NON-ADJACENT SEGMENTAL EFFECTS IN TONAL REALIZATION OF ACCENTUAL PHRASE IN SEOUL KOREAN

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ABSTRACT

This paper investigates the degree to which an onset consonant of an accentual phrase affects the f0 of the following syllables within the phrase in Seoul Korean. Korean tense or aspirated onset consonants raise f0 values of the following adjacent vowel, and when they are positioned on the first syllable onset of an accentual phrase, they continuously raise f0 values of the following non-adjacent vowels.

This f0 raising after aspirated or tense consonants supports the previous claim that the microprosody in Korean is phonologized in phrase initial position. The results also confirms the previous claim regarding the location of the underlying 4 tones of the accentual phrase and the interpolation hypothesis.

1. INTRODUCTION

It has been known that Korean obstruents influence f0 of the following vowel. e.g., [1, 4, 5, 6, 9, 10, 14 (for stops), 13 (for stops, affricates, and fricatives)]: a vowel shows a higher f0 after voiceless aspirated obstruents and voiceless tense obstruent but shows a lower f0 after voiceless lax obstruents. Cross-linguistically it has been generally accepted that the preceding consonant influences the f0 of the following vowel onset. Voiceless aspirated or tense consonants raise the f0 of the following vowel more than voiced consonants and breathy consonants do [2, 7, 8]. However, studies on consonant effects on the f0 value have mainly focused on the following adjacent vowel, and little is known about the effect of a consonant on the following non-adjacent vowels within a word or a phrase.

The aim of this paper is to present some experimental evidence for Korean which suggests that a consonant affects the f0 of the non-adjacent following vowels within an accentual phrase. I will show that the f0 value of a vowel is influenced by its position in the accentual phrase as well as the type of the phrase initial consonant.

In this study I will basically follow Jun's [9, 11, 12] definition of Accentual Phrase in Korean. According to Jun, the tonally defined lowest prosodic unit in the prosodic hierarchy in Korean is an Accentual Phrase. The Accentual Phrase (henceforth AP) in Korean is a prosodic level lower than an Intonational Phrase (henceforth IP) and higher than a Phonological Word (a lexical item followed by case markers or postpositions). An IP in Korean is composed of more than one AP which is tonally marked. She suggests that the underlying tonal pattern of the AP in Seoul Korean is Low-High-Low-High (LHLH) or High-High-Low-High (HHLH) where the AP-initial tone is determined by the laryngeal feature of the phrase initial segment. When an AP initial consonant is either aspirated or tensed, having [+stiff vocal cords] [3], the AP begins with a High tone, and otherwise a Low tone. These underlying tones are realized on the surface when an AP has more than four syllables: the two initial tones are associated with the two initial syllables of an AP and the two final tones are associated with the two final syllables of an AP.

Jun [11] shows that the initial f0 triggered by a consonant (microprosody) in Korean is far more different from that triggered by voiced-voiceless consonants in other languages such as English and French, and that the difference persists until the end of a syllable in Korean which is longer than English or French. A question raised from Jun's study: How far this initial difference would sustain through an AP? Does the influence of AP initial consonant persist in 1st and 2nd syllable, or farther away? To examine the consonant effects on f0 values of the follwing syllables and the tonal realzation of Korean AP, 4 and 5 syllable APs are examined in this study because these APs show the full realization of those 4 basic underlying tones (LHLH or HHLH) in Korean.

2. METHODS

Target APs are composed of 4 or 5 syllable nonsense words (/CaCaCaka/ and /CaCaCaCaka/ (-ka is a subject case marker)) and each AP was placed at the beginning of a carrier sentence: "_____ yəkiɛ issə" (___ is here.). To examine whether affricate consonants trigger different tonal patterns, if any, from that triggered by stop consonants, two data sets are provided. In the control APs, all Cs were either lax stops /t/ or lax affricates /ʤ/ (shown as 'L' in Table 1). And, one C in each AP was replaced by either a tense or an aspirated consonant, 'T' and 'A' in Table 1, respectively. Table 1 shows a full set of data. Symbols in Table 1 (e.g., LLLL, ALLL, TLLL) will be used as a legend in the X-axis of Figures 1-5.

Two male (M1 and M2) and two female (F1 and F2) speakers of the Seoul dialect participated in the experiment. To help speakers to produce nonsense words more naturally, 4 or 5 syllable dummy APs composed of real words are inserted among target APs. Sentences were pseudo-randomized so that the sentences having dummy APs come at the beginning of a page and after every 3 or 4 sentences having the target AP. All sentences are read six times each. The data were recorded in an anechoic chamber in the UCLA phonetics lab using a head-

worn microphone (SHURE 10A) and a DAT recorder (TASCAM DA-30). The speech was digitized with 11,000Hz sampling rate and f0 values were measured at the mid point of each vowel using xwaves (Entropics).

	types	symbol	APs(Stop)	APs(Affricate)
4-syl AP	lax (control)	LLLL	tatataka	dʒadʒadʒaka
	aspirated	**A**LLL	**t^h**atataka	**dʒ^h**adʒadʒaka
		L**A**LL	tat**t^h**ataka	dʒa**dʒ^h**adʒaka
		LL**A**L	tatat**t^h**aka	dʒadʒa**dʒ^h**aka
	tensed	**T**LLL	**t'**atataka	**dʒ'**adʒadʒaka
		L**T**LL	tat**t'**ataka	dʒa**dʒ'**adʒaka
		LL**T**L	tatat**t'**aka	dʒadʒa**dʒ'**ka
5-syl AP	lax (control)	LLLLL	tatatataka	dʒadʒadʒadʒaka
	aspirated	**A**LLLL	**t^h**atatataka	**dʒ^h**adʒadʒadʒaka
		L**A**LLL	tat**t^h**atataka	dʒa**dʒ^h**adʒadʒaka
		LL**A**LL	tatat**t^h**ataka	dʒadʒa**dʒ^h**daʒaka
		LLL**A**L	tatatat**t^h**aka	dʒadʒadʒa**dʒ^h**aka
	tensed	**T**LLLL	**t'**atatataka	**dʒ'**adʒadʒadʒaka
		L**T**LLL	tat**t'**atataka	dʒa**dʒ'**adʒadʒaka
		LL**T**LL	tatat**t'**ataka	dʒadʒa**dʒ'**adʒaka
		LLL**T**L	tatatat**t'**aka	dʒadʒadʒa**dʒ'**aka

Table 1: Combination of consonant types in the target AP. L stands for lax obstruent, T for tense obstruents and A for aspirated obstruents.

3. RESULTS AND DISCUSSION

Since all speakers show similar tonal patterns of stops and affricates and do not show consistent differences, pooled data from stops and affricates are considered.

The results show that the initial tense or aspirated consonants not only raise f0 of the immediately following vowel, but also f0 of the vowels in the following non-adjacent syllables. Results also show that the f0 value of the vowel is influenced by its position in the AP. That is, f0 value largely varies depending on its position within a prosodic unit (AP).

In the first syllable of an AP, all speakers show that the f0 value of the vowels after the phrase initial aspirated or tense consonants (**A**LLL, **T**LLL, **A**LLLL and **T**LLLL) is significantly higher than that after lax consonants (**L**LLL and **L**LLLL), confirming the previous results in Jun [9, 11]. As an example, f0 of two speakers (M1 and F1) are shown in Figure 1.

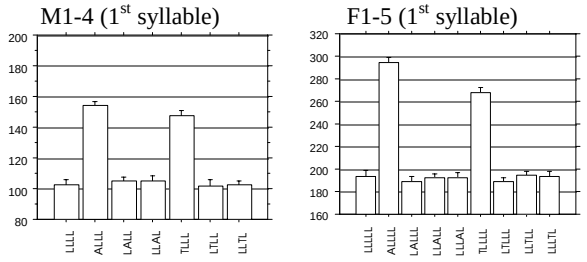

Figure 1: F0 of the 1st syllable in 4 syllable (for M1) or 5 syllable (for F1) APs. (Y-axis represents f0 value and X-axis represents the type of AP described in Table 1, error bars = 95% confidence interval: these are the same in the following graphs)

In the second syllable of an AP, the f0 of the vowel is significantly higher after a tense or aspirated onset (L**A**LL, L**T**LL, L**A**LLL and L**T**LLL) than after a lax onset consonants (L**L**LL and L**L**LLL), for all speakers. Figure 2 shows f0 values of two speakers (M1 and F1).

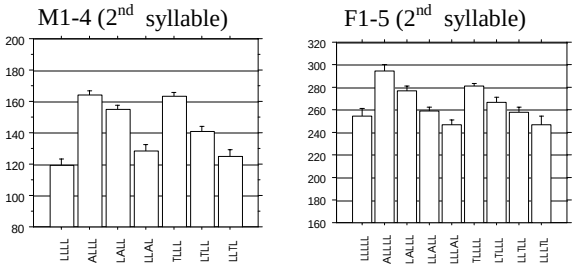

Figure 2: F0 of the 2nd syllable vowel in 4 or 5 syllable APs.

In Figure 2, it should be noted that when the first syllable onset is an aspirated or tense consonant, the f0 of the second syllable vowel with a lax onset (A**L**LL, T**L**LL, A**L**LLL and T**L**LLL) is still higher than the control vowel f0 (L**L**LL and L**L**LLL), and even higher than the f0 of second syllable vowels with an aspirated or tense onset (L**A**LL, L**T**LL, L**A**LLL and L**T**LLL). All speakers show the same results. This means the AP initial aspirated or tense stops and affricates substantially raise the f0 of the second syllable as well as that of the first syllable vowel. This suggests that the H tone in Korean AP needs to be implemented differently depending on the initial segment of an AP. That is, the second H tone in H**H**LH pattern has not the same f0 as the first H tone in L**H**LH pattern in Seoul Korean. The second H in H**H**LH is significantly higher ($p < 0.001$) than the first H in L**H**LH even if the onset consonant of the first H in LHLH has an aspirated or tense onset.

In the third syllable of 5-syllable APs, the f0 of the vowel after an aspirated or tense onset consonant (LL**A**LL and LL**T**LL) is not always higher than that after a lax onset (LL**L**LL) for all speakers. Two speakers (M2 and F2) show f0 raising after aspirated or tense onset consonants than after lax onset consonants. ($p < 0.05$), but the other two speakers (M1 and F1) show f0 raising after an aspirated onset consonant but not after a tense onset.

However, three out of four speakers (M1, M2, and F2) show when the AP initial syllable onset consonant is a tense or aspirated consonant, the f0 of the third syllable vowel with a lax onset (TL**L**LL and AL**L**LL) is still significantly higher than the control vowel f0 (LL**L**LL), and sometimes even higher (for M1 and F2) than that of the vowels with tense or aspirated onset consonants (LL**A**LL and LL**T**LL). Figure 3 shows data from all speakers.

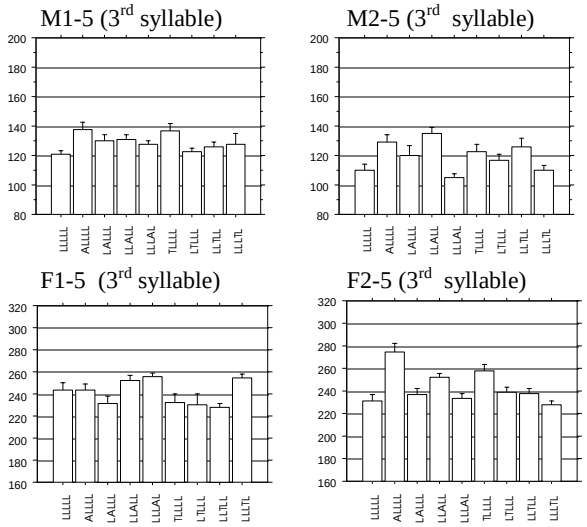

Figure 3: F0 value of the 3rd syllable vowel in 5 syllable APs.

It should be also noted that when the second syllable onset consonant of the AP is an aspirated or tense consonant, the f0 of the third syllable vowel (LA**L**LL and LT**L**LL) is not always significantly higher than the control f0 (LL**L**LL). That is, for speaker F1, LL**L**LL is higher than LA**L**LL and LT**L**LL, and for speaker F2, LL**L**LL is not significantly lower than LA**L**LL ($p > 0.08$). LL**L**LL is also not significantly lower than LT**L**LL for speaker M1 ($p > 0.07$). In addition, even if the third vowel in LA**L**LL or LT**L**LL is higher than the third vowel in the control LL**L**LL in some cases, the f0 difference between them is much smaller than the f0 difference between the second vowel in A**L**LLL or T**L**LLL, and the second vowel in the control L**L**LLL (see Figure 2).

In the penultimate syllable where L tone is realized for both HHLH and LHLH tonal patterns in Seoul Korean, all speakers show higher f0 for the vowel with an aspirated or tense onset (LLL**A**L and LLL**T**L) than that with a lax onset (LLL**L**L). Interestingly, three out of four speakers (M1, M2, and F2) show that the f0 of penultimate vowels in AL**L**L, TL**L**L, ALL**L**L and TLL**L**L is still higher than control vowel f0 (LLL**L**L) while one speaker (F2) shows lower f0 value for the vowel with an aspirated or tense onset then that with a lax onset, as shown in Table 2.

	4-syl			5-syl		
	LL**L**L	AL**L**L	TL**L**L	LLL**L**L	ALL**L**L	TLL**L**L
M1	105.7	*119.9	*119.9	101.0	*106.3	104.1
M2	104.4	*116.6	*119.6	96.1	*104.3	*102.4
F1	220.3	*208.5	*198.2	204.1	*186.1	*180.3
F2	203.1	*246.9	*227.3	210.7	*230.0	*223.1

Table 2: F0 value of the penultimate syllable vowel in 4 or 5 syllable APs. (* represents that the value is significantly ($p < 0.05$) different from the control value.)

This suggests that aspirated and tense consonants in phrase initial position have a strong effect on the f0 of the following syllables up to the penultimate even though the effect is less strong after the second syllable of an AP.

As for the AP final syllable, all speakers show rather consistent f0 value of final syllable vowel regardless of the difference in preceding consonant types: f0 variations are less than 20Hz. Since the final syllable is a particle *–ka*, no aspirated or tense onset was given to the final syllable as shown in Table 1. Figure 4 shows f0 values of two speakers (M1 and F1).

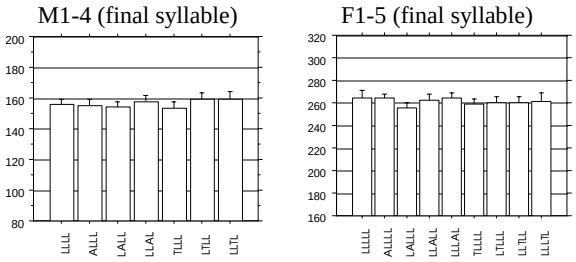

Figure 4: F0 value of the final syllable vowel in 4 or 5 syllable APs.

Besides this f0 raising due to the AP initial consonant, positional f0 differences are found. Three out of four speakers (M2, F1, and F2) show that the f0 values of vowels after an aspirated or tense onset in the second syllable (L**A**LL, L**A**LLL, L**T**LL and L**T**LLL) (partially shown in Figure 2) are significantly lower ($p < 0.05$) then those after an aspirated onset in the first syllable (**A**LLL, **A**LLLL, **T**LLL and **T**LLLL) (partially shown in Figure 1). Also all speakers show that the f0 values of vowels after an aspirated or tense onset in the third syllable in 5 syllable APs (shown in Figure 3) and the penultimate syllable in 4 syllable APs (LL**A**L, LL**A**LL, LL**T**L and LL**T**LL) are significantly lower ($p < 0.05$) then those after an aspirated or tense onset in the first syllable (**A**LLL, **A**LLLL, **T**LLL and **T**LLLL). This suggests that the consonantal effect on f0 raising of the second or third syllable is weaker than that in the first syllable of 4 or 5 syllable APs. Figure 5 shows f0 values after aspirated and tense consonant in each syllable of an AP except for the AP final syllable. 5-syllable AP data from the speaker M2 and 4 syllable AP data from the speaker F1 are shown as an example. Similar patterns are also observed in other speakers' data.

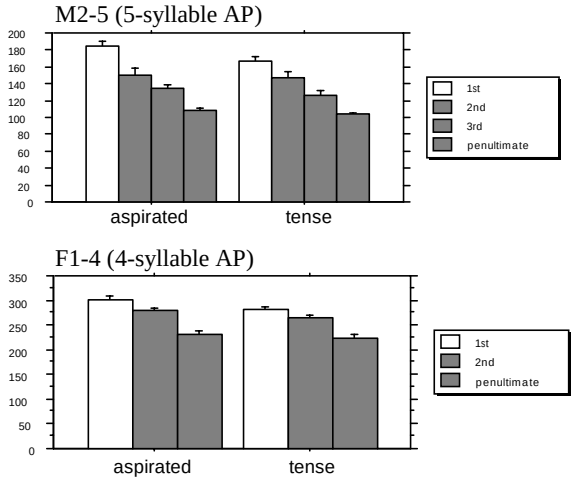

Figure 5: F0 value of the vowel with an aspirated or tense onset in each syllable position in an AP.

Finally, it is found that the average f0 of the vowel with an aspirated onset is always higher than that with a tense onset in any syllable position. However, in previous studies [1, 4, 5, 6, 9, 10, 13, 14], the f0 values of vowels after an aspirated and tense onset was not always higher than that after a tense onset. To confirm that the vowel after aspirated consonants is higher than that after tense consonant as seen in this study, more experiments are needed in which prosodic and segmental context and number of syllables are strictly controlled.

So far we have seen that raising f0 value by aspirated and tense consonants in phrase initial position has a consistent and strong effect up to the second syllable in 4 and 5 syllable APs and even the third and penultimate syllable, with a lesser degree, in 4 or 5 syllable APs. But the influence of aspirated or tense consonants was found to be limited to its own syllable when the consonant was in the middle of an AP. This f0 raising by the aspirated or tense consonant in AP initial position supports Jun's [11] claim that microprosody in Korean is phonologized in phrase initial position. That is, a high f0 after aspirated or tense consonants in Korean behaves as the underlying tonal pattern of an AP in Korean intonation.

Since the AP initial 2 syllables with a H-H tone arre significantly higher than that with a L-H tone, but both have similar f0 values in the final 2 syllables of an AP, we can predict the f0 values of the intervening syllables by interpolation between the second H and the penultimate L. This supports the location of 4 tones in AP and interpolation hypothesis claimed in Jun [10, 12]. Figure 6 shows schematics of f0 targets and interpolation within an AP.

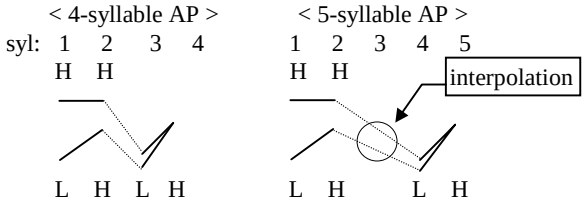

Figure 6: Schematics of the targets and interpolation within an AP.

Thus, for the implementation of a HHLH pattern AP (having an initial tense/aspirated onset), we need the f0 value of the initial syllable (which has 2 kinds, or 3 if we consider aspirated/tense difference) depending on the type of a consonant, the penultimate syllable, and the final syllable of the AP. For a LHLH pattern AP (having an initial lax onset), we also need the f0 of the second syllable (L**H**LH).

4. CONCLUDING REMARKS

In summary, we have seen that the Korean tense or aspirated onset consonant raises f0 values of the following vowel, and when it is positioned on the first syllable of an AP, it raises f0 values of the following non-adjacent vowels up to the penultimate syllable of an AP. That is, Korean AP initial aspirated and tense consonants strongly and consistently affect the f0 of the second syllable and even the third and fourth syllables in 4 and 5 syllable APs. In addition, the f0 value of a vowel with an obstruent onset is influenced by its syllable position in the AP as well as the type of the onset consonant. Finally, in any syllable position of 4-5 syllable APs, the vowel with an aspirated onset has higher f0 than the vowel with a tense onset. The results imply that investigations of segmental phonetics without considering the accompanying prosodic structure can lead to misleading results. Finally, this study also can be used as relevant data for the implementation of AP in Korean.

5. REFERENCES

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