

Prosodic Typology Revisited: Adding Macro-Rhythm

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Abstract

This paper introduces a new model of prosodic typology by adding a parameter called macro-rhythm to the two known prosodic parameters, types of prominence marking (head, head/edge, edge) and word prosody (stress, tone, lexical pitch accent). Macro-rhythm is a tonal rhythm (a sequence of H/L alternation) in an Intonation Phrase. It captures similarities and differences across languages in terms of pitch contours whether the contour is from a head tone (pitch accent, 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 framework of autosegmental-metrical (AM) model of intonational phonology, intonational tones are composed of pitch accents and/or boundary tones [e.g., 5, 18, 23]. Pitch accents are prominent pitch targets or movements over a stressed syllable (or a head syllable of a word), and boundary tones, typically realized at the edge of a prosodic unit, mark a prosodic structure and phrasing. The model of prosodic typology proposed in Jun [12] was based on typologically various 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 the parameter 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 stress, lexical pitch accent, tone, or some combination of these, or none of these. The prominence marking at the postlexical/phrase level was categorized by head vs. edge: i.e., whether the prominence is cued by the head of a phrase (e.g., a nuclear pitch accent) or by a boundary tone at the phrase edge, or by both. The parameter of phrasing was categorized in terms of what type of prosodic units a language has. The phrasing was represented by the prosodic units: lexical level prosodic units included a mora, a syllable, and a foot, depicting the traditional typology of rhythm, e.g., syllable-timed or stress-timed, and the phrasal level prosodic units included an Accentual Phrase, an Intermediate Phrase, and an Intonation Phrase. In sum, the proposed model tried to combine two types of well-studied prosodic typology, i.e., typology of word prosody and speech rhythm, with phrasing defined in the models 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 *tonal* aspects of prosody. As noted in Jun [12], this way of typology did not capture similarities or differences across languages based on the tonal pattern of intonation. Specifically, it could not distinguish languages that have different global tonal patterns of utterances but belong to the same type of prominence marking, nor capture the similarity of global tonal pattern of languages belonging to a different type of prominence marking. For example, English and Greek [1] were categorized as the same type, i.e., stress-based head-prominence languages, but this could not capture the fact that Greek has more regular phrase-medial tonal pattern than English. Similarly, both Chickasaw [9] and French [13] were categorized as the head/edge-prominence languages, having their phrasal prominence marked by both pitch accents and an Accentual phrase boundary tone, but the model could not capture the fact that French has much more regular intonational pattern than Chickasaw. On the other hand, Spanish [21] and Bengali [11, 15] have similar phrase-medial rising tonal patterns, but they differ in how the rising tone is composed of, i.e., rising pitch accent in Spanish, a head-prominence language, but low pitch accent (L*) plus a 'H' AP boundary tone in Bengali, a head/edge-prominence language. This suggests that a global tonal pattern of an utterance is another prosodic dimension that is orthogonal to the types of prominence marking, motivating the need to add 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 a phrase-medial, global, tonal pattern of an utterance, called macro-rhythm, together with the types of prominence marking and word prosody. In the earlier model of prosodic typology [12], 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 a smaller prosodic unit such as a syllable or a foot, respectively, for syllable-timed or stress-timed rhythm). Specifically, in the earlier model, macro-rhythm referred to the rhythm created by a regular tonal pattern of a small prosodic unit (e.g., Accentual Phrase) as well as by a semi-regular tonal pattern of larger prosodic boundaries in an utterance (e.g., Intonation Phrase). But, in this revised model, I will define macro-rhythm as the phrase-medial tonal rhythm regardless of whether the tonal pattern is originated from the edge tones or head tones (pitch accents, tones), or a combination of these. That is, macro-rhythm is a rhythm created from a pitch contour, i.e., tonal rhythm.

Tonal rhythm or rhythm perceived based on a regular pitch movement has also been noted in other studies [3, 4, 7, 8, 10, 17, 19, 20, 24]. Thomassen [24] and Lerdahl & Jackendoff [19] 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, and Barry and his 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, 20] 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 Accentual Phrase (AP), defined by a regular tonal pattern. In French [26], Japanese [25], and Korean [16], where an AP-initial boundary is marked by a rising tone, a word onset with a rising tonal pattern facilitated word segmentation. In these edge-prominence languages, tonal rhythm (i.e., phrasing) functions like stress/pitch accent in stress-accent languages, by marking prominence of words and delivering information of syntactic, semantic, and information structure of a phrase.

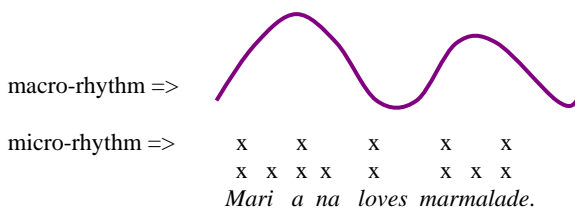
The organization of this paper is as follows. Section 2 describes the criteria to determine and predict the degree of macro-rhythm of languages analyzed in the AM model of intonational phonology, and provides macro-rhythm data for various languages. Section 3 shows how each prominence type is divided in three degrees of macro-rhythm. 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, fundamental frequency (f0), or amplitude [19, 10, 4, 20]. The traditional speech rhythm, which I called 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...). A subunit of tonal rhythm (i.e., LH or HL) can include materials larger or smaller than a word.

(1) illustrates macro-rhythm, by a schematic f0 contour, and micro-rhythm, the metrical structure, of a sentence, *Mariana loves marmalade*. A grid mark, 'x', represents the head of a metrical unit [22].

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



The degree of macro-rhythm can be evaluated by considering the three rules 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 that with less similar ones.

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

In sum, a pitch contour has a stronger degree of macro-rhythm if the tone is alternating between Lows and Highs and if the sub-tonal unit of the alternating contour is more similar and regular. This will lead us to predict the degree of macro-rhythm of a language analyzed in the AM model of intonational phonology. (3) lists three criteria.

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

- (i) *The number of possible prenuclear pitch accents and/or AP/word boundary tones (or tonal melodies)*: Among the languages that have pitch accents, a language with more types of prenuclear pitch accents is less macro-rhythmic than that with fewer types. Similarly, among languages having an AP or word accent, a language with more types of AP/word tones is less macro-rhythmic than that with fewer AP/word tones.
- (ii) *The type of most common prenuclear pitch accent and/or AP/word boundary tones (or tonal melodies)*: Languages employing a level tone as the most common prenuclear pitch accent (H* or L*) is less macro-rhythmic than those employing a rising (L+H* or L*+H) or falling (H+L* or H*+L) tones. Similarly, languages employing rising or falling AP/word tones the most often is more macro-rhythmic than those with level tones.
- (iii) *The frequency of pitch accents or AP/word boundary tones (or tonal melodies)*: Languages where every word receives a pitch accent is more macro-rhythmic than those with less frequent or more frequent pitch accent per word. Similarly, edge-prominence languages where the edge of every word is marked by an AP/word tone are more macro-rhythmic than those where only some of the word edges are marked by a tone.

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 prenuclear pitch accent in declaratives and AP/word tones are underlined. Due to the lack of space, the frequency of pitch accent/AP-tone information is not included. Based on the data in Table 1, Section 3 describes languages belonging to three degrees of macro-rhythm in each prominence type.

Table 1. *Inventories of pitch accents/lexical tones/AP tones for various languages described in intonational phonology, grouped in each prominence type. The most common prenuclear/AP tones are underlined.*

Language	*/tone/AP-tone inventory
<i>Head-prom languages</i>	
Arabic(Egyptian)	<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	<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 (Braz.)	H*, L+H*, <u>L*+H</u> , H+L*, (H+)[LH]*
Portuguese (Euro)	<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 HL*, H*L, L*H, H*LH

Head/edge-prom languages

Basque (Lekeitio) lex H*+L / AP-initial LH
 Basque (Standard) (L+H)* / AP-final rise (optional)
 Bangladesh Bengali H*, L*, L*+H / AP-final H, AP-final L
 Biniñj Gun-Wok H*, <H*, ^H*, L+H* / AP-final L
 Chickasaw H*, !H*, H[^] / AP-initial LH or final HL
 Farsi L*+H / AP-final H
 French AP-final LH*, H*, L*
 Georgian L*, L*+H / AP-final H
 Japanese (Tokyo) H*+L if accented / AP-initial LH
 Serbo-Croatian H*+L, L*+H / word-initial L%
 Tamil L* / AP-final H

Edge-prom languages

Korean (Seoul) AP-initial LH or HH, AP-final LH, L, H
 Mongolian (Halh) AP-initial LH
 Mongolian (Oirat) AP-tone melodies LH, HH, HL, H, L
 W. Greenlandic PW-final HLH or HL

3. Macro-rhythmicity in Each Prominence Type

3.1. Head-prominence languages

Head-prominence languages are languages where the prominence at a phrase level is marked by the *head* of a phrase, which is derived from the head of a word, i.e., a designated syllable of a word. Therefore, languages that have a pitch accent, regardless of whether the pitch accent location or type is determined lexically (i.e., lexical pitch accent as in Swedish) or postlexically (i.e., pitch accent realized on a stressed syllable as in English) are head-prominence languages. Tone languages are also head-prominence languages because the prominence is derived from the tonal specification of a specific syllable in the lexicon. Though the degree of macro-rhythm is gradual, we can divide the head-prominence languages roughly in three macro-rhythm groups: Strong, Medium, and Weak.

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, Samoan [27]) 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 belongs to this group because it has two types of word accent, which are ‘rising’ tones.

3.1.2. Head-prom with Medium macro-rhythm

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

Different varieties of the same language can have different macro-rhythm. European Portuguese is less macro-rhythmic than Brazilian Portuguese, and Lebanese Arabic is

less macro-rhythmic than Egyptian Arabic ([6]) because the former in each group has more types of pitch accent, with H* most common, while for the latter a rising type pitch accent is most common.

3.1.3. Head-prom with Weak macro-rhythm

Languages belonging to this group are free 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 happen within a syllable more often.

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 that also have a word/phrasal tone marking the edge of a word boundary such as an AP.

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

This type of languages has a fairly fixed location of stress and almost every content word is realized as a rising tone, either by a combination of a level tone pitch accent and a boundary tone of the opposite tone type (e.g., L* and Ha in Bengali, Georgian, and Tamil) or a rising pitch accent and a H boundary (e.g., Farsi), or a rising pitch accent (LH*) simultaneously marking the edge of an AP (e.g., French). However, Farsi would be less macro-rhythmic than Bengali or Tamil because Farsi has some variation in stress location depending on the parts of speech while Bengali and Tamil have a fixed word-initial stress.

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

Languages belonging to this group have a weaker degree of macro-rhythm than the Bengali type languages because, in addition to having an AP/word boundary tone, this group has one or two types of head tones (e.g., two types of lexical pitch accent in Serbo-Croatian) or has accented vs. unaccented word distinctions in the lexicon (e.g., Tokyo Japanese, Lekeitio Basque).

3.2.3. Head/edge-prom with Weak macro-rhythm

Languages in this group have a few types of pitch accent, with H* the most common, similar to English, and an AP-like tonal unit. However, the AP phrasal/boundary 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 (e.g., Chickasaw, Biniñj Gun-Wok).

3.3. Edge-prominence languages

Edge-prominence languages are languages that do not have any lexically specified head (stress, pitch accent, 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. So, they are “head-less” AP-languages (e.g., Korean, Mongolian, W. Greenlandic, accentless dialects of Japanese). Since each word in these languages tends to be marked by a

phrasal or boundary tone, these languages generally have stronger macro-rhythm than head-prominence languages, but depending on the type and frequency of the AP phrasal/boundary tones, edge-prominence languages can also have different degrees of macro-rhythm.

3.3.1. Edge-prom with Strong macro-rhythm

Languages in this group have a fixed AP boundary tone (e.g., Halh Mongolian, [14]) or a fixed AP phrasal tone melody (accentless Japanese dialects) and each AP will have one content word most of the time.

3.3.2. Edge-prom with Medium macro-rhythm

Languages in this group have a few tonal melodies in an AP-like prosodic unit (W. Greenlandic, [1]). The timing of tone-text alignment in these languages is more variable than that in the edge-prominence languages with Strong macro-rhythm

3.3.3. Edge-prom with Weak macro-rhythm

Languages in this group have multiple tonal melodies in an AP-like prosodic unit (Seoul Korean, Oirat Mongolian). Seoul Korean would belong to this group because the tonal pattern of AP varies in 13 types depending on the AP-initial segment (AP-initial L vs. H) and AP-length.

4. Discussion and Conclusion

Some generalizations can be made. First, the head-prominence languages are in general less macro-rhythmic than languages which mark prominence by edge, i.e., head/edge or edge-prominence languages. But this relationship does not hold for all languages across prominence types. Languages with strong macro-rhythm in each prominence type, i.e., Spanish type (head-prom), Bengali type (head/edge-prom), and Mongolian type (edge-prom), seem to have a similar degree of macro-rhythm by having a regular sequence of rising tones over a word, whether it is from L+H* pitch accent, L* pitch accent followed by H boundary tone, or a 'LH' AP tone.

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 head tone 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 frequency, 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 marking tones, marking prominence of words/phrases.

In sum, macro-rhythm captures the tonal aspects of phrasal prosody of languages, and combining prominence types, word prosody, and the degree of macro-rhythm provides new directions in prosodic typology. More studies on intonational phonology of various languages are needed to help establishing a better model of prosodic typology.

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] Dille, L. and McAuley, J. D. "Distal prosodic context affects word segmentation and lexical processing", *J. Mem. Lang.* 59: 294-311, 2008.
- [8] Dille, 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] Jun, S.-A., "Prosodic Typology", in S.-A. Jun (ed.) *Prosodic Typology: The Phonology of Intonation and Phrasing*. OUP. 2005.
- [13] Jun, S.-A. and Fougeron, C. "The realizations of Accentual Phrase in French intonation", *Probus* 14: 147-172, 2002.
- [14] 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.
- [15] Khan, S. u. *Intonational Phonology and Focus Prosody of Bengali*. Ph.D. dissertation, UCLA. 2008.
- [16] 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.
- [17] Kohler, K. "Rhythm in Speech and Language: A new research paradigm", *Phonetica* 66: 29-45, 2008.
- [18] Ladd, R. *Intonational Phonology*. Cambridge Univ. Press. 1996/2008
- [19] Lerdhal, F. and Jackendoff, R. *A Generative Theory of Tonal Music*. MIT Press, Cambridge, MA. 1983.
- [20] Niebuhr, O. "F0-based rhythm effects on the perception of local syllable prominence", *Phonetica* 66: 95-112, 2009.
- [21] Prieto, P., and Roseano, P. (Eds.) *Transcription of Intonation of the Spanish Language*. LINCOM EUROPA: Muenchen, 2010.
- [22] Prince, A. "Relating to the grid", *LI* 14: 19-100, 1983.
- [23] Shattuck-Hufnagel, S. & Turk, A. "A prosody tutorial for investigators of auditory sentence processing", *Journal of Psycholinguistic Research* 25: 193-247, 1996
- [24] Thomassen, J. M. "Melodic accent: Experiments and a tentative model", *JASA* 71(6): 1596-1605, 1982.
- [25] Warner, N., Otake, T., and Takayuki, A. "Intonational structure as a word boundary cue in Japanese", *Language and Speech* 53: 107-131, 2010.
- [26] Welby, P. S. "The role of early fundamental frequency rises and elbows in French word segmentation", *Speech Communication* 49: 28-48, 2007.
- [27] Yu, K. "The sound of ergativity: Morphosyntax-prosody mapping in Samoan" *NELS* 39, 2009.