Prosodic Typology Revisited: Adding Macro-Rhythm

Sun-Ah Jun

Department of Linguistics, University of California Los Angeles, U.S.A.

jun@humnet.ucla.edu

Abstract

This paper introduces a new model of prosodic typology by adding a parameter called macro-rhythm to the two known prosodic parameters: type of prominence marking (head, edge, or head/edge) and word prosody (stress, tone, or lexical pitch accent). Macro-rhythm is a tonal rhythm (a sequence of H/L alternation) formed *within* an Intonation Phrase. It captures similarities and differences across languages in terms of pitch contours whether the contour is composed of a head tone (pitch accent, lexical tone), an edge tone (phrasal/boundary tone), or both. Various criteria defining the degree of macro-rhythm are suggested.

Index Terms: prosodic typology, macro-rhythm, head-prominence, head/edge-prominence, edge-prominence

1. Introduction

In the autosegmental-metrical (AM) model of intonational phonology, intonational tunes are composed of pitch accents and/or boundary tones (e.g., [5], [22], [27]). Pitch accents are prominent pitch targets or movements over a stressed syllable (or the head syllable of a word), and boundary tones, typically realized at the edge of a prosodic unit, mark prosodic structure and phrasing. The model of prosodic typology proposed in Jun [14] was based on typologically diverse languages whose intonation was described in the AM model of intonational phonology. The typology model, therefore, included two major parameters of prosody—prominence and phrasing—and each of these was examined at both lexical and postlexical levels. This was so because the prosodic property of an utterance is a combination of prosody at the word level as well as the phrase level, and both word- and phrase-level prosody mark prominence and phrasing. The prominence marking at the lexical/word level was categorized by the type of lexical prosody, i.e., whether a language has lexical pitch accent, stress, tone, some combination of these, or none of these. The prominence marking at the postlexical/phrase level was categorized as head vs. edge: i.e., whether the prominence is cued by the head of a phrase (e.g., a nuclear pitch accent), by a tone at the phrase edge, or by both. The parameter of phrasing was categorized by the types of prosodic units a language has at the lexical and postlexical levels. Lexical prosodic units include morae, syllables, and feet, and reflect the traditional typology of speech rhythm, e.g., syllable-timed or stress-timed. Postlexical prosodic units include Accentual Phrases (AP), Intermediate Phrases (ip), and Intonation Phrases (IP). In sum, the model combines two traditions of prosodic typology, i.e., typology of word prosody and speech rhythm, with phrasing defined in the model of intonational phonology.

However, because the phrasal prosody represented in the typology was prominence types and prosodic units, the model did not have any way to compare purely *tonal* aspects of prosody. As noted in Jun [14], this typology did not capture similarities or differences across languages based on the pitch pattern of intonation. Specifically, it does not distinguish languages with different global tonal patterns of utterances but the same type of prominence marking, nor does it capture the similarity of global tonal patterns of languages with different types of prominence marking. For example, English and Greek [1] were categorized as having the same feature of prosodic typology, i.e., stress-based head-prominence languages having same type of prosodic phrases, thus not capturing the fact that Greek has more regular phrase-medial tonal patterns than English. Similarly, both Chickasaw [9] and French [15] were categorized as the head/edge-prominence languages, having their phrasal prominence marked by both pitch accents and an AP boundary tone, but the model could not capture the fact that French has much more regular intonational patterns than Chickasaw. On the other hand, Spanish [25] and Bengali ([11], [18], [19]) have similar phrase-medial rising tonal patterns, but they differ in how the rising tone is composed of, i.e., a rising pitch accent in Spanish, a head-prominence language, but a sequence of a low pitch accent (L*) and a high AP boundary tone (Ha) in Bengali, a head/edge-prominence language. This suggests that the global tonal pattern of an utterance is another prosodic dimension that is orthogonal to the types of prominence marking, motivating the need to include the complexity or regularity of phrase-medial tonal patterns as a parameter of prosodic typology.

In this paper, I propose a revised model of prosodic typology by considering the phrase-medial, global, tonal pattern of an utterance, called macro-rhythm, together with prominence marking and word prosody. In my earlier model of prosodic typology [14], I used the term 'macro-rhythm' to refer to the rhythm created by a prosodic unit larger than a word, to be in contrast with the traditional speech rhythm, which I called 'micro-rhythm' (because the rhythm is created by a sequence of smaller units such as syllables or feet, respectively, for syllable-timed or stress-timed rhythm). Specifically, in the earlier model, macro-rhythm referred to the rhythm created by the regular tonal pattern of a sequence of small prosodic units (e.g., AP) as well as by a semi-regular tonal pattern of larger prosodic boundaries in an utterance (e.g., IP). But, in this revised model, I will narrow the definition of 'macro-rhythm' as phrase-medial tonal rhythm, regardless of whether the tonal pattern is composed of edge tones (i.e., AP or word tones), head tones (i.e., pitch accents or lexical tones), or both. The tonal rhythm of phrases larger than an AP (e.g., IP or ip) is not included because the ip or IP tonal rhythm tends to vary more within a language (due to the variable size of phrases) and vary less across languages (for both size and the boundary tone type).

Perceived rhythm based on a regular pitch movement has also been noted in other studies (e.g., [3], [4], [7], [8], [10], [21], [24], [28]). Thomassen [28] and Lerdahl & Jackendoff [23] showed that repetitions of simple tonal sequences, such as a sequence of rising pitch contours or a sequence of falling

pitch contours, affect perceived grouping of words and meter, while Barry and colleagues ([3], [4]) showed that fundamental frequency (f0) contributes to the perception of rhythm as much as duration.

Tonal rhythm has also been shown to facilitate word segmentation in both stress languages ([7], [24]) and non-stress languages. In languages that do not have lexical stress, each content word tends to form a small prosodic unit such as an AP, defined by a regular tonal pattern. In French [30], Korean [20], and Japanese [29], which mark the AP-initial boundary with a rising tone, a word onset with a rising tonal pattern facilitated word segmentation. In these edge-prominence languages, tonal rhythm (i.e., accentual phrasing) functions like stress/pitch accent in stress-accent languages, by marking the prominence of words and conveying syntactic and semantic properties and information structure of a phrase ([13], [22]).

The organization of this paper is as follows. Section 2 describes the criteria to determine and predict the degree of macro-rhythm of languages analyzed in the AM model of intonational phonology, and provides macro-rhythm data for various languages. Section 3 shows how languages in each prominence type can be divided in different degrees of macro-rhythm group. Finally, Section 4 provides generalizations found in the new prosodic typology model.

2. Macro-rhythm

Rhythm is defined as temporal organization of speech perceived by a regular occurrence of events, whether the event is aural or visual and whether the acoustic medium is timing, f0, or amplitude (e.g., [4], [10], [24]). Traditional speech rhythm (or micro-rhythm) is formed by a sequence of syllables or a sequence of alternating strong and weak syllables. Macro-rhythm is a tonal rhythm, a rhythm perceived by changes in f0. Therefore, a stronger degree of macro-rhythm would be created by a sequence of alternating low and high tones (LH-LH-LH…) or high and low tones (HL-HL-HL…). The cyclic subunit of tonal rhythm (i.e., LH or HL) can include materials larger or smaller than a word.

(1) illustrates the macro-rhythm (via an f0 contour), and micro-rhythm (via a metrical grid) of the sentence, *Mariana loves marmalade*. Each grid mark, 'x', represents the head of a metrical unit [26].

(1) Macro-rhythm and micro-rhythm of a sentence


```
macro-rhythm =>

micro-rhythm =>     x     x     x     x     x
                  x  x  x  x     x        x  x  x
                  Mari  a  na  loves  marmalade.
```
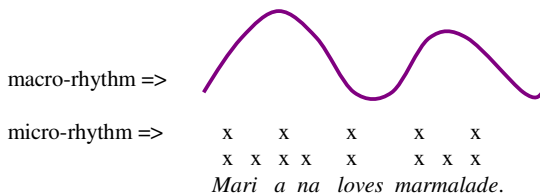
The degree of macro-rhythm can be evaluated by considering the three parameters of pitch contour given in (2).

(2) a. Low/High alternation: a pitch contour with a sequence of rising or falling tones is more macro-rhythmic than that with level tones.
b. Similarity of sub-tonal units: a pitch contour with a similar shape of sub-tonal units is more macro-rhythmic than one with less similar shapes.

c. Regularity of sub-tonal units: a pitch contour with a regular durational interval of sub-tonal units is more macro-rhythmic than one with irregular intervals.

In sum, a pitch contour has a stronger degree of macro-rhythm if the contour is composed of alternating Low and High tones and if the sub-tonal units (i.e., tonal cycles) of the pitch contour are more similar to one another and occur at regular intervals. These parameters can be converted into the three criteria described in (3) by which we can predict and compare the degree of macro-rhythm of languages analyzed in the AM model of intonational phonology.

(3) Three criteria for predicting the macro-rhythmicity of a language analyzed in intonational phonology

(i) *The **number** of possible phrase-medial pitch accents and/or AP/word boundary tones*: Among the languages that have pitch accents, languages with more types of phrase-medial pitch accents are less macro-rhythmic than those with fewer types. Similarly, among languages having AP or word tones, languages with more types of AP/word tones are less macro-rhythmic than those with fewer AP/word tones.
(ii) *The **type** of most common phrase-medial pitch accent and/or AP/word boundary tones*: Languages employing a level tone as the most common phrase-medial pitch accent (H* or L*) are less macro-rhythmic than those employing a rising (L+H* or L*+H) or falling (H+L* or H*+L) tones. Similarly, languages that most often employ rising or falling AP/word tones are more macro-rhythmic than those with level tones. For, head/edge-prominence languages, languages that build a rising or falling contour through a sequence of pitch accent and AP tone are more macro-rhythmic than those that do not.
(iii) *The **frequency** of pitch accents or AP/word boundary tones*: Languages where every word receives a pitch accent or AP/word boundary tone are more macro-rhythmic than those with less or more frequent pitch accents or AP/word boundaries per word.

Table 1 provides information about the tonal inventory for various languages described in the AM model of intonational phonology, grouped in each prominence type. The most common pitch accents and/or AP/word tones in declaratives are underlined. The frequency of a tone, that is, how often a tone occurs per word in a phrase (i.e., tonal domain), is similar across languages listed in Table 1 except that the domain of pitch accent is larger than a word in European Portuguese but smaller than a word in contour tone languages such as Mandarin and Cantonese.

Based on the data in Table 1 and the information on tonal domain, Section 3 shows how languages can be categorized by different degrees of macro-rhythm for each prominence type.

3. Macro-rhythmicity by Prominence Type

3.1. Head-prominence languages

Head-prominence languages are those in which the phrase-level prominence is marked by the phrase's *head*, which is derived from the head of a word, i.e., the designated syllable of a word. Therefore, languages that have pitch accents, regardless of whether the pitch accent location or type is

determined lexically (as in Swedish) or postlexically (as in English) are head-prominence languages. Tone languages are also head-prominence languages because the tonal pattern of a phrase is derived from the lexical specification of particular syllables. Though the degree of macro-rhythm is gradual, we can divide the head-prominence languages roughly into three macro-rhythm groups: Strong, Medium, and Weak.

Table 1. *Pitch accent/lexical tone/AP tone inventories for various languages described in intonational phonology, grouped by prominence type. The most common phrase-medial tones are underlined.*

| Language | */tone/AP-tone inventory |

Head-prominence languages

Language	*/tone/AP-tone inventory
Arabic (Egypt)	<u>L+H*</u>
Arabic (Lebanon)	<u>H*</u>, L*, L+H*, H+!H*
Cantonese	6-9 tones (levels and contours)
Catalan	H*, L*, L+H*, <u>L+>H*</u>, L*+H, H+L*
Dutch	<u>H*</u>, L*, L*H, <u>H*L</u>, H*LH
English (US)	<u>H*</u>, L*, L+H*, L*+H, H+!H*
German	<u>H*</u>, L*, L+H*, L*+H, H+L*, H+!H*
Greek	H*, L*, L+H*, <u>L*+H</u>, H*+L
Mandarin	4 tones (L, H, LH, HL)
Portuguese (Brazil)	H*, L+H*, <u>L*+H</u>, H+L*, (H+)[LH]*
Portuguese (Europe)	<u>H*/(H)</u>, L*, L*+H, H+L*, H*+L
Samoan	<u>LH*</u>
Spanish (Castilian)	<u>L+>H*</u>, L*+H, H+L*, L*, H*
Swedish	<u>HL*</u>, <u>H*L</u>, L*H, H*LH

Head/edge-prominence languages

Language	*/tone/AP-tone inventory
Basque (Lekeitio)	<u>lex H*+L</u> / <u>AP-initial LH</u>
Basque (Standard)	(L+H)* / AP-final rise (optional)
Bengali (Bangladesh)	H*, <u>L*</u>, L*+H / <u>AP-final H</u>, AP-final L
Bininj Gun-Wok	<u>H*</u>, <H*, ^H*, L+H* / AP-final L
Chickasaw	<u>H*</u>, !H*, H^ꟲ / <u>AP-initial LH</u>, final HL
Farsi	<u>L*+H</u> / <u>AP-final H</u>
French	<u>AP-final LH*</u>, H*, L*
Georgian	L*, L*+H / <u>AP-final H</u>
Japanese (Tokyo)	<u>H*+L</u> if accented / <u>AP-initial LH</u>
Serbo-Croatian	<u>H*+L</u>, <u>L*+H</u> / <u>word-initial L%</u>
Tamil	<u>L*</u> / <u>AP-final H</u>

Edge-prominence languages

Language	*/tone/AP-tone inventory
Greenlandic (West)	<u>PW-final HLH</u> or HL
Korean (Seoul)	<u>AP-initial LH or HH</u>, <u>AP-final LH</u>, L, H
Mongolian (Halh)	<u>AP-initial LH</u>
Mongolian (Oirat)	AP-tone melodies <u>LH</u>, HH, HL, H, L

3.1.1. *Head-prom with Strong macro-rhythm*

Languages belonging to this group have a small number of pitch accents (e.g., Egyptian Arabic [6], Samoan [31]) and/or a rising tone as the most common pitch accent in a phrase (e.g., Spanish, Catalan, Greek, Brazilian Portuguese, Egyptian Arabic, Samoan). They also tend to have one pitch accent per every content word. Swedish also belongs to this group as it has two types of word accent, both falling tones.

3.1.2. *Head-prom with Medium macro-rhythm*

This group includes languages such as English, Dutch, German, and European Portuguese. These languages are less macro-rhythmic than Spanish-type languages in that they generally have multiple types of pitch accents, with the most common prenuclear pitch accent in declaratives being a level tone (e.g., H*), and the domain of pitch accent is larger than a single content word.

Varieties of the same language can have different macro-rhythms. European Portuguese is less macro-rhythmic than Brazilian Portuguese, and Lebanese Arabic is less macro-rhythmic than Egyptian Arabic ([6]) not only because the former in each group has more pitch accent types than the latter, but also because H* is most common in the former while a rising pitch accent is most common in the latter.

3.1.3. *Head-prom with Weak macro-rhythm*

Languages belonging to this group are tone languages. Since each syllable/word can carry various tone types, a tone language would have the least regular alternation of H and L within a phrase, thus having the weakest macro-rhythm in head-prominence languages. Among the tone languages, however, contour tone languages like Mandarin and Cantonese would be less macro-rhythmic than level tone languages because in contour tone languages the H/L alternation can occur even within a syllable.

3.2. Head/edge-prominence languages

Head/edge-prominence languages are languages where the prominence is marked by both the *head* and the *edge* of a phrase. That is, they are head-prominence languages but also have a word/phrasal tone marking the edge of a word boundary such as an AP. Because each word is marked by an edge tone, head/edge-prominence languages are in general more macro-rhythmic than head-prominence languages. Therefore, we see only two groups of macro-rhythm in head/edge-prominence languages: Strong and Medium.

3.2.1. *Head/edge-prom with Strong macro-rhythm*

With the exception of Bininj Gun-Wok and Chickasaw, all head/edge-prominence languages in Table 1 belong to this group in that the pitch contour of utterances in these languages is generally a sequence of rising tones and each rising tone tends to correspond to one word. Among these languages, some have a fairly fixed location of L* pitch accent (e.g., Bengali, Georgian, Tamil [17]) followed by a High AP boundary tone, thus forming a rising tonal unit, and others have lexically-specified rising or falling pitch accent (Japanese, Lekeitio Basque, Serbo-Croatian). French also belongs here because it dominantly has a rising pitch accent in the AP-final full syllable. Farsi might be less macro-rhythmic than Bengali or Tamil because Farsi has some variation in stress location depending on grammatical category.

3.2.2. *Head/edge-prom with Medium macro-rhythm*

Languages in this group (e.g., Chickasaw, Bininj Gun-Wok) have few pitch accent types, with H* being the most common (similar to English), and an AP-like tonal unit. However, the AP tone is either variable or optional, and the size of AP is often larger than a word, thus not contributing much to the regularity of tonal rhythm in a phrase.

3.3. Edge-prominence languages

Edge-prominence languages are languages that do not have any lexically-specified head (stress, pitch accent, or tone), nor

any postlexically-marked head, so the prominence at the word and phrasal level is only marked by the *edge* of a word/phrase. They are "head-less" AP-languages (e.g., Korean, Mongolian, West Greenlandic, accentless dialects of Japanese). Since each word tends to be marked by a rising or falling AP tone or tonal melody, these languages have strong macro-rhythm. But, Halh Mongolian and West Greenlandic might be more macro-rhythmic than Korean or Oirat Mongolian [12] because the former group has fewer types of AP/tonal melodies than the latter.

4. Discussion and Conclusion

By adding a macro-rhythm parameter, we can make some generalizations about the prosodic features of languages. First, the order of macro-rhythmicity among the three prominence types is, from the strongest to the weakest, head- > head/edge- > edge-prominence. But this relationship does not hold for all languages across prominence types. As shown above, the languages with strong macro-rhythm in each prominence type share the same degree of macro-rhythmicity.

Second, among head-prominence languages, tone languages are not likely to have strong macro-rhythm while lexical pitch accent languages are not likely to have weak macro-rhythm. This is because tone languages typically have multiple tonal categories per syllable while lexical pitch accent languages typically have one or two types of rising/falling head tones per word. On the other hand, stress languages have various degrees of macro-rhythm because stressed syllables can have any pitch category and the domain of pitch accent can vary from one syllable to multiple words.

Third, in head-prominence languages, stress is realized fully through longer duration, stronger amplitude, and/or higher/lower pitch, but in head/edge-prominence languages, the acoustic realization of stress is generally weak and the existence of stress is often controversial. This weak stress is probably compromised by the presence of edge tones, marking the relative prominence of words/phrases.

In sum, macro-rhythm captures the tonal aspects of phrasal prosody, and by combining prominence types, word prosody, and the degree of macro-rhythm, it provides new directions in prosodic typology. In this paper, the degree of macro-rhythm is predicted based on the tonal inventory, common phrase-medial tones, and the tonal domain of languages analyzed in the AM model of intonation, but in order to establish a better model of prosodic typology, further research is needed to quantify the degree of macro-rhythm across languages as well as to develop a more comprehensive model of intonational phonology of various languages.

5. References

[1] Arnhold, A. "Prosodic structure and focus realization in West Greenlandic", in S.-A. Jun (ed.) *Prosodic Typology II: The New Development in the Phonology of Intonation and Phrasing* (tentative title), OUP. To appear.

[2] Arvaniti, A. and Baltazani, M., "Intonational Analysis and Prosodic Annotation of Greek Spoken Corpora", in S.-A. Jun (ed.) *Prosodic Typology: The Phonology of Intonation and Phrasing*. OUP. 84–117, 2005.

[3] Barry, W. J. "Prosodic functions revisited again!", *Phonetica* 38: 320–340, 1981.

[4] Barry, W. J., Abdreeva, B., and Koreman, J. "Do rhythm measures reflect perceived rhythm?", *Phonetica* 66: 78–94, 2009

[5] Beckman, M., "The parsing of prosody", *Language and Cognitive Processes* 11(1/2), 17–67, 1996.

[6] Chahall, D. and Hellmuth, S. "The intonation of Lebanese and Egyptian Arabic", in S.-A. Jun (ed.) *Prosodic Typology II: The New Development in the Phonology of Intonation and Phrasing* (tentative title), OUP. To appear.

[7] Dilley, L. and McAuley, J. D. "Distal prosodic context affects word segmentation and lexical processing", *J. Mem. Lang.* 59: 294–311, 2008.

[8] Dilley, L. and Shattuck-Hufnagel, S. "Effects of repeated intonation patterns on perceived word-level organization", *Proc. of ICPhS*, San Francisco, CA. 1999.

[9] Gordon, M. "Intonational Phonology of Chickasaw", in S.-A. Jun (ed.) *Prosodic Typology: The Phonology of Intonation and Phrasing*. OUP. 301–330, 2005

[10] Handel, S. *Listening: An Introduction to the Perception of Auditory Events*. MIT Press, Cambridge, MA. 1993.

[11] Hayes, B. and Lahiri, A., "Bengali intonational phonology", *Natural Language and Linguistic Theory* 9:47–96, 1991.

[12] Indjieva, E. *Oirat Tones and Break Indices (O-ToBI): Intonational Structure of the Oirat Language*. Ph.D dissertation, University of Hawai'i. 2009.

[13] Jun, S.-A. *The Phonetics and Phonology of Korean Prosody*. Ph.D dissertation. Ohio State University. 1993.

[14] Jun, S.-A., "Prosodic Typology", in S.-A. Jun (ed.) *Prosodic Typology: The Phonology of Intonation and Phrasing*. OUP. 2005.

[15] Jun, S.-A. and Fougeron, C. "The realizations of Accentual Phrase in French intonation", *Probus* 14: 147–172, 2002.

[16] Karlsson, A. "Intonation in Halh Mongolian" in S.-A. Jun (ed.) *Prosodic Typology II: The New Development in the Phonology of Intonation and Phrasing* (tentative title), OUP. To appear.

[17] Keane, E. "Tamil", in S.-A. Jun (ed.) *Prosodic Typology II: The New Development in the Phonology of Intonation and Phrasing* (tentative title), OUP. To appear.

[18] Khan, S. D. *Intonational Phonology and Focus Prosody of Bengali*. Ph.D. dissertation, UCLA. 2008.

[19] Khan, S. D. "The intonational phonology of Bangladeshi Standard Bengali" in S.-A. Jun (ed.) *Prosodic Typology II: The New Development in the Phonology of Intonation and Phrasing* (tentative title), OUP. To appear.

[20] Kim, S. and Cho, T. "The use of phrase-level prosodic information in lexical segmentation: Evidence from word-spotting experiments in Korean", *JASA* 125(5): 3373–3386, 2009.

[21] Kohler, K. "Rhythm in Speech and Language: A new research paradigm", *Phonetica* 66: 29–45, 2008.

[22] Ladd, R. *Intonational Phonology*. Cambridge Univ. Press. 1996/2008

[23] Lerdhal, F. and Jackendoff, R. *A Generative Theory of Tonal Music*. MIT Press, Cambridge, MA. 1983.

[24] Niebuhr, O. "F0-based rhythm effects on the perception of local syllable prominence", *Phonetica* 66: 95–112, 2009.

[25] Prieto, P., and Roseano, P. (Eds.) *Transcription of Intonation of the Spanish Language*. LINCOM EUROPA: Munich, 2010.

[26] Prince, A. "Relating to the grid", *LI* 14: 19–100, 1983.

[27] Shattuck-Hufnagel, S. & Turk, A. "A prosody tutorial for investigators of auditory sentence processing", *Journal of Psycholinguistic Research* 25: 193–247, 1996

[28] Thomassen, J. M. "Melodic accent: Experiments and a tentative model", *JASA* 71(6): 1596–1605, 1982.

[29] Warner, N., Otake, T., and Takayuki, A. "Intonational structure as a word boundary cue in Japanese", *Language and Speech* 53: 107–131, 2010.

[30] Welby, P. S. "The role of early fundamental frequency rises and elbows in French word segmentation", *Speech Communication* 49: 28–48, 2007.

[31] Yu, K. "The sound of ergativity: Morphosyntax-prosody mapping in Samoan", *NELS* 39, 2009.