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The effect of word length on f0 intervals: Evidence from North Kyungsang children

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ABSTRACT

The present experiment investigated the effect of word length on the length of f0 intervals for North Kyungsang children. In order to find out the lengths of the f0 intervals, the f0 values at the midpoints of vowels in words were measured. F0 estimates were computed as intervals consistent with the logarithmic scale corresponding to the number of syllables in the words. The results indicated that the mean f0 intervals in words of different lengths showed a significant difference for the HH in HH vs. HHL and the LH in LH vs. LLH for North Kyungsang children. Adult speakers from the North Kyungsang region significantly differed only within the HH in HH vs. HHL. Adult speakers made a noticeable contribution in this characteristic from the children. The result of the adult study was presented to confirm whether the children used a North Kyungsang dialect. With respect to individual speaker differences, the North Kyungsang children showed more or less consistent patterns in quantile-quantile plots for the HH vs. HHL, but for the HL vs. LHL and LH vs. LLH, there were more variations than for the HH vs. HHL. The individual speakers' variation was the largest for the HL vs. LHL and the smallest for HH vs. HHL. Considering these results, the effect of word length on f0 intervals tended to show pitch accent-type-specific characteristics in the process of prosodic acquisition.

Keywords: lexical pitch accent, f0 intervals, word length, prosodic acquisition, North Kyungsang Korean

1. Introduction

The current paper aims at investigating the prosodic characteristics in North Kyungsang children's speech. The previous studies on North Kyungsang Korean (Kim, 1976; Kim, 1988; Chung, 1991; Kim, 1997; Kenstowicz & Sohn, 1997; Jun et al., 2006) have suggested that the pitch accent of this dialect in Korean is lexically determined (e.g., [kaci]: HL 'kind,' LH 'eggplant,' HH 'branch'). The current paper deals with how the length in syllables (for two- and three-syllable words) is related to fundamental frequency (f0) intervals. F0 intervals refer to differences in the pattern of pitch range variation relative to syllables in North Kyungsang Korean. In particular, individual differences associated with f0 intervals among North Kyungsang children are examined in order to identify the properties of a North Kyungsang dialect. Furthermore, the current paper explores the question whether North Kyungsang children exhibit the effects of dialect-specific representation that result from listening to North Kyungsang Korean.

A considerable body of phonetic evidence reveals prosodic properties based on the ambient language in language acquisition (Fernald & Mazzie, 1991; Jusczyk, Cutler, & Redanz, 1993; Levitt, 1993; Gerken, 1994; Nazzi, Bertoncini, & Mehler, 1998; Chen & Kent, 2009). Jusczyk et al. (1993) showed that American infants 9 months of age were significantly sensitive to words with strong/weak stress patterns (e.g., final vs. define), whereas there were no noticeable preferences for 6-month-old infants. Jusczyk et al. (1993) implied that 9-month-old infants' attention to strong/weak stress patterns may play a critical role in developing the prosodic structure of their lexical representations. Levitt (1993) examined the prosodic properties of French- and

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English-learning infants' babbling and found the impact of fundamental frequency and syllable-timing patterns clearly representing the prosodic structure of the native language. Gerken (1994) investigated 2-year-olds' prosodic sensitivity in stressed multisyllabic words and sentences, focusing on English weak syllable productions, and suggested a production model wherein children were sensitive to apply strong (-weak) stress patterns (e.g., monkey vs. giraffe) to their multisyllabic words. Gerken's (1994) study showed evidence of additional prosodic units such as metrical templates in their intended phonological patterns. These previous studies propose that infants and children develop language-specific prosodic information to classify utterances within the environment of their ambient language.

The prosodic properties relevant to the process of language acquisition have been found in the interaction between mothers and their infants (Stern et al., 1982; Fernald & Simon, 1984; Grieser & Kuhl, 1988; Fernald & Mazzie, 1991; Papousek, M., & Hwang, S. F. C., 1991; Papousek, M., Papousek, H., & Symmes, D. 1991; Liu, Tsao, & Kuhl, 2007). Fernald and Mazzie (1991) found that when talking to infants, mothers use more exaggerated pitch peaks in certain prosodic positions, and implied that mothers' speech with exaggerated pitch peaks may facilitate the use of prosodic cues for their infants. Liu et al. (2007) confirmed for Mandarin that, in infant-directed speech used by infants' mothers, lexical tone shows an expansion in the f0 range and a higher pitch as opposed to adult-directed speech. Moreover, Liu et al.'s (2007) study demonstrated that mothers adjust the turning point of f0 in infant-directed speech in order to preserve lexical tones when the pitch is changed. Grieser and Kuhl (1988) also compared infant-directed and adult-directed speech of mothers who were Mandarin native speakers and revealed that f0 is noticeably higher and its range is larger in infant-directed than adult-directed speech. In particular, infant-directed speech showed longer pauses per sample in certain utterances or phrases.

The phonetic dimension of the pitch range shape acquired has mostly been investigated in terms of pitch peak alignment corresponding to the input languages. The analyses of alignment dimensions for pitch contours have shown variability, in which prosodic cues are aligned with pitch contours when it comes to consonants and vowels (Arvaniti et al., 1998; Atterer & Ladd, 2004; Schepman et al., 2006; Ladd et al., 2009). As Arvaniti et al. (1998) mentioned, in Greek prenuclear accents, the alignment of the H and L targets with the segmental string is relatively consistent, but for all speakers, the alignment of the H may be not affected by the position of the accent in the word. Atterer and Ladd (2004) argued that, in German, the pattern of alignment shows significant differences between Southern and Northern German speakers, and, in their study, the differences of alignment are accounted for by the quantitative phonetic dimension. Furthermore, Schepman et al. (2006) suggested that, in Dutch, the alignment of the f0 target could be defined as the time interval representing a nearby segmental anchoring. Ladd et al. (2009) confirmed that pitch peak alignment can vary from language to language or from one variety of a language to another (e.g., Scottish Standard English and Southern British English).

On the basis of previous literature on how the segmental string is relative to the alignment of the f0 contour, it may be possible to account for the time interval between the positions of an f0 movement. Moreover, according to Ishihara's (2003) study, f0 peak alignment in Japanese appeared a lot earlier for one-syllable word with two moras than one mora. Prieto and Torreira (2007) claimed that the interaction between syllable structure and speech rate could be influential factors for determining tonal alignment patterns. Given these results, the current paper investigates the difference among the lengths of words relative to f0 intervals, focusing on individual speaker variability. More specifically, when it comes to prosodic acquisition in North Kyungsang children, individual speakers may show an idiosyncratic variation in the effect of word patterns on the f0 interval.

The lexical pitch accent in North Kyungsang Korean has traditionally been examined from the point of view of the association between tone and syllable relative to phonological interpretation (Kim, 1976; Kim, 1988; Chung, 1991; Kim, 1997; Kenstowicz & Sohn, 1997; Jun et al., 2006). The acquisition of lexical pitch accent in Korean has not received any attention from researchers. In recent studies, Kim's (2010) production experiment showed different pitch accent types corresponding to different f0 values for the first and second vowels in disyllabic words in North Kyungsang children; Kim (2010) also compared the f0 values of North Kyungsang children and adults. However, the data in Kim's (2010) study was insufficient to show whether children's production revealed the various properties of North Kyungsang Korean. In addition, with respect to the acquisition of lexical pitch accent, Kim (2012) conducted part of a mimicry task to elicit mimicry responses from North Kyungsang children and observed continuous patterns of f0 values along acoustic continua when compared to North Kyungsang adults.

Regarding the literature on prosodic development in other languages, as discussed above, developmental changes in production have mostly observed three- to six-month-old infants. The current study concerned the speech of North Kyungsang children about six years of age. As children's age increases, they, unlike infants, learn how sound patterns are assembled into longer consonant and vowels strings and connect these strings with meanings. Accordingly, the experiment in the current study looked at f0 intervals in relation to word length. The children's age is appropriate for the purpose of this experiment. The current study was conducted to answer three research questions. First, are there any mean differences associated with f0 intervals between adults' and children's productions in North Kyungsang Korean? Second, is there any effect of word length on f0 intervals for North Kyungsang children? Finally, does North Kyungsang children's speech show individual differences in f0 intervals? The current study aimed at examining these three research questions to identify the prosodic characteristics of North Kyungsang children's speech.

2. Experimental Method

2.1 Participants

The experimental group consisted of eight native North Kyungsang children (four males, four females), whose mean age is 6.25 years. Additionally, this experiment also involved adult native speakers of North Kyungsang Korean (three females, mean age: 26 years) in order to confirm the effect of lexical pitch accent in North Kyungsang Korean. All the participants come from Daegu, which is the metropolitan area of the North Kyungsang region. None of the participants had any history of speaking or hearing disability. All the participants were paid for taking part in this experiment.

2.2 Stimuli

Experimental materials were chosen from two- and three-syllable words with lexical pitch accent in North Kyungsang Korean. The two-syllable words are characterized by pitch accent patterns HL, HH, LH; the three-syllable words include LHL, HHL, and LLH patterns. For each two-syllable accent pattern, five words were chosen, and for each three-syllable accent pattern, five words were chosen also; these 30 words were used in the production experiment. In total, there were 360 stimuli in this experiment (15 words × 3 repetitions × 8 children) for the child participants and 135 (15 words × 3 repetitions × 3 adults) for the adult participants. Table 1 exhibits the two- and three-syllable words used in the production test.

Table 1. Experimental materials: two- and three-syllable words

Two-syllable words			Three-syllable words		
Phonetic form	Pitch pattern	Meaning	Phonetic form	Pitch Pattern	Meaning
tʃaŋkap	HH	'glove'	nɛŋtʃaŋko	HHL	'refrigerator'
ankyuŋ	HH	'glasses'	mulkoki	HHL	'fish'
oɾi	HH	'duck'	tʃəŋkɨltʃim	HHL	'jungle gym'
koŋtʃak	HH	'peacock'	tolkoɾɛ	HHL	'dolphin'
mulkɛ	HH	'seal'	k^hop'ulso	HHL	'rhinoceros'
taŋkɨn	LH	'carrot'	panana	LLH	'banana'
kapaŋ	LH	'bag'	tʃintallɛ	LLH	'azalea'
motʃa	LH	'hat'	mintɨllɛ	LLH	'dandelion'
tʃaŋmi	LH	'rose'	koɾilla	LLH	'gorilla'
yəu	LH	'fox'	tɛnamu	LLH	'bamboo'
kawi	HL	'scissors'	taɾimi	LHL	'iron'
pinu	HL	'soap'	kɛnaɾi	LHL	'forsythia'
yaŋmal	HL	'socks'	kɛkuɾi	LHL	'frog'
manɨl	HL	'garlic'	tutətʃi	LHL	'mole'
napi	HL	'butterfly'	nəkuɾi	LHL	'raccoon'

2.3 Procedure

This experiment employed a picture-naming task. That is, cards with pictures for two- and three-syllable words were used for the children and adults. With respect to each picture card, the participants were asked to name what they see on the card. The production of each participant was digitized directly to a PC hard disk via Wavesurfer software.

2.4 Measurement

To obtain f0 measurements, three f0 values, V1, V2, and (in three-syllable words) V3 were measured at the midpoints of the corresponding vowels. The points of f0 measurements were identified using spectrogram and waveform displays in Praat. The examples in Figures 1 and 2 for f0 measurements were obtained from one of the adult subjects. For example, Figure 1 shows three two-syllable words with three pitch accent patterns, HL, HH, and LH. The f0 value on each word representing a pitch accent pattern was measured at the midpoint of the first and second vowel of that word. For the word, [pinu] 'soap' with HL, V1 was the f0 value across the first vowel, [i], while V2 was the f0 value on [u] in [pi.nu]. For the word [o.ɾi], 'duck,' V1 was the f0 value across [o], while V2 was the f0 value on [i] in [o.ɾi]. For the word [tʃaŋ.mi] 'rose,' V1 was the f0 value on [a], while V2 was the f0 value on [i], the second vowel, in [tʃaŋ.mi]. Likewise, in Figure 2, V1 in [kɛnaɾi] 'forsythia' was the f0 value on [ɛ], while V2 was the f0 value on [a], and V3 on [i]. For [nɛŋtʃaŋko] 'refrigerator,' V1 was the f0 value across [ɛ], V2 on [a], and V3 on [o]. Finally, for [tɛnamu] 'bamboo,' V1 was the f0 on [ɛ], V2 on [a], and V3 on [u].

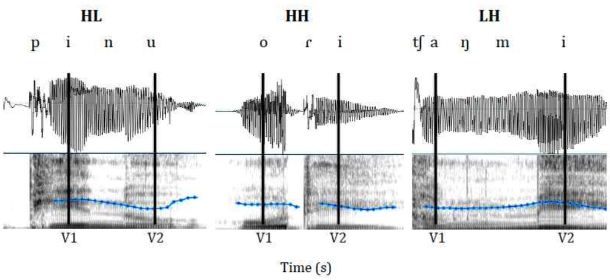

Figure 1. F0 measurement points of pitch contours for two-syllable words (e.g., [pinu] 'soap,' [oɾi] 'duck,' [tʃaŋmi] 'rose'). The solid lines indicate the f0 values of V1 and V2 on each word with pitch accent patterns, HL, HH, and LH, using spectrogram and waveform displays. The spectrogram of each word also shows its pitch accent contour.

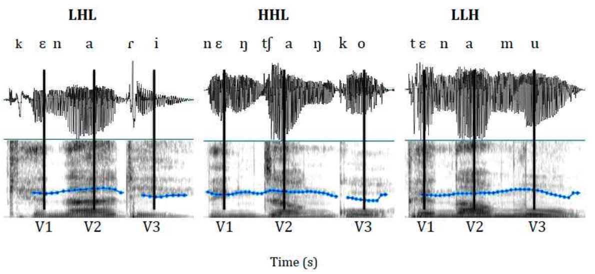

Figure 2. F0 measurement points of pitch contours for three-syllable words (e.g., [kɛnaɾi] 'forsythia,' [nɛŋtʃaŋko] 'refrigerator,' [tɛnamu] 'bamboo'). The solid lines indicate the f0 values of V1, V2, and V3 on each word with pitch accent patterns, LHL, HHL, and LLH, using spectrogram and waveform displays. The spectrogram of each word also shows its pitch accent contour.

2.4 Data analysis

The f0 values for V1, V2, or V3 measured were computed as intervals (ratios) using the three equations below as proposed by Dilley (2010).

(1) log (interval) = log (V1 / V2) for HH vs. HHL

(2) log (interval) = log (V1 / V2) for HL vs. log (V2 / V3) for LHL

(3) log (interval) = log (V1 / V2) for LH vs. log (V2 / V3) for LLH

The log-produced f0 intervals of HH for both HH and HHL in two- and three-syllable words, HL for both HL and LHL, and LH for both LH and LLH were analyzed. The log-produced f0 intervals in the children's productions were analyzed using a mixed-effects linear regression model to identify the fixed and random effects, using an lme4 package (Bates, 2005, Bates & Sarkar, 2007). The model contained participants as one random effect. The fixed effects are pitch accent patterns (i.e., HH vs. HHL, HL vs. LHL, LH vs. LLH), reflecting the number of syllables (i.e., two- and three-syllable words). The analysis was conducted, in the mixed-effects model, to add one random effect to the fixed effects. The random effect for 'subject' characterizes idiosyncratic variation triggered due to individual differences. More specifically, an Intraclass Correlation Coefficient (ICC) (Kreft & DeLeeuw, 2008) was calculated to examine the variance of individual speech for children. To confirm the properties of the children's productions for a North Kyungsang dialect, adult speakers productions were compared with those of children. The prediction of the log-produced f0 intervals for the adult speakers was conducted using a simple linear regression model. The predictor variables were pitch accent patterns, and the dependent variables were the log-produced f0 intervals.

3. Results

3.1 Log-produced f0 intervals for adult speakers in two- and three- syllable words

The output of the adult speakers shows that the log-produced f0 intervals have a significant effect on HH vs. HHL (β=.05, t=5.4, p<.001). The beta value represents the gradient of the regression line. Pitch accent patterns (i.e., HH vs. HHL) made a noticeable difference to predicting f0 intervals. In addition, R-squared is .51, which shows that the pitch accent patterns can account for 51% of the variation in the values of f0 intervals. On the other hand, log-produced f0 intervals were no significant differences in HL vs. LHL (β=-.01, t=-.68, p=.51) and LH vs. LLH (β=-.01, t=-1.39, p=.18). As for each pitch accent pattern, R-squared is .01 for HL vs. LHL and .06 for LH vs. LLH. As shown in Figure 3, log-produced f0 intervals in HH for both HH and HHL appears differently in the range of variation. However,

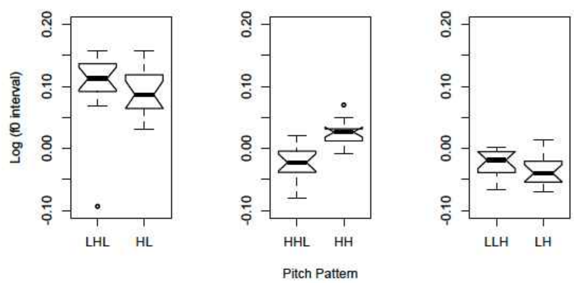

Figure 3. Log-produced f0 intervals depending on each pitch accent pattern for adult speakers

HL vs. LHL and LH vs. LLH were overlapped in log-produced f0 intervals.

3.2 Log-produced f0 intervals for children in two- and three- syllable words

With respect to the children's productions, the ranges of variation for log-produced intervals are much larger than those of the adult speakers. The result showed that the f0 intervals significantly differed for HH vs. HHL (β=.04, t=3.1, p<.01). R-squared is .11, indicating that there is lower in the proportion of variance for the children than for the adult speakers. Moreover, the output of the log-produced f0 intervals in LH vs. LLH revealed that there was a stronger significant difference (β= -.04, t= -3.8, p< .001) than that in HH vs. HHL. R-squared is .15, showing there are more variations than f0 intervals between HH and HHL. On the other hand, the pitch accent pattern HL vs. LHL did not make a significant difference to predicting log-produced f0 intervals (β=-.02, t=-1.3, p=.185). Also, the R-squared is .02, showing why the variation is not explained by the model.

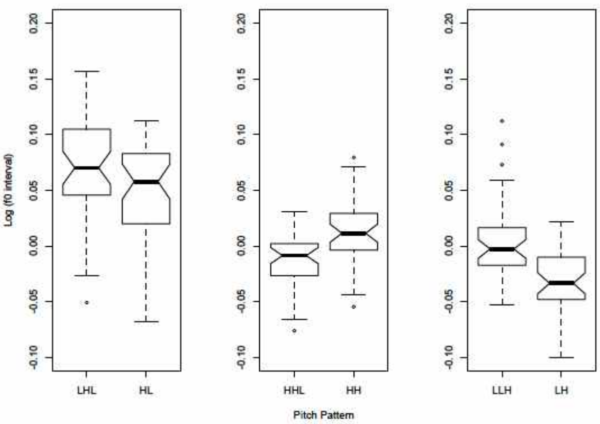

Figure 4. Log-produced f0 intervals depending on each pitch accent pattern for children

3.3 Individual difference in log-produced f0 intervals

The log-produced intervals for the adults and children were different for each pitch accent pattern; a complicating factor in this difference is that the children showed a lot of idiosyncratic variation in their f0 intervals in the two- and three-syllable words. Thus, it was important to characterize all the intervals for all the words for each child. To interpret the individual differences among the children, a linear regression mixed-effects model was applied in this analysis; a random effect of speaker was added to the fixed effects in order to examine the amount of individual differences. In this model, the intercept for the fixed-effects term for HH vs. HHL is -.02, and the slope is .04. For LH vs. LLH, the intercept for the fixed-effects is .009 and the slope is -.04. For HL vs. LHL, the intercept is .08 and the slope is -.02. Table 2 summarizes the random-effects terms for individual speaker differences in the model.

Table 2. Random intercepts for each subject for each pitch pattern

	HH vs. HHL	LH vs. LLH	HL vs. LHL
Subjects	Intercept		
S1	-0.00657	0.00449	-0.06204
S2	0.00368	-0.00074	-0.00821
S3	-0.00159	0.00907	0.03625
S4	0.00965	0.03376	0.00519
S5	0.00261	0.00445	0.00651
S6	-0.01404	-0.03045	-0.05282
S7	0.02436	-0.01078	0.06107
S8	-0.01809	-0.00980	0.01403

By assuming different random intercepts, these individual differences were modeled for each child. Within these pitch accent patterns, there is a lot of individual variation, showing some children having relatively higher values and others having relatively lower values. That is, a different intercept value was assigned to each child. These intercepts were estimated in the mixed-effects model. As shown in Table 2, for HH vs. HHL, S1 is the lowest intercept (i.e., -0.00657) and S7 is the highest intercept (i.e., 0.02436). For LH vs. LLH, S2 is the lowest intercept (i.e., -0.00074) and S4 is the highest intercept (i.e., 0.03376). For HL vs. LHL, the lowest intercept is -0.00821 for S2 and the highest intercept is 0.06107 for S7. S2 shows the lowest intercepts for LH vs. LLH and HL vs. LHL, and S7 shows the highest intercepts for HH vs. HHL and HL vs. LHL. Regarding random intercepts for each child, there seem to be individual differences across the children reflecting different production strategies when producing pitch accent patterns in North Kyungsang Korean.

Additionally, to examine the distribution of the log-produced f0 intervals, Figure 5 displays separate quantile-quantile plots (i.e., probability plots) for each child. These plots help us understand how variable the effects can be.

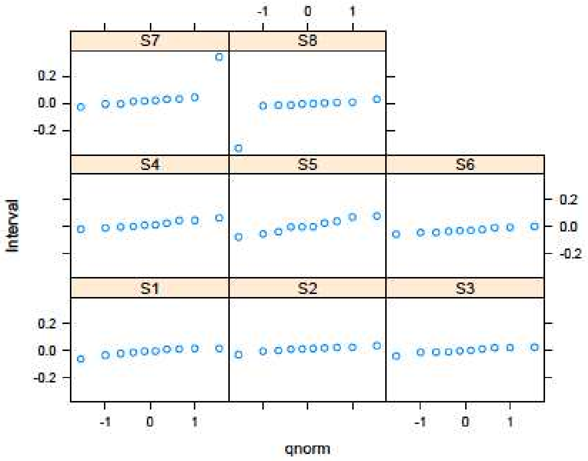

Figure 5. Quantile-quantile plots for the log-produced f0 intervals of HH vs. HHL grouped by subject. Y-axis represents the log-produced f0 intervals.

As can be seen in Figure 5, S7 has a clear outlier at the right end of the pattern, whereas S8 has a clear outlier at the left end of the pattern in the data. As for S5, the slope is increasing from left to right in a more or less curved pattern, indicating some degree of skewing to the right. For the other children, the patterns show relatively long tails for intervals at both ends of the data distribution, representing flatter patterns in the data.

Figure 6 shows quantile-quantile plots of the log-produced f0 intervals of LH vs. LLH for each child in the data.

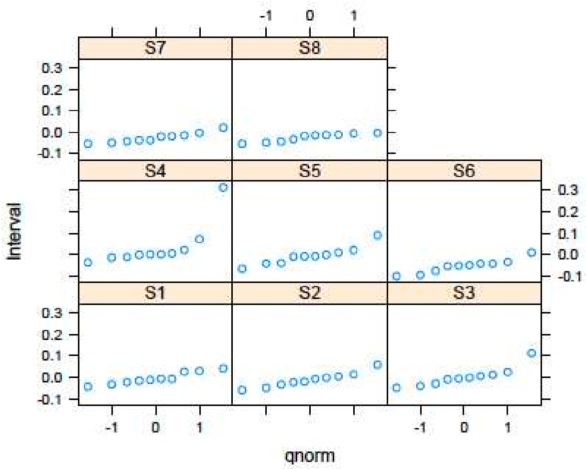

Figure 6. Quantile-quantile plots for the log-produced f0 intervals of LH vs. LLH grouped by subject. Y-axis represents the log-produced f0 intervals.

In Figure 6 , the patterns for each child are to some degree different compared to those of HH vs. HHL. For S4, one outlier is evident at the high end on the right. The nonlinear patterns for most children suggest that the data were not normally distributed. The points at both ends of the pattern tend to show relatively long tails, representing the intervals between the points in each pattern. The rise around the right end of the pattern seems to indicate more left-skewed data, indicating more or less continuous differences between LH and LLH.

Figure 7 represents quantile-quantile plots of log-produced f0 intervals for HL vs. LHL for the children.

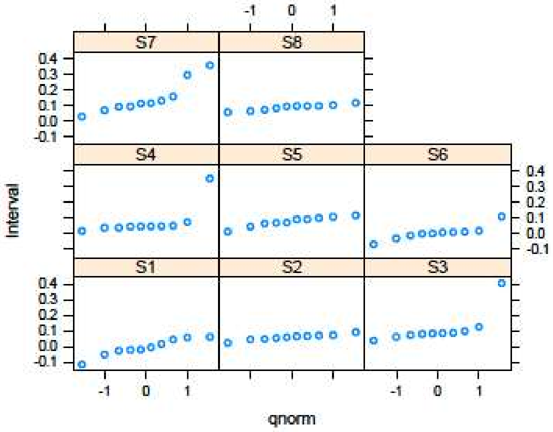

Figure 7. Quantile-quantile plots for the log-produced f0 intervals of HL vs. LHL grouped by subject. Y-axis represents the log-produced f0 intervals.

In Figure 7, again, some subjects' patterns show clear outliers. S7 shows two outliers in a continuous curve at the right end, and S4 and S3 each have one outlier at the right end of their patterns. S7 and S1 tend to show a difference for f0 intervals between two- and three-syllable words. For the other patterns, in particular, for S2, S5, and S8, the points in the patterns form more or less flat lines. Overall, the points at both ends of each pattern's curve tend to be spaced at wider intervals, as can be seen in both HH vs. HHL and LH vs. LLH.

3.4 Residuals for children's data

To assess the quality of the linear regression model, residual plots were used. A histogram plot of the residuals should exhibit a symmetric bell-shaped distribution, indicating whether the variance is normally distributed. Figure 8 shows the histogram of residuals for log-produced f0 intervals in HH vs. HHL.

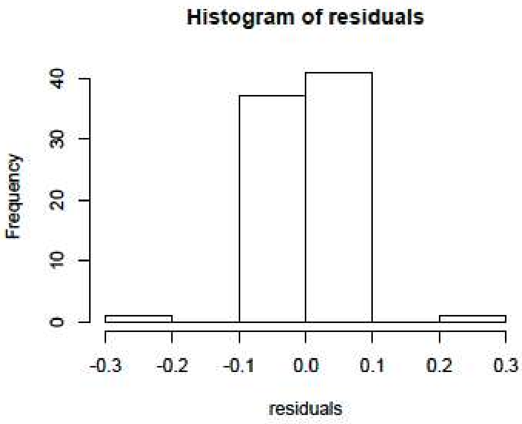

Figure 8. Histogram of the residuals in HH vs. HHL for children

A histogram evenly distributed around zero is likely to indicate that the deviation is normally distributed; Figure 8 is an example of just such a histogram. This looks like a roughly bell-shaped distribution. That is, the histogram of residuals is high peaks between -.1 and .1, whereas the other values for the residuals are between .2 and .3 and between -.2 and -.3. The frequencies of the residuals around zero are from over 30 to 40, whereas the frequencies at both ends of the histogram plot are close to zero.

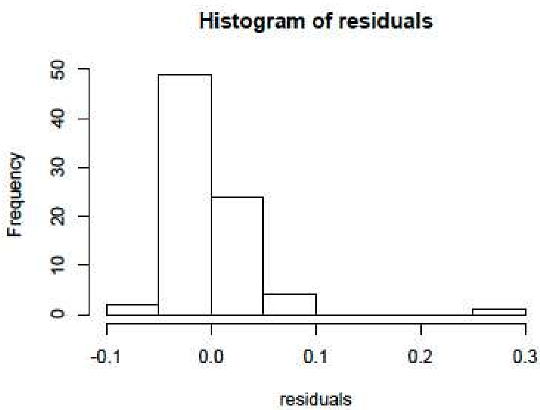

Figure 9. Histogram of the residuals in LH vs. LLH for children

The variance in the histogram for LH vs. LLH, as can be seen in Figure 9, is not normally distributed, indicating that the frequency of the residuals does not form a symmetric bell-shaped histogram plot. The frequency (i.e., about 50) for the residuals is the highest in the closed to zero area toward the left, and this histogram is skewed (i.e., asymmetrical) to the left, indicating a non-normal distribution. The frequency toward the right around zero is between 20 and 30. In addition, this indicates that the outliers around .3 for residuals appear, though those are almost closed to zero for their frequencies.

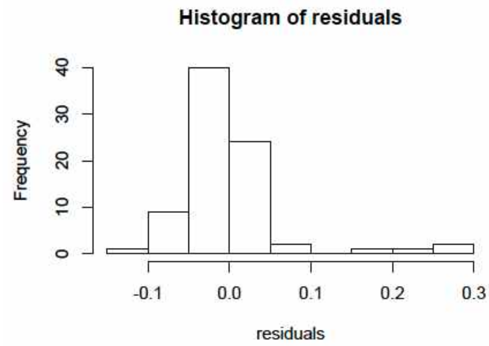

Figure 10. Histogram of the residuals in HL vs. LHL for children

In Figure 10, the histogram of residuals also exhibits an asymmetric-shaped distribution, indicating that the normality assumption is not likely to be true. There are deviations around .2 and .3, although the frequency of the residuals is the highest around zero toward the left. The patterns representing the variances are more or less irregular, showing a left-skewing distribution. The variation is higher at around -.1 than around .2 and .3. The shape of this histogram is thus a sign of non-normality of this distribution. Considering the deviations in this histogram, the log-produced f0 intervals for HL vs. LHL are likely to occur less noticeable differences than the other pitch accent patterns.

3.5 Intraclass Correlation Coefficient (ICC)

To investigate more specifically the variance of individual children's speech, an ICC was computed. The ICC represents the amount of individual speaker variance, which can be accounted for children. The ICC for HH vs. HHL indicates 8.1% of the variances in log-produced f0 intervals. For LH vs. LLH, the ICC exhibits 16.1% of the variances, and for HL vs. LHL, the ICC shows 30.6% of the variances in log-produced f0 intervals for individual speaker differences.

4. Discussion

The present experiment was designed to test whether word length has an effect on f0 intervals in North Kyungsang children's speech. Productions from the North Kyungsang children in this experiment showed a significant effect of word length on f0 intervals when compared to the mean f0 intervals from the North Kyungsang adult participants, although the children showed a lot of idiosyncratic variation in specific pitch accent patterns. The present experiment yielded three interesting results. First, the results of the adult speakers from the North Kyungsang region revealed that there is a significant difference only between HH vs. HHL for the mean f0 interval values. On the other hand, for the North Kyungsang children, log-produced f0 intervals significantly differed for HH vs. HHL and LH vs. LLH. For HL vs. LHL, there was no significant effect for f0 intervals. Second, there were individual differences relying on each pitch accent pattern. The ICC of f0 intervals indicating individual speaker variance was the highest for HL vs. LHL. The ICC for HH vs. HHL was the lowest, pointing out less variation than in other pitch accent patterns. Third, the histogram of the residuals for HH vs. HHL was normally distributed, in the sense that word length contributed to a noticeable increase in the length of f0 intervals. The residuals for the other pitch accent patterns showed non-normal distributions.

4.1 The effect of mean f0 intervals in North Kyungsang children’s speech

The significant effects for North Kyungsang children’s f0 intervals in two- and three-syllable words were found for HH vs. HHL and for LH vs. LLH. This result is interpreted as the effect of word length relying on lexical pitch accent patterns. That is, the f0 intervals in shorter (two-syllable) words were different from those in longer (three-syllable) words. The HL and LHL patterns did not show a statistical difference for the children’s speech. The HL patterns in two- and three-syllable words were produced with similar lengths of f0 intervals. The North Kyungsang adult speakers showed a significant effect only for HH vs. HHL. For the HL patterns in HL vs. LHL, both the children and adults did not make a noticeable difference for f0 intervals in their productions. Considering this observation, for both the children and adults, there seemed to be predominant pitch accent patterns in the native dialect. Similarly, for the stress patterns in English, the perception of 9-month-old American infants was distinctive for strong/week stress patterns, compared to weak/strong patterns (Jusczyk et al., 1993). Accordingly, the prosodic acquisition in the HL pattern for either HL or LHL may be an important part of language processing for children to develop a lexicon for lexical pitch accent. For North Kyungsang children, the HH for either HH or HHL and the LH for either LH or LLH could be more idiosyncratic pitch accent patterns in the process of prosodic acquisition in a North Kyungsang variety. In particular, the HH for either HH or HHL may form a unique pattern that is acquired as a dialect-specific pattern for both children and adults. For HH vs. HHL, both the children and adults had a significant difference for the effect of word length on f0 intervals. For the North Kyungsang adult speakers, the variation in the values of f0 intervals was 51% when compared to the other patterns. For LH vs. LLH ($p<.001$), the North Kyungsang children’s productions were more distinctive at the significant level than for HH vs. HHL($p<.01$). Interestingly, the f0 interval for the LH in the three-syllable words was larger than in the two-syllable words. On the other hand, the HH relative to the f0 intervals in the three-syllable words was smaller than in the two-syllable words. In this respect, the adult speaker’s productions also showed the same result in the sense that the range for the f0 intervals of the HH was smaller in the three-syllable words than in the two-syllable words. The HH seemed to have longer f0 intervals, reflecting an atypical pitch accent pattern that represents the sequence of high tones. That is, it implies that the general articulatory factors in the process of prosodic acquisition can trigger the combination of a high and low tone.

4.2 The individual effects of word length for f0 intervals

In this experiment, the individual differences were indicated in terms of pitch accent patterns associated with f0 intervals, representing the effect of word length. With respect to individual-level variation in f0 intervals, the value of the ICC is 30.6% for HL vs. LHL, 16.1% for LH vs. LLH, and 8.1% for HH vs. HHL.

Based on the ICC’s output, the HL pattern for either HL or LHL has much variation, in the sense of various production strategies, for individual speakers. The variance for HL vs. LHL was also presented in the form of a histogram for the residuals; this histogram has skewed shape indicating a non-normal distribution. The individual’s curved patterns in the quantile-quantile plots for HL vs. LHL revealed more outliers than other pitch accent patterns. In these plots, the curves were not consistent for individual speakers. When predicting the HL pattern for either HL or LHL, the differences among individuals for producing this pattern should take into account the fact that there is a preference for a falling tone (i.e., HL) in a North Kyungsang variety. Accordingly, the effect of word length for f0 intervals did not play a critical role in the production of the HL vs. LHL patterns.

Concerning the result of the ICC for LH vs. LLH, individual speaker differences showed less variation than for HL vs. LHL. The rising tone (i.e., LH) is more difficult for articulatory movements than the falling tone (i.e., HL), as argued in the previous literature (Jusczyk et al., 1993) relative to the acquisition of the stress patterns in American English. In this respect, however, it is not clear whether individual differences for the LH in LH vs. LLH can provide an explanation of the effect of word length. In the quantile-quantile plots, the LH in two- and three-syllable words shows a more continuous effect than the other pitch accent patterns for individual speakers, though some speakers appear to have distinctive outliers on their probability curves. As shown in the LH vs. LHL, the residuals for the LH vs. LLH showed a left-skewed pattern, but the distribution for frequency in this histogram showed less variation than the one in the histogram for HL vs. LHL. This result for the histograms seemed to reflect similar patterns for individual speaker differences, based on the effect of word length for f0 intervals.

The patterns for HH vs. HHL tended to show consistent curves for individual speakers. The value of the ICC was the lowest among pitch accent patterns. There was a difference in the HH vs. HHL for the mean f0 intervals, but individual speakers did not show various production strategies. This conclusion was supported by the histogram of the residuals, which indicated a bell-shaped distribution. The variation in individual speakers tended to show higher frequency when closed to zero in the histogram, without showing various residuals related to individual differences. To sum up, the effect of word length in the HH vs. HHL for f0 intervals tended to hold across individual speakers except for some outliers for some speakers, between two different word lengths.

5. Conclusion

The current study investigated the effect of word length associated with f0 intervals in North Kyungsang Korean. The important finding is that the effect of word length was different for pitch accent patterns. The HL pattern for either HL or LHL was prevalent in the proportion of individual variation. This HL pattern in two- and three-syllable words did not produce any difference for the mean f0 intervals, in contrast to the other pitch accent patterns. In particular, the HH for either HH or HHL produced a noticeable difference for the mean f0 intervals, but for individual speakers, the proportion of variance was less than in any other pitch accent patterns. Also, when taking into account the LH for either LH or LLH, the LH patterns for the speakers in probability curves were more various than those of the HH vs. HHL pattern. Future studies may include investigating the effect of word length on f0 intervals using different methods of measurement as well as words with different syllable structures and of different lengths.

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