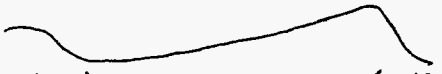
7
Durationally specified intonation in English and Bengali

B. Hayes and A. Lahiri

1. Introduction

Most intonation contours can be described using pitch information alone. For example, in the model developed by Bruce (1977), Pierrehumbert (1980), and others, a contour may be represented as a sequence of pitch targets (tones), together with an algorithm for lining up the tone sequence with any given linguistic text:



(1) [This còntour expresses surpríse!] (H = High, L = Low)
H L H L

In many languages, however, the intonational system contains a peripheral set of patterns that are manifested not just with pitch, but with characteristic durational properties. The most familiar English case is the so-called "calling contour", as in (2):

(2) [ǰá:ni:]

When aligned with a text like *Johnny*, as shown, the contour often involves considerable lengthening of both syllables.

The calling contour has previously been discussed in the literature. Ladd (1978) offers a penetrating account of its semantics (noting among other things that it is named incorrectly); and Liberman (1975) makes proposals concerning its rhythmic structure, of which several are adopted below. However, to our knowledge no one has tackled the following question: what kind of formal representation should be attributed to durationally-specified contours to distinguish them from ordinary intonation contours?

To make this clearer, consider again the contour under (1). In a formal theory, it may be given the following abstract representation:

(3) H_b L* H* L_b where T* = tone to be associated with a stressed syllable
T_b = tone to be associated with the left or right phrase boundary ([or]).

As Pierrehumbert (1980), Pierrehumbert and Beckman (1988), Hayes and Lahiri (in press), and others have shown, such formulae can account for a wide range of data in various languages. The question here is: with what additional information should an intonation pattern be represented when it has distinctive durational properties?

This paper discusses durationally-specified intonation contours in English and Bengali. We propose tentative formal analyses for both languages, making two main points. First, at least in English the duration rules do not lengthen some particular syllable; rather, they specify a hierarchical rhythmic structure, and syllable lengthening results indirectly when the syllables on which the structure is realized are closely spaced. Second, our comparative data show that languages may differ radically in how the rhythmic structure is aligned with a given text.

Given the lack of broad typological and theoretical research on durationally specified intonation, our results are tentative. But we think they may be of interest in the context of a volume on music and language. Music elaborates, in fantastically complex ways, some of the formal elements we discuss here: standardized patterns of pitch, duration, and rhythm, along with processes that align such patterns with linguistic texts.

2. English: Data

We begin with some basic observations about the English calling contour. First, as several authors have pointed out, the contour comes in two versions, one chanted and one not. Thus while Johnny's mother would likely call him home to dinner with (2), an older Johnny's boss, thinking on the spur of the moment of a task for him to do, could say "Johnny" on High-Mid pitch, without any sort of chanting effect. It seems that the non-chanted vocative intonation is endowed solely with tonal information, whereas the chanted vocative contains exactly the same tones, along with information about duration. To keep the two patterns distinct, we will refer to (2) henceforth as the "chanted call".

A second point is that pitch is *terraced* in the chanted call; that is, aside from variation beyond the speaker's control, pitch is level throughout the syllable(s) that bear H(igh) or M(id) pitch. Level intonation occurs elsewhere in the English intonational system (e.g. Beckman and Pierrehumbert (1986, Fig. 16)), but in non-chanted intonation, pitch most typically moves in glides. Durational specification implies level pitch, but not the converse.

A third point to consider is one made in detail by Liberman (1975): both pitches of the chanted call are located on the basis of stress, as follows.

(4) a. H begins on the main stress.
b. M begins on the strongest stress after H.
c. If all syllables after the main stress are stressless, then M begins on the final syllable.

d. If the main stress is final, it receives the HM sequence.
e. Pitches extend in time to the next pitch or to phrase end.

These rules are illustrated by the following examples, where /´/ denotes main stress, /`/ secondary stress. To demonstrate unusual stress patterns, we give non-names in (5b) and (5d); these sound more plausible perhaps if one imagines them as names for pets.

(5)a. Ábernàthy! b. Rígamaròle c. Pámela! d. Hésitancy! e. Jóhn!

Some salient points: *Ábernàthy* and *Rígamaròle* differ in the location of their post-tonic secondary stress, and this is reflected (by rule (4b)) in where the M pitch begins. *Pámela* and *Hésitancy* show the onset of M pitch on the final syllable when there is no secondary stress after the main, and *Jóhn* shows the sharing of the two pitches by the

The next observation is (we think) a novel one, and the one on which our analysis depends. The phonetic lengthening of syllables in the chanted call is not an invariant of the contour, but rather depends on the number of syllables present. Consider the following data.[1] In a form with final main stress, lengthening is obligatory; in fact, the stressed syllable is doubly lengthened:

(6) Jóhn! [ǰá::n]

When main stress is penultimate, the penult and the final are lengthened obligatorily:

(7) Jóhnny! [ǰá:ni:]

For words with antepenultimate main stress (e.g. *Ábigàil*, *Pámela*), the antepenult is optionally lengthened, the final obligatorily:

(8)a. Ábigàil! [á(:)bɪgè:l] b. Pámela! [pá(:)mələ:]

For words with preantepenultimate main stress (e.g. *Rígamaròle*, *Hésitancy*), lengthening of the main stressed syllable is strongly dispreferred. lengthening of the final syllable is obligatory:

(9)a. Rígamaròle! [rɪ́gəmərò:l] b. Hésitancy! [hɛ́zɪtənsi:]

A variant here is the pattern of *Ábernàthy*, with preantepenultimate main stress and penultimate secondary stress. Here, both stressed syllables are lengthened optionally:

(10) Ábernàthy! [á(:)bɚnæ̀(:)θi]

Finally, in a word like *élevator òperator*, where the stresses are widely spaced, no syllable may be lengthened:

(11) élevator òperator! [éləvetr̩ àpəretr̩]

These and similar data may be characterized more simply using the notion of &tone domain&, defined as the sequence of syllables on which a given tone (H or M) is realized. Using this term, we can summarize the facts as follows:

(12) Syllables in Tone Domain	Lengthening of Initial Syllable
1	obligatory
2	optional
3	dispreferred
4 or more	impossible

It can be seen that the same patterns hold for both the H and the M tone domains. To (12) must be added that in a monosyllable, where there are two tone domains, we get double lengthening (cf. (6)).

One final observation is that the length added in the chanted call is independent of, and overrides, any distinctions of segmental length. For example, in British English the stressed vowels of *Polly* /pó li/ and *Pauley* /pó:li / are distinguished primarily by length. This difference is wiped out in the chanted call, and only the small difference in vowel quality remains:

(13)a. *Pólly:* [pó:li:] b. *Páuley:* [pó:li:]

This, together with the possibility of double length, suggests to us that the formal representations used by phonologists to represent segmental length (e.g. Clements and Keyser (1983), Levin (1985), Hyman (1985)) should not be carried over to represent the length found in the chanted call.[2]

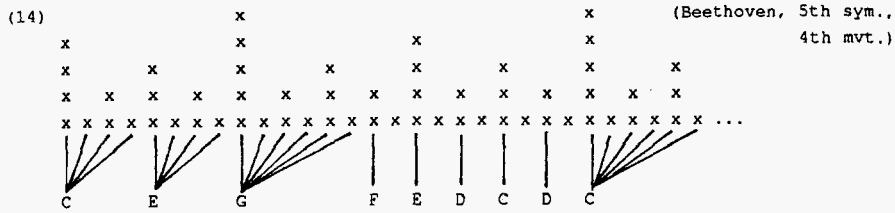
3. Analysis for English

The analysis we propose below attributes to the chanted call a *rhythmic structure*, with alternating strong and weak beats associated with the syllables of the chanted text as well as with the tones of the chant. Crucially, there are cases in which a single syllable associates with more than one beat; when this happens, the syllable is lengthened.

As a representation for rhythmic structure we adopt the metrical grid. Grids are employed by phonologists as a representation for stress, as well as by Lerdahl and Jackendoff (1983) for metrical structure in music. Grids characterize both the horizontal and vertical aspects of rhythm: vertically, grid columns represent the salience of individual beats; horizontally, they depict beat sequences at varying intervals. Grid columns plausibly serve as docking sites for tonal association, both in chanted contours (see below), and in music. Example (14) depicts a familiar theme associated with its grid.

The notions of strong and weak beats can be defined on the grid: a grid mark forms a strong beat if another mark is found in the same column on the next level up;

(14)



otherwise it is weak (Lerdahl and Jackendoff 1983, 19). Thus strong and weak beats are defined relative to context, as is appropriate in a hierarchical structure.

For the principles determining well-formed grid structure we will rely on recent phonological work (e.g. Liberman and Prince (1977), Prince (1983), Hayes (1984), Dell (1984), Selkirk (1984)). No full consensus emerges from this literature, but the picture seems clear enough to motivate our analysis of the chanted call. Two crucial principles are the following:

(15) a. *Clash Avoidance*: Strong beats should not be adjacent.
b. *Lapse Avoidance*: Long sequences of weak beats (lapses) are avoided; the longer the lapse, the more ill-formed.

For our purposes we require a constraint somewhat stronger than Clash Avoidance, proposed in Selkirk (1984):

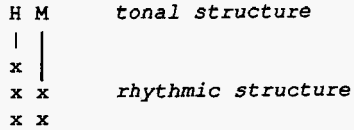
(16) *Obligatory Offbeat Condition*: Any strong beat must be directly followed by a weak beat.

The Obligatory Offbeat Condition subsumes Clash Avoidance (if we had two consecutive strong beats, the first of them would not be followed by a weak), and also requires that a rhythmic structure end on a weak.

The validity of the Obligatory Offbeat Condition is hard to determine. In language, the effects of syllable quantity (Prince 1983, 57-60) and final lengthening (Selkirk 1984, Ch. 6) makes it difficult to decide whether it is Clash Avoidance or the Obligatory Offbeat Condition that is empirically correct. In music, there is a phenomenon suggestive of the Obligatory Offbeat Condition: pieces whose last overt note occurs on a strong beat are notated with rests to fill out the measure; these arguably represent silent beats that are heard but not played.[3]

With this background, we may now hypothesize the following underlying form for the chanted call:

(17)



(Beethoven, 5th sym., 4th mvt.)

x
x x
x x x x x ...

hus strong and weak beats
ıical structure.
ıre we will rely on recent
nce (1983), Hayes (1984),
rom this literature, but the
: chanted call. Two crucial

djacent.
.ts (lapses) are avoided;
e ill-formed.

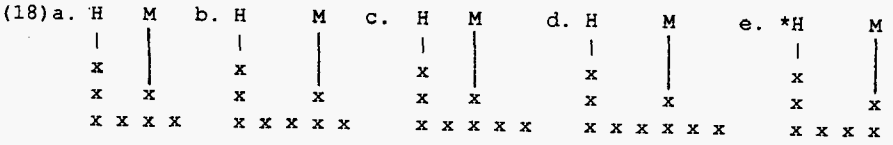
ıger than Clash Avoidance,

t be directly followed by a

voidance (if we had two
lowed by a weak), and also

. to determine. In language,
final lengthening (Selkirk
s Clash Avoidance or the
ect. In music, there is a
on: pieces whose last overt
ill out the measure; these
3
owing underlying form for

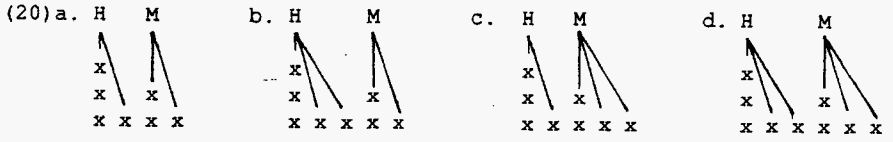
Here, the tones of the tune are linked to a schematic grid, which violates the Obligatory Offbeat Condition. To be instantiated concretely, it must undergo a process of "Beat Splitting," whereby a variable number of weak beats are inserted after the strong beats. Some possible outputs of Beat Splitting are as in (18a-d); (18e) is excluded as an Obligatory Offbeat Condition violation.



We also adopt the tone-sharing principle in (19), which when applied to (18a-d) yields (20):

(19) *Tone Sharing*

When a beat is split, all parts of the beat retain the tone of the original.

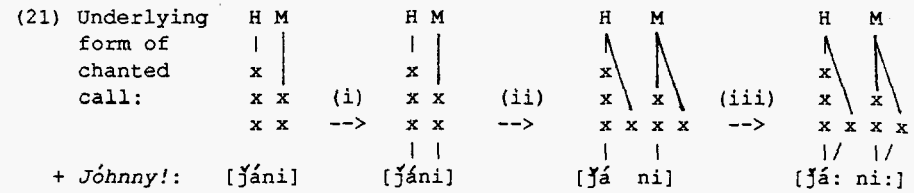


These four forms are the most common concrete instantiations of the abstract pattern in (17).

To complete the analysis, we need a suitable algorithm to align the rhythmic structures of (20) with the stress pattern of a text. The strong beats are associated as follows: the strong beat bearing H tone links to the strongest stress of the text, and the strong beat bearing M links to the strongest stress following the H. If there is no stress after the H, then a default pattern asserts itself, aligning the beat of M with the final syllable. Other than the final default just noted, these rules are basically those that apply in ordinary intonation. The rules should be applied before Beat Splitting.

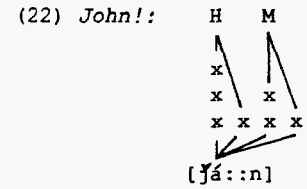
The weak beats of the rhythmic pattern are aligned as follows: (a) When Beat Splitting is applied, at least enough beats must be inserted to give every syllable a beat. However, provided a long lapse (in practice, about three weak beats in a row) is avoided, it is possible to insert more beats than syllables. (b) Where more beats than syllables are present, extra weak beats are preferentially associated to the nearest preceding syllable bearing a strong beat.

To see how these principles work, consider some examples. In (21), we provide the underlying form of the chanted call (from (17)), along with the text *Jóhnny*. In step (i), the strongest beat of the chant links to the main- stressed initial syllable of *Jóhnny*, and the second strongest beat links by default to the final syllable. In step (ii), Beat Splitting adds a weak beat after each strong beat to satisfy the Obligatory Offbeat Condition. These inserted beats acquire H and M tone by Tone Sharing (19). In step (iii), stray weak beats associate leftward, deriving the final output:



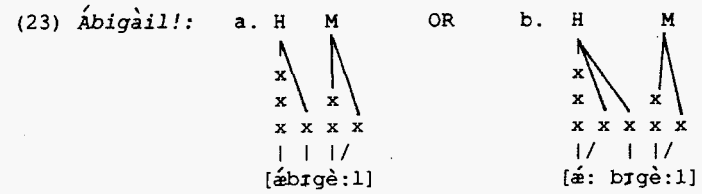
It is assumed that the rhythmic structure of the chant overrides the inherent rhythmic structure of the text. (We believe the latter is also a grid, but do not depict it here.) As a result, in *Jóhnny*, both syllables must be lengthened. Note that we could have added more weak beats when expanding the underlying form of the chant; this is reflected in the free variation in the length that may be assigned to the syllables.

In a form with final stress, such as *Jóhn*, all four beats in the minimal expansion of the chant must lodge on a single syllable:



Thus the output is doubly lengthened, with a clear perception of two strong beats. (Again, more weak beats could be added, with greater lengthening effect.)

The freedom with which weak beats may be inserted shows up most clearly in forms with a disyllabic tone domain. Since a well-formed rhythmic structure can be derived with insertion of either one or two weak beats after a strong, there is freedom in lengthening the strong syllable, as shown:



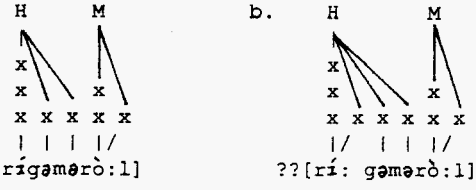
The analysis essentially claims, then, that the sequence [ǽbI] in (23a) is in duple time; the corresponding [ǽ:bI] in (23b) in triple time, a judgment we find intuitively plausible. Note that the final syllable is obligatorily lengthened, since by the Obligatory Offbeat Condition the strong beat on M must have a weak offbeat.

The form *Ábernàthy* [ǽ(:)bɪ̀næ̀(:)θi] with optional lengthening of either the first or third syllable, would be derived like *Ábigàil*, only with two disyllabic tone domains. We note a preference for either lengthening both stressed syllables or neither; this may reflect a preference for consistent duple or triple time.

Pámela ([pǽ(:)mələ:]) also would resemble *Ábigàil* in its derivation, the only difference being that the second strong beat of the chanted call docks onto the final syllable by default, rather than by attraction to stress.

In *Rígamaròle*, the final syllable is lengthened as usual, but lengthening the main stress seems unnatural. This follows from the assumption that placing three weak beats after a strong forms a rhythmic lapse. Thus (24a) is preferred to (24b):

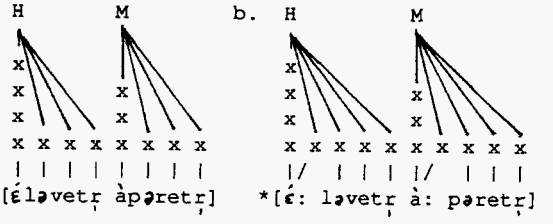
(24) *Rígamaròle!:* a. b.



Hésitancy ([hézətənsi:)] is the same, only with default finale linking of the second strong beat.

Finally, if the tone domains are quite long, as in *élevator òperator*, lengthening is impossible. To lengthen either stressed syllable would create a lapse four syllables in length, which is rhythmically unacceptable.

(25) *élevator òperator!:* a. b.

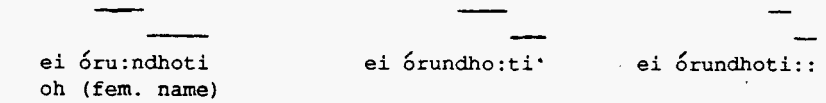


To sum up, our analysis generates the observed outputs by attributing to the chanted call an abstract rhythmic structure. By assuming that this structure obeys general principles of rhythm, and that syllable lengthening is the result of assigning more than one beat per syllable, our analysis can derive the surface length pattern.

4. Bengali: Data

Bengali has a durationally-specified chanted call that closely resembles its English counterpart in tonal shape. The call may in fact have been recently borrowed from English: of the four speakers whose judgments we have consulted, the oldest regards the contour as possible only in English, whereas the other three find it natural in Bengali.

(26) a. *Antepenultimate Fall* b. *Penultimate Fall* c. *Final Fall*



a. *Antepenultimate Fall* b. *Penultimate Fall* c. *Final Fall*

What is crucial for present purposes is that the Bengali version differs radically from the English one in how tune and text are associated. With a name of sufficient length, the call has three variants, based on where the transition from H to M pitch occurs. The initial part of the contour is spoken, not chanted; and involves a gradual rise from the beginning up to the lengthened H-pitched syllable. We will discuss it separately below. Observe that extra length coincides with H pitch, and that there is also variation in the length of the final syllable: relative to the Antepenultimate Fall cases, it is about 25% longer (transcribed /ta˙/) in the Penultimate Fall cases and over twice as long (transcribed /ta::/) in the Final Fall cases.

When the name is shorter than four syllables, there are fewer possibilities, which we list. The marginal status of (27a) is discussed below.

(27) *3 syllables:* ??ei šǽ:moli ei šǽmo:li˙ ei šǽmoli::

(28) *2 syllables:* ei šǐ:la˙ ei šǐla::

(29) *1 syllable:* ei rá::m

The system is not open-ended. For example, H pitch cannot occur four or five syllables from the end:

(30)a. *ei šóbi:tabroto b. *ei šó:bitabroto

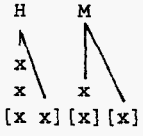
The significance of this will become clear below.

As can be seen, there are important differences between the Bengali and English chants. In Bengali, some syllable always gets lengthened, irrespective of the structure of the text. Moreover, the connection with the (word-initial) stressing of the text is quite loose: the lengthened syllable may occur on or after the stress, but not before it.

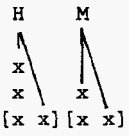
5. Analysis for Bengali

We assume that the Bengali chanted call is based on the same abstract underlying structure as the English one (see (17)). The differences lie in how the rhythmic structure is expanded and mapped onto texts. First, we posit that the basic rhythmic structure of (17) may be expanded only in the simplest way, with insertion of just a single weak beat after each strong. In addition, we propose that the Bengali structure is syllabically annotated; i.e. marked for how the beats may be mapped onto syllables. Our notation for this is: [x x x x], [x x], [x]; meaning that whatever is enclosed within a pair of brackets must be mapped onto a single syllable. In this notation, the three variants of the Bengali chanted call have the following structures:

(31)a. *Antepenultimate Fall*



b. *Penultimate Fall*

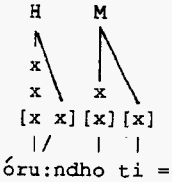


c. *Final Fall*

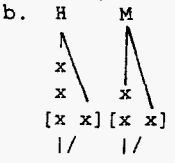
Mapping of bracketed units onto syllables proceeds one-to-one, right-to-left, in the manner of autosegmental phonology (Goldsmith 1976, Pulleyblank 1986). If mapping reaches back to the stressed syllable of the word, all further stray beats must associate with the stress.

Such a mapping straightforwardly derives the three variants of a quadrisyllabic name:

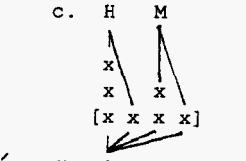
(32)a.



b.



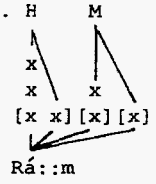
c.



Our representations predict that the syllable /ta/ should be longer in (32b) than in (32a). Measurements confirm this, but the ratio is only about 1.25/1 rather than 2/1. We have no explanation of this, except to suggest that the difference may be blurred by phrase-final lengthening.

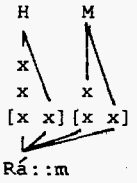
The more limited variation in shorter names follows from the assumption that mapping cannot go beyond the stressed syllable. For example, in a monosyllable like *Rám*, all four beats must lodge on the single syllable, irrespective of how they were initially bracketed:

(33)a.



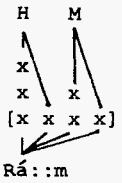
=

b.



=

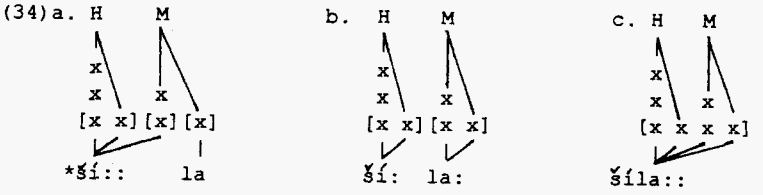
c.



Plausibly (34a) is disallowed because the strong beat of M falls in the middle of a syllable, rather than in the rhythmically more salient position at the beginning of the syllable /la/.

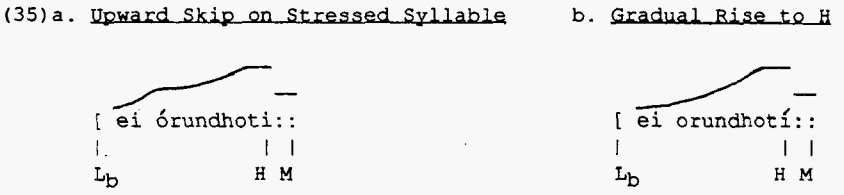
The trisyllabic form in (27a) is marginal in status, and we are not sure why this is so. We note that the penultimate vowel in *šǎ́moli* is phonetically weak: it immediately follows the initial stressed syllable, and it is not reinforced by phonetic lengthening in final position (indeed, this particular name has a variant with the /o/ deleted: *šǎ́mli*.

For disyllables, mapping works correctly with (31b) and (31c), but with (31a) the output is ill-formed:



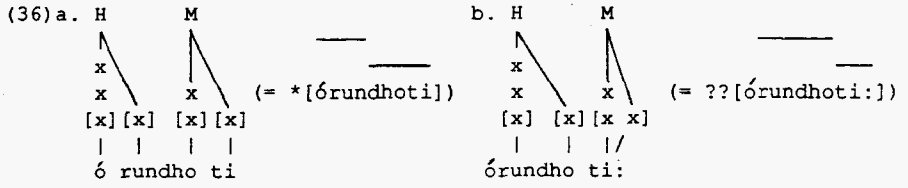
The unacceptability of this form may have to do with its placing a strong rhythmic beat on a weak syllable.

To complete our account, we must also be able to derive the initial, non-chanted part of the Bengali chanted call. This takes two forms, which are illustrated below:



To account for the initial low pitch, we posit an initial L boundary tone, symbolized being as linked to [. A gradual rise to H is what one would expect given the phonetic pitch interpolation rules found elsewhere in Bengali (Hayes and Lahiri (in press)). Where there is an upward skip on the first syllable of the name (35a), we attribute this to a phonetic effect of the stress on this syllable, rather than to any actual tone in this position. Where there is no such upward skip (35b), our claim is that stress has shifted to the lengthened syllable /ta::/. This accords with the cross-linguistic pattern that length tends to attract stress, and also with native intuition: the intuitively strongest rhythmic beats fall on /po/ in (35a) and /ta::/ in (35b).

A final question that must be addressed is why the beats in the rhythmic template are bracketed the way they are (i.e. (31)). A natural restriction that holds of these templates is that at the lowest levels strong beats are grouped together with following weaks; this is proposed for music by Lerdahl and Jackendoff (1983, 29). Assuming such a principle, the only remaining questions are how to rule out (36a) and (36b):



The absence of (36a) possibly reflects a constraint to the effect that at least some syllable must be lengthened. Example (36b) actually is marginally acceptable; its deviance may be due to a preference for awarding length to the stronger beat.

To sum up, we posit that the Bengali chanted call has the same underlying form as the English one, namely (17). The crucial differences lie in how it is aligned with a text: Bengali involves essentially a syllable-counting process, whereas in English strong beats seek out strong stresses. In addition, Bengali limits itself to a simple four-position expansion of the basic rhythmic structure.

6. Comparison and Summary

The differences in how the calling chant is realized in English and Bengali can plausibly be related to differences in the prosodic structure of the two languages. English stress is phonetically salient and is a contrastive phonological property of words, whereas Bengali stress is phonetically weak and completely predictable. From this it seems plausible that in English the strong beats of the chanted call should be strongly attracted to stressed syllables, even at the cost of lapses in the rhythmic structure (e.g. (25), *élevator òperator*). Bengali, having a marginal stress system, is a better candidate for an algorithm that mostly ignores the stress pattern of the text, and instead optimizes the rhythmic structure of the call. In particular, the call in Bengali always has just four beats, the simplest possible instantiation. Contrasting the two, we can say that English needs a "stretchable" chant to accomodate the attraction of strong beats to strong stress; whereas Bengali, having no such requirement, adopts a simple four-beat version of the chant.

Two observations fit this picture. (a) Bengali, but not English, imposes a maximum distance in syllables from the first strong beat to the end of the text, since the Bengali chant is not stretchable and the English one is. For example, a "preantepenultimate fall" contour in Bengali like (30a) would require five beats, and is ill-formed because the Bengali limit is four. (b) English, but not Bengali, has versions of the chant in which no syllable at all is lengthened. These arise where syllable lengthening would add to an already excessive rhythmic lapse (25). Since the Bengali chant never undergoes stretching, the Bengali system can more easily impose a requirement that at least one syllable be lengthened.

To summarize, we have argued that the patterning of durationally specified intonation can be explicated by attributing to it an abstract rhythmic structure, which obeys principles of rhythm proposed in earlier research. Some of the specifics of our account are fairly speculative, particularly our use of the Obligatory Offbeat Condition instead of Clash Avoidance. We hope that future research, especially on other languages, will clarify these issues as well as establish whether our overall approach is correct. One thing we hope we have already established is that the formal basis for what is superficially the same durationally-specified contour can differ across languages in interesting ways.

References

Beckman, Mary and Janet Pierrehumbert (1986). Intonational structure in Japanese and English. *Phonology*, **3**, 255-309.

Bruce, Gösta (1977). *Swedish Word Accents in Sentence Perspective*, Gleerup, Lund.

Clements, George N. and S. Jay Keyser (1983). *CV Phonology: A Generative Theory of the Syllable*, MIT Press, Cambridge.

Dell, Francois (1984). L'accentuation des phrases en francais. In Francois Dell, Daniel Hirst, and Jean-Roger Vergnaud (eds.), *Forme sonore du langage*, Hermann, Paris, 65-122.

Goldsmith, John (1976). *Autosegmental Phonology*, MIT dissertation. (Published 1979 by Garland Press, New York.)

Hayes, Bruce (1984). The phonology of rhythm in English. *Linguistic Inquiry*, **15**, 33-74.

Hayes, Bruce and Aditi Lahiri (in press). Bengali intonational phonology. To appear in *Natural Language and Linguistic Theory*.

Hyman, Larry (1985). *A Theory of Phonological Weight*, Foris, Dordrecht.

Ladd, D. Robert (1978). Stylized intonation. *Language*, **54**, 517-540.

Lerdahl, Fred and Ray Jackendoff (1983). *A Generative Theory of Tonal Music*, MIT Press, Cambridge.

Levin, Juliette (1985). *A Metrical Theory of Syllabicity*, MIT dissertation, Cambridge, MA.

Liberman, Mark (1975). *The Intonational System of English*, MIT dissertation. (Reproduced 1978 by the Indiana University Linguistics Club, Bloomington.)

Liberman, Mark and Alan Prince (1977). On stress and linguistic rhythm. *Linguistic Inquiry*, **8**, 249-336.

Pierrehumbert, Janet (1980). *The Phonetics and Phonology of English Intonation*, MIT dissertation.

Pierrehumbert, Janet and Mary Beckman (1988). *Japanese Tone Structure*, MIT Press, Cambridge, MA.

Pulleyblank, Douglas (1986). *Tone in Lexical Phonology*, Reidel, Dordrecht.

Prince, Alan (1983). Relating to the grid, *Linguistic Inquiry* **14**, 19-100.

Selkirk, Elisabeth (1984). *Phonology and Syntax: The Relation between Sound and Structure*, MIT Press, Cambridge.

Footnotes

*We would like to thank P. Keating and D. R. Ladd for helpful comments on an earlier version of this paper. Our work was made possible by a Visiting Research Fellowship for Hayes from the Max-Planck-Institut für Psycholinguistik, Nijmegen.

[1] We have checked these judgments with other speakers. Some instrumental evidence we have gathered also confirms them, provided one compensates for the ritardando effect of final lengthening. Typically the H and M pitch segments divide the word in about a 40/60 ratio.

[2] This decision leaves aside the difficult question of how the extra length of the chanted call is distributed among the segments of the lengthened syllables. We can observe that words which normally can be pronounced as either one or two syllables must be pronounced as two under the chanted call: *Tire* [tá:jɹ:], *Flower* [flá:wɹ:]. Beyond this, the matter is uninvestigated.

[3] The Obligatory Offbeat Condition is only valid for the lower grid levels; for example, it does not hold for top level of (14). See Lerdahl and Jackendoff (1983, 21-25) for discussion of how rhythmic structure becomes less rigid at higher levels.

MUSIC, LANGUAGE, SPEECH AND BRAIN

Proceedings of an International Symposium
at the Wenner-Gren Center, Stockholm, 5–8 September 1990

Edited by

Johan Sundberg
Lennart Nord
and
Rolf Carlson

Dept of Speech Communication and Music Acoustics
Royal Institute of Technology
Stockholm, Sweden

MACMILLAN
PRESS
Scientific & Medical

First published 1991 by
MACMILLAN ACADEMIC AND PROFESSIONAL LTD
Houndmills, Basingstoke, Hampshire RG21 2XS
and London
Companies and representatives throughout the world

Printed in Great Britain at the University Press, Cambridge

ISBN 0-333-56429-4
ISSN 0-0083-7989

A catalogue record of this book is available from the British Library.