Phonetic variability of /h/ in Korean: aspiration or tensification

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This paper examines variation of the glottal fricative /h/ in Korean: in an innovative form, /h/ triggers tensification to the following obstruent rather than merges to be an aspirated obstruent, e.g., /nahta/ ‘give birth to’ becomes [na.tʰa] in a standard form; /nahta/ becomes [nat’.t’a] in an innovative form. Motivations of the variability are accounted for within the modified theory of ‘effective contrast’ (Ussishkin and Wedel, 2002). I argue that sound variability of /h/ is affected by the number of minimal pairs (i.e., neighbors) and FAMIQUENCY, an interaction between token frequency and word familiarity. I hypothesize that the lexical items with low FAMIQUENCY in a relatively dense neighborhood show a great rate of variability. Among three groups categorized by presence of minimal pairs and degree of FAMIQUENCY, Group III that has low FAMIQUENCY with minimal pairs shows a great degree of variability, and the sound change of /h/ in this group seems to be almost completed.

1. Introduction

The glottal fricative /h/ in Korean behaves differently from other obstruents and shows diverse surface realizations depending on what precedes or follows it. In the present study, I examine the /h/ that occurs in coda position followed by a plain stop: the environment where aspiration is normally triggered. In standard Korean when a coda /h/ is preceded by an onset plain obstruent, it is not realized in the coda, but triggers aspiration to the following obstruent. In other words, /h/ and the following plain obstruent merge to become an aspirated obstruent, i.e., /nahta/ becomes [na.tʰa] ‘give birth to’.

However, Lee (2004) observed phonetic variation with respect to this process: in a more innovative form of Korean, /h/ triggers tensification to the following obstruent, i.e., /nahta/ becomes [nat’.t’a]¹, like Post Obstruent Tensification (POT). The POT is a

¹ The diacritics [’] and [.] indicate a tense consonant, and a syllable boundary respectively.

* I would like to thank Sonya Bird for her thorough supervision through the research. Thanks to Soo-Youn Ham, Pauliina Saarinen, and Su Urbanczyk for their valuable discussions and suggestions, and the audiences of ICEAL for comments and suggestions. This research would not be possible without the Korean participants. Many thanks to them!
language specific phonological process in Korean where plain consonants are changed into tense consonants after an obstruent. Lee claims that a word such as /nahta/ ‘give birth to’ be considered to undergo POT, i.e., [nat.t’a].

A number of studies on sound changes show that sound changes are affected by frequency (Bybee, 2001; Phillips 1984, 2002; Pierrehumbert, J. 2001 among others). In addition, more recent researchers have claimed that neighborhood density influences sound change (Luce and Pisoni 1998; Phillips 2001; Vitevitch and Luce 1998). Furthermore, Ussishkin and Wedel (2002) propose that frequency and neighborhood density interact and affect lexical access. Lexical access efficiency can be predicted through both relative frequency and neighborhood density, or ‘effective contrast’. For example, an infrequent lexical item in a sparse neighborhood may be accessed as efficiently as a relatively frequent one in a dense neighborhood, i.e., both lexical items may have the same effective contrast.

This paper examines Lee’s (2004) claim and the degree of phonetic variability of /h/. This research aims to look into the motivations of the /h/ variation and to provide an explanation for variation patterns within the theory of modified ‘effective contrast’, I argue that sound variability of /h/ is affected by the number of minimal pairs (neighbors) and FAMIQUENCY. The “FAMIQUENCY” represents an interaction of token frequency and word-familiarity. The token frequency and the word familiarity interplay and determine the FAMIQUENCY. In other words, familiarity to a word increases FAMIQUENCY, whereas unfamiliarity to a word decreases FAMIQUENCY. Two words with a similar token frequency may have different FAMIQUENCY depending on word familiarity. I hypothesize that lexical items with low FAMIQUENCY in relatively dense neighborhoods show the innovative form (POT) to the great degrees, where sound change has been almost completed.

In order to examine this hypothesis, I categorize relevant underlying representations into three groups according to the FAMIQUENCY and the presence of minimal pairs; (I) a group of words which has no minimal pairs and shows high FAMIQUENCY, (II) a word with three minimal pairs and high FAMIQUENCY, and (III) a word with one minimal pair and low FAMIQUENCY. An experiment is conducted with twelve fluent Korean speakers, and predictions are made; group I will show no variation due to high FAMIQUENCY, and/or a sparse neighborhood; group II may have phonetic variability to some degree as high FAMIQUENCY mitigate a dense neighborhood; group III is predicted to have a great degree of phonetic variation because of low FAMIQUENCY and a dense neighborhood. The results will be accounted for within the theory of modified ‘effective contrast’ (Ussishkin and Wedel 2002).

This paper is organized as following: section 2 provides background information on relevant Korean linguistics. Section 3 introduces the theoretical framework. Section 4 presents the methodology of the experiments. Section 5 shows the results of the experiment. Section 6 presents discussion and section 7 concludes.

2. Background information

For the understanding of the nature of variation, phonological processes such as Coda Neutralization and Post Obstruent Tensification are provided in this section.
2.1. Korean obstruents

Korean shows a three-way contrast in phonation among stops and affricates: plain, aspirated, and tense. Fricatives show a two-way distinction: plain and tense, but glottal fricative /h/ does not differentiate phonation. Table 1 shows Korean consonant inventory.

<table>
<thead>
<tr>
<th></th>
<th>Bilabial</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>Plain</td>
<td>p</td>
<td>t</td>
<td>k</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tense</td>
<td>p'</td>
<td>t'</td>
<td>k'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aspirated</td>
<td>p^h</td>
<td>t^h</td>
<td>k^h</td>
<td></td>
</tr>
<tr>
<td>Affricate</td>
<td>Plain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tense</td>
<td>c'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aspirated</td>
<td>c^h</td>
<td></td>
<td></td>
<td></td>
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<td>Fricative</td>
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<td>s</td>
<td></td>
<td></td>
<td>h</td>
</tr>
<tr>
<td></td>
<td>Tense</td>
<td>s'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td></td>
<td>η</td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>l</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2. Coda neutralization

In the coda position, the labial and velar stops are always neutralized into their unreleased counterparts [p’] and [k’] respectively, losing their laryngeal distinction. All coronal obstruents are neutralized into unreleased [t’] regardless of whether they are stops, fricatives, or affricates. The data relevant to the study is presented in (1).

(1) a. Coronal stops are neutralized into the unreleased [t’].
   /t/ /t^h/       [t’]
   /kot/          [kot’]   ‘instantly’
   /k’it^h/       [k’it’]  ‘a point’

b. Affricates are neutralized into the unreleased [t’].
   /c/ /c^h/       [t’]
   /nac/          [nat’]   ‘day’
   /nac^h/        [nat’]   ‘face’

c. Fricatives are neutralized into the unreleased [t’].
   /s/ /s’/        [t’]
   /nas/          [nat’]   ‘sickle’
   /kas’/         [kat’]   ‘to go (past)’

2.3. Post Obstruent Tensification (POT)

POT refers to the phenomenon in which plain consonants /p, t, k, c, s/ are changed

\[^2\] I use [c] as IPA [tʃ] following a number of Korean linguists (Kang 1999, Kim Renaud 1974, Lee 1997, Lee 1999 among others). [c] has been used to indicate a voiceless palatal affricate in Korean in order to emphasize that it is a single phoneme and due to typographic simplicity, even though [c] stands for a voiceless palatal stop in the IPA.
into tense consonants [p', t', k', c', s'] after an obstruent.

(2) a. Tensification after coronal stops
/kot-caŋ/ [kot'.c'aŋ] ‘instantly’
/k'it'–caŋ/ [k'it'.c'aŋ] ‘end’

b. Tensification after affricates
/nac-p'am/ [nat'.p'am] ‘day and night’
/day-night
/nac'–k'wa/ [nat'.k'wa] ‘face and’

face-and

c. Tensification after fricatives
/nas–cil/ [nat'.c'il] ‘sickling’
sickle - doing something
/kas'–ta/ [kat'.t'a] ‘went’
to go (past)-declarative mood marker

As shown above, plain obstruents in onset position undergo tensification after stops, affricates, and fricative.

2.4. Behavior and variation of /h/

Glottal fricative /h/ is neutralized into [t'] like other fricatives as shown below.

(3) /coh/ [cot'] ‘to be good’
/nah/ [nat’] ‘to give birth’
/tah/ [tat’] ‘to be reach’

The fact that /h/ undergoes neutralization into coronal plain stop is one of the main factors that is leading to the innovative process discussed in the introduction.

In standard Korean, however, the fricative /h/ does not trigger tensification of the following obstruent. Instead, the /h/ merges into a following obstruent and realizes as an aspirated obstruent as illustrated in (4) (Kim, 1989).

(4) The behavior of /h/ (Standard form)
a. /noh-ta/ [no.t'h'a] ‘put’
b. /nah-ta/ [na.t'h'a] ‘give birth to’
c. /nah-ko/ [na.k'h'o] ‘give birth to and’
d. /coh-ko/ [co.k'h'o] ‘be good and’
e. /nah-ca/ [na.c'h'a] ‘right after giving a birth’

However, Lee (2004) observed that the /h/ undergoes tensification rather than aspiration as in (5)

(5) The variation of /h/ (Innovative form)
a. /nah-ta/ [nat’.t'a] ‘give birth to’
b. /tah-ta/ [tat’.t'a] ‘reach’
In this paper, the innovative form where the /h/ triggers tensification is examined by experiments.

3. Theoretical framework

In order to account for the /h/ variability, I adopt the model of Ussishkin and Wedel and modify it by adding familiarity to the factors that motivate sound variation. In 3.1, I introduce Ussishkin and Wedel’s effective contrast, and in 3.2, I present my modified version of effective contrast.

3.1. Effective contrast (Ussishkin and Wedel, 2002)

Ussishkin and Wedel (2002) notice that interaction between neighborhood density and frequency determines efficiency of lexical access. A lexical entry which has many phonemically similar entries in the lexicon (lexical neighbors) is less efficiently accessible than an entry that has fewer neighbors. For example, orange is more easily recognized than cat which has neighbors like scat, at, bat, and cot. They account for this neighborhood density effect through the Neighborhood Activation Model (NAM) of Luce and Pisoni (1998). Luce and Pisoni claim that a stimulus such as an uttered word activates entries in the lexicon to the degree of similarity to the stimulus. Then the activated lexical entries compete for selection. In a final stage, the lexical entry with greatest activation is most likely to be selected. In other words, in a dense neighborhood, a stimulus activates many lexical items, which results in relatively smaller differences among lexical items. Thus lexical entries in dense neighborhoods are accessed with reduced efficiency.

On the other hand, frequency affects the efficiency of lexical access as well. All else being equal, a lexical item with higher frequency is prone to achieve an easier access. Furthermore, high frequency mitigates the dense neighborhood effect. Thus, a high frequency lexical item in a dense neighborhood may be accessed nearly as efficiently as one in a low density neighborhood.

Phonemic contrast (i.e. neighbors) and relative token frequency interact and function to produce contrast: effective contrast (Ussishkin and Wedel, 2002). Thus, two lexical items can have the same effective contrast but have different neighborhood density and frequency. For instance, an infrequent lexical item in a sparse neighborhood may have the same effective contrast as a relatively frequent one in a dense neighborhood.

3.2. Implementation of ‘effective contrast’

Ussishkin and Wedel (2002) modeled ‘effective contrast’ in order to account for the uncommon behavior of affixes in Hebrew. See Ussishkin (2005) for details. Although ‘effective contrast’ is not originally modeled for sound changes, it predicts a certain pattern of phonetic variability.

For the purpose of this study, I add familiarity to the token frequency as factors to affect sound variability, and propose “FAMIQUENCY”. The FAMIQUENCY represents the decision by interacting between token frequency and word familiarity. The word familiarity plays an important role to decide the FAMIQUENCY. As a consequence, two words with same token frequency may have different FAMIQUENCY depending on word
familiarity. Therefore, a familiar word with a low frequency may have high FAMIQUENCY, whereas an unfamiliar word with a low frequency has low FAMIQUENCY. For example, /nahta/ ‘give birth to’ has a low or a moderate frequency. However, it is a familiar word, and easy to utilize whenever applicable. Thus, FAMIQUENCY of /nahta/ maintains high.

Then how do FAMIQUENCY and neighborhood influence each other in terms of sound changes? I assume that low FAMIQUENCY and/or a dense neighborhood lead speakers to phonetic variability. When a lexical item has high FAMIQUENCY, speakers do not necessarily hesitate to pick up the standard form; the high FAMIQUENCY will mitigate the dense neighborhood effect and improve efficiency to access the standard form. However, lexical items which do not maintain enough effective contrast result in phonetic variation. When speakers are exposed to a lexical item with insufficient contrast, they may produce output by analogy to other items in the neighborhoods. For instance, when speakers have access to /tahta/ ‘reach’ which has low FAMIQUENCY in a dense neighborhood, thus, low effective contrast, they have difficulty in articulating the standard form [ta.tʰ'a]. The innovative form [ta.tʰ'a] may be produced by analogy to the lexical item with high effective contrast such as /tatta/ ‘close’. The effect of analogy is to apply a different person and result in different degree of variability.

In this research, I categorize stimuli into three sets according to the FAMIQUENCY and neighborhood density and will examine the findings through the prediction. I predict that (i) the lexical items with high FAMIQUENCY in a sparse neighborhood, such as /cohta/ ‘be good’ /nəhta/ ‘put s.t. into’ /nohta/ ‘put s.t. on’, will have optimal effective contrast. No variation is predicted, so the /h/ merges with the following onset and aspirates. On the other hand, (ii) the word which has high FAMIQUENCY in a dense neighborhood, such as /nahta/ ‘give birth to’, may have phonetic variability to some degree. The /h/ may trigger tensification instead of aspiration by analogy to similar forms such as /nasta/, /nacta/, and /nas'ta/. (iii) the low FAMIQUENCY lexical item in a relatively dense neighborhood, /tahta/ ‘reach’ ‘touch’ has little effective contrast. Accordingly, it is difficult for speakers to access the standard form, [ta.tʰ'a]. I predict that /tahta/ may realize as an innovative form, [ta.tʰ'a] rather than a standard form, [ta.tʰ'a] to a great degree. The rate of phonetic variability will be increased if a neighbor has high FAMIQUENCY. I also expect that ‘words in isolation task’ will have more innovative form than ‘words in context task’ of two test types, because a psychological neighborhood density is increased in the word list. As the words in a word list appear to be denser than words distributed in a story, speakers may consider the lexical items in the word list much more similar to each other. I propose this effect a psychological neighborhood density.

4. Methodology

4.1. Subjects

Twelve fluent Korean speakers participated in the study. The participants are grouped according to their age and gender. Four of them are teenagers; another four in their 20s; and another four in their 30s and 40s. Each group consists of two males and two females.

4.2. Procedure

Interviews were conducted in the quite room at a church in Victoria, British
Columbia. The participants were asked to read a short story written in Korean. Right after reading a story, they were asked to read a word list of nine words. Each word was read three times consecutively. The word list is provided in (5), (6), and (7) below. The interviews were recorded using a Sony MZ-B10 portable min-disc recorder and a Lavalier Condenser Microphone. Data were digitalized to a computer using Sony Mini Disc Recorder MDS E10 and Audacity.

4.3. The data

4.3.1 Tokens

Tokens were selected by permuting 14 onset consonants (p, pʰ, t, tʰ, k, kʰ, c, cʰ, s, h, m, n, η, l) and six vowels (a, ə, o, u, i, i) plus coda /h/: five possible roots out of 84 permutations are obtained. Suffix /ta/ was added to the monosyllabic roots.

I categorize these tokens into three groups depending on the presence of minimal pairs and the degree of frequency and familiarity: FAMIQUENCY. The group I consists of three items which have no neighbors with high FAMIQUENCY as in (5). The group II comprises one lexical item with high FAMIQUENCY with a control group where three lexical items are neighbors as in (6), in which I predict both innovative form and standard form. The group III has one item which has very low FAMIQUENCY and a control group having one neighbor with high FAMIQUENCY as shown in (7), where a high degree of variation is predicted.

(5) Group I: No Neighbor and High FAMIQUENCY
a. /coh-ta/ ‘be good’
b. /nah-ta/ ‘put s.t. into’
c. /noh-ta/ ‘put s.t. on’

(6) Group II: Three Neighbors (control group) and High FAMIQUENCY
a. /nah-ta/ ‘give birth to’
   Control group
b. /nac-ta/ ‘be low’
c. /nas-ta/ ‘get well’
d. /nas’-ta/ ‘(past) get become’

(7) Group III: One Neighbor and Low FAMIQUENCY
a. /tah-ta/ ‘reach’ ‘touch’
   Control group
b. /tat-ta/ ‘close’

In total, 432 tokens were recorded from 12 speakers: 9 words x 12 speakers = 108 (in the context) plus 9 words x 3 times repetition x 12 speakers = 324 (in the word list). In the isolated word condition, the middle of the three repeated tokens was chosen to

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3 The minimal pair in this paper is restricted to the pairs which exhibit one segment difference, which is /h/. Thus /tahta/ and /tatta/ are minimal pairs, but /nahta/ and /nohta/ are not regarded as minimal pairs for the clarity of the research. However, /nahta/ and /nohta/ are likely to influence each other to produce high degree of aspirated onset. This fact is not considered in this paper.
encode; other repetitions (216) were discarded. Thus 216 tokens were analyzed: 120 tokens from words with /h/, 96 tokens from words with other obstruents (control group).

4.3.2 Frequency and familiarity (FAMIQUENCY)

In order to confirm the frequency of tokens, a corpus which contains 121,675 words is built by collecting on-line newspapers. The tokens of the corpus are counted using Microsoft Word Editing Function. Table 2 shows the results of the frequency.

Table 2: Frequency of tokens in the corpus (out of total 121,675 words)

<table>
<thead>
<tr>
<th>Group</th>
<th>Tokens</th>
<th>Token frequency</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>coh</td>
<td>164</td>
<td>0.13478529</td>
</tr>
<tr>
<td></td>
<td>n̄h</td>
<td>24(^5)</td>
<td>0.01972468</td>
</tr>
<tr>
<td></td>
<td>noh</td>
<td>100</td>
<td>0.08218615</td>
</tr>
<tr>
<td>II</td>
<td>nah</td>
<td>9</td>
<td>0.00739675</td>
</tr>
<tr>
<td></td>
<td>nas</td>
<td>3</td>
<td>0.00246558</td>
</tr>
<tr>
<td></td>
<td>nas'</td>
<td>114</td>
<td>0.09369221</td>
</tr>
<tr>
<td></td>
<td>nac</td>
<td>55</td>
<td>0.04520238</td>
</tr>
<tr>
<td>III</td>
<td>tah</td>
<td>2</td>
<td>0.00164372</td>
</tr>
<tr>
<td></td>
<td>tat</td>
<td>7</td>
<td>0.00575303</td>
</tr>
</tbody>
</table>

(Italianized words are control groups which undergo tensification)

As can be seen in Table 2, group I exhibits high token frequency. In addition, /cohta/ ‘to be good’ /n̄hta/ ‘put s.t. into’ /nocta/ ‘put s.t. on’, are familiar words. The FAMIQUENCY of this group is high. In group II, /nah/ does not show high frequency, but it is still higher than words in group III. Despite moderate token frequency of /nahta/ ‘give birth to’, I claim that /nahta/ is a high FAMIQUENCY word because of its familiarity. /nahta/ is an easy word and used in both written and spoken forms when applicable. In group III /tah/ exhibits low frequency. I claim that /tahta/ ‘touch, reach’ is not a word with familiarity. It is usually used in written form such as literature. The unfamiliarity causes /tahta/ to even lower FAMIQUENCY. The control token /tatta/ does not have high frequency, but it is a familiar word which maintains its FAMIQUENCY high.

4.4 Analysis

Throughout the data, onset obstruents are analyzed whether they undergo aspiration or tensification. The aspiration or tensification of the onset consonants are determined by the investigator, trusting her intuition as a native speaker and a linguist. The 216 tokens (9 words x 12 speakers x 2 conditions = 216 tokens) are all analyzed whether the onset obstruents undergo tensification or aspiration.

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\(^4\) The first trial of having frequency of the data was made with the translated novel, Da Vinch Code. The results did not seem to reflect proper frequency due to the limited usages of vocabulary. The corpus from Da Vinch Code was discarded. In order to obtain the words used on the daily basis, I drew a corpus from on-line newspapers. The corpus was built by copying from the newspapers and pasting in Microsoft Word.

\(^5\) Note that the frequency of ‘nah’ is not as high as ‘coh’ and ‘noh’, but higher than words in group II and III (except for the control tokens).
5. Results

Of the 120 tokens expected to produce an aspirated onset, 87 tokens (72.5\%) exhibits aspiration. Of these 87 aspirated tokens, 49 tokens (56.3\%) come from the test with the words in context, and 38 tokens (43.6\%) occurred in the test with the words in isolation.

5.1. The results of the group

The figure 1 shows that the group I exhibits little variation. In the instance of words in context, one out of 36 tokens (2.8\%) shows tensification, but the variability increases when lexical items were read in a word list: five tokens are found (13.9\%).

Group II in the figure 2 illustrates that the variability of /nahta/ increases when tested in isolation: one out of 12 tokens (8.3\%) is found in context, and eight out of 12 tokens (66.7\%) are obtained in isolation.

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\(^6\) Please notice that in the graph /nahta/ is spelled /nehta/ because of the restriction on what font can be used in graphs.
Figure 2: *Group II*

Group III in Figure 3 demonstrates high variability whether in context or in isolation. The words read in a short story show nine tokens out of 12 (75%). Of nine variations, eight cases exhibit tensification of the onset obstruent (88.9%) and one shows vowel insertion (11.1%). In the word list test, on the other hand, ten tokens which show variation are observed (83.3%): seven with tensification (70%) and three with vowel insertion (30%) are shown among variations. The rate of vowel insertion increases to 19.9%.

Figure 3: *Group III*

5.2. The results by Age and Gender

Throughout the results, no noticeable difference is observed by gender and by age group between 20s and 30s/40s. However, the teenage group shows an interesting phenomenon. 10s tend to produce vowel insertion rather than tensification where the variation occurs. From the Table 5, we can see 11 variations in the words in context...
situation. Of 11 variations, two vowel insertions are observed and they are produced by 10s group. More striking results are from the word list test. Of 23 variations, 10 vowel insertions are found and all of them are outputs of teenagers. The results are summarized in Table 3 and 4.

Table 3: Variation types by age group (tensification vs. vowel insertion) in words in context task

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Vowel Insertion</th>
<th>Tensification</th>
</tr>
</thead>
<tbody>
<tr>
<td>10s</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>20s</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>30s/40s</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 4: Variation types by age group (tensification vs. vowel insertion) in words in isolation task

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Vowel Insertion</th>
<th>Tensification</th>
</tr>
</thead>
<tbody>
<tr>
<td>10s</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>20s</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>30s/40s</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>

6. Discussion

Phonetic variability is exhibited when a sound has been undergoing diachronic change (Phillips 1984). I claim that /h/ in coda position in Korean is undergoing change of phonological process from triggering aspiration to triggering tensification, the behavior of obstruents rather than glottal fricative /h/. I argue that this sound change, i.e., from aspiration to tensification, occurs to a varying degree depending on the FAMIQUENCY of the lexical item and its neighborhood.

If my prediction is correct, the group III /tahta/ ‘touch, reach’, the unfamiliar word used least frequently in a dense neighborhood, may exhibit the highest degree of variability. On the other hand, /cohta/ ‘to be good’ /nahta/ ‘put s.t. into’, /nocta/ ‘put s.t. on’, (group I) familiar words occurring most frequently in the least dense neighborhood are not predicted to have variation. Furthermore, /nahta/ ‘give birth to’ (group II) which has the most dense neighborhood and high FAMIQUENCY may show variation to some degree.

The results of the experiment show that my hypotheses are correctly predicted. First, group I, as shown in Figure 1 above, exhibit little variation: 2.8% and 13.9% in context and in isolation respectively. This reflects the fact that effective contrast is salient enough to access the lexical items. Therefore speakers successfully produce a standard form, ‘the aspirated onset’. Figure 4 illustrate effective contrast of the group I visually.
The small bars represent neighbors (tokens of minimal pair in this research) and the thicker bar in the middle represents FAMIQUENCY. The different degree of variation between words in context and words in isolation is noticed. When the words are produced while reading a story, participants did not have difficulty in producing standard forms. However, sequences of words are similar enough to confuse speakers, in which case they adopted vowel insertion.

Vowel insertion is not predicted, but it is not a surprising result. I argue that speakers inserted a vowel as a strategy to avoid the choice of aspiration or tensification; /nahta/, /nacta/, /nasta/, and /nast' ta/ can be all realized as [na.a(t)a] in a standard form regardless of underlying representation. There are two characteristics in choosing vowel insertion as a variation. First, throughout the results, most cases of vowel insertion are found among teenage participants (14 out of 15 tokens, 93.3%; if results of control groups are excluded, 100% of vowel insertion are observed in teenagers). Second, a large number of vowel insertions are observed in a word list task (13 out of 15 tokens, 86.7%).

The fact that teenage participants are more likely to produce a vowel insertion shows that teenagers are flexible in terms of language skills. If they do not know the standard form, they may find another strategy to avoid the choice given in the situation. It is interesting that the teenage participants took a strategy of neutralization (Vowel Insertion) rather than analogy (Tensification). The second characteristic confirms that the task of words in isolation is more challenging in that psychological neighborhood density is increased.

Group II, which has high FAMIQUENCY in a dense neighborhood, was predicted to have phonetic variability to some degree. The results illustrated in Figure 2 above show that the prediction is partly met: in the task of reading in context, no substantial variation is observed (8.3%). This proves that FAMIQUENCY mitigates neighborhood density effect somehow. Thus effective contrast is maintained enough to access standard forms. However, 66.7% of innovative form is produced in the word list task. I argue that high rate of variability is resulted from the psychological effect. As the word list task probably drew participants too much attention to neighbors, psychological neighborhood density is increased.

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7 In some cases, glottal stop after vowel was heard.
8 Three of the teenage participants have stayed in Canada less than 6 month, and one is a balanced bilingual. No noticeable difference is found among them in terms of types of variation.
9 I consider vowel insertion neutralization, because it neutralizes contrast between tensification and aspiration.
radically increased. As a consequence, effective contrast is decreased despite high FAMIQUENCY.

Figure 5 illustrates that contrast is sufficient enough to access the proper lexical item, but it is not as effective as in Figure 4. Therefore, sometimes dense neighbors lead speakers to produce variable outputs. The effective contrast in figure (5b) is lower than the effective contrast in (5a) due to the psychological effect caused by artificial increase of neighborhood density in the word list, i.e., psychological neighborhood density.

![Figure 5: Effective contrast in group II](image)

Group III, a low FAMIQUENCY word in a relatively dense neighborhood, is expected to have little effective contrast and the speakers are less likely to successfully access the standard form. If my prediction is correct, group III may show highest rate of variability and the results in Figure 3 proves the great degrees of variation.

Figure 6 describes effective contrast for group III visually. The low FAMIQUENCY of lexical item /dahta/ ‘reach’ ‘touch’ and the presence of a neighbor interplay and drastically reduce effective contrast. Figure 3 above shows the great degree of variability (75% and 83.3) regardless of test types.

![Figure 6: Effective contrast in group III](image)

As can be seen above, effective contrast is very low, so that the rate of innovative form increases by analogy to other obstruents (POT).

Another motivation of the high variability of this group is that the neighbor /tatta/ ‘close’ is a higher FAMIQUENCY word than /tahta/. Luce and Pisoni (1998) argue that the
accessibility to a lexical item is affected to a little degree by frequency of its near neighbors: “neighborhood frequency”. All the factors, i.e. FAMIQUENCY, neighborhood density, and neighborhood frequency being considered, the variability of group III is correctly predicted and well explained.

7. Conclusion

Studies on /h/ variation have not been done before Lee (2004). In the present study, I examine Lee’s claim that /h/ undergoes POT rather than aspiration. An experiment with 12 participants was conducted in order to investigate degrees of aspiration or/and tensification. The data grouped into three categories depending on presence of minimal pairs and FAMIQUENCY are examined. Within a modified theory of ‘effective contrast’ (Ussishkin and Wedel, 2002), I predict and explain the results: the group I has salient effective contrast and does not exhibit significant variation. The group III has little effective contrast and show variation to a great degree. The group II is in-between I and III, and demonstrates differences depending on the test method.

Through the findings, I conclude that /h/ is undergoing sound change: from aspiration to tensification. Given the overall results, it is not plausible to conclude that the underlying phonological process of coda /h/ is tensification. The presence of the phonological process that /h/ triggers tensification, i.e. POT should still be considered as phonetic variation at the moment. However, in the case of /taht a/, the sound change seems to be established to great extent. Therefore, considering increased tokens with tensification in this study and overall tendency of getting testified of plain stops in the onset position (Kwen 2001; Shin and Davis 2003), the innovated form may slowly take over the standard form and make no distinction between /h/ and other obstruents.

There are limitations in this study; because there are a limited number of possible words, the stimuli were not evenly distributed in each group. It remains for future research to test lexical density effect by creating nonsense words in order to control the number of neighbors. Also, providing concrete definition of FAMIQUENCY and quantifying the familiarity of the words are left for the future study.

References


