

Rightward tone spread revisited

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Kim, Sung-A. 2000. Rightward tone spread revisited. *Studies in Phonetics, Phonology and Morphology* 6.1, 41-57. Recent studies of phonetics and phonology have provided us a better understanding of the relationship between phonetics and phonology. They informed us that not all the phonological rules previously proposed correspond to the phonological representation of the language. This paper develops this line of inquiry further, and seeks phonetic assessment of phonological analysis of the tone alternation in Yao. It also presents some data of 'F0 peak lagging' phenomenon in English. We argue in the present work that the facts that have been considered as post-lexical rightward tone spread in Malawian Yao deserve a phonetic account. (Korea National University of Education)

Keywords: phonetic assessment, tone spread, Yao, F0 peak lagging, English

1. Introduction

There is a substantial body of recent studies to show a richer role of phonetics, which leads to a rethinking of both the role of phonetics and its relationship to phonology. A couple of important branches of the studies include the approaches of Pierrehumbert (1980), Cohn (1990) and the ones of laboratory phonology. They have provided us a better understanding of the relationship between phonetics and phonology. Moreover, they have led to a view that not all the phonological rules previously proposed correspond to the phonological representation of the language. Pierrehumbert (1980) demonstrates this point convincingly in her characterization of English intonational contours. In the most often cited work by Pierrehumbert and Beckman (1988), they argue against a phonological analysis of Japanese in which low tone is spread over strings of syllables. Instead, they show that syllables previously described as targets of tone spread are in fact toneless and the *F0* values are determined by phonetic implementations. According to this analysis, low tone spread in Japanese is not a pattern that phonological

theory should account for.

Rightward tone spread is a phonological process whereby 'a tone moves beyond its original segmental domain to replace or displace the tone of the following syllable or syllables' (Schuh 1978: 231). In autosegmental phonology, the tone spread is formalized as a process in which two tone-bearing units share the same tone.

Recent studies on fundamental frequency realization (*F0* realization henceforth) cast doubt on the nature of the phonological analysis of tone spread. They show that the *F0* peak corresponding to a high tone tends to be delayed until the later part of the tone-bearing unit or the onset of the next syllable. This phenomenon is often called '*F0* peak lagging.' The findings of the phonetic studies of *F0* realization raise a serious question of how tone spread is distinguished from *F0* peak lagging described above. Could *F0* peak lagging and tone spread be isomorphic in nature? This issue has not been seriously addressed before, simply assuming that phonological tone spread would be realized by an *F0* plateau laid upon two tone-bearing units at the phonetic implementation level.

This paper develops this line of inquiry further by conducting phonetic assessments of a phonological analysis of the tone pattern in Malawian Yao. Based on the experimental results, we argue in this paper that the facts that have been considered as a phonological process in Yao deserve a phonetic account. More specifically speaking, the tonal alternation in Malawian Yao, the phenomenon previously described as post-lexical rightward tone spread, results from physiological constraints of *F0* realization.

The paper is structured as follows: in section 2, the literature of phonetic studies on *F0* realization is briefly sketched out. In section 3, facts of the tone pattern in Malawian Yao are presented, followed by a critical review of the previous phonological analysis. The experimental method and the statistical analysis of *F0* will be addressed in sections 4 and 5, respectively. Due to space limit, partial data related to the *F0* alignment pattern will be presented in the present work. Implications of this study will be discussed in the conclusion.

2. *F0* Peak Alignment: *F0* Peak Lagging and Articulatory Binding

Before moving onto the tone patterns in Malawian Yao, it would be useful to review some phonetic studies on *F0* realization. This section can be divided into two: the first half deals with the phenomenon of *F0* peak lagging. The second half concerns the phonetic timing of *F0*.

A number of studies on the phonetic realization of accent and tone have found that phonetic prominence, specifically pitch prominence, may not align with the onset of the accented or tone-bearing syllable and is delayed (Steele 1986, Silverman and Pierrehumbert 1990, Kim 1998b, 1999 for English, Prieto et al. 1995 for Mexican Spanish, Liberman 1996 for Yoruba, Grimm 1997 for Oneida, Arvaniti et al. 1998 for Modern Greek, Hata and Hasegawa 1988 for Japanese, Barteles 1995 for Czech among others). For example, Silverman and Pierrehumbert (1990) examine the alignment of the *F0* peak corresponding to the accent (H* following the terminology of Pierrehumbert 1980) in English under various conditions. They find that two factors, rhyme duration and upcoming prosodic contexts, are the main source of peak location variation in English. That is, when a rhyme is lengthened because of slow speech, the *F0* peak is correspondingly delayed. The *F0* peak corresponding to a stress is preferentially aligned past the end of the high tone-bearing rhyme and delayed into the following unaccented syllable in phrase medial positions. Kim (1999) finds that the *F0* peak is also heavily delayed into the following syllable when the duration of the accented syllable is intrinsically very short (as in a syllable containing high front vowels). Despite the *F0* peak carried over to the next syllable, the temporal location of *F0* peak is turned out to be determined by the duration of the tone-bearing syllable: there is a positive correlation between syllable duration and *F0* peak lagging relative to the syllable onset. In contrast to this, *F0* peak is aligned early in the syllable where the syllable is close to a prosodic edge in English. When the syllable is prosodically lengthened in a phrase boundary, *F0* peak is aligned in an early portion of the syllable itself. In spite of the asymmetric behavior of the *F0* peak in different phrasal positions, no

theory of phonology embodies *F0* peak lagging in English as a phonological rule of accent spread or accent shift. Instead, all of the theories posit a categorical core and rely on phonetic implementation rules to explain the regularities shown in the pattern of *F0* peak lagging.

If the pattern of a lagging *F0* peak is widely attested, it definitely has implications that need to be tested. Probably the most important one regards to tone spread in phonology. If the lagging *F0* peak is due to the limited speed of pitch change, and the *F0* peak is spilled over to the next syllable when desired pitch change is too large to be completed within the particular syllable, does the presence of *F0* peak in the next syllable mean tone spread as assumed in phonology of tone languages? This type of suspicion has been widely shared by phoneticians. For example, Ohala (1978) has already noticed the potential relation between the lagging *F0* peak and the tonal patterns described as tone spread. However, this idea has not been systematically pursued since then. This study takes up Ohala's old idea seriously and examines tone patterns in Malawian Yao. In Malawian Yao, the tone alternation is conditioned by the location of a high tone in a phrase as in English. In the next section, we will present how the tone patterns in Yao have been treated in the phonological theories.

Going back to the discussion of the *F0* peak lagging, Ohala (1978) and Fujisaki (1988) argue that the *F0* peak lagging is due to sluggish cessation of an *F0* movement. In other words, *F0* is a function of the strain of the muscles such as cricothyroid, mass of the thyroid cartilages and stiffness of the cricothyroid joint. Given this, it takes more time to attain the pitch target than the segmental targets, although there are commands for producing a pitch target given simultaneously with those for producing the syllable that carries it. Therefore, it is possible that *F0* peak is realized at the following syllable (Ohala 1978).

So far we have mentioned an underlying mechanism that may cause the *F0* peak lagging pattern. That may sound as if *F0* peak lagging were an irregular and unpredictable pattern. However, another line of studies on *F0* realization has shown that there is a tight temporal relation between *F0* peak and landmarks of the syllables. The peak

lagging pattern represents regular timing with landmarks in the syllable (syllable onset, syllable offset). Arvaniti et al. (1998) observe that *F0* peak tends to stay close to the offset of an accented syllable in Modern Greek. The notion of regular and proportional timing between gestures of different articulators has been well established in the works within the framework of Speech timing model (Tuller and Kelso 1984, Lofqvist and Yoshioka 1984 among others) and is often called 'articulatory binding' in recent studies (Kingston 1990). A similar type of stability is observed elsewhere as well. For instance, Huffman (1993) shows that syllable landmarks are important in the timing of velar gestures.

To sum up this section, we saw that pitch change requires a relatively longer time than formant changes because of laryngeal inertia. As a result, *F0* peak tends to lag behind the tone-bearing syllable. We also saw that the *F0* peak is constantly timed with the tone-bearing syllable. With this phonetic perspective, let us move onto the discussion of the tonal phenomenon in section 3.

3. Tonal Phenomenon in Yao

Malawian Yao has a tone system with two level tones, H(high) and L(low). It is assumed that underlying representations contain only single high tones. Low tones play no active role in the language and thus are assumed to be absent in the phonological component, with the possible exception of a boundary low tone found in pre-pausal position.

Tone alternation in Yao is of significant interest because it is sensitive to positions where a lexical high tone appears in a phrasal boundary. High tones generally spread forward one mora as in (1). Tone, however, does not spread onto a pre-pausal mora or within the bimoraic penultimate syllable as in (2). High-toned vowels by tone spread are additionally italicized in (1). The examples are obtained from Mtenje (1993) and Whiteley (1966).

- | | | |
|-----------------|------|-------------|
| (1) a. liciingá | | 'a byre' |
| b. liciingá | l/la | 'that byre' |
| c. liijelá | | 'a hoe' |
| d. liijelá | l/la | 'that hoe' |

- | | | |
|--------------------|-----------------|---------------------|
| e. <i>liijelá</i> | <i>lfgwílla</i> | 'a hoe has fallen' |
| f. <i>liciingá</i> | <i>lfgwílla</i> | 'a byre has fallen' |

In (1b), and (1d), the italicized vowels are supposed to bear a high tone because they are preceded by a high tone at the final mora of the noun *liijelá* and *liciingá*. They show that toneless mora in the demonstrative *lila* becomes high toned when it is immediately preceded by a high tone. Likewise, the high italicized vowels in (1e) and (1f) are supposed to be high toned because of a preceding high tone.

In comparison with the examples in (2), there is no tone spread in (2a), (2c), and (2e). In (2a), the phrase final vowel *a* is not high toned, since the high tone does not spread onto the utterance final vowel. In addition, we can easily see that tone spread does not occur in bimoraic penultimate syllable as in (2c) and (2e), although the target mora is not in the pre-pausal position at all.

(2) Suspension of High Tone Spread

Prepausal vowels

- | | |
|---------------------------------|----------------------------|
| a. <i>nga-ni-ju-teléka</i> | 'he did not cook' |
| b. <i>nga-ni-ju-teléka cilo</i> | 'he did not cook at night' |

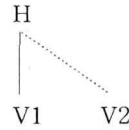
Phrase-penultimate long vowels

- | | |
|-----------------------------------|-----------------------------|
| c. <i>nga-ni-ju-valáanga</i> | 'he did not count' |
| d. <i>nga-ni-ju-valáanga cilo</i> | 'he did not count at night' |
| e. <i>nga-ni-ju-sevéés-a</i> | 'he did not work' |
| f. <i>nga-ni-ju-sevéés-a cilo</i> | 'he did not work at night' |

In order to account for this seemingly position-sensitive tone alternation, Mtenje (1993) assumes extraprosodicity of the pre-pausal mora (i.e., V2 in the tone-doubling rule below) and formulates the position-sensitive tone spread rule for the data in (1) and (2) as a post-lexical tone spreading rule, as in (3).

(3) Tone-doubling Rule in Yao (Mtenje 1993: 183)

Tone-doubling:

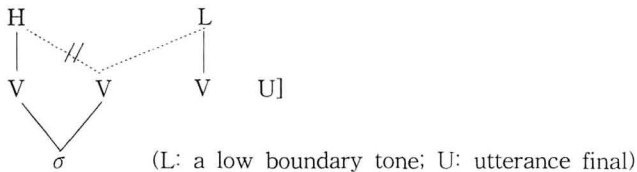


Pre-pausal Extraprosodicity: $V \dashrightarrow [+ext]/ \text{ ___ } U]$
(U: utterance final)

This rule spreads a high tone onto the following mora if the target mora is not in the utterance final position. According to this rule, the high tone in (2b) spreads to the next mora since the target mora is not a penultimate one. On the other hand, the high tone in (2a) does not spread to the following mora because the target mora is extraprosodic. Positing an extraprosodicity, however, does not account for the suspension of tone spread in (2c) and (2e).

Mtenje (1993) proposes a post-lexical rule called Penultimate Fall as shown in (4) to account for the absence of tone spread in a long penultimate syllable.

(4) Penultimate Fall (Mtenje 1993: 184)



Penultimate fall in (4) is assumed to apply after the tone-doubling rule in (3). The rule in (4) states that, if the penultimate syllable is long, then the association line on the second mora is disassociated.

With regard to this rule, Odden (1998) makes an insightful comment, which we will cite:

This can be explained in terms of a phonetic boundary low tone presented in pre-pausal position, and the tendency of that low tone to extend its domain to the non-head mora of the penult. It is possible that the falling tone in this position is

not due to phonology at all but rather is handled in the phonetic component Odden (1998: 272).

The phonological analysis of post-lexical tone spread calls for several questions. First, a drawback of the tone-doubling rule as described above arises from the special reference to the presence of an additional mora. According to the phonological analysis, the penultimate fall rule in (4) must refer to three moras ahead before the delinking process is applied. It makes these rules typologically peculiar in the sense that the application of the rule is triggered by the third element at the end of a phrase. This pattern leads to a violation of an otherwise well-motivated generalization: the locality condition. Phonological rules are usually assumed to be subject to conditions of locality where the rule should not refer to any element other than the trigger and the target that are structurally adjacent to each other (McCarthy and Prince 1986). The delinking process as described certainly requires the presence of a third element. In this sense, it is a violation of the locality condition. If grammars have the ability of counting up to three, then in principle they have the ability to count up to any number desired (Sietsema 1989). Compared with the pitfalls of the phonological analysis in Yao mentioned above, the position-sensitive process is not typologically unusual from the perspective of phonetic timing of *F0* peak presented in section 2.

More crucially, there is another piece of evidence that supports the absence of any type of phonological process in the long phrase penultimate syllables. In Malawian Yao, there is another phenomenon called High tone retraction in the long penultimate syllables. This rule states that when a phrase final word bears a lexically assigned high tone and it is preceded by a long syllable, then the high tone spreads to the preceding mora. Kim (2000) shows that the high tone retracted to the preceding long syllable is not realized on the second mora of the long syllable as proposed by a phonological rule called high tone retraction (Mtenje 1993). The long syllable displays a falling tone pattern. *F0* peak corresponding to a high tone is constantly aligned with an earlier portion of the preceding long vowel. The phonological rule fails to account for why the *F0* peak skips the second half of the syllable. This indicates that the phrasal position-sensitive tonal phenomenon in Yao results from

the phonetic interaction. Since the phenomenon of high tone reduction deserves another discussion, we will not go further into the discussion of it in this paper.

Such a disparity between a phonological rule and the phonetic realization in *F0* calls for several questions. If the tonal phenomenon in phrase-penultimate long syllables is indeed phonetic in nature, this leads to a question of why we should complicate the grammar of the language by postulating post-lexical rules such as tone spread, penultimate delinking, and high tone retraction in Yao. If the phenomenon is phonetic rather than phonological, what would be the underlying mechanism in speech production?

This paper attempts to answer these questions by exploring an instrumental analysis, which suggests another description of the facts and another analysis. We claim that such a tone spread does not exist in Yao and that the phenomenon previously analyzed as post-lexical tone spread is in fact a consequence of *F0* peak lagging.

4. Experimental Design

The experiment was designed to examine the *F0* alignment patterns in two contexts: one corresponds to the so-called spreading context and the other corresponds to the non-spreading context. Two male Malawian Yao speakers participated in the experiment.

The speakers uttered the sentences in (5). Among those, the high tones underscored are the main concern here. In order to minimize segmentally induced perturbation on *F0*, the segments around the target vowels are indicated by italics and they all are composed of sonorants. Also note that the target vowels are [a] to control the intrinsic *F0* of vowels.

(5) Corpus in Yao

- a. Target word in pre-penultimate positions:

Ajiigéle mbavalá makumi nsáno.

'S/he takes fifty bushbucks.'

- b. Target word in penultimate positions:

Nambó nganavaláanga.

'But s/he does not count (them).'

The second word in (5a) includes a high tone in a pre-penultimate position, while the one in (5b) contains a high tone in a long penultimate syllable. Therefore, the word in (5a) corresponds to the tone spread case, whereas the one in (5b) corresponds to the non-spread case.

To induce a broad range of F_0 values and syllable duration, the speakers were asked to vary loudness and speech rate. There were three conditions with respect to loudness: loud (as if shouting to a person in the hall), normal (as if speaking to a person across the booth), and soft (as if speaking quietly to a person right next to the speaker). Loud speech tends to have a higher and broader pitch range (Liberman and Pierrehumbert 1984). With respect to speech rate, the conditions were normal and fast. Also, they uttered the sentence in two different ways: statements and questions. There were four sessions in the recording with a 10-12 minute break between sessions. A total of 1476 tokens was obtained from the two speakers. The utterances were all recorded on Sony portable recorder MZ-R30, after which the speech signals were digitized and analyzed by using *xwaves* (Entropic, Inc). F_0 extraction was conducted on a Sun Sparc 20 workstation. The segmentation was carried out using the *xlabel* program (which runs as an attachment to *xwaves*). One such example is displayed in figure 1.

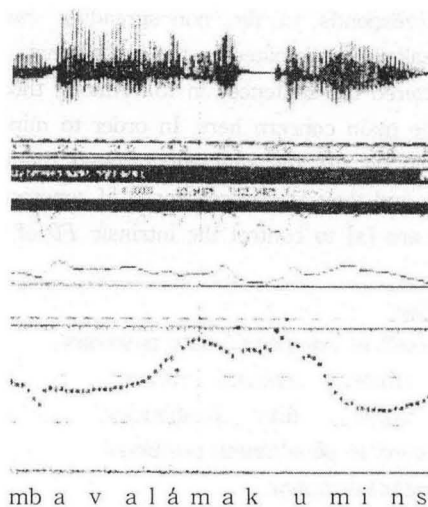


Figure 1: A Pitch Track of *mbavalá* in Yao

4.1 Hypotheses

The hypotheses being tested in the experiment are given in (6):

(6) The hypotheses:

- a. In penultimate positions, the tone-bearing syllable and the following syllable have like *F0* values.
- b. The temporal locations of the *F0* peak are determined by reference only to high tone-bearing syllables in both penultimate and pre-penultimate positions.

The hypotheses in (6) are directly relevant to the issue of what is expected by the phonological analysis of tone spread. In autosegmental phonology, tone spread is represented by a tone associated with multiple tone-bearing units. Therefore, a clear difference between tone spread and non-spread contexts is expected in either the vertical (i.e., *F0* values) or the horizontal (i.e., *F0* alignment) dimension of phonetic realization of tone spread, as posited in various phonological studies. Before proceeding to the discussion of predictions borne out of the phonological representation of tone spread, let us first assume that [X] represents a phonetic realization of a phonological element X. Goldsmith (1976) suggests that if feature X is associated with segment Y, then [X] [Y] are simultaneous in temporal terms. Sagey (1988) states that [X] overlaps with [Y] in physical space. Keating (1988) and Cohn (1990) show that [X] is realized at a steady-state level throughout most of [Y]. In the same line with Keating (1988) and Cohn (1990), Pierrehumbert and Beckman (1988) propose that the phonological analysis of tone spread predicts that there are two tonal targets for high tones and the consequent *F0* plateau is laid upon two syllables. Kim (1998a) also finds that the physical location of *F0* peak is significantly related to the duration of the target syllable (the syllable next to the tone-bearing syllable) in case of phonological tone spread (i.e., Yoruba). The predictions made by phonological analysis of tone-spread are summed up in (7):

(7) Predictions of Phonological Analysis of Tone Spread

Spread	1. <i>F0</i> plateau laid upon two syllables
Additional target	2. <i>F0</i> peak has a constant relation with the target syllable (i.e., the syllable next to the tone-bearing syllable)
Non-spread	1. No plateau (single <i>F0</i> peak)
No additional target	2. No relation between <i>F0</i> peak and the target syllable

The hypothesis in (6a) is relevant to the vertical dimension in *F0* realization. In Malawina Yao, the hypothesis is supported if the *F0* values of the tone-bearing syllable are not significantly different from those of the target syllable in pre-penultimate position.

In comparison, the hypothesis in (6b) concerns the horizontal dimension of *F0* realization. A crucial difference between spread and non-spread cases is whether there is a tone target at the syllable next to the underlying high tone-bearing syllable. As shown in (7), the so-called spread case is characterized by the existence of an additional tone target. In order to test the prediction borne out of the phonological analysis of tone spread, we examine the *F0* peak alignment in the target word in (5a). As shown in many studies on proportional timing among articulatory gestures, having a constant timing relation between *a* and *b* means that there is a positive correlation between the duration of *a* and that of *b*: the longer the duration of *a* becomes, so does the duration of *b*. Likewise, if there is a tone spread in pre-penultimate positions, then we would see *F0* peak is most constantly timed with the duration of the syllable following the high tone-bearing syllable (target syllable). If not, the *F0* peak has a constant relation with the duration of the high tone-bearing syllable itself. Simple regression will show with which syllable *F0* peak has a more regular relation. As described in (6b), if there is no tone spread, *F0* peak is expected to be determined by reference to the tone-bearing syllable in both penultimate and pre-penultimate positions.

5. Results and Discussions: Evidence against Tone Spread

The main idea being tested in the present study is the one described in (6b). Namely, the facts previously analyzed as a tone spread are in fact results from the *F0* alignment patterns: *F0* peak is delayed unless the host syllable is prosodically lengthened. Before proceeding to this hypothesis, let us begin the discussion of the experimental results with the hypothesis in (6a).

5.1 The Vertical Dimension: *F0* Values of the Two Tone-bearing Units

As mentioned earlier, the hypothesis in (6a) concerns the issue of the *F0* values in the two syllables in pre-penultimate positions: The the *F0* values of the tone-bearing syllable and the following syllable. *F0* values are measured from the mid-point and end-point of each rhyme. The two values are averaged out and tabulated in table 1.

Table 1: *F0* Values of the Tone-bearing Syllable and the Next Syllable

<i>F0</i> values	Mean	Std. Dev	Speaker
Tone-bearing syllable	171.052	43.262	FY
Next syllable	162.415	46.041	FY
Tone-bearing syllable	175.989	44.627	DT
Next syllable	166.306	47.099	DT

As shown in table 1, the mean of *F0* values of the tone-bearing syllable is about 10 Hz higher than that of the following syllable. Unpaired t-test confirms that the difference in the *F0* values is statistically significant ($p < 0.05$, for each speaker). Therefore, the hypothesis that the two syllables would exhibit like *F0* values is rejected.

5.2 The Horizontal Dimension: *F0* Alignment Patterns

In the previous section, we saw that *F0* values of the tone-bearing syllable are significantly different from those of the following syllable in

the context where tone spread is expected. We now proceed to the next question: *F0* alignment. Would it display a constant relation with the syllable next to the tone-bearing syllable in the pre-penultimate position, as expected by the tone spread analysis? In order to answer this question, a simple regression is conducted. In the simple regression, the dependent variable is Peak lag (the temporal distance between the onset of the tone-bearing syllable and the time at which *F0* maximum is attained). The independent variables are duration of the tone bearing syllable and the duration of the following syllable. In the simple regression equations in table 2, *Tsyll* and *Nsyll* indicate the two independent variables respectively.

Table 2: Simple Regression

Independent variables	Simple regression equations	r	speaker
Tone-bearing syllable	Peak lag=0.063+0.549* <i>Tsyll</i>	0.800	DT
Next syllable	Peak lag=0.102+0.168* <i>Nsyll</i>	0.030	DT
Tone-bearing syllable	Peak lag=0.102+0.561* <i>Tsyll</i>	0.838	FY
Next syllable	Peak lag=0.166+0.034* <i>Nsyll</i>	0.025	FY

Table 2 shows that Peak lag has a higher correlation with the duration of the tone-bearing syllable in pre-penultimate position. It displays little relation to the duration of the following syllable as suggested by the very low correlation coefficient shown in the third column. This means that the tone-bearing syllable rather than the following syllable mainly determines the temporal location of the *F0* peak. Namely, the syllable next to the tone-bearing syllable plays no role in determining *F0* peak alignment. This result is important since it is in contrast to the experimental results in Yoruba where the duration of the following syllable largely determines the temporal location of *F0* peak (Kim 1998a, 1999). Although, all the relevant data are not fully addressed in this paper, the present experimental results suggest that phonological analysis of tone spread cannot be supported in Yao. Neither *F0* values nor *F0* peak alignment patterns have anything to do with the target syllable (i.e., the syllable next to the tone-bearing syllable) in the pre-penultimate position.

In this paper, we have explored phonetic assessment of the facts previously analyzed as a phonological process. Based on instrumental data, we have shown that *F0* realization at phrasal level does not support phonological analysis of tone spread in Yao. Instead, the Yao tonal phenomenon can be better accounted for by resorting to phonetic principles based on relative timing with segmental landmarks and prosodic positions. The phenomenon viewed as an instance of tone spread is quite similar to *F0* alignment patterns in English: the facts known as *F0* peak lag (refer to section 3).

The findings in the study have both empirical and theoretical importance. Empirically, they provide instrumental data about little studied *F0* peak delay phenomenon in tone languages. Theoretically, the experimental results in Yao indicate that the tone alternation in the language deserves a phonetic account rather than a phonological analysis. More importantly, the phonetic account does not require that Yao be an exception to phonological constraint on locality.

References

- Arvaniti, A., R. Ladd and I. Mennen. 1998. Stability of Tone Alignment: The Case of Greek Prenuclear Accents, *Journal of Phonetics* 26, 3-26.
- Barteles, C. 1995. Pitch and Non-pitch Cues to Word Stress in Czech, *Proceedings of the International Congress of Phonetic Science 95*, Stockholm, 332-335.
- Beckman, M. and J. Pierrehumbert. 1986. Intonational Structure in Japanese and English, *Phonology Yearbook* 3, 255-309.
- Browman, C. and L. Goldstein. 1990. Tiers in Articulatory Phonology, with Some Implications for Casual Speech, J. Kingston and M. Beckman, eds., *Papers in Laboratory Phonology I*, 341-376.
- Bruce, G. 1977. *Swedish Word Accents in Sentence Perspective*. Gleerup, Lund.
- Clark, M. 1990. *The Tonal System of Igbo*. Foris, Dordrecht.
- Clements, G. and K. Ford. 1979. Kikuyu Tone, Shift and its Synchronic Consequences, *Linguistic Inquiry* 10, 179-210.
- Cohn, A. 1990. *Phonetics and Phonological Rules of Nasalization*. Doctoral dissertation, UCLA, Los Angeles, California.
- Fujisaki, H. 1988. A Note on the Physiological and Physical Basis for the Phrase and Accent Components in the Voice Fundamental Contour, in O.

- Fujimura, ed., *Vocal Physiology: Voice Production, Mechanisms and Functions*. 347-355. Raven Press, New York
- Goldsmith, J. 1976. *Autosegmental Phonology*. Garland Press, New York.
- Grimm, C. 1997. *The Phonetic Realization of Pitch Accent in the Ontario Dialect of Oneida*. MA project report, SUNY-buffalo.
- Hata, K. and Y. Hasegawa. 1988. Delayed Pitch Fall in Japanese: Perceptual Experiment, *JASA* 88, s127.
- Hayes, B. and A. Lahiri. 1991. Bengali Intonational Phonology, *Natural Language and Linguistic Theory* 9, 47-96.
- Huffman, M. 1993. Phonetic Patterns of Nasalization and Implications for Feature Specification, in M. Huffman and R. Krakow, eds., *Phonetics and Phonology 5: Nasals Nasalization and the Velum*, 303-327 Academic Press, New York.
- Keating, P. 1988. Underspecification in Phonology, *Phonology* 5, 275-292.
- Kim, Sung-A. 1998a. Phonetic Assessment of Tone Spreading, *Proceedings of the 24th Annual Meeting of the Berkeley Linguistics Society*, 129-139. University of California, Berkeley.
- Kim, Sung-A. 1998b. Tone Spread Decomposed, *Proceedings of the 29th Northeastern Linguistics Society*, 155-169. University of Delaware, Newark.
- Kim, Sung-A. 1999. *Issues in Phonetically Grounded Phonology: Evidence from Suprasegmentals*. Doctoral dissertation. University of Texas at Austin, Austin, Texas.
- Kim, Sung-A. 2000. Interaction between Lexical and Non-Lexical Tones: High Tone Retraction or something else? Ms.
- Laniran, Y. 1992. *Intonation in Tone Languages: The Phonetic Implementation of Tones in Yoruba*. Doctoral dissertation, Cornell University, Ithaca, New York.
- Lieberman, M. 1996. Tone, Accent and Relative Prominence, Talk given at University of Texas at Austin.
- Lieberman, M. and J. Pierrehumbert. 1984. Intonational Invariance Under Changes in Pitch Range and Length, in M. Aronoff and R. Oehrle, eds., *Language Sound Structure*, 157-233. MIT Press, Cambridge.
- Lofqvist, A. and H. Yoshioka. 1984. Intrasegmental Timing: Laryngeal-Oral Coordination in Voiceless Consonant Production, *Speech Communication* 3, 279-289.
- McCarthy, J. and A. Prince. 1986. Prosodic Morphology, Ms. University of Massachusetts, and Brandeis University, Amherst and Waltham, MA.
- Mtenje, A. 1993. Verbal Structure and Tone in CiYao. In S. Mufwene and L. Moshi, eds., *Topics in African Linguistics*. 179-190. Philadelphia: Benjamins.

- Odden, D. 1998. Principles of Tone Assignment in Tanzanian Yao, in L. Hyman and C. Kisseberth, eds., *Theoretical Aspects of Bantu*, 195-230.
- Ohala, J. 1978. The Production of Tone, in V. Fromkin ed., *Tone: A Linguistic Survey*, 5-39. Academic Press, New York.
- Pierrehumbert, J. 1980. *The Phonetics and Phonology of English Intonation*. Doctoral dissertation, MIT, Cambridge, Massachusetts.
- Pierrehumbert, J. and M. Beckman. 1988. *Japanese Tone Structure*. MIT Press, Cambridge, Massachusetts.
- Prieto, P., J. Santen, and J. Hirschberg. 1995. Tonal Alignment Patterns in Spanish, *Journal of Phonetics* 23, 429-451.
- Pulleyblank, D. 1986. *Tone in Lexical Phonology*. Reidel, Dordrecht.
- Sagey, E. 1988. On the Ill-formedness of Crossing Association Lines, *Linguistic Inquiry* 19, 109-117.
- Schuh, R. 1978. Tone Rules, in V. Fromkin ed., *Tone: A Linguistic Survey*. 221-256. Academic Press, New York
- Sietsema, B. 1989. *Metrical Dependencies in Tone Assignment*. Doctoral dissertation, MIT, Cambridge, Massachusetts.
- Silverman, K. and J. Pierrehumbert. 1990. The Timing of Prenuclear High Accents in English, in J. Kingston and M. Beckman, eds., *Papers in Laboratory Phonology I*, 72-106.
- Steele, S. 1986. Nuclear Accent *F0* Peak Location: Effects of Vowel, Rate, and the Number of Syllables Following, *JASA*, Supplement 1.80, s 51.
- Tuller, B. and S. Kelso. 1984. The Timing of Articulatory Gestures: Evidence for Relational Invariants, *JASA* 76, 1030-1076.
- Whiteley, W. 1966. *A Study of Yao Sentences*. Clarendon Press, Oxford.

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