

F0 Extrema Timing of HL and LH in North Kyungsang Korean: Evidence from a Mimicry Task

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ABSTRACT

This paper describes the categorical effects of pitch accent contrasts in a mimicry task. It focuses, specifically, on examining how fundamental frequency (f0) variation reflects phonological contrasts from speakers of two distinct varieties of Korean (i.e., North Kyungsang and South Cholla). The results showed that, in a mimicry task using synthetic speech continua, there was a categorical effect in f0 peak timing for North Kyungsang speakers, but the timing of f0 peaks and valleys in the responses of South Cholla speakers was more variable, presenting a gradient or non-categorical effect. Evidence of categorical effects was represented as the shift of f0 peak times along an acoustic continuum for North Kyungsang speakers. The range for the shift of f0 valley times was much narrower, compared to that of f0 peak times. The degree of a shift near the middle of the continuum showed variability across individual mimicry responses. However, the categorical structure in mimicry responses regarding the clustering of f0 peak points was more significant for North Kyungsang speakers than for South Cholla speakers. Additionally, the finding of the current study implies that the location of f0 peak times depends on individuals' imitative (or cognitive) abilities.

Keywords: mimicry, categorical effect, f0 peak time, f0 valley time, Kyungsang Korean, Cholla Korean

1. Introduction

The phonetic realization of tone contrasts is dependent on a variety of prosodic factors. This paper investigates how the f0 extrema (i.e., f0 peaks and valleys) reflect phonological distinctions in the pitch contours of two varieties of Korean. Furthermore, the current study employs a mimicry task to examine whether the categorical behavior in the timing or alignment of f0 peaks and valleys can be regarded as evidence to account for lexical pitch accent contrasts in a North Kyungsang variety of Korean.

A great deal of research addressing tone as it relates to prosodic phenomena has examined whether the times of f0 peaks and valleys play a reliable role in phonologically

distinguishing prosodic units. For example, Bruce (1977) found that the precise alignment of an f0 peak is the most important cue for a phonetic correlate of Swedish word accent distinction. Arvaniti, Ladd, and Mennen's (1998) study of Greek prenuclear accents examined whether f0 targets for high and low tone are stable in tonal alignment. They revealed that the slope or duration for the alignment of a high and low tone was not constant. The findings of Arvaniti et al's study replicated those of Prieto, van Santen and Hirschberg (1995), which showed f0 peak location in Spanish varies depending on the effects of prosodic factors such as duration and prosodic context.

The distinctions signalled by the alignment of an f0 peak and valley have been investigated within varieties of a language. Atterer and Ladd (2004) found that, in segmental anchoring of f0, there were small but significant differences in the alignment of Northern and Southern German. Speakers of the two varieties differed clearly in low tone, rather than in their production of high tone. Ladd et al's (2009) investigation of the f0 peak alignment of prenuclear and nuclear accents in Scottish Standard

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English and Southern British English revealed the alignment of an f_0 peak for both prenuclear and nuclear accents was earlier in Southern British English than in Scottish Standard English. Arvaniti and Garding (2007) also observed alignment differences between dialects in their analysis of two varieties of American English, Southern Californian English and Minnesotan English.

In order to account for whether given times of f_0 peaks and valleys represent a phonological distinction, various experimental approaches have been employed to measure the prosodic phenomena of languages or language varieties. Pierrehumbert and Steele (1989) used manipulated stimuli to have speakers imitate a number of artificial contours. They observed a bimodal distribution of the times of an f_0 peak in speakers' imitations, and peak alignments were clustered clearly in two categories, reflecting a phonological distinction (e.g., H*+L, L*+H). As an extension of this study, Dilley and Brown (2007) also revealed that the timing of an f_0 extremum was imitated categorically.

The current study examines whether f_0 variations of pitch contours in cross-dialect of Korean show divergence categorically from speakers of two distinct varieties of Korean, North Kyungsang, one of the eastern varieties, and South Cholla, one of the western varieties. According to previous studies related to the Korean pitch accent system, the assignment of a high tone in North Kyungsang Korean is lexically determined (Kim, 1976; Kim, 1988; Chung, 1991; Kim, 1997; Kenstowicz & Sohn, 1997; Kim, 2000; Jun et al., 2006). That is, the location of a high tone in a minimal pair appears as a phonological contrast. This points out the different assignment of a high tone playing a meaningful role in a lexical pitch accent minimal pair (e.g., [kaci]: HL 'kind', LH 'eggplant', HH 'branch'). On the other hand, the assignment of a high tone in South Cholla Korean relies on the phonetic properties of laryngeal features of segments in a phrase-initial position (Jun 1993, 1998). The tone pattern of a phrase begins with a high tone when the phrase-initial segment contains a laryngeal feature, and with a low when it does not. From a phonological view, the realization of a high tone is considered as the association of a high tone and syllable. However, previous studies aimed at distinguishing lexical pitch accent categories have provided an uncertain account for the mapping of f_0 variations and phonological distinctions.

In an acoustic analysis of the relation between f_0 contours and lexical pitch accent contrasts, Kim (2010) suggested that a reliable measurement for detecting lexical pitch accent categories is a relative turning point of f_0 (i.e., the timing of an f_0 peak).

Kim (2012) used a mimicry task to analyze the f_0 measurement of the difference at the mid point of the first and second vowel in a synthetic acoustic continuum. Pitch movement in North Kyungsang Korean was distinguished as a separate category in terms of this measurement point, at least for the HL and LH, contrast though there was a more or less continuous or gradient effect for other pitch accent categories.

The purpose of the current study is to investigate whether there are specific f_0 points (i.e., f_0 peak or valley timing) corresponding to tone levels for detecting a phonological distinction in f_0 variations. This study specifically focuses on a lexical pitch accent contrast, HL versus LH, in North Kyungsang Korean, and examines whether North Kyungsang and South Cholla speakers imitate categorically the timing of an f_0 extremum on the basis of the resynthesized stimulus continuum. Moreover, this paper discusses what factor in the f_0 extremum induces a phonological distinction for North Kyungsang speakers.

The current study applied a mimicry task that involves use of the perceptual, production, or cognitive system. Kim and de Jong (2007) and Kim (2012) reported that there is a correlation between the perception and production systems of lexical pitch accent, using a mimicry task. As in Kim (2012), the current study employed a mimicry paradigm similar to Pierrehumbert and Steele (1989). Participants imitated the pitch of each stimulus that they heard.

2. Experimental Method

2.1 Participants

Two groups of participants were recruited from the North Kyungsang (i.e., Daegu), and South Cholla (i.e., Kwangju) regions. The North Kyungsang (KS) group consisted of five participants, three females (KS1, KS2, KS3) and two males (KS4, KS5) aged 19-20. The South Cholla (CL) group consisted of five participants, five females (CL1, CL2, CL3, CL4, CL5) aged 30-42. All of the native North Kyungsang and South Cholla speakers were born and grew up in their hometown (i.e., Daegu and Kwangju, respectively). None of the participants reported any hearing or speaking problems.

2.2 Stimuli

To create the experimental stimuli, a North Kyungsang speaker from Daegu pronounced a target minimal pair (e.g., [mo.i]: HL 'feed', LH 'conspiracy') with the different location

of the high tone. The token obtained was resynthesized with nine different f0 contours using a pitch-synchronous overlap and add (PSOLA) method in Praat (Boersma & Weenink, 1992-2009).

2.3 Data Analysis

In order to compute the normalized location of an f0 peak and valley, the onset time of the first syllable and the times of the f0 peak and valley were determined, using Praat software. The difference between the onset time of the first syllable (T1) and the time of the f0 peak or valley (T2) was divided by the duration of the target syllable sequence (D), as in Pierrehumbert and Steele (1989) and Dilley and Brown (2007). The normalized f0 peak or valley time was considered by the formula in (1).

$$(1) \text{ Normalized f0 peak or valley time} \\ = T1 - T2 / D$$

The categorical effect of tonal alignment was tested in a univariate analysis of variance (ANOVA) with the lexical pitch accent category (HL, LH) as the independent variable and the effect of stimulus as the dependent variable. When the homogeneity of variance assumption was violated, Welch's *F*-ratio-corrected degrees-of-freedom values were used. In addition, regression plots were used to inspect the relation between the alignment of peaks and syllable duration. This will account for the variation of the f0 peak points associated with the function of syllable duration.

3. Results

3.1 Mean f0 peak times

Figures 1 and 2 show the normalized peak locations for the North Kyungsang and South Cholla speakers. In general, the North Kyungsang speakers supported the distinction of a pitch accent minimal pair. The categorical effect was significant for stimuli 1-3 and 7-9 ($F(1, 28) = 115.087, p < .01, \eta^2 = .80$). As seen in Figure 1, North Kyungsang speakers' imitation of the target showed that the normalized times of f0 peaks in imitations of stimuli 6-9 fall into the range 0.7-0.8, with an apparent shift occurring around stimuli 5-6. This suggests a categorical effect along this stimulus continuum. However, the abrupt shift in normalized peak values in Figure 2 did not occur in imitations produced by the South Cholla speakers. The differences between stimuli 1-3 and 7-9 were not significant

($F(1, 28) = 5.294, p > .01, \eta^2 = .16$). South Cholla speakers' imitations showed that the normalized peak locations appeared within the range 0.5-0.8 for all stimuli, though f0 peak alignment varied.

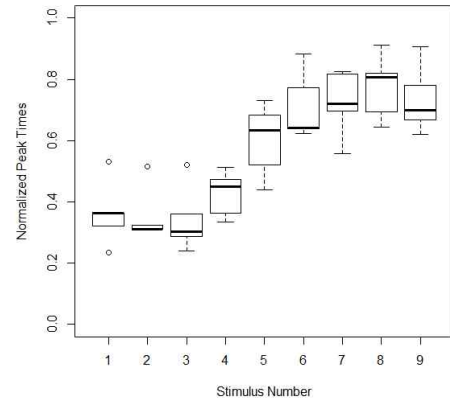


Figure 1. Normalized peak locations for North Kyungsang speakers

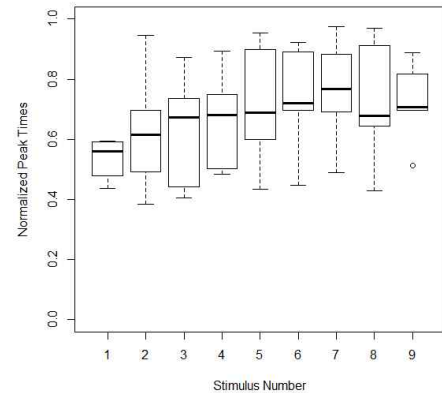


Figure 2. Normalized peak locations for South Cholla speakers

3.2 Mean f0 valley times

Figures 3 and 4 show the normalized valley locations for the North Kyungsang and South Cholla speakers respectively. The abrupt shift in the values of an f0 valley was not observed as can be seen in Figure 3 or 4. The normalized valley locations of the North Kyungsang speakers in Figure 3 fall within the range 0.04-0.19 for all stimuli. The mean f0 valley time of stimuli 1-2 is 0.07, and that of stimuli 8-9 is 0.14. This represented a medium-sized effect ($\eta^2 = .34$), compared with that of the mean f0 peak times, though the categorical effect was significant ($F(1, 16.845) = 14.285, p < .01$; Welch's *F* correction). The normalized valley locations of the South Cholla speakers as shown in Figure 4 appear within the range 0.06-0.1

for all stimuli. The mean normalized time of an f0 valley for imitations of stimuli 1-2 is 0.065, and that of stimuli 8-9 are 0.1. There was no categorical effect on stimulus continuum ($F(1, 28) = 5.654, p > .01, \eta^2 = .17$).

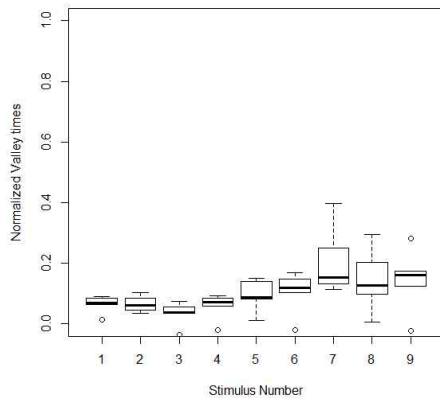


Figure 3. Normalized valley locations for North Kyungsang speakers

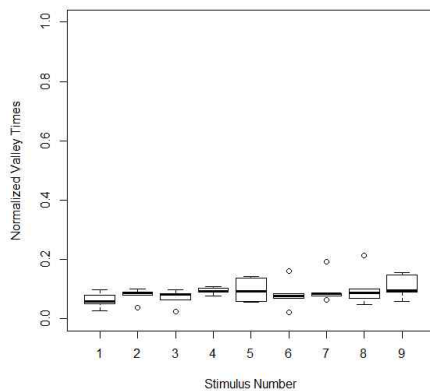


Figure 4. Normalized valley locations for South Cholla speakers

3.3 F0 peak times in individual mimics

To investigate, in greater detail, the categorical effect in the mean f0 peak times of the North Kyungsang speakers, the individual mimics in the timing of normalized f0 peak are presented in Figures 5 and 6.

The individual responses of imitations showed less variability for the North Kyungsang speakers than for the South Cholla speakers. As seen in Figures 1 and 2, there was a significant difference between the two speaker groups in terms of normalized peak locations. However, it is also interesting to observe the f0 peak times in individual mimics. A univariate ANOVA indicated that the effect of stimulus was significantly different for each North Kyungsang speaker (KS1: $F(1, 7) = 51.76, p < .000178, MSE = .4733$, KS2: $F(1, 7) = 7.942, p <$

.0258, $MSE = .02867$, KS3: $F(1, 7) = 42.76, p < .000322, MSE = 0.3635$, KS4: $F(1, 7) = 19.71, p < .00301, MSE = .25732$, KS5: $F(1, 7) = 27.07, p < .00125, MSE = .23589$). To confirm this result, Figure 5 displays f0 peak times in the mimicry responses of individual speakers from the two dialect regions. The mimics of the North Kyungsang speakers showed an apparent shift around stimuli 4-6, despite the individual differences of the s-shaped curve. In Figure 5, the s-shaped curves of KS1, KS3, and KS5 are much steeper than those of KS2 and KS4.

The South Cholla speakers demonstrated individual differences in the shift near the middle of the continuum. There was no shift around stimuli 4-6 for CL1, CL2, or CL4. The mimicry patterns of CL3 and CL5 showed a shift similar to those of individual North Kyungsang speakers, though there was great variability. However, the slope of the s-shaped curve for CL3 or CL5 was more gradient or less steep, compared with that of the North Kyungsang speakers. Therefore, a univariate ANOVA showed that the stimulus effect was not significant for CL1, CL2, and CL4 (CL1: $p = .947, MSE = .0000057$, CL2: $p = .215, MSE = .02389$, CL4: $p = .312, MSE = .004969$), but significant for CL3 and CL5 (CL3: $F(1, 7) = 33.05, p < .000699, MSE = .11641$, CL5: $F(1, 7) = 38.66, p < .000438, MSE = .12615$).

Regarding individual variations among the South Cholla speakers in comparison with the North Kyungsang speakers, Figure 6 presents the f0 peak times as a function of syllable duration. The figure shows great inter-individual variability, but for individual North Kyungsang speakers, the distribution of f0 peak points is divided into two clouds, indicating the two categories of mimicry responses. The boundary of the two clouds for individual North Kyungsang speakers appeared clearly on the f0 peak points as a function of syllable duration, especially for KS1, KS3, and KS5. The boundary for KS2 and KS4 was more or less gradient, compared to boundaries for the other speakers. However, the distribution of f0 peak points for the individual speakers of a South Cholla variety appeared as one cloud. Otherwise, the points of the f0 peak were not clustered into two separate categories, but appeared fuzzy. Especially, for CL3 and CL5 as shown by the relatively s-shaped curve in Figure 5, the distribution of f0 peak points in Figure 6 was not as clearly clustered as the two separate clouds as observed for the North Kyungsang speakers.

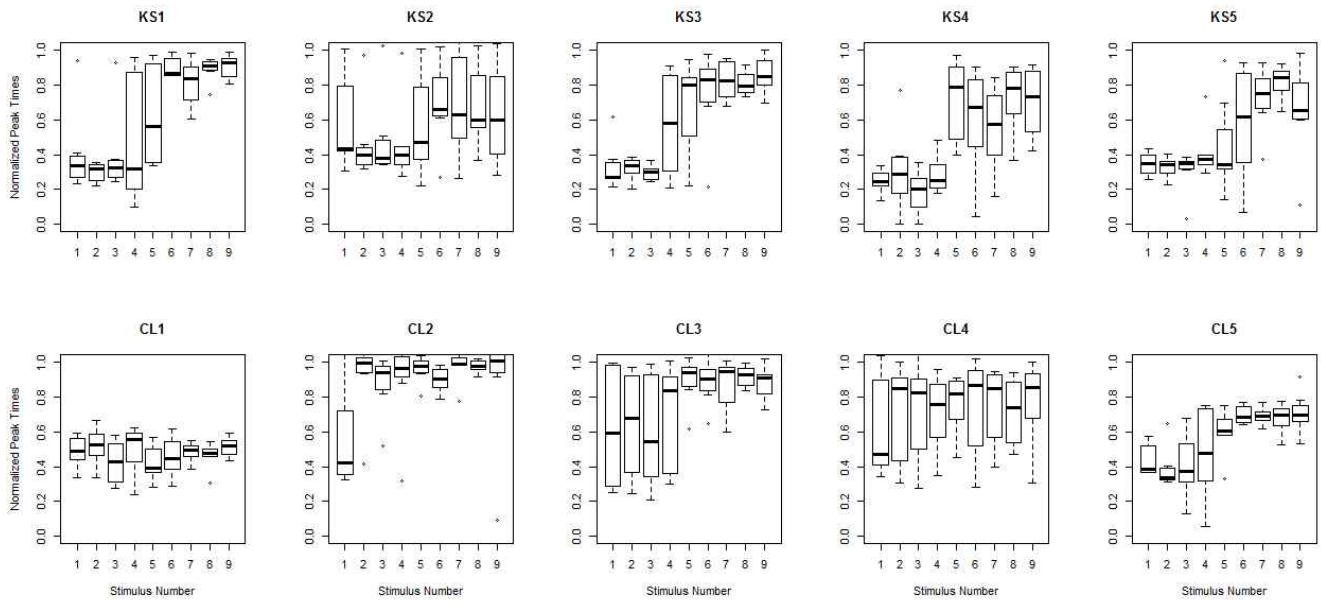


Figure 5. Individual differences for normalized peak locations

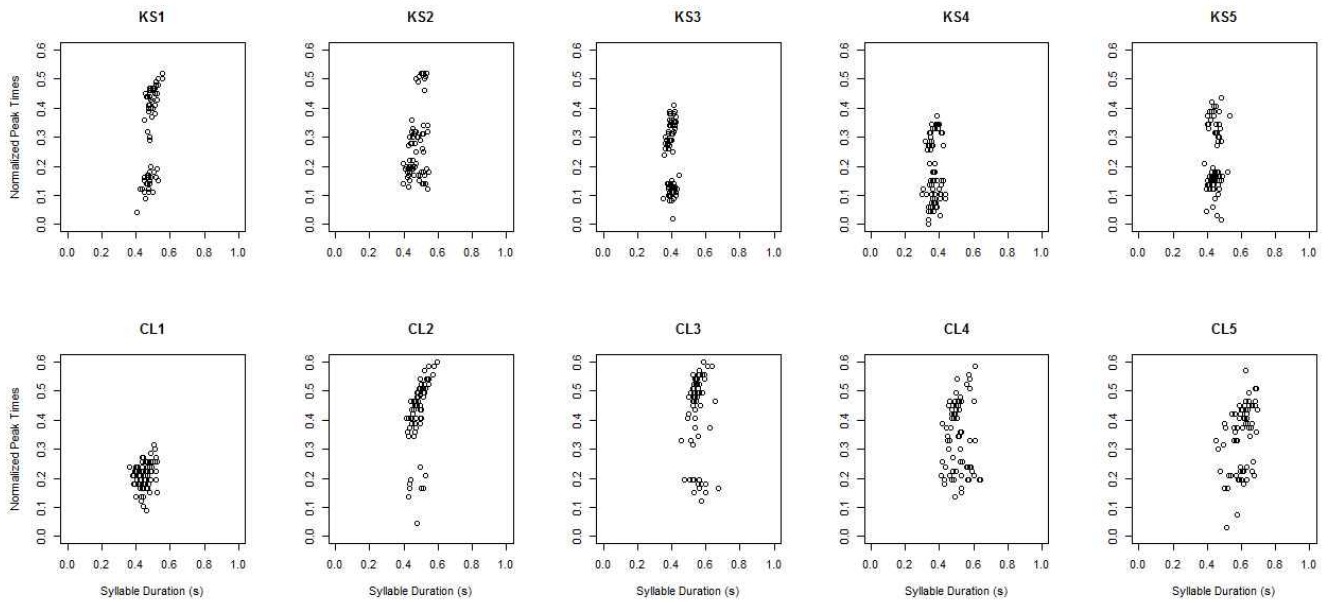


Figure 6. The points of f0 peak time as a function of syllable duration

4. Summary

This paper examined the mapping between f0 peak and valley time and a phonological distinction in a mimicry task. The results in the current study indicated that, regarding the shift of f0 peak time, evidence supports the phonological representation of a lexical pitch accent contrast for North KyungSang speakers. Furthermore, the results suggested that the location of f0 peak times may depend on individuals' cognitive

abilities, despite the weakness that this experiment should be conducted with a larger group of speakers in order to generalize the finding.

4.1 Mean f0 peak and valley times

The major finding of the current study is that, in the use of pitch by North KyungSang speakers, the locations of normalized f0 peak times showed categorical effects in a mimicry task. Evidence of categorical effects was represented as the shift of

f0 peak times along a stimulus continuum for speakers of a North Kyungsang variety. However, the range of f0 valley times was not large as that of f0 peak times. The range for the shift of f0 valley times was much narrower, compared to that for f0 peak times.

On a basis of this finding, this paper suggests that the shift in f0 peak times can account for the phonetic or perceptual correlate of a phonological distinction in the HL-LH contrast of North Kyungsang Korean. The result of the current study focused on the shift of f0 peak times along a stimulus continuum, rather than on the precise timing of an f0 peak as a phonological reflex. The difference between the two categories of lexical pitch accent was, for the North Kyungsang speakers, highly significant for the shift of f0 peak times. The difference of f0 valley times did not reach the level of significance as in the case of f0 peak times, although there was a shift in the same direction as that of f0 peak times. These findings suggest the likelihood that the shift of f0 peak times may give rise to phonological contrasts in cross-dialect of Korean.

4.2 More about variability in f0 peak times

The current research showed that there were variations in imitative performances for individual speakers of the two varieties of Korean. It seemed apparent, in the individual responses of North Kyungsang speakers, that the contrast in the locations of normalized f0 peak times for HL and LH was relative to the shift near the middle of the stimulus continuum. Although the f0 peak times varied by each stimulus for each North Kyungsang speaker, the range of normalized f0 peak times at the end point of stimuli 1-3 and 7-9 was narrower than that of stimuli 4-6, especially for KS1, KS3, and KS5 (see Figure 5). This indicates that f0 peak times were shifted generating more or less variability between the endpoints of stimuli representing a pitch accent contrast, (i.e., HL vs. LH). These responses closely corresponded to the distribution of normalized f0 peak times as a function of syllable duration (see Figure 6). The points of f0 peak times were closely clustered into two clouds representing separate categories. For KS2 and KS4, as shown in Figure 5, the locations of normalized f0 peak times were apparently different between stimuli 1-4 and 5-9, though there was, for KS2, greater variability of the f0 peak times corresponding to stimulus 1. The normalized f0 peak times in stimulus 4 were shifted in stimulus 5. The shift for KS2 was much greater variability than for KS4. These patterns were reflected in the distribution of f0

peak times as a function of syllable duration (see Figure 6). The clustering for the points representing f0 peak times was distributed in a continuous or gradient way between two categorical boundaries.

The individual mimicries of the South Cholla speakers were not the same with those of the North Kyungsang speakers, despite, for some speakers, the difference in the effect of stimulus. The categorization in the timing of an f0 peak was not consistent across individual mimicry responses of the South Cholla speakers. The normalized f0 peak times were not shifted near the middle of the stimulus continuum. Otherwise, the shift of f0 peak times was variable without any clustering representing two categories. In Figure 5, there was little or no shift for the normalized f0 peak times of CL1, CL2, and CL4. The stimulus effects of CL3 and CL5 were significant, but the mimicry behavior appeared in a variable or gradient structure. Moreover, the effect of syllable duration for the distribution of f0 peak points did not confirm those similar to North Kyungsang speakers in imitative skills. The f0 peak points showed more fuzzy distribution, and were not clearly positioned as two clouds representing two categories, HL and LH. Nevertheless, the mimicry patterns of CL3 and CL5 may be regarded as some sensitivity on the change of f0 peak times.

Overall, the current study examined whether the imitative skills of f0 peak and valley times reflect a phonological distinction. The individual mimicries of the North Kyungsang speakers confirmed that the shift of f0 peak times plays a certain role as a phonological indicator. The degree of a shift near the middle of the stimulus continuum seemed to be influenced in terms of individual imitative ability.

5. Conclusion

The current study reported that North Kyungsang speakers present evidence of categorical effects from the shift of an f0 peak along an acoustic continuum. The degree of a shift around the middle of the stimulus continuum showed variability depending on individual mimicry abilities. However, the categorical structure of the North Kyungsang speakers' mimicry responses was more significant for the clustering of f0 peak points in comparison to that of South Cholla speakers. In a phonological analysis of lexical pitch accent categories, the high tone in the phonological HL-LH contrast in North Kyungsang Korean is assigned on a different syllable of a word. The current study showed that the HL-LH contrast is represented in

terms of the degree of the shift of f0 peak times in synthetic speech continua, rather than a fixed timing of an f0 peak or its precise location. The gradient or non-categorical effects in non-native participants' responses result in little or no sensitivity to the shift of f0 peak times in the mimicry paradigm. Nevertheless, in this respect, other possible explanations should be discussed or researched in future work. Based on the results in the current study, it is recommended that the f0 extrema timing of other pitch accent patterns in North Kyungsang Korean be analyzed in future research.

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