are met. There cannot be the case a phonological process happens in some words but not in other words in the same condition. Therefore, traditional theory cannot account for English flap production, palatalization, or French liaison. However, the optional realization of lenition process can be explained in the position of usage-based model well, specially in the respect of frequency.

The current paper is intended to contribute to the general effort to show effects of word frequency on a lenition process. Specifically, we will test whether stop voicing and /h/ reduction in Korean occur more frequently in the words with higher frequency than in the less frequent words.

2. Experiment 1: Stop Voicing

2.1 Background

It is widely assumed that voiceless plain stops are voiced between two voiced segments in Korean. This change, which we call the Plain Stop Voicing (PSV) here, has been argued to be categorical modification of the target consonants in traditional analyses based on a phonological approach (Cho, 1987, 1990; Kim-Renaud, 1974; Kang, 1992). Cho (1990), for example, presents a voicing rule in the segmental framework: [-continuant, -aspirated, -tense] → [+voice]/[+voice] ___ [+voice] (p.48), where plain, voiceless stops are voiced between two voiced segments. On the other hand, work based on phonetic data addresses a fundamental question with respect to such categorical explanation of the plain stop voicing process, since the voicing process shows variation depending on the context. According to Jun (1995), a plain stop is more likely to be voiced in faster rate, in shorter duration, and next to a segment with a stronger voicing gesture. Further, voicing is sensitive to the prosodic domains: plain stops are voiced within words, but are progressively less voiced in the edge of the bigger prosodic categories (Silva, 1992; Jun, 1995). Based on the gradience of the lenis stop voicing process, Jun (1995) argues that stop voicing does not involve the categorical modification of segments at all, and rather better explained with a gestural overlap and reduction (Browman & Goldstein, 1986, 1992).

In the present study, how the extent of voicing in intervocalic plain stops is influenced by the frequency of the words with plain stops is examined. To show this, we count the number of

words with the plain stop whose closure appears as fully voiced. We focus on the intervocalic plain stops in word-internal position where plain stops are held to be almost completely voiced, for example, 91% in Silva (1992). Several phonetic studies already showed that even in word-internal structure, the voicing distinction in Korean is not categorical, and thus not congruent with the phonological analyses considering voiced stops as allophones (Jun, 1995; Han, 2000; Yun, 2000). Through the acoustic examination, we test whether the realization of the plain stops as voiced is affected by the lexical frequency even in the word-internal position.

2.2 Method

2.2.1 Material

The test words consisting of VCV sequences were constructed, in which the C segment was the bilabial stop /p/. The reason why the place of articulation for stops was limited to a bilabial position is that this position was more clearly displayed and thus more easily discernable, as compared to other places of articulations (Silva, 1992). The speech data for recording were selected based on the written corpus named 'A Survey of Word Frequency of the Modern Korean (henceforth SWFMK)' (Cho, 2001). This database consists of 58,437 words, extracted from a large body of material in books, magazines, dialogue scripts of the TV sitcoms, etc., for a total of 176 kinds of material. The words in this database were collected at the National Institute for the Korean Language and produced on CD-ROM. The words in the database show their token frequency ranged from 1 through 25,567, among which two groups of words were chosen for recording, one group of which ranged from 25,567 through 69 in word frequency (upper 5%), other, with the frequency of one to 26 (approximately lower 30%). To test the reliability of the database, a separate survey to examine the familiarity of each token was done at the end of the experiment by four native Korean speakers. Two raters were doctoral candidates majoring in Korean linguistics at Konkuk university and two were Korean teachers in a secondary school in Korea. They scored the test words for frequency on a scale from 1 (for "least frequent") to 7 ("most frequent"). This survey is based on Kreuz (1987)'s finding that printed frequency (from corpus) and subjective familiarity generally covary, but the subjective familiarity is a more reliable index of the underlying psychological construct, word frequency. Table 1 shows the set of words included in the study along with the frequency of usage.

Table 1. Token Frequency of Test Words

	High frequency group			Low frequency group		
	Words	Freq.of SWFMK (max=25,567)	Freq.of natives' rating (max=7)	Words	Freq.of SWFMK (max=25,567)	Freq.of natives' rating (max=7)
1	cʌŋpu	1249	5.23	sinpjʌŋ	14	1.69
2	paŋpʌp	1061	6.38	supal	3	3.15
3	cipaŋ	695	5.92	manpaŋ	2	2.61
4	pupun	652	6.23	kopo	1	1.15
5	hanpun	513	6.54	sampu	1	1.31
6	cʌŋpo	460	6.62	sanpat	1	1.38
7	kipun	402	6.85	kipjʌk	1	1.46
8	cupjʌn	334	6.38	tʰopaŋ	1	1.46
9	tampæ	322	5.69	copap	1	1.54
10	pupu	227	5.92	cinpap	1	1.54
11	sæpjʌk	215	6	cɛpun	1	1.77
12	cunpi	211	6.92	anpin	1	1.92
13	cæpʌl	205	5.23	pʰjɛpu	1	2.08
14	sʌnpæ	204	6.85	kopu	1	2.31
15	pʰipu	193	6.08	kopi	1	2.38
16	kapaŋ	149	6.62	upi	1	2.46
17	cupu	127	5.85	cʌnpʌm	1	2.54
18	capon	118	5.46	wipjʌk	1	2.69
19	sopi	107	5.69	mupʌp	1	3.38
20	kanpu	99	4.08	ʌmpʌl	1	3.46
21	sinpu	94	5.69	kupi	1	3.46
22	kinpon	90	5.38			
23	hupæ	85	6.31			
24	hanpok	82	4.38			
25	ipul	78	6.31			
26	cuŋpan	73	5.54			

The test words were selected based on both SWFMK 2001 and natives' rating. A word belonged to the high frequency group when both conditions were met: 1) the word frequency of SWFMK was more than 40 and 2) the frequency of rating was more than four. A word belonged to the low frequency group when both conditions were met: 1) the word frequency of

SWFMK was less than 30 and 2) the frequency of rating was less than 3.5. The words that did not satisfy both conditions were excluded in the analysis. As a result, 47 words were taken into consideration in the analysis.

2.2.2 Subjects and Recording

Fourteen male speakers, who are in their twenties, participated in the recording. They were native speakers of the standard Korean and none of them reported either speaking or hearing disorder. They were recorded in a quiet room in the Applied Linguistics Lab at Konkuk University, using a microphone (Shure SM48) and a CSL (model 4400). Before recording, each speaker was asked to read test sentences, which were presented in several paragraphs.[1] Then, they were asked to read each test utterance twice in a random order, at a natural, comfortable speed. The test sentences were presented in Korean orthography. After the recording, they were asked to take a quiz to test whether they read the paragraphs without thinking of their meaning. The purpose of this test was to exclude the possibility that subjects perform the task through shallow word-form routes without getting access to the lexicon. The participants were paid for their participation in the experiment.

2.2.3 Measuring procedure

The recorded data were digitized onto a CSL (Computerized Speech Lab) (model 4400) at a sampling rate of 22,050 sample/second, and then stored as files to be processed. Waveforms and spectrograms for each token were created. The total number of tokens was 1,316 (47 words x 14 speakers x 2 repetitions).

The marks were placed based on the waveforms as well as spectrograms. When the two displays appeared to show minor discrepancies, the mark was placed with reference to the waveform. The cues for the beginning of stop closure were the reduction of complex, periodic waves in the waveform and the attenuation of the second formant structure of the preceding vowel in the spectrogram. The beginning of stop release was captured with a sudden increase in energy in both waveform and spectrogram. The amount of voicing during stop closure was measured with periodic vibration in the waveform and a voice bar in the spectrogram during the interval of stop closure.

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1) The test words were included in a paragraph, rather than a frame sentence, in order to get data produced in a more naturalistic setting. However, contextual variability from different phonological and/or prosodic positions was not able to be controlled for this reason.
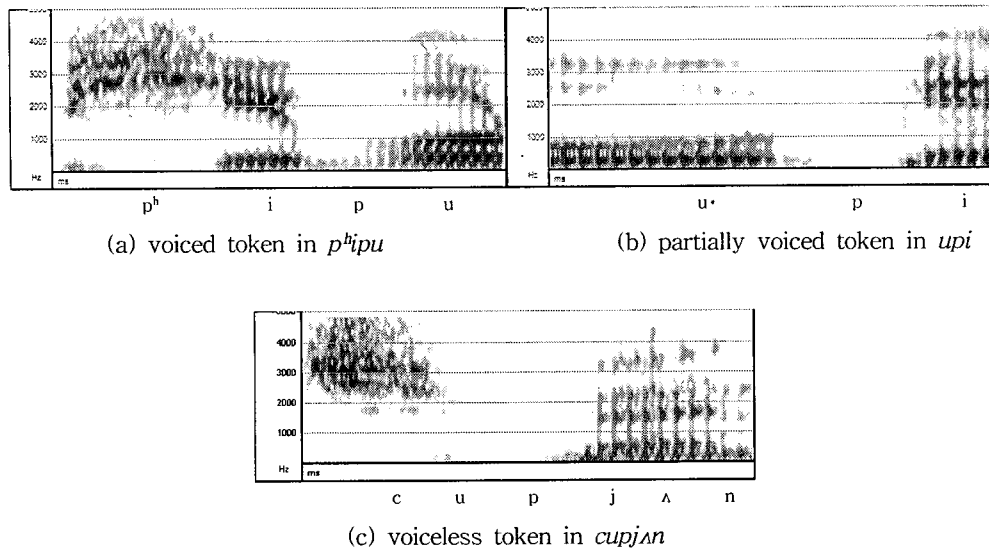
(a) voiced token in *pʰipu*

(b) partially voiced token in *upi*

(c) voiceless token in *cupjʌn*

Figure 1. Illustration of the spectral properties of the three types of
intervocalic /p/ by Korean speakers

2.3 Results and Discussion

The results of the experiment do not seem to be consistent with the expectation that lenition occurs more predominantly in items with high frequency. As shown in Table 2, there was no such significant difference in the percentage of voicing during the closure between two groups of words ($F(1,45)=0.16$, $p>.05$). Both high and low frequency words, were shown to be fully voiced in word-internal, intervocalic position.

Table 2. Mean voice percentage of high- and low-frequency words

	N	Mean(%)	SD
High-frequency words	26	97.8	11.82
Low-frequency words	21	98.05	11.2

The results in Table 2 show that in word-internal position, many Korean speakers seem to produce plain stops as fully voiced. Thus these results seem to provide an empirical evidence against a strong version of the phonetic account of the PSV, where even in word-internal position, voicing is not categorical. Even though PSV is greatly influenced by speech rate, adjacent segments, and prosodic categories, it does not seem to be directly related to the word frequency. Thus voicing in word-internal position might be a phonological knowledge independent of statistical generalizations across the lexicon, namely that obtained from true abstraction across the lexicon. However, without the experimental results in other phonological

positions such as phrase-initial or phrase-internal/word-initial positions, it is not clear whether the PSV shows such non-significant effects of frequency in the realization of the plain stops in general. Silva (1992) shows that the percentage of closure that is voiced is significantly different across the prosodic positions such as 31% for the bilabial stop in phrase-edge position, 45% for that in word-edge position, and 89% for that in word-internal position. Thus it is likely that stops in phrase-edge position and word-edge positions show more variation in terms of the word frequency.

3. Experiment 2: /h/ Reduction

3.1 Background

/h/ in Korean shows different behaviors according to the phonological positions it occurs as in (1) through (4).

(1) a. /hɛ/	[hɛ]	'sun'	
b. /hanil/	[hanil]	'sky'	
(2) a. /ahop/	[ahop]/[aop]	'nine'	
b. /ilhin/	[ilhin]/[ilin]	'seventy'	
(3) a. /nah-/ + /ta/	[nat^{h}a]	'give birth to'	
b. /nah-/ + /a/	[naa]	'give birth to (a baby) and'	
c. /nah-/ + /nin/	[nannin]	'giving birth to'	
(4) a. /k'inh-/ + /ʌ/	[k'inʌ]	'cut and'	
b. /k'inh-/ + /nin/	[k'innin]	'cutting'	
		(Kim, 1989)	

/h/ can appear initially as in (1), medially as in (2), and in final position as in (3) and (4) (Yoo, 1985; Kim, 1989). When /h/ appears in the initial position, usually followed by a vowel, it is realized as a voiceless fricative, [h]. In the medial position in which /h/ is preceded by a vowel or a sonorant, it can be deleted optionally according to the speed of production or the degree of formality, as is remarked by Ahn (1986). A medial /h/ was also claimed to be realized as a voiced fricative, [ɦ] or an approximant, [w] (Huh, 1985; Ku, 1999; Shin, 2003). For example, an intervocalic /h/ can be produced as a voiceless fricative (e.g., [wɛhalmʌni] 'grandmother-in-law'), a voiced fricative ([wɛɦalmʌni]), an approximant ([wɛwalmʌni]), or /h/ can be deleted completely ([wɛalmʌni]). In the final position, its realization is determined by immediately following segment. When /h/ is followed by another obstruent /p, t, k, c/, they are represented as the corresponding aspirated consonants (3a). When it is followed by a vowel, /h/ deletes

obligatorily (3b or 4a). On the other hand, when it is followed by a sonorant, it geminates (3c) or deletes (4b).

Therefore, there are four variants in the realization of /h/ in Korean when it appears between two vowels. Given the results of the previous studies on lenition such as schwa deletion or intervocalic /t/ reduction, it is likely that /h/-reduction is also influenced by lexical frequency: /h/ in more frequent words is more easily reduced than that in less frequent words. If so, it cannot be explained in the traditional theory of phonology, since there should be one output from the same context in this theory. Here, the present study examines whether /h/ reduction process in Korean is operated as a function of lexical frequency. Specifically, this study investigates whether intervocalic /h/ in Korean is more likely to be reduced in high frequency words than in low frequency words.[2]

3.2 Method

3.2.1 Material

Thirty-one bisyllabic words containing intervocalic /h/ were selected from SWFMK and were also rated by four native Korean speakers. The rating procedure was the same as in Experiment 1. Test words were divided into two groups - high frequency group or low frequency group. The cut-off point was chosen based on two dimensions, SWFMK 2001 and four Korean experts' rating. The criteria for selecting the test words were the same as in Experiment 1. Thirteen words in each group were taken into consideration in the analysis as in Table 3.

Table 3. Token Frequency of Test Words

	High frequency group			Low frequency group		
	Words	Freq. of SWFMK (max=25,567)	Freq. of natives' rating (max=7)	Words	Freq. of SWFMK (max=25,567)	Freq. of natives' rating (max=7)
1	sahwɛ	2770	6.5	kuho	22	3.5
2	ihu	710	4.75	kahæ	19	3.25
3	tæhwɛ	425	5.25	sihjo	12	2.5
4	ohu	354	5.75	suho	10	3
5	ihæ	242	6	cihwɛ	7	2.75
6	poho	237	6.25	kaho	3	2.25
7	pʰihæ	215	4.5	aho	2	1.75
8	cʌhij	185	5.75	siho	2	1.75
9	ciha	129	4.75	pohwa	1	3
10	cohwa	115	4.25	kihwa	1	2.75
11	iha	112	4.25	cʰwiha	1	2.25
12	kihu	89	5.25	cɛho	1	2
13	kiho	40	4.7	tʰoho	1	1.25

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2) Other examples showing /h/ reduction as in (3) and (4) were not tested in this study.

Test words were all bisyllabic mono-morphemic words, which consisted of 25 nouns and one pronoun (cʌhij). Those words were followed by another open monosyllabic affixes such as ka, ɛ, ij, ro, wa. All of the test words were embedded into 23 paragraphs which were extracted from the internet, and one, two or three words were contained in each paragraph.

3.2.2 Subjects and Recording

Ten native speakers of the standard Korean, (all male) aged from 23 through 31, participated in the experiment, and none of them reported either speaking or hearing disorder. The other recording procedure was the same as that of Experiment 1.

3.2.3 Measuring procedure

Overall measuring procedure was similar to that of Experiment 1. The total number of tokens was 520 (26 words x 10 speakers x 2 repetitions) and /h/ was classified as one of four different categories. First, /h/ was regarded as a voiceless fricative, [h] if noise could be seen clearly but voice bar was not present between two vowels. Second, it was considered as a voiced fricative, [ɦ] if both noise and voice bar were evidently identified. Third, /h/ was identified as an approximant, [w] if weak formant patterns with a very low F2 and F3 were shown between the two vowels surrounding the segment /h/. Finally, /h/ was considered to be deleted when no clue for /h/ was found in both waveform and spectrogram.
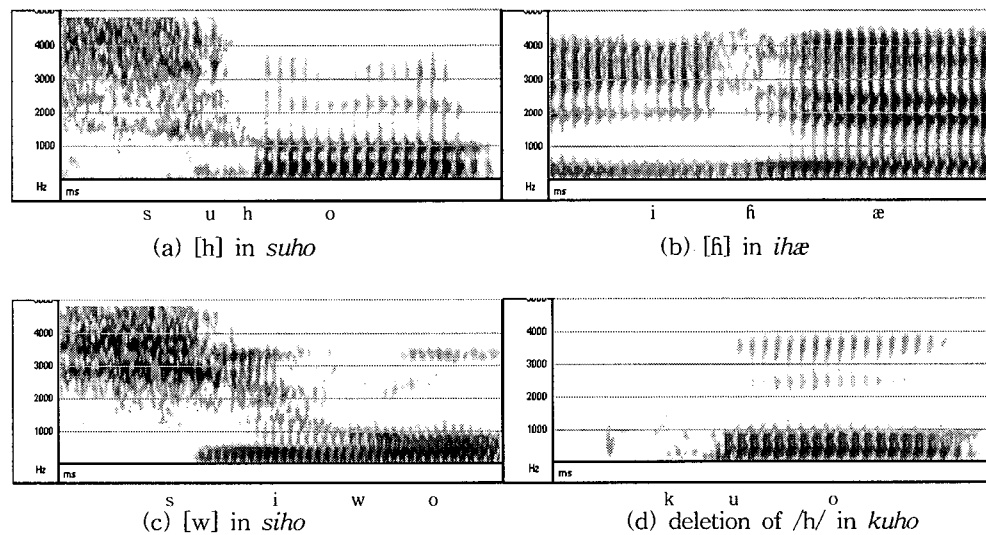

s   u   h   o

(a) [h] in suho

i   ɦ   æ

(b) [ɦ] in ihæ

s   i   w   o

(c) [w] in siho

k   u   o

(d) deletion of /h/ in kuho

Figure 2. Illustration of the spectral properties of the four types of
the Intervocalic /h/ by Korean Speakers

3.3 Results and Discussion

As expected, four different phonetic realizations of the intervocalic /h/ appeared. The results of the study show that deletion of the intervocalic /h/ was dominant over the other realizations ([h, ɦ, w]) in spoken Korean. Of 520, 86.73% (n=451) of the test words were deleted, 7.89% (n=41) were produced as [w], 3.65% (n=19) were produced as [h], and 1.73% (n=9) were produced as [ɦ] (see Table 4). More importantly, intervocalic /h/ in high frequency words was shown to be deleted predominantly, but that in low frequency words exhibited variability in their pronunciation, showing a shift in production to [h] or [w]. In the high frequency words, 90% of the test words were deleted, 6.15% were produced as [w], 2.31% were produced as [ɦ], and 1.54% were produced as [h]. On the other hand, in the low frequency word group, 83.46% were deleted, 9.62% were produced as [w], 5.77% were produced as [h], and 1.15% were produced as [ɦ].[3]

Table 4. Percentage of Phonetic Realizations of Intervocalic /h/

	N	[h](%)	[ɦ](%)	[w](%)	deletion(%)
High-frequency words	13	1.54	2.31	6.15	90.00
Low-frequency words	13	5.77	1.15	9.62	83.46
mean		3.65	1.73	7.89	86.73

The statistical results show that there were significant differences in the realizations of /h/ between high-frequency word group and low-frequency word group. Specifically, One-Way Analysis of Variance (ANOVA) on Korean intervocalic /h/-deletion revealed a main effect of frequency of each word ($F(1, 24) = 4.492, p<.05$). That is, the percentage of intervocalic /h/ deletion in Korean is significantly higher in the high frequency words, as compared to the low frequency words. 90% of intervocalic /h/ in the high frequency words were deleted, whereas 83.46% of /h/ were deleted in the low frequency words. These results suggest that low-frequency words have less experience to the reductive process, supporting the usage-based explanation to the lenition process. There was neither trial effect ($F(1, 24) = 1.881, p>.05$) nor interaction effect between frequency and trial ($F(1, 24) = 0.14, p>.05$).

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3) One reviewer pointed out the possibility that [w] as in [siwo] from /siho/ appeared to prohibit the vowel hiatus after the intervening /h/ was deleted. Based on this hypothesis, he/she argues that this variant then can be the case /h/ is completely deleted. In this study, we only counted the surface variants related to the underlying /h/, but if we combine the results of '[w]' and 'deletion' as in Table 4, the general tendency for the /h/ reduction pattern as a function of word frequency remains unchanged. The source of [w] is worthy to be examined in a future study.

4. Conclusion

The present study was designed to test the hypothesis that words with higher frequency have more exposure to the lenition process such as intervocalic stop voicing and /h/ reduction. Contrary to the previous research findings, the results of the present study are indefinitive.

First, Experiment 1 examined whether word-internal stops in intervocalic position occur more often in the words with higher frequency than in the less frequent words. It was shown that the rate of voicing was not significantly different between the high frequency group and the low frequency group. Rather, both high and low frequency words were shown to be fully voiced in this prosodic position. However, Experiment 2 showed that there was significant difference in the realizations of /h/ between high-frequency group and low-frequency group. Deletion and [ɦ] were found more in high frequency word group, whereas [h] and [w] were found more often in low frequency group, although, even in this case, intervocalic /h/s are mostly deleted.

Several explanations for this indefinitive finding could be offered, even though the data at hand did not permit choosing them. As mentioned before, the intervocalic voicing was only examined in the word-internal, intervocalic position. Even though the voicing process abstracted the general representation from the use of words at least in this prosodic position, intervocalic stops in other prosodic positions such as phrase-edge or word-edge position might show more meaningful differences between these two groups. Or, it might have to do with the finding that difference has been found in lexical access and production (Balota & Chumbley, 1985; Whalen, to appear). The experimental setup is an artificial situation and thus speakers might produce both frequent and infrequent words with a clear articulation, which could lead to the equivalent amount of lenition. Further studies through a naturalistic setting are required to draw any conclusion on the frequency effects on lenition.

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