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Table of Contents

Influence of microprosody on macroprosody: a case of phrase initial strengthening [1]

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1. Introduction

Cross-linguistically, it is widely accepted that f0 of a vowel onset is influenced by the preceding consonant type (i.e. the microprosody). For example, voiceless aspirated or tense consonants raise the f0 of the following vowel while voiced consonants and breathy consonants lower the f0 of the following vowel (Gandour 1974; Hombert 1978; Hombert et al. 1979). But, there are also studies showing no rise-fall dichotomy. Ohde (1984) measured nonsense syllables produced by American English speakers both in isolation and embedded in carrier phrases. He found that after voiced stops f0 was either level or slightly falling as in f0 after voiceless stops. Silverman (1984, from Silverman 1986) also found falling f0 after voiced as well as voiceless stops, though the fall was much shallower after voiced stops. From monotone German utterance, Kohler (1982, 1985) also found no falling f0 after voiced stops. Silverman (1986) claims that these differences of microprosody between voiced and voiceless consonants are an artifact of the experimental design: the intonational contour (i.e. the macroprosody) was not controlled for. The direction of f0 movement after release of a stop will show rise-fall dichotomy when it is in the middle of a rising intonation, but not in other intonational contexts. That is, the microprosody is influenced by the macroprosody (also see Steele 1986). In contrast, Kingston and Diehl (1994) present crosslinguistic data revealing that f0 perturbation pattern differs from language to language. Based on these results, they claim that the f0 perturbation may not be a low level phonetic phenomena.

Korean obstruents have also been shown to influence f0 of the following vowel (Kim 1965, Han & Weitzman 1970, Hardcastle 1973, Kagaya 1974): a higher f0 after voiceless aspirated stops and voiceless unaspirated (tense) stops but a lower f0 after voiceless breathy (lenis) stops. Interestingly, these segmentally induced f0 perturbations have been shown to play an important role in the intonation pattern of Korean (Jun 1989, 1993). An Intonational Phrase (=IP) of Korean can consist of more than one smaller phrase which is also tonally marked. This tonally marked small phrase is called an Accentual Phrase. When an Accentual Phrase initial consonant is either aspirated or tensed (both are [+stiff vocal cords] following Halle & Stevens (1971)), the phrase begins with a H tone and otherwise a L tone. That is, the tonal pattern of a non-IP-final Accentual Phrase in Seoul is either LHLH or HHLH and that of Chonnam is either LHL or HHL. (When an Accentual Phrase is in IP final, the Accentual Phrase final tone is preemptied by an IP boundary tone.) It was claimed that, in both dialects, in an Accentual Phrase longer than three syllables, the first and the second tone of an Accentual Phrase are associated with the first and the second syllable of the phrase, respectively. (For a detailed description of an Accentual Phrase, see Jun 1993.) But, it was not clear whether the segmentally triggered phrase initial H tone is phonetic (due to undershoot of L tone) or is phonologized, i.e. underlying. That is, since the second syllable of an Accentual Phrase is associated with a H tone, it would be possible that the phrase

[1] A shortened version of this paper was presented as a poster at the fifth meeting of the Laboratory Phonology conference at Evanston, Illinois, in July 1996. I thank J. Kingston for providing his ASA paper and all speakers who participated in this experiment and especially Cécile Fougeron for her help in recruiting French speakers.

initial H triggered by the microprosody may stay high phonetically due to the following H tone. If so, we expect the phrase initial H tone would persist for a shorter duration as in other languages when it is followed by a Low tone. On the other hand, if the H tone is underlying, we expect it will persist regardless of the following tone types, and it will furthermore be influenced by the constraints on the underlying tonal sequences.

The goal of this study is to determine the status, phonetic or phonological, of the accentual phrase initial H tone in Korean, and to examine how the pattern of microprosody in Korean differs from those in English and French in different prosodic positions and different intonational environments. English is chosen since most of the relevant studies are based on English data. French is chosen since it was shown in Jun & Fougeron (1995) that the Accentual Phrase of French has a similar tonal pattern (LHLH) to that of Seoul Korean.

2. Method

The target syllable CV was placed in four different prosodic/intonational positions shown in Table 1. In order to match prosodic conditions across languages, the target syllable was placed in a prosodically similar carrier sentence: for English, "This is a ___ note" or "This is ___"; for French, "Il a dit ___." (He said __); for Korean, "iɾɨmi ___ja." (The name is ___.). Data sets for each language are shown in the appendix. In Set 1, there were two Accentual Phrases for Korean and French, and the target CV was put at the beginning of the second Accentual Phrase (=AP) which has two syllables. For English, the target CV was in the nuclear pitch accented position. This prosodic condition is the same as that used in earlier studies (Lehiste & Peterson 1961, Lea 1973, Hombert 1978). In Set 2, the target CV was put after focused word, thus in the middle of an AP in French and Korean, and in a post-nuclear pitch accented position in English. Sentences in both sets were declaratives ending in a L boundary (%) tone. In Set 3, the target syllable was in the same position as in Set 1 but the sentences were interrogatives ending in a H% tone. Lastly, in Set 4, the target syllable was at the beginning of a four-syllable AP in French and Korean, and for English, it was an unstressed syllable immediately preceding a nuclear pitch accented syllable followed by two more syllables. (Similar data are tested in Silverman 1986.) Since both Korean and French have a H tone on the second syllable of an accentual phrase when the accentual phrase is longer than three syllables (i.e. Set 4), English data were designed to have a primary stress on the second syllable of trisyllabic target words. Since stress is lexical in English, all target CVs were embedded in a real word in English. Most vowels were [ɚ] except for those in Set 4 where the vowel was often [o]. For French, a set of real words containing the target syllable was included as a control data in addition to these four sets. These are listed in Set 0 of the Appendix. For Korean, 10 out of the 13 words in each set except Set 4 were real words. But all other nonsense words satisfy Korean phonotactics, and thus were easily pronounceable by native speakers of Korean. For both French and Korean nonsense words, the vowel was [i].

English consonants examined were /b, d, g, v, z, m, l, p, t, k, f, s, h/ and French consonants were /b, d, g, v, z, m, p, t, k, f, s/, and Korean had 9 lenis, tense, aspirated stops plus /m, l, s, h/. Four speakers of each language, Parisian French, Seoul Korean, and Californian English, participated in the experiment. Each subject repeated sentences 7 to 10 times. The utterances were digitized and analyzed using Entropic Research Laboratory's XWAVES speech analysis software. f0 was measured at vowel onset, and 20, 40, 60, 80, and 100 ms into the vowel.

Table 1. Four prosodic conditions

set #	sentence format	prosodic conditions
Set 1	{σσσ}{CV σ}.	AP initial in French & Korean In nuclear pitch accented syllable in English Followed by L%
Set 2	{σσσ CV σ}.	AP medial in French & Korean In post-nuclear pitch accented syll in Eng. Followed by L%
Set 3	{σσσ}{CV σ}?	AP initial in French & Korean In nuclear pitch accented syll in English Followed by H%
Set 4	{σσσ}{CV σσ(σ)}.	AP initial in French & Korean Before nuclear pitch accented syll in Eng. Followed by H phrase or H* tone

3. Results and Discussion

Since the f0 pattern of sonorant consonants in English and French was the same as that after voiced obstruents, sonorant consonants were grouped together to form a voiced consonant group to compare with the group of voiceless consonants for all languages. Mean f0 after each voiced vs. voiceless consonants from English and French is shown in Figure 1 and 3, respectively. For Korean, since the f0 pattern of sonorant consonants was the same as that after lenis stops, sonorant consonants were grouped together with lenis stops. The mean f0 of lenis stops and sonorants vs. other voiceless consonants from Korean is shown in Figure 4. The X-axis in these figures refers to the time from the vowel onset until 100ms in every 20 ms. In each figure, Set 1 data is shown in the upper left graph, Set 2 in the upper right graph, Set 3 in the lower left graph, and Set 4 in the lower right graph. For all languages, the place where the target CV syllable appears is indicated as a square box. The error bar in each graph represents one standard deviation.

As shown in Figure 1, f0 values after voiceless and voiced consonants in English merged sooner than those in previous studies (e.g. Hombert 1978): 20-40 ms rather than 80-100ms. This pattern is similar to the pattern shown in Kingston and Diehl (1994, p. 433). Furthermore, f0 after voiced stops did not rise under the same intonation patterns as those used in early studies. That is, the target CV in English Set 1 and Set 4 is the same prosodic condition as in Hombert (1978) but the f0 after voiced consonants was either level or falling as in f0 after voiceless consonants. This is the same pattern found in Ohde (1984) where nonsense words were used. The f0 difference between voiced vs. voiceless consonants was even smaller in Set 2 and Set 3, indicating that the consonant perturbation pattern is indeed influenced by the overall intonational contours (Kohler 1982, Steele 1986, and Silverman 1986). When the target CV is in the middle of a falling intonation, (i.e. Set 2) or before rising (Set 4), f0 perturbation pattern was very similar between voiced and voiceless consonants. A similar pattern is also shown in Kingston & Diehl (1994, p. 434).

For French data, the f0 perturbation pattern after voiced vs. voiceless consonants in real words (Set 1) was in general very similar to that in nonsense words (Set 0) as shown in Figure 2. Overall, f0 showed more variation in real words. Also, f0 after voiceless consonants in real words tends to be more separated from f0 after voiced consonants for most speakers than they are in nonsense words. This may be caused by the different types of segments following the word initial consonant in real words. But, in both cases, f0 after voiced consonants was either level or rising and f0 after voiceless consonants was falling as claimed in previous studies. This f0 separation between voiced and voiceless consonants in real words was not significant from 20 to 40ms after consonant onset, and this timing was the same in nonsense words. This verifies that as far as a f0 pattern is concerned, using nonsense words for French data was not different from using real words. f0 values after voiced and voiceless consonants in French also merge around 20-60ms after vowel onset, but unlike in English, f0 after voiced consonants is rising except for that in Set 2. This may be due to the fact that French voiced stops are more often fully voiced than English voiced stops. Again, the f0 pattern after voiced and voiceless consonants is less different in Set 2, showing the influence of macroprosody. Basically, the f0 pattern in Set 2 was similar in all three languages.

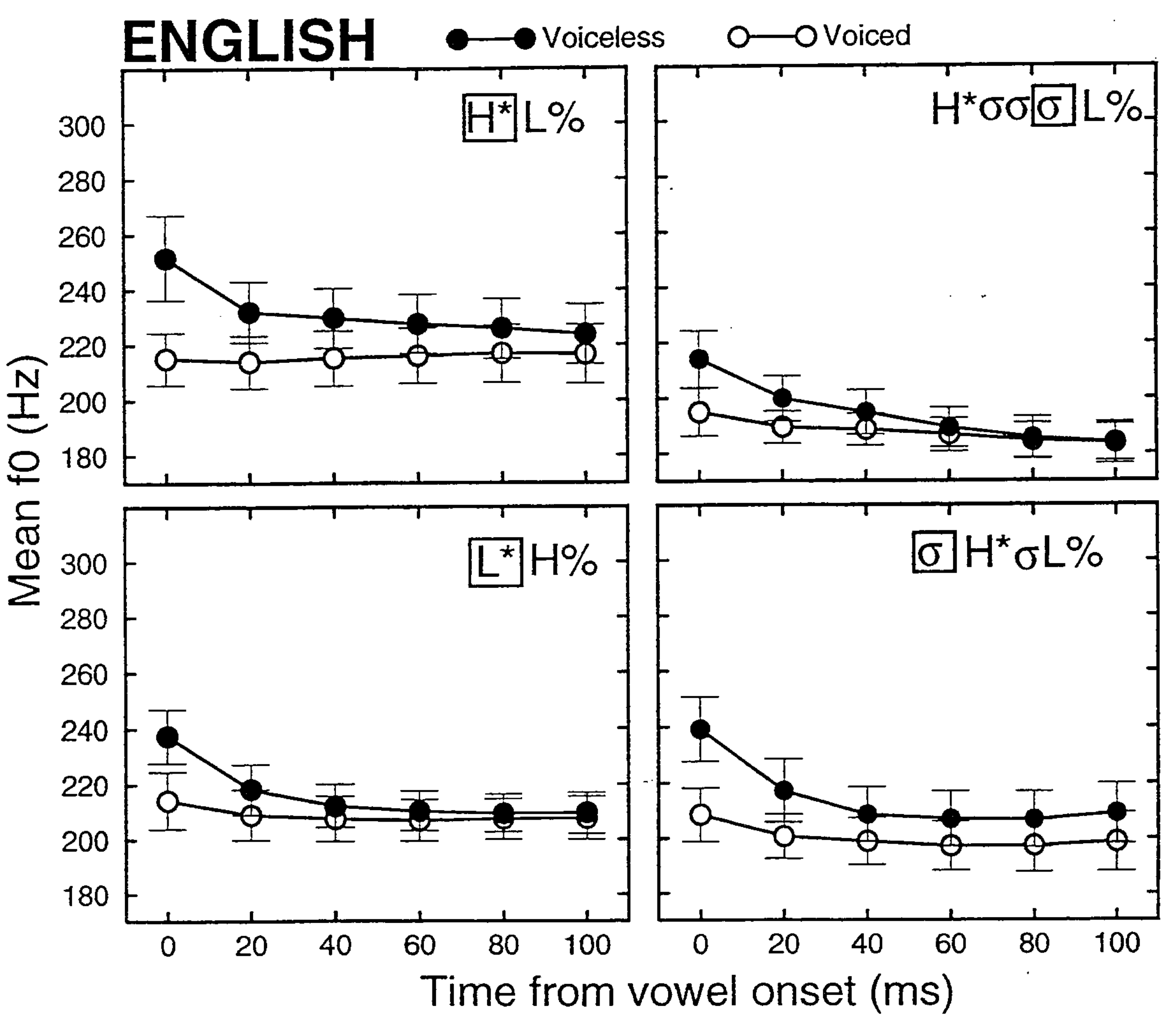


Figure 1. Mean f0 (in Hz) pattern of English voiceless (filled circle) vs. voiced (empty circle) consonants

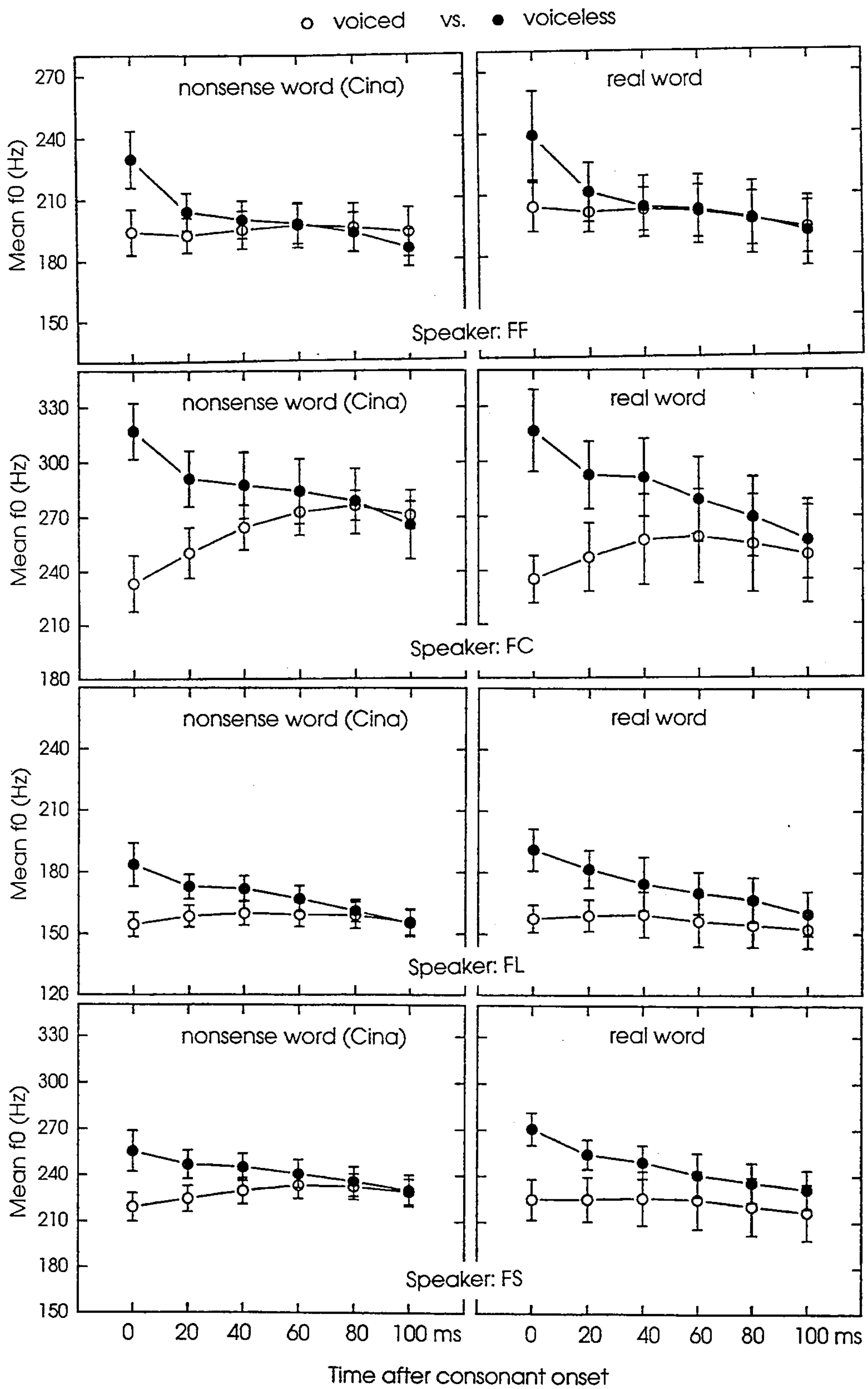


Figure 2. Mean f0 (in Hz) pattern of French Set 0 (real words) and Set 1 (nonsense words) produced by four French speakers

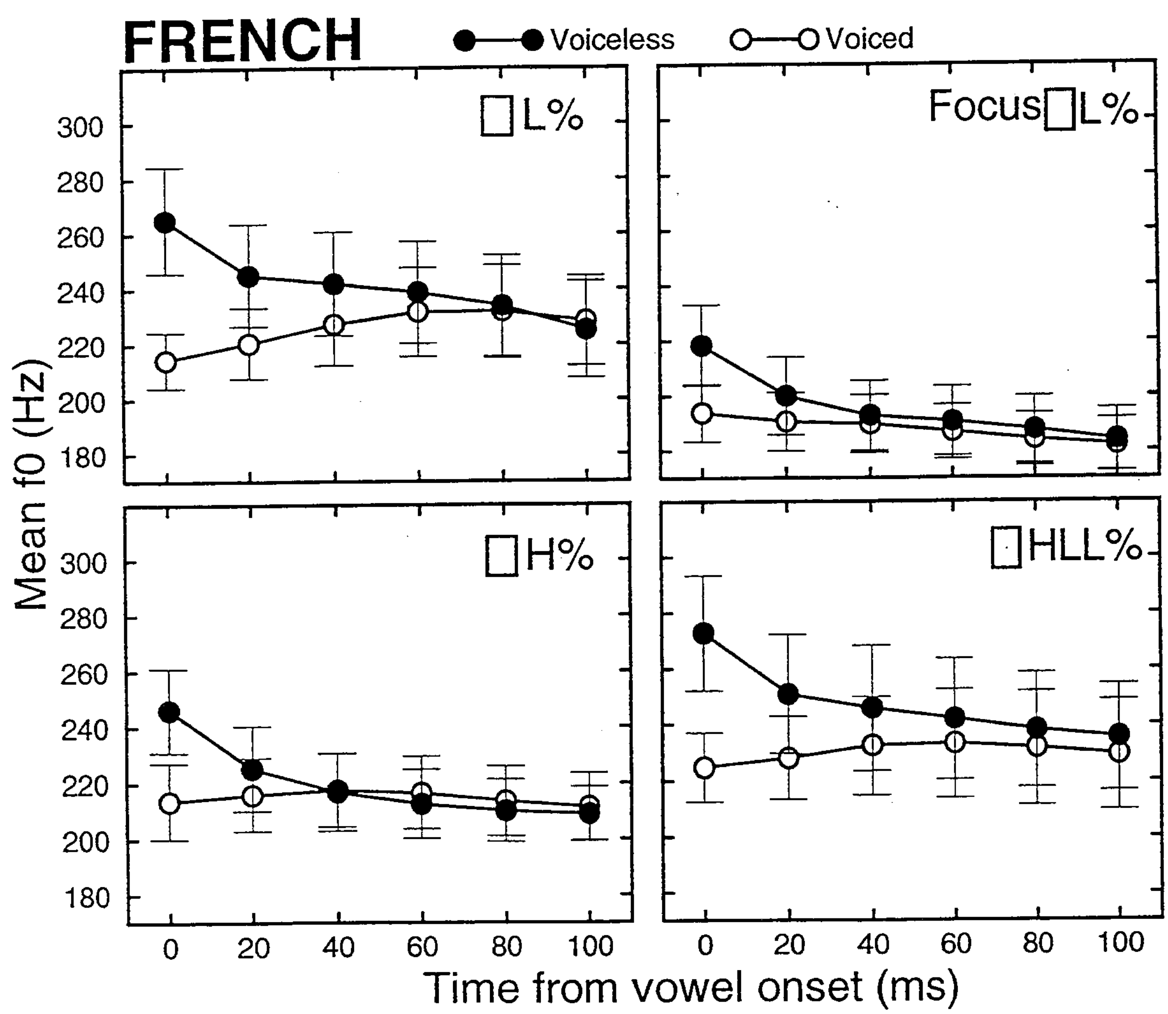


Figure 3. Mean f0 (in Hz) pattern of French voiceless (filled circle) vs. voiced (empty circle) consonants

The f0 pattern after Korean consonants (Figure 4) was very different from English and French, except for that in Set 2. For Korean, as noted in Jun (1993), f0 after aspirated and tense stops was significantly higher (in average 50-80 Hz) than that after lenis stops and sonorant consonants, and these f0 differences persisted until the end of the vowel. This f0 difference was far greater than that found in English or French, suggesting that the f0 perturbation type in Korean is not the same as that in other languages. If the phrase initial H tone results from L tone undershoot due to the following H tone, we would expect a similar pattern of f0 values both in English and French, especially in Set 4 where the phrase initial syllable is followed by H* in English and by phrasal H in French. But as shown in Figure 1 and 3, the f0 values differ only at phrase initial position and the difference does not persist longer than 40-60 ms into the vowel. In addition, the phrase initial high f0 triggered by [+stiff vocal cords] consonants in Korean remained high regardless of the following tone types and showed a tonal interaction with the following tones, suggesting the phrase initial H tone in Korean is not due to phonetic undershoot but is part of the underlying representation of intonation. For example, when the phrase initial consonant has a [+stiff vocal cords] feature, the phrase initial syllable had a H tone even before the L boundary tone (%) of a declarative sentence (Set 1 in Figure 4). At the same time, when the syllable was followed by an interrogative marker which is H% by default, the boundary tone became either LH% or upstepped H% or HL%, as shown in Figure 5.

Further evidence for an underlying phrase initial H tone was found in EMG data from a Chonnam speaker (the author). From EMG data (Thyroarytenoid (Vocalis) muscle and Posterior Cricoarytenoid muscle) collected for vowel devoicing (Jun and Beckman in preparation), we found that the Vocalis muscle was highly active at a vowel onset after tense consonants, but also active in parallel with a high f0 contour. Representative examples are shown in Figure 6. In the first example, the last Accentual Phrase begins with an aspirated stop [p^h], and pitch tracks show a high f0 value. At the same time, the Vocalis muscle also shows a high level of activity, about 80 ms before the timing of high f0 in pitch track, as marked by an arrow. (EMG activity trace is 80 ms advanced compared to acoustic waveform and airpressure data.) The second example shows when the last Accentual Phrase begins with a lenis stop /t/. f0 values in the pitch tracks are low during this syllable and the corresponding Vocalis activity is also low, lower than the following peak which is aligned with the phrasal H tone of the second syllable of the phrase. The Vocalis muscle trace (first window) still shows a high level of activity after [+stiff vocal cords] consonants even when the vowel /i/ was devoiced as indicated by an arrow in Figure 7. The waveform (fourth window) shows frication of /s/ but no periodic movement before stop closure for /k'/ (tense velar stop) and the corresponding intraoral air pressure trace (second window) shows no dip during the vowel portion, indicating a complete devoicing of vowel [i].

However, when the consonant was in the middle of an Accentual Phrase, the Vocalis activity was changed following the f0 pattern. The same sentences shown in Figure 6 but with focus on the word preceding the target word is shown in Figure 8. In Korean, a focused word always initiates an Accentual Phrase and all the following unfocused words are dephrased showing a L tone (Jun 1993). Thus, the target syllable, [p^hu], in the upper graph, now has a L tone and the corresponding Vocalis muscle activity is also lowered (indicated by an arrow) compared to the case where the consonant was at the beginning of an Accentual Phrase (Figure 6). For the same reason, the target syllable, [tu], in the lower graph shows a L tone and low Vocalis muscle activity (indicated by an arrow), thus neutralizing with the phrase medial aspirated syllable in the upper graph.

In sum, f0 and EMG pattern show that phonologization of pitch perturbation in such a way it affects Korean intonation is only limited to an Accentual Phrase initial position. In other words, in Korean, microprosodically triggered tone is phonologized only phrase initially. This limitation can be interpreted as a phrase initial strengthening. Crosslinguistically, production data have been shown that acoustic duration as well as lingual contact duration of EPG is longer phrase initially than phrase medially, indicating that segments at the phrase initial position are strengthened (Jun 1993 for Korean; Hsu and Jun 1996 for Taiwanese; Fougeron 1996 for French; Fougeron and Keating 1996 for English; Gordon 1996 for Estonian). That is, by producing a High or Low tone on the vowel following the phrase initial consonant, the perception of three consonant types, i.e. the three-way contrast either in the laryngeal feature or VOT/closure duration, is enhanced in the phrase initial position (Stevens and Keyser 1989), but not in the phrase medial position. However, since there are only two tonal contrasts in phrase initial position, H for [+stiff vocal cords] consonants and L for [-stiff vocal cords] consonants, this would imply that what is enhanced is not the distinction among three consonant types, but between lenis versus the other two tense consonant types. This way of strengthening seems to match well with the acoustic/articulatory characteristics of these consonants. Among three types of consonants, lenis consonants have in general the weakest acoustic/articulatory property. That is, aspirated stops have the longest VOT and largest oral airflow, and tense stops have the longest closure duration, the strongest burst energy, and the strongest oral airpressure, but lenis stops have the medium or weak value in all these phonetic dimensions. Thus, the perceptual saliency of the lenis stop itself is weaker than other stops. Thus, by producing a Low tone following the phrase initial lenis stop but a High tone following the other two types of stops, the perceptual saliency of the lenis stop would increase and, so, the contrast is enhanced.

Employing f0 perturbation to enhance a phonological contrast has been claimed in Kingston (1986). He argues that f0 perturbation is phonologized to enhance a distinctive feature of [voice]. Thus, languages where [voice] is not a distinctive feature as in Tamil, f0 perturbation does not need to be phonologized "because speakers are not trying to transmit a contrast between [+voice] and [-voice] stops, but between short and long ones". However, [voice] is not a distinctive feature in Korean, either, (all obstruents are voiceless) but f0 perturbation is still phonologized to enhance the contrast between lenis vs. other two types of consonant. This suggests that f0 perturbation in Korean is used to enhance [tense] feature which was claimed by Kim (1965) to distinguish [-tense] (= lenis stops) consonants from [+tense] (=aspirated and tense stops) consonants. What is interesting in Korean is that enhancing [tense] feature through the phonologization of f0 perturbation depends on the prosodic position of the consonant: it is limited to the phrase initial position.

This interpretation is supported by the perception experiments reported in Cho (1996) and Han (1996). Cho (1996) found that native Korean subjects were able to perceive (67%) the prevocalic consonants based on f0 and intensity of the following vowel. Interestingly, subjects perceived lenis stops and tense stops more accurately (71~83% and 65%~86%, respectively) than aspirated stops (42~57%). Furthermore, aspirated consonants were more often misperceived as tense consonants (52%) than as lenis consonants (10%), and tense consonants were more often perceived as aspirated consonants (26%) than as lenis consonants (12%). This pattern of error matches the pattern of f0 following the consonants. In this experiment, the perception token was from the first syllable (CV) of a two-syllable word produced in a citation form, thus a phrase initial CV. Han (1996, pp. 174-179), on the other hand, tested if the f0 pattern found in production data is also utilized in the perception of the stops by Korean speakers. She created synthetic stimuli of tense and lenis stops followed by a vowel, and varied the onset f0 values continuously from

122Hz to 158Hz for each stops. Then she asked Korean subjects to identify the CV stimulus either as a lenis or tense stop. The result showed that "the subjects perceived the stimuli systematically, with lower f0 giving rise to lenis stops and higher f0 giving rise to tense stops", and the category boundary was 134 Hz when the consonant part of the stimulus was from a lenis stop, and 143Hz when the consonant was from a tense stop. This indicates that there is an inherent quality of lenis vs. tense consonants, and f0 strongly enhances the perception of the consonant. Here again, the CV was also at word initial and phrase initial position. These two perception experiments show that the tonal difference produced after stops is perceptually salient when stops are in the phrase initial position. It would be very interesting to examine the case when the perception token is from an accentual phrase medial position.

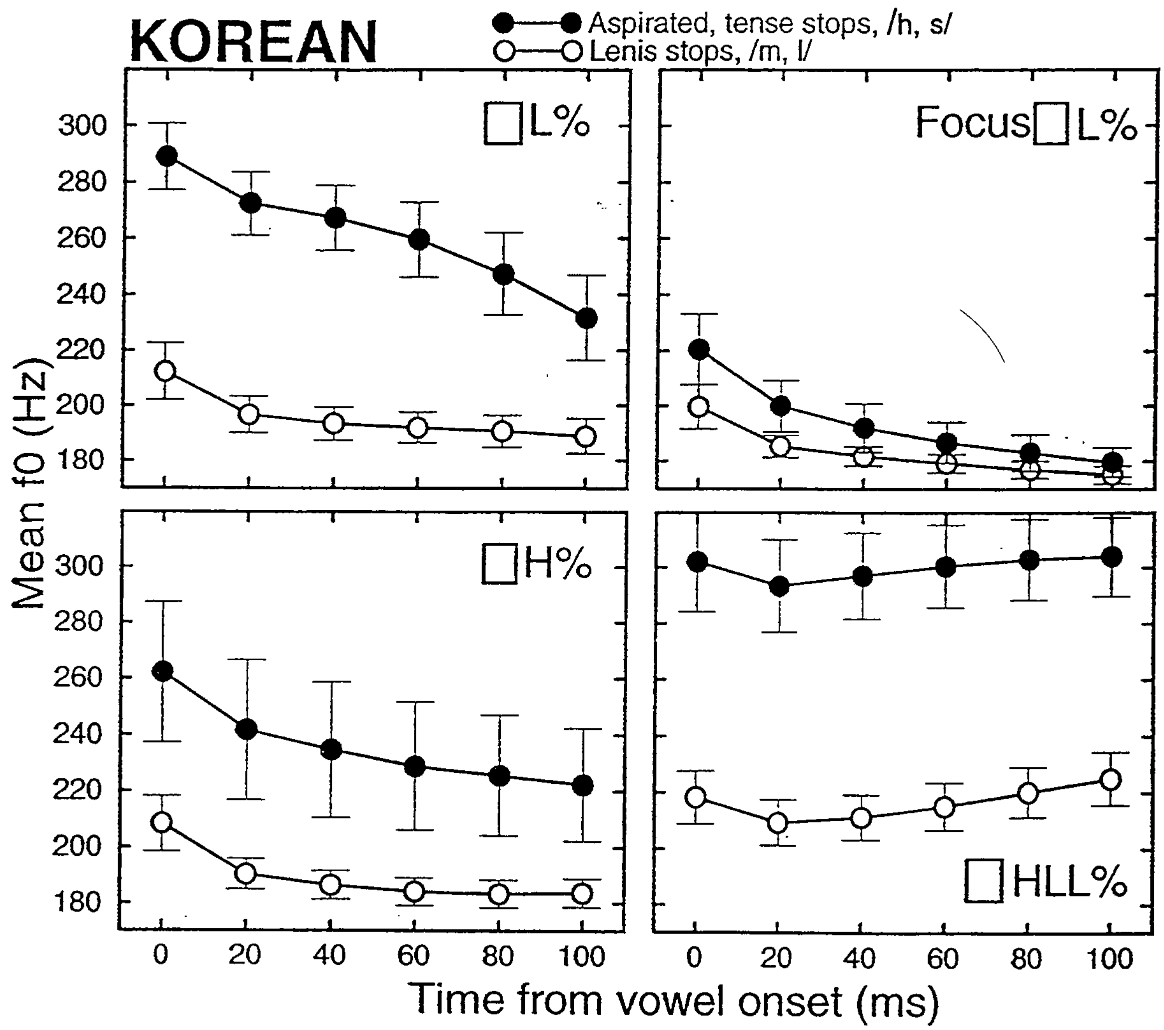


Figure 4. Mean f0 (in Hz) pattern of Korean: aspirated and tense stops, and /h, s/ group is shown as a filled circle, and lenis stops and /l, m/ group is shown as an empty circle.

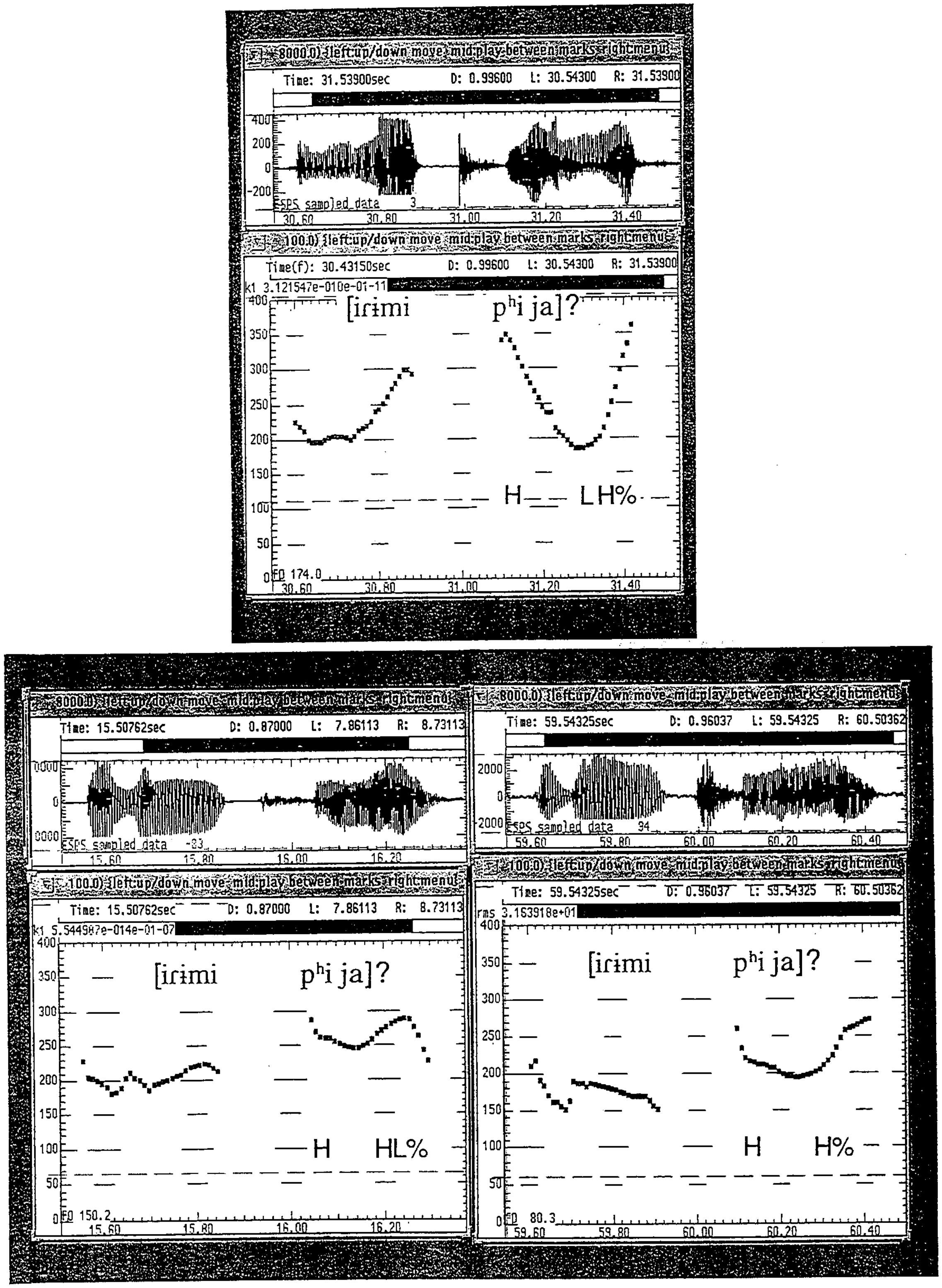
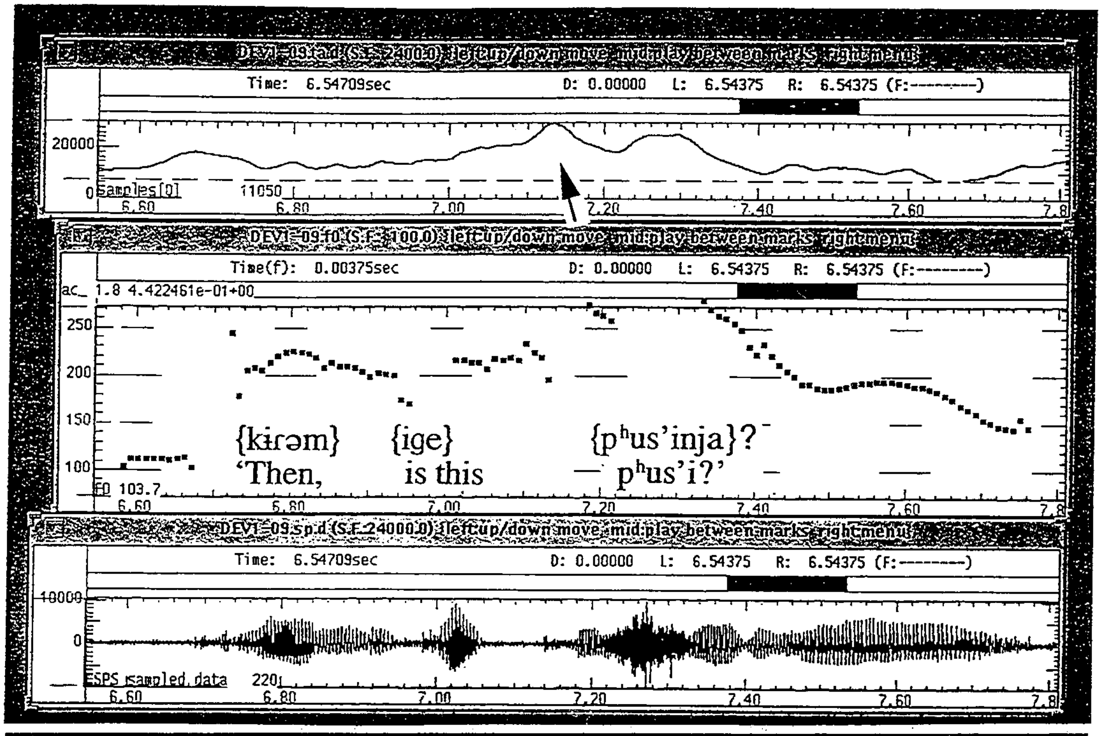


Figure 5. Three types of interrogative boundary tones after phrase initial [+stiff vocal cords] consonant, /p^h/.



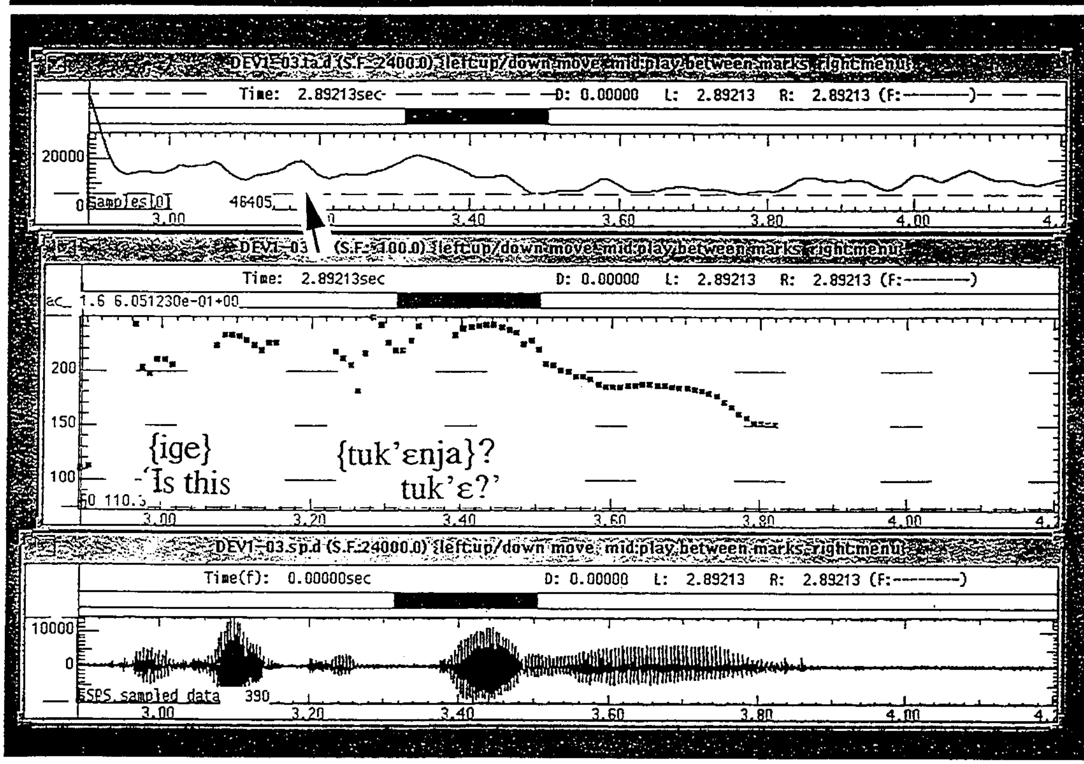


Figure 6. Examples of Vocalis muscle activity, f0 tracks, and waveforms when the Accentual Phrase initial segment is [+stiff vocal cords], /pʰ/, (above) and [-stiff vocal cords] consonant, /t/ (below).

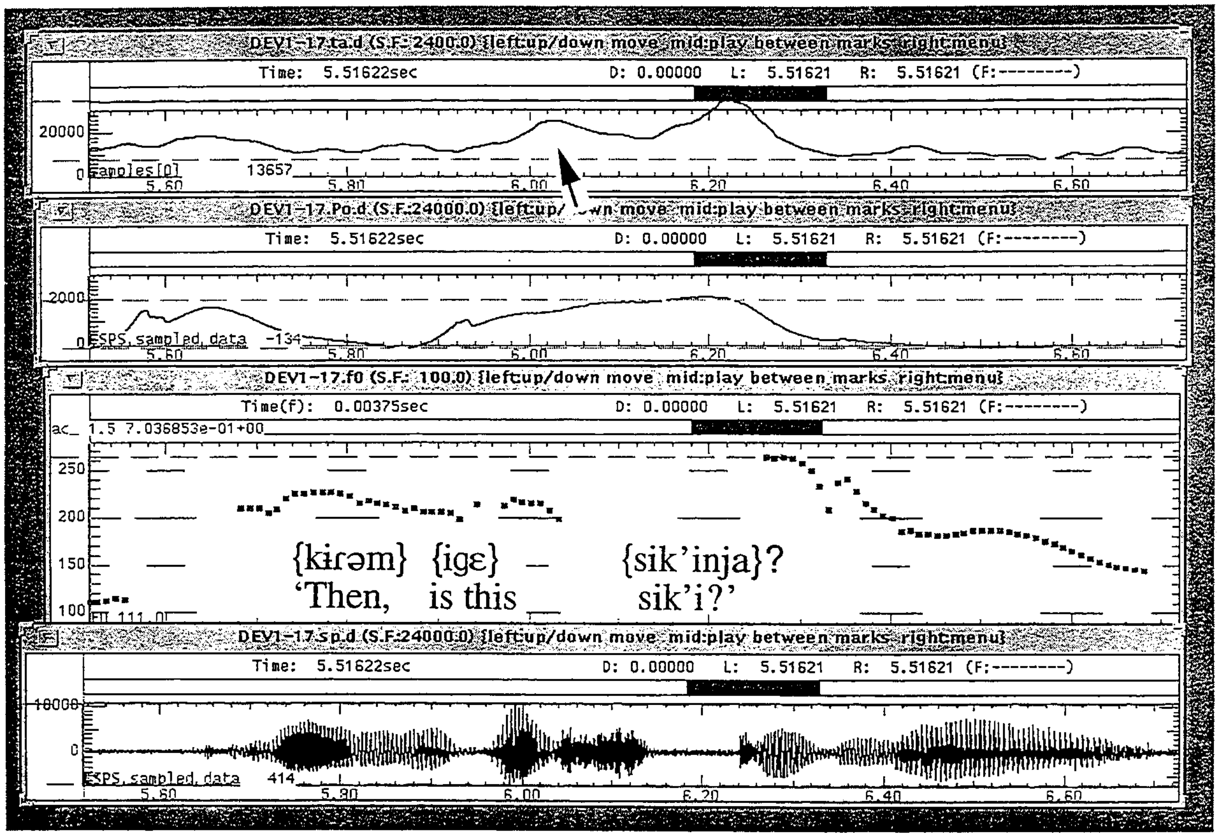


Figure 7. An example of Vocalis muscle activity (first window), intraoral pressure (second window), f0 tracks (third window), and waveforms (fourth window) when a vowel /i/ is devoiced after an Accentual Phrase initial [+stiff vocal cords] consonant.

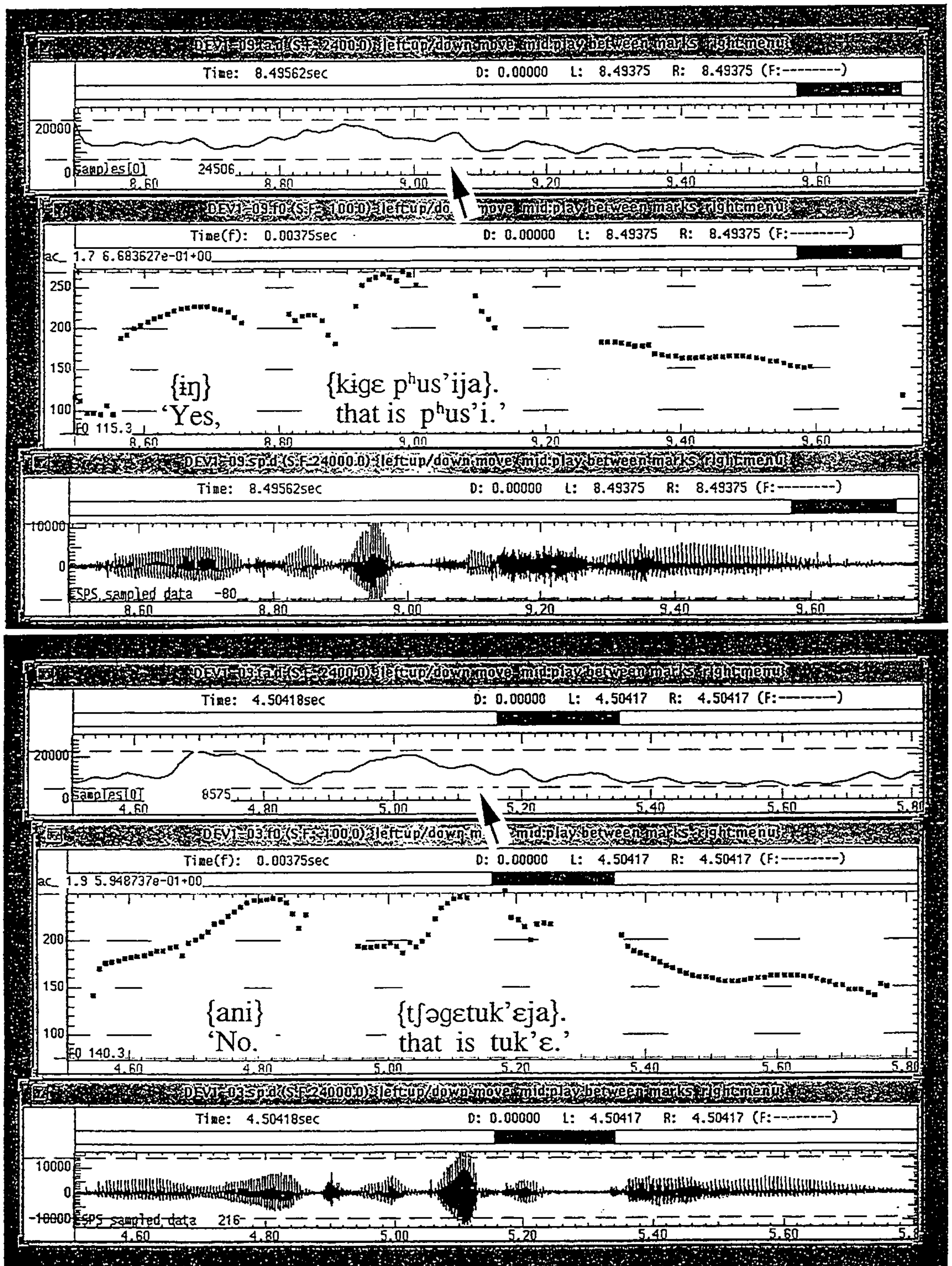


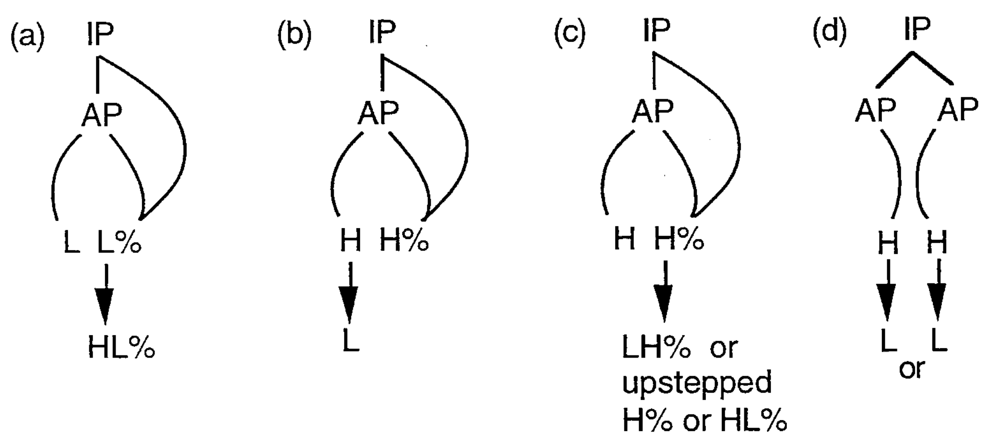
Figure 8. Examples of Vocalis muscle activity, f0 tracks, and waveforms when the target syllable, /pʰ/ (upper) and /t/ (lower) is in the middle of an Accentual Phrase.

Next, in addition to phrase initial strengthening due to tonal contrast triggered by a consonant, it was found that there is a constraint on tonal sequence in Korean which is also sensitive to a phrase boundary. I call this constraint the 'see-saw effect'.

(1) The 'see-saw' effect: A sequence of two identical tones tends to become different from each other if they are boundary tones belonging to a different prosodic level (AP or IP) or belonging to a different prosodic group ({AP}{AP}).

For example, an accentual phrase initial H tone followed by L% was not changed, but an accentual phrase initial L tone followed by L% became L and HL%. This is schematically represented in (2a) below and an example pitch track is shown in Figure 9(a). In the same way, an accentual phrase initial L tone followed by H% sequence was not changed, but an accentual phrase initial H tone followed by H% was changed so that they are not identical. That is, as shown in Figure 5, H% after the phrase initial H became one of the three types: LH% or upstepped H% or upstepped HL% . A schematic representation of the tonal change is shown in (2c) below. Alternatively, the phrase initial H can become L before H% as schematized in (2b) below. An example pitch track is shown in Figure 9(b). All these changes have something in common: one of the two adjacent tones changes to sound different from each other, either categorically (from L to H or vice versa) or phonetically (from H to upstepped H).

(2) schematic representation of the 'see-saw' effect



Cases shown in (2 a, b, c) show interaction between tones belonging to a different prosodic level. But, tones belonging to the same prosodic level but belonging to a different prosodic grouping also behave similarly. For example, when an Accentual Phrase initial H is preceded by an Accentual Phrase final H, one of the H often becomes a L tone. However, when the phrase initial H is also followed by H% which marks an Intonational Phrase boundary, the phrase initial H often becomes L. This explains why there is a large variation in Set 3 of Figure 4 above, larger than the variations shown in Set 1 or Set 4. In Set 4, where the phrase initial H is preceded by a phrase final H but followed by a phrase medial H which does not mark any phrase boundary, the phrase initial H was less likely to change into a L tone. Rather, the preceding phrase final H tone often became L tone. A schematic representation of this change is shown in (2d) and an example pitch track is shown in Figure 9(c). In all cases, the tones were changed to avoid a sequence of the same tone. But, when both tones are within the same prosodic group as in the Accentual Phrase initial HH sequence, no tones were changed. So, it seems that the 'see-saw' effect applies when both tones are marking a boundary of a prosodic group. I believe there is a perceptual motivation for the 'see-saw' effect: namely, identical tones are perceptually hard to distinguish in sequence. Thus, when they mark prosodically important boundaries, they change in order to be perceived better.

4. Conclusion

In this paper, it was shown that unlike English and French, the phrase initial H tone in Korean is triggered by segmental perturbation, and that this tone is phonologized in Korean. This segmental perturbation in Korean triggers an underlying tonal difference only in phrase initial position, thus, supporting the phrase initial strengthening phenomena found in the production data from several languages. Finally, a sequence of two identical boundary tones belonging to different prosodic levels or different prosodic grouping tends to be modified so that they differ from each other: the 'see-saw' effect.

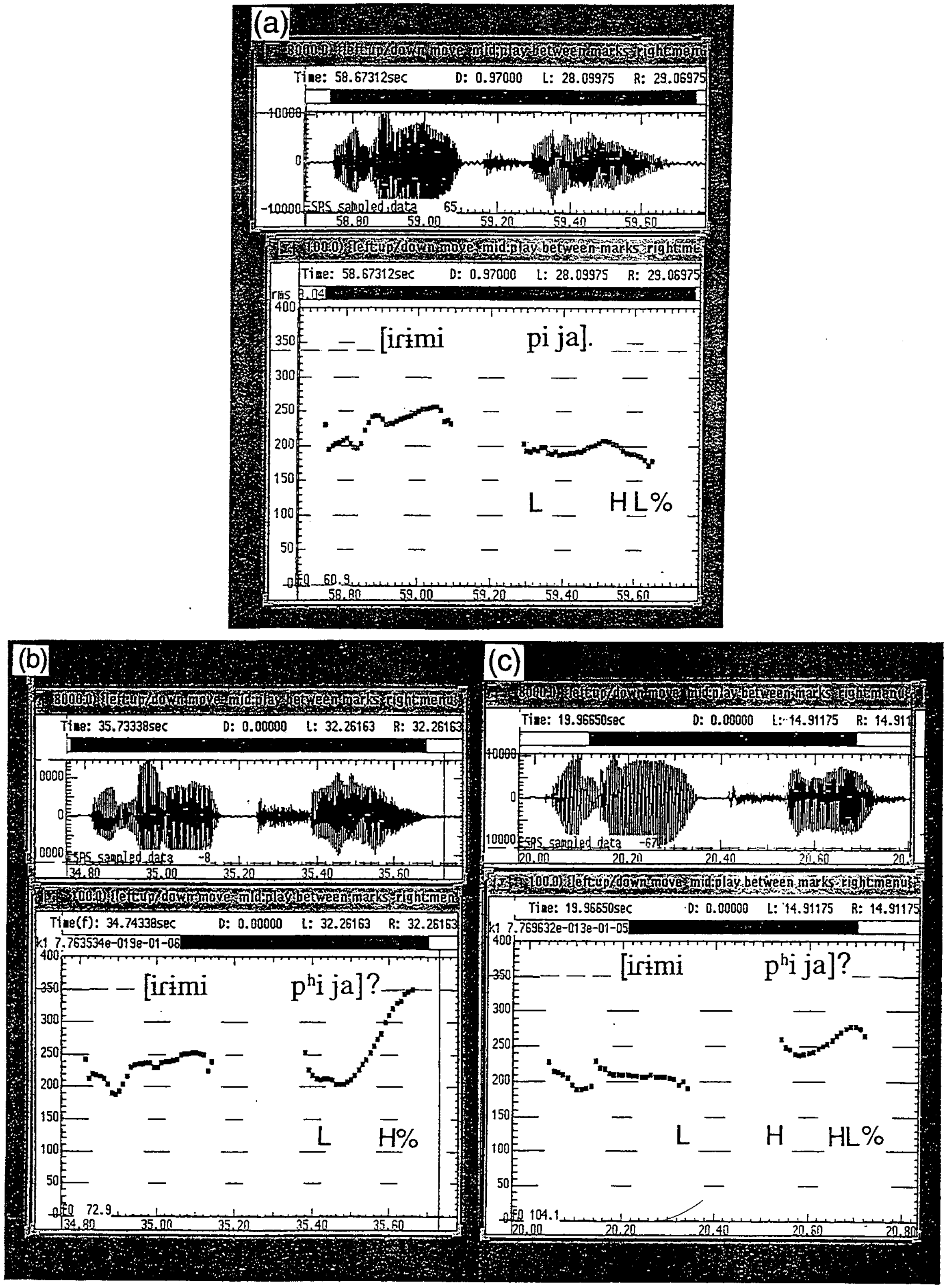


Figure 9. Tone interaction patterns showing the 'see-saw' effect. (a) L% after L becomes HL%, (b) H before H% becomes L, and (c) phrase final H becomes L before phrase initial H.

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Appendix (Words in italics are focused.)

English Data

Set 1.
0. This is a "learn" note.
1. This is a "perm" note.
2. This is a "turn" note.
3. This is a "kern" note.
4. This is a "fern" note.
5. This is a "seal" note.
6. This is a "burn" note.
7. This is a "meal" note.
8. This is a "durn" note.
9. This is a "girl" note.
10. This is a "Verne" note.
11. This is a "zeal" note.
12. This is a "heel" note.

Set 1.
0. *This* is a "learn" note.
1. *This* is a "perm" note.
2. *This* is a "turn" note.
3. *This* is a "kern" note.
4. *This* is a "fern" note.
5. *This* is a "seal" note.
6. *This* is a "burn" note.
7. *This* is a "meal" note.
8. *This* is a "durn" note.
9. *This* is a "girl" note.
10. *This* is a "Verne" note.
11. *This* is a "zeal" note.
12. *This* is a "heel" note.

Set 3
0. Is this a "learn" note?
1. Is this a "perm" note?
2. Is this a "turn" note?
3. Is this a "kern" note?
4. Is this a "fern" note?
5. Is this a "seal" note?
6. Is this a "burn" note?
7. Is this a "meal" note?
8. Is this a "durn" note?
9. Is this a "girl" note?
10. Is this a "Verne" note?
11. Is this a "zeal" note?
12. Is this a "heel" note?

Set 4.
0. This is "logician".
1. This is "pomaceous".
2. This is "tornado".
3. This is "Koranic".
4. This is "foramen".
5. This is "Somalia".
6. This is "Bohemian".
7. This is "momentum".
8. This is "donation".
9. This is "Gorgonian".
10. This is "voracious".
11. This is "zoology" [zoʊɑlədʒi].
12. This is "homology".

French data:

Set 0.
1. il a dit piler.
2. il a dit tisane.
3. il a dit kiné.
4. il a dit fila.
5. il a dit sigma.
6. il a dit bilan.
7. il a dit disons.
8. il a dit guider.
9. il a dit villa.
10. il a dit zigzag.
11. il a dit miner.

Set 1.
1. il a dit pina.
2. il a dit tina.
3. il a dit kina.
4. il a dit fina.
5. il a dit sina.
6. il a dit bina.
7. il a dit dina.
8. il a dit guina.
9. il a dit vina.
10. il a dit zina.
11. il a dit mina.

Set 2.
1. il a *dit* pina.
2. il a *dit* tina.
3. il a *dit* kina.
4. il a *dit* fina.
5. il a *dit* sina.
6. il a *dit* bina.
7. il a *dit* dina.
8. il a *dit* guina.
9. il a *dit* vina.
10. il a *dit* zina.
11. il a *dit* mina.

Set 3.
1. At-il dit pina?
2. At-il dit tina?
3. At-il dit kina?
4. At-il dit fina?
5. At-il dit sina?
6. At-il dit bina?
7. At-il dit dina?
8. At-il dit guina?
9. At-il dit vina?
10. At-il dit zina?
11. At-il dit mina?

Set 4.
1. il a dit pinanamou.
2. il a dit tinanamou.
3. il a dit kinanamou.
4. il a dit finanamou.
5. il a dit sinanamou.
6. il a dit binanamou.
7. il a dit dinanamou.
8. il a dit guinanamou.
9. il a dit vinanamou.
10. il a dit zinanamou.
11. il a dit minanamou.

Korean data:

[irɨm-i] 'a name-NOM.', [li-ja] 'li-a declaratives or an interrogative ending of be'
=> "The name is 'li'".

Set 1.

1.	이름이 리야.	[irɨmi lija]
2.	이름이 비야.	[irɨmi pija]
3.	이름이 피야.	[irɨmi pʰija]
4.	이름이 삐야.	[irɨmi p'ija]
5.	이름이 시야.	[irɨmi sija]
6.	이름이 히야.	[irɨmi hija]
7.	이름이 미야.	[irɨmi mija]
8.	이름이 디야.	[irɨmi tija]
9.	이름이 티야.	[irɨmi tʰija]
10.	이름이 띠야.	[irɨmi t'ija]
11.	이름이 기야.	[irɨmi kija]
12.	이름이 키야.	[irɨmi kʰija]
13.	이름이 끼야.	[irɨmi k'ija]

Set 2.

1.	*이름이 리야.*	[irɨmi lija]
2.	*이름이 비야.*	[irɨmi pija]
3.	*이름이 피야.*	[irɨmi pʰija]
4.	*이름이 삐야.*	[irɨmi p'ija]
5.	*이름이 시야.*	[irɨmi sija]
6.	*이름이 히야.*	[irɨmi hija]
7.	*이름이 미야.*	[irɨmi mija]
8.	*이름이 디야.*	[irɨmi tija]
9.	*이름이 티야.*	[irɨmi tʰija]
10.	*이름이 띠야.*	[irɨmi t'ija]
11.	*이름이 기야.*	[irɨmi kija]
12.	*이름이 키야.*	[irɨmi kʰija]
13.	*이름이 끼야.*	[irɨmi k'ija]

Set 3.

1. 이름이 리야? [irɨmi lija]
2. 이름이 비야? [irɨmi pija]
3. 이름이 피야? [irɨmi p^{h}ija]
4. 이름이 삐야? [irɨmi p'ija]
5. 이름이 시야? [irɨmi sija]
6. 이름이 히야? [irɨmi hija]
7. 이름이 미야? [irɨmi mija]
8. 이름이 디야? [irɨmi tija]
9. 이름이 티야? [irɨmi t^{h}ija]
10. 이름이 띠야? [irɨmi t'ija]
11. 이름이 기야? [irɨmi kija]
12. 이름이 키야? [irɨmi k^{h}ija]
13. 이름이 끼야? [irɨmi k'ija]

Set 4.

1. 이름이 리아나래. [irɨmi lianare]
2. 이름이 비아나래. [irɨmi pianare]
3. 이름이 피아나래. [irɨmi p^{h}ianare]
4. 이름이 삐아나래. [irɨmi p'ianare)
5. 이름이 시아나래. [irɨmi sianare]
6. 이름이 히아나래. [irɨmi hianare]
7. 이름이 미아나래. [irɨmi mianare]
8. 이름이 디아나래. [irɨmi tianare]
9. 이름이 티아나래. [irɨmi t^{h}ianare]
10. 이름이 띠아나래. [irɨmi t'ianare]
11. 이름이 기아나래. [irɨmi kianare]
12. 이름이 키아나래. [irɨmi k^{h}ianare]
13. 이름이 끼아나래. [irɨmi k'ianare]