

The Use of Phonetic Evidence for the Phonological Controversies: A Case of Leftward Tone Spreading

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This paper seeks a phonetic assessment of a tonal alternation in Hamkyeong Korean, a yet little studied pitch accent language. The tonal alternation has been analyzed as a leftward tone spreading in previous studies. Central to the analysis in the present study is the claim that tone alternation in Hamkyeong Korean can be better accounted for in terms of phonetic implementation of high tones rather than phonological analysis of leftward tone spreading. In the experiment, Hamkyeong Korean speakers' speech data were pitch tracked and measurement was conducted on fundamental frequency (F0 henceforth) values of pitch peak, pitch trough and intermediate points. Statistical results show that F0 values of the intermediate points result from a linear transition function of F0 values of peak and trough and the temporal distance from the peak. This supports the claim that there is no tone spreading in Hamkyeong Korean and the phenomenon previously considered as a phonological process is a result of phonetic implementation.

Key words: phonetics and phonology interface, phonetic implementation, leftward tone spreading, Hamkyeong Korean

1. Introduction

As speech is both discrete and continuous, the relationship between phonetics and phonology has long been the subject of debate. By and large, there have been two different positions regarding phonetics and phonology. The first is the traditional view that was adopted in the generative phonology since *The Sound Pattern of English* (SPE henceforth). The SPE view assumed that the binary features of the phonology

were translated into numeric scales, and this procedure was called 'the phonetic implementation.' Everything beyond this numeric specification of features, for example coarticulation, was thought to be universal and therefore outside the scope of the linguistic grammar. Thus the distinction between phonological rules and phonetics appears to be clear cut: phonology is equal to the language specific rules whereas phonetics consists of universal mechanical realization of the phonology. As a consequence, phonetic implementation was little help from a linguistic point of view. Phonology serves as a substantial part of grammar and there is only an arbitrary relation between phonetics and phonology across languages.

Since 1980s, much evidence of the language-specific nature of coarticulation and other aspects of phonetic implementation has been widely noted. Recent works on phonetic implementation have led to a view that linguistic aspects of the phonetics are a system parallel to the phonology: phonetics is distinct from phonology. The core idea is that phonology manipulates discrete abstract unit (target interpretation) and phonetics manipulates gradient quantitative values which are context-sensitive. This distinction has been underscored by the discovery that a number of patterns that had previously been analyzed in terms of phonological rules are better analyzed as gradient phonetic implementation: Japanese tone 'spread' (Pierrehumbert & Beckman 1988), lateral velarization in English (Sproat & Fujimura 1993), and English vowel nasalization (Cohn, 1993).

Clarifying this distinction is of fundamental significance to both phonetics and phonology. If we cannot reliably distinguish phonological pattern from phonetic pattern, we do not know what facts our theories of these domains should be held accountable for. Not enough work has been devoted to distinguishing the two sorts of patterns. More than twenty years after Pierrehumbert (1980) established the need for a phonetic implementation component, we still have no more than a vague idea of the properties that distinguish phonetic implementation from phonology.

One theoretical aim of the proposed study is to address this important but understudied issue. For every pattern in fundamental frequency (F0 henceforth) that we encounter, we should consider two types of model: phonology and phonetic implementation. The comparison of the two models will contribute to our understanding of the distinction between the two sorts of pattern.

In the same line with the distinct phonetics-phonology model, this paper explores a phonetic examination of a phonological analysis of the tone

pattern of the Hamkyeong dialect of Korean, a yet little studied pitch accent language spoken in the northeastern part of Korea. The data for the present study were obtained from three native speakers of Hamkyeong Korean who have politically defected to South Korea since 1990. I argue in this paper that a better understanding of the relationship between phonetic implementation and phonological representation provides another description of the facts that have been considered as a phonological process in Hamkyeong Korean.

Since the ground-breaking work by Ramsey (1978), the tone system of Hamkyeong Korean has been studied by researchers such as Cheong (1988), Cheon (1993), G-R Kim (1988), and Kwak (1991). As Kwak (1991) and Cheon (1993) pointed out, most of the previous studies do not reflect the dialect that is currently spoken in Hamkyeong provinces, because they are based on the impressionistic data obtained from Hamkyeong speakers who have resided in South Korea since the Korean War. The present study distinguishes itself from the previous studies in this respect. The data were collected during the period of 1996-1997. The recording was made on digital audiotape and all of the data were confirmed by the acoustic analysis of pitch tracking.

The remainder of the paper is organized as follows: The aspects of the pitch realization pattern in Hamkyeong Korean and the phonological analysis are introduced in section 2. Given the problems of the phonological analysis pointed out in section 2, a brief sketch of the literature on phonetic interpolation will be presented in section 3. The experimental method and the statistical analysis of F0 linear interpolation will be addressed in sections 4 and 5 respectively. Implications of this study will be discussed in the conclusion.

2. Phonological Analysis of Pitch Assignment Rule

Before proceeding to discussion of the pitch assignment rule in Hamkyeong Korean, let us begin with a brief sketch of the tone pattern in Hamkyeong Korean. There are several characteristics of verbal morphology of Hamkyeong Korean which differ from Seoul Korean. First, it has no honorification suffixes such as *-si* in Seoul Korean. Second, a causative suffix *-li* does not occur in Hamkyeong Korean. In stead, other causative suffixes such as *-ki* and *-ku* replace it. For instance, *'tol-li-ta'* 'to make

something turn' in Seoul Korean corresponds to 'tol-ki-ta' in Hamkyeong Korean (Cheong 1988, p. 217).

With regard to the tone pattern in Hamkyeong Korean, four basic observations should be noted. First, the tone-bearing unit in Hamkyeong Korean is a syllable rather than a mora (Kim, S-A 1997, 1998b, 1999b). Second, there is an asymmetry between high and low tones. All phonological processes involve high tones only. It is always high tone that undergoes tone alternations. Nothing occurs if two low toned syllables are juxtaposed. Presence and absence of low tones does not make any contribution in defining tone classes.

Third, three classes of verbal stems are recognized with regard to the distribution of high tones. The first type is post-stem tone class. In this type of stem, a high tone does not undergo tonal alternation and it is always on the affixal vowel immediately following the stem, as observed in some Slavic languages such as Russian (Halle 1997). The second type is pre-linked class which corresponds to accented stems in previous descriptions. In this class, a high tone is fixed to one of the stem syllables regardless of following affixes. The third type is floating tone class. In this class, a high tone in a stem alternates when followed by various suffixes. The high tone is realized on the stem if it is followed by a consonant-initial suffix, otherwise the suffixal vowel is high toned. There are several exceptional forms in the floating tone class. More detailed analysis of tone patterns within Optimality theory is found in S-A Kim (1999b).

Finally, Hamkyeong Korean is subject to the Obligatory Contour Principle. In other words, one and only one syllable is high toned in a word in Hamkyeong Korean. Compounds are also subject to the Obligatory Contour Principle (Kim, S-A 1997, 1998b, Ramsey 1978). Consider the tone pattern in (1). In (1), /E/ and /I/ represent mid central vowel and unrounded high back vowel respectively and high-pitched syllables are indicated by bold.

(1) Tone patterns in compounds

- | | | | | | |
|-----------------|-----------------|--------------|------------------------|----------------|-----------------|
| a. nun | 'eyes' | mul | 'water' | nunmul | 'tears' |
| b. pi | 'rain' | soli | 'sound' | pisoli | 'sound of rain' |
| c. yElIm | 'summer' | os | 'clothes' | | |
| | yElImos | | 'summer clothing' | | |
| d. mul | 'water' | koki | 'meat' | mulkoki | 'fish' |
| e. pal | 'foot' | patak | 'sole' | | |
| | palpatak | | 'the sole of the foot' | | |

In Hamkyeong Korean, phrasing can produce a relatively long sequence of low toned syllables after the tone sandhi is applied as shown in (2). In (2), syllables with the highest pitch are indicated by bold.

- (2) Tone patterns in phonological phrases
- a. hamkyENto mAl ‘dialect of Hamkyeong province’
 - b. hamkyENto mal yEnku ‘a study of Hamkyeong dialect’
 - c. hamkyENpukto mal yEnku
 ‘a study of the dialect in North Hamkyeong province’

The generalizations born out of the above data are summarized in (3).

- (3) The generalizations of the tone pattern in phonological phrases
- a. One and only one syllable is high toned in a phonological phrase.
 - b. If high tone-bearing syllables are adjacent, then the leftmost one is high toned.
 - c. If high tone-bearing syllables are not adjacent, the rightmost one is high toned (Ramsey 1978).

Researchers in previous studies have a tendency to assign every tone-bearing unit a specific phonological tone (such as High and Low). However, there is a fundamental problem with this approach. Previous studies do not make a distinction between lexical and non-lexical tones. Consequently, they assume many phonological rules to account for the pitch pattern at the post-lexical level. Pitch Assignment Rule (Ramsey 1978, p. 70) is one of such cases:

- (4) Pitch Assignment Rule (PAR):

Within a phonological phrase, the initial mora is low pitched, unless it is accented, and all the moras following an accented mora are also low-pitched. All the remaining moras are high pitched (condition: optional).

The PAR can be restated as follows: Non-initial syllables optionally become high pitched when they are followed by a high tone-bearing syllable in a phonological phrase. Therefore, words are supposed to exhibit the pitch pattern schematically illustrated in (5). Underlyingly high tone-bearing syllables are marked by an acute marker and high-pitched syllable created by PAR is underscored in (5).

(5) Pitch pattern of a phonological phrase (slightly modified version of Ramsey 1978)

a. Two syllables

$\sigma \ \sigma'$
 $\sigma' \ \sigma$

b. Three syllables

$\sigma' \ \sigma \ \sigma$
 $\sigma \ \sigma' \ \sigma$
 $\sigma \ \underline{\sigma} \ \sigma'$

c. Four syllables

$\sigma' \ \sigma \ \sigma \ \sigma$
 $\sigma \ \sigma' \ \sigma \ \sigma$
 $\sigma \ \underline{\sigma} \ \sigma' \ \sigma$
 $\sigma \ \underline{\sigma} \ \underline{\sigma} \ \sigma'$

In autosegmental analysis of pitch pattern in Hamkyeong Korean, G-R Kim (1988) interpreted the PAR as a post-lexical leftward high tone spreading rule, followed by an Initial Dissociation rule, as shown in (6a) and (6b) respectively.

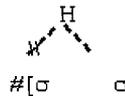
(6) Autosegmental interpretation of pitch assignment rule:

Leftward H-spreading and Initial Dissociation

a. Leftward H-spreading



b. Initial Dissociation



(Condition: Leftward H-spreading and Initial Dissociation are both optional)

According to the leftward H-spreading rule, any sequence of syllables preceding a high tone-bearing syllable can be an optional target of a high tone spreading as long as it is followed by the Initial Dissociation rule. It does not matter how many syllables precede the high tone-bearing syllables.

The problem of the phonological analysis arises from the fact that such a long-distance leftward high tone spreading is typologically peculiar in several respects. First, the tone spread as described above is unusual in the sense that it is the only type of tone spreading in Hamkyeong Korean. It should be noted that there is no rightward spreading in Hamkyeong Korean. It is not typologically common to have a leftward tone spread in a language where no rightward tone spread is attested (Hyman in personal communication). Given that leftward tone spreading is cross linguistically more marked than rightward tone spreading (Hyman & Schuh, 1974), the naturally arising question is why it is the case that more marked tone alternation should be assumed in a language where less marked tone alternation does not occur. Is Hamkyeong Korean an exception to the cross-linguistic generalization?

More importantly, the pitch track result as shown in Figure 1 casts

serious doubts about the phonological analysis of the leftward tone spreading. The Figure shows the waveform display, F0 contour and spectrogram corresponding to a compound noun *hamkyENto mal* ('Hamkyeong dialect'). Segmental transcription is given at the bottom of the Figure. In the pitch track, the sharp trough at the beginning of the word should be noted. I observed a recurrent pattern of such a trough. This recurrent F0 trough is always aligned with the initial syllable. I interpret the F0 trough as a type of a non-lexical tone: low boundary tone (i.e., L%), as argued in Pierrehumbert and Beckman (1988). On the other hand, the F0 peak corresponds to a lexical high tone. With respect to the F0 peak, it should be noted that only a single F0 peak is shown and it corresponds to the high tone affiliated to the second component of the compound (i.e., *mal*).

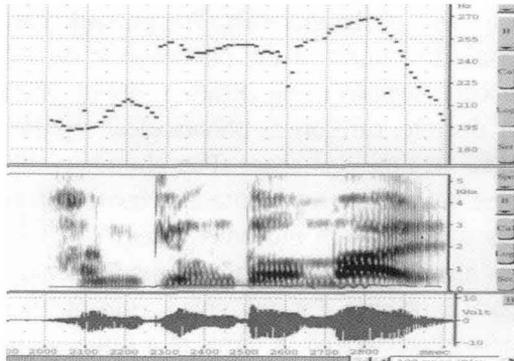


Figure 1. A pitch track of a compound noun: hamkyENto mal.

Now let us move on to the non-initial syllables preceding high tone-bearing syllables (i.e., *kyEN, to*). They appear to have F0 values significantly different from the F0 value of a high tone-bearing syllable (i.e., *mal*). It should be noted that the word spoken in a citation form is supposed to undergo the Leftward H spreading in phonological accounts. If tone spreading refers to a single high tone shared by multiple tone-bearing units as assumed in the non-linear representation of tone spreading, how can we account for the significantly different F0 values among the syllables?

The experimental analysis in the present study suggests a totally different understanding of facts previously described as a tone spreading. I claim that such a tone spreading does not exist in Hamkyeong Korean and that the phenomenon previously analyzed as tone spreading is in fact a conse-

quence of phonetic interpolation between low boundary tone and lexical high tone (cf. Kim, S-A, 1998a, 1999a for other languages).

3. Alternative Phonetic Account: Target-Interpolation Model

Compared to the unnatural accounts of the phonological analysis given in section 2, the pitch pattern in question is not typologically unusual from the perspective of a target-interpolation model of phonetic representation (Keating, 1988, 1990a, b). Keating distinguishes categorical phonological pattern from phonetic implementation in which a linguistic element's value for a particular feature is gradient and transitional. She assumes that phonetic implementations are linguistic structures, insofar as they are derived by a component of the grammar. The phonetic component consists of rules which map the output of the phonological component to a level of parametric phonetic representation (Keating, 1990b). Phonetic representations differ from discrete, categorical phonological representations in that they are continuous in time and space (Pierrehumbert, 1980). It is further assumed that these parametric representations consist of targets and interpolation functions which govern movement from target to target.

Phonetic targets are defined as abstract representational units with both spatial and temporal properties. For any given segment, there is a phonetic space which can be characterized in terms of a finite set of phonetic parameters associated with that element. There is also evidence that targets may be time-aligned with segment-internal landmarks or structures (Huffman, 1993; Kingston, 1990). In comparison, surface phonetic realization of non-targets exhibits variation and is determined by phonetic interpolation.

The core idea of phonetic interpolation is well captured by Keating (1988) who proposes that not every linguistic element is fully specified and the phonetic values for underspecified segments may be independently derived by principles of phonetic implementation which depend on neighboring target values.

Consider, for example, the often cited case of intervocalic /h/. Glottal fricatives are typically thought to be phonologically unspecified for supralaryngeal features. If this underspecification persists into the phonetic component then [h] would lack phonetic targets (e.g. tongue body specifications) which would perturb an otherwise smooth and continuous trajectory from the initial vowel to the following vowel in [VhV] sequences.

Stated in other terms, the spectral shape of [h] is entirely predictable from the adjacent vowels. Choi (1995) also found that F2 value of schwa in Marshallese is dependent on the surrounding vowels. Cohn (1993) and Huffman (1993) observed similar dependency in nasality in Sundanese and Yoruba respectively.

Phonetic interpolation is not limited to segmental features. It is also found in suprasegmental features. Pierrehumbert (1980) demonstrated that not every syllable is tonally fully specified in English. Pierrehumbert and Beckman (1988) argued that the syllables previously described as low tones are in fact toneless where their F0 values are determined by phonetic interpolation between two targets in Japanese. Davison (1992) also showed that the F0 values of tone in unstressed syllable are a result of phonetic interpolation of adjacent tones in northern Mandarin.

To sum up, recent phonetic studies indicate that the not every linguistic element has articulatory target, and thus the phonetic values for elements lacking articulatory targets are assigned by a transition function, which depends on nearby target values.

These phonetic studies are important in the sense that they provide crucial counter-evidence against the phonological analyses which assume a full specification for each linguistic element. Such phonological analysis ranges from derivational autosegmental analysis of tones to Optimality theory (McCarthy & Prince, 1995).

4. Experimental Method

In the experiment conducted in this study, the recording was obtained by one male and two female Hamkyeong Korean speakers. Demographic information of the speakers is tabulated in (7). They are recently fled from North Korea and immigrated into South Korea.

(7) Demographic information of the speakers

Speakers	Age/Gender	Birth Place
CTC	30 /male	North Hamkyeong Province (Onseong)
JHY	52 /female	South Hamkyeong Province (Hamhung)
LSO	50 /female	North Hamkyeong Province (Cheongchin)

The hypotheses being tested in the experiment are as follows:

(10) The hypotheses:

- a. There is no tone spread in Hamkyeong Korean.
- b. F0 values of non-peaks are interpolation between the F0 peak corresponding to a lexical high tone and the F0 trough corresponding to a low boundary tone.

The hypothesis in (10a) is concerned with the issue of what is expected by the phonological analysis of tone spreading. In autosegmental phonology, the tone spread is formalized as the process in which two tone-bearing units share the same tone. Therefore, tone-bearing units associated with a single tone are expected to have the same F0 value, resulting in an F0 plateau laid upon the multiple tone bearing units (Pierrehumbert & Beckman 1988). The tone spreading analysis predicts that F0 values of syllables preceding the F0 peak are irrelevant to the temporal distance from the F0 peak corresponding to the high tone. Consequently, the hypothesis in (10a) is supported if the temporal distance from the F0 peak turns out to be a significant factor in determining the F0 values of the syllables preceding the high tone-bearing syllable in Hamkyeong Korean.

The hypothesis in (10b) is supported if the F0 value of syllables preceding high tone-bearing syllables is a linear function of F0 values of two tonal targets (i.e., lexical high tone and non-lexical boundary tone).

5. Results and Discussions

First of all, the mean F0 values of the peak, trough and non-peaks are schematically shown in Figure 2 on the next page. The intermediate non-peaks such as non-peak 1, non-peak 2, and non-peak 3 represent the F0 values of the time points at 30-csec, 20-csec, and 10-csec intervals from the F0 peak. Each slope corresponds to each speaker who participated in the experiment.

The most important aspect of Figure 2 is the absence of F0 plate laid upon non-peak positions. It should be noted that F0 values of non-peak points are inversely related to their position relative to the F0 peak: the farther the non-peak is placed from the F0 peak, the lower it becomes. The another important aspect in Figure 2 is the degree of the slope. Two

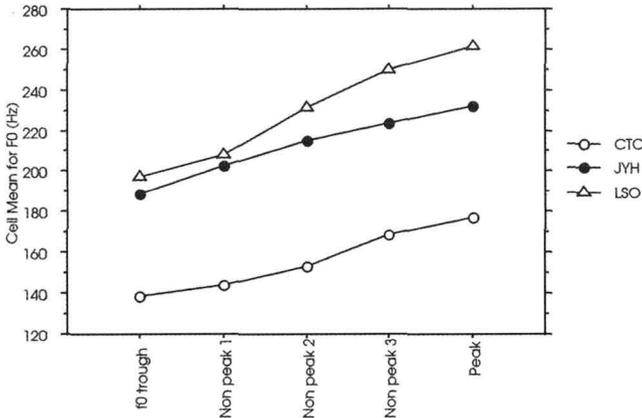


Figure 2. Mean values of F0 at five measurement points.

female speakers (i.e., JYH & LSO) have higher F0 values than the male speaker in general. When the slopes of the two female speakers are compared, LSO who is from northern Hamkyeong province displays a steeper slope than JYH who is from southern Hamkyeong province.

The absence of F0 plateau in Figure 2 leads us to the first hypothesis presented in the previous section. The first hypothesis is that there is no tone spreading in Hamkyeong Korean. If this is the case, then the temporal distance from the F0 peak should be a significant factor affecting the F0 values of non-peaks. ANOVA (repeated measures) was conducted to test the first hypothesis. The temporal distance from the F0 peak was encoded as a variable called 'position.' For example, the time point which is 10-csec away from the F0 peak was encoded as non-peak position 3. Likewise, the time point of 20-csec from the F0 peak was encoded as non-peak position 2. F0 values of non-peak at these time points were given as a dependent variable. Across all the speakers, the temporal distance encoded as 'position' turned out to be a significant factor in determining the F0 values of the non-peaks (P -value < .01 level) as shown in (11).

(11) ANOVA result of position relative to the F0 peak

Speaker	F-value	P-value
LSO	18.125	<.01
CTC	24.048	<.01
JYH	35.711	<.01

Post-hoc Bonferroni tests show that the difference between each pair of points is also significant (P -value $<.05$). Thus, the F_0 decrease from non-peak position 3 to non-peak position 2 is significantly different from the F_0 decrease from non-peak position 2 to non-peak position 1.

To sum up, the hypothesis (10a) in the current study turned out correct.

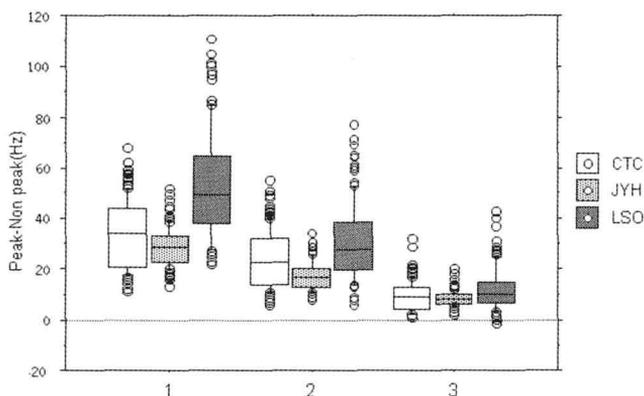


Figure 3. F_0 mean difference between peak and non-peaks.

Figure 3 above illustrates the F_0 mean difference between peak and each non-peak position. For instance, boxes at 1 on the X axis represent the mean difference between F_0 peak and the non-peak 1 which is 30-csec away from the F_0 peak. It can be seen that the F_0 value decrease is greater, the farther it is away from the F_0 peak, across all the speakers. Figure 3 suggests that the extent of F_0 decrease at each non-peak can be predicted as a function of the F_0 values of the peak, the trough, and the position of non-peaks relative to the F_0 peak, as outlined in the hypothesis in (10b). In order to test this hypothesis, stepwise multiple regression analysis was conducted. The multiple regression will find out the best equation to predict the F_0 values of the non-peaks. If the F_0 values are a result of interpolation between two tonal targets, the multiple equation is expected to explain a great portion of the variation in the F_0 values of non-peaks. The relevant variables used in the multiple regression are given in (12):

(12) Variables

- a. Non-peak: F0 values of the non-peak points
- b. Peak: Values of F0 maximum
- c. Trough: Values of F0 minimum at the beginning of the target word
- d. Position: Temporal distance from the F0 peak

In the stepwise multiple regression, the F0 value of non-peak is the dependent variable, while the F0 values of the peak and the trough, and the temporal distance of the non-peak from the F0 peak (i.e., the position relative to the F0 peak) are the independent variables. The regression equations are summarized in (13) below.

(13) Multiple regression equations for predicting the F0 values of non-peaks

Speaker	Multiple regression equation	R ²
LSO	Non-peak=.323*Peak+.752*Trough-20.561*Position +38.109	.96
CTC	Non-peak=.233*Peak+.774*Trough-12.162* Position +31.192	.95
JYH	Non-peak=.643*Peak+.395*Trough-10.395* Position +10.682	.97

In these equations, F0 values of non-peaks are dependent on all of the three factors. The numeric values in the equation indicate the weight of each factor. The R² values reflect the fact that 95-97% of the variation in the F0 values of non-peaks is captured by these equations. Notice that 'position' is the most important factor and it is inversely correlated with the F0 values of non-peaks. This means that non-peaks farther from the F0 peak undergo more F0 decrease, as illustrated in Figure 3. High R² values obtained by the multiple linear regression model in (13) evidence that the F0 values of the non-peaks are a linear interpolation among the three factors mentioned above.

We have seen that for all three speakers, the F0 values of non-initial syllables preceding a high tone-bearing syllable depend on how far they are placed from the high toned-syllable. The longer the temporal distance, the lower the F0 value of the syllable. I proposed that we can account for this fact by assuming that there is no tone spreading and the F0 value is assigned by a linear transition function between F0 peak and F0 trough.

The findings in the study are important both empirically and theoretically. Empirically, this study offers experimental data on tones in Hamkyeong

Korean. Theoretically, this work raises fundamental questions about the distinction between phonetic pattern and phonological pattern. According to the experimental results, the phenomenon previously considered as phonological process is not a pattern that phonological theories have to account for. It results from phonetic interpolation between L% and H. Some might ask why the phonetic approach is considered to be better equipped to account for tonal phenomenon in question. The answer is as follows: The phonetic approach proposed in the study does not require Hamkyeong Korean to be an exception to typologically common phonological patterns. We do not need to resort to the uncommon phonological rule, which simplifies the grammar of Hamkyeong Korean as well. Further experimental studies are sure to help to have a better understanding of tonal phenomena in Hamkyeong Korean.

References

- Cheon, H-S. (1993). *Hamkyeoung Pagnennuy Umcoyeonku (A study on the tone in Hamkyeoung dialect)*. Seoul: Taehaksa
- Cheong, Y-H (1988). *Hamkyeongdo Pangeon Yeonku. (A study on Hamkyeong dialect)*. Pyeongyang: Kyoyuktose Chulpansa.
- Cohn, A. (1993). Nasalization in English: phonology and phonetics. *Phonology* 10, 43-82.
- Choi, J. (1995). An acoustic-phonetic Underspecification account of Marshallese vowel allophony. *Journal of Phonetics* 23, 323-347.
- Davison, D. (1992). Parametric variation in pitch realization of neutral tone syllables in Mandarin. *Proceedings of the 18th Annual Meeting of the Berkeley linguistics society: Special session on the typology of tone*. Berkeley: Berkeley Linguistics Society. 67-79.
- Halle, M. (1997). *On stress and accent in Indo-European*. *Language* 73, 275-313.
- Huffman, M. (1993). Phonetic patterns of nasalization and implication for feature specification. In M. Huffman and R, Krakow eds., *Phonetics and Phonology, Volume 5: Nasals, Nasalization, and the Velum*. San Diego: Academic Press. 303-327.
- Hyman, L. and R. Schuh. (1974). Universals of tone rules: evidence from west Africa. *Linguistic Inquiry* 5, 81-115.
- Keating, P. (1988). Underspecification in phonology. *Phonology* 5, 275-292.

- Keating, P. (1990a). The window model of coarticulation: articulatory evidence. In John Kingsoton and M. Beckman eds., *Papers in Laboratory Phonology 1: Between the Grammar and the Physics of Speech*. Cambridge: Cambridge University Press. 451-490.
- Keating, P. (1990b). Phonetic representations in a generative grammar. *Journal of Phonetics* 18, 321-33.
- Kim, G-R. (1988). *The Pitch Accent System of the Taegu Dialect of Korean with Emphasis on Tone Sandhi at the Phrasal Level*. Doctoral dissertation, The University of Hawaii.
- Kim, S-A. (1997). Accent neutralization in Hamkyeong Korean as an output-to-output correspondence. *Proceedings of 1998 Mid-America Linguistics Society*. 71-83.
- Kim, S-A. (1998a). Phonetic assessment of tone spreading. *Proceedings of the 24th Berkeley Linguistics Society*. 128-138.
- Kim, S-A. (1998b). Two types of high tone in Hamkyeong Korean. Paper presented at the 4th Southwest Optimality Workshop. The University of Arizona.
- Kim, S-A. (1999a). Tone spread decomposed. *Proceedings of the 29th NELS*. 153-166.
- Kim, S-A. (1999b). *Issues in Phonetically Grounded Phonology: Evidence from Suprasegmentals*. Doctoral dissertation, The University of Texas at Austin.
- Kingston, J. (1990). Articular binding. In John Kingston and Mary Beckman eds., *Papers in Laboratory Phonology 1: Between the Grammar and Physics of Speech*. Cambridge: MIT Press. 406-434.
- Kwak, C-G. (1991). *Phonology of Yucin Dialect in Hamkyeong North Province*. Doctoral dissertation, Seoul National University.
- Lieberman, M., J. Schult, S. Hong, and V. Okeke. (1993). The Phonetic Interpretation of Tone in Igbo. *Phonetica* 50, 147-160.
- Lieberman, M. and J. Pierrehumbert. (1984). Intonational variance under changes in pitch range and length. In M. Arnoff and R. Oehler eds., *Language Sound Structure*. Cambridge: MIT Press. 157-233.
- McCarthy, J. and A. Prince. (1995). Faithfulness and Reduplicative Identity. In J. Beckman, L. Walsh Dickey and S. Urbanczyk eds., *Papers in Optimality Theory*. Amherst: GLSA. 249-384.
- Pierrehumbert, J. (1980). *The Phonetics and Phonology of English Intonation*. Doctoral dissertation, MIT.
- Pierrehumbert, J. and M. Beckman. (1988). *Japanese Tone Structure*. Cam-

bridge: MIT Press.

Ramsey, S. R. (1978). *Accents and Morphology of Korean Dialects: A Descriptive and Historical Study*. Seoul: Tower Press.

Sproat, R. and O. Fujimura. (1993). Allophonic variation in English /l/ and its implications for phonetic implementation. *Journal of Phonetics* 21, 291-311.

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