

Phonemic Length and Pre-Boundary Lengthening: An experimental investigation on the use of durational cues in Hungarian

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ABSTRACT

The use of increased duration to signal prosodic boundaries has been demonstrated for many languages. However, a number of studies have claimed that languages in which length is phonemic do not have pre-boundary lengthening or the amount of lengthening at boundaries is not perceptually relevant. We show that for Hungarian, a language with phonemic length, there is consistent pre-boundary lengthening at three levels: word, syllable and phone. The amount of pre-boundary lengthening observed in our data was well within the limits of perceptible phonemic contrasts shown for short and long vowels and consonants in Hungarian.

1. INTRODUCTION

Right edges of prosodic boundaries can be marked by a variety of acoustic cues. Among these features, increased segmental duration, referred to as pre-boundary length (PBL), is of particular interest, because it raises the question of how this phonetic lengthening interest with segmental length distinction. While the general consensus is that PBL is widely used among to mark phonological phrasing [4], and therefore it might be universal [21] some languages are considered exceptions. It has been argued, for instance, that languages with phonemic length distinctions, such as Finnish, Estonian [11] and Skolt-Sami [16] do not have PBL, because they would not utilize duration for additional functions.

In this paper we report the results of an investigation on PBL in Hungarian, a Finno-Ugric language known to have phonemic length distinctions. We begin by showing that there is no convincing evidence against PBL in Finno-Ugric languages, especially not in Hungarian. We will argue based on our data that Hungarian shows a consistent tendency for pre-boundary lengthening and that the amount of lengthening we observe should be well within the range of perceptibility for native speakers of Hungarian.

2. PREVIOUS RESEARCH ON PBL

PBL is one of the acoustic cues used to segment speech into linguistically meaningful units. Early studies on PBL assumed a complete overlap between prosodic and syntactic constituents. Therefore, they used a limited set of read-aloud sentences in which syntactic boundaries were selected first, then duration measured. Findings invariably indicated that: 1) PBL reflects the syntactic structure, and 2) it exists in a great variety of languages, such as English [9] [12], Swedish [14], French, Spanish and German [2], to name the most well-known examples.

Linguistic theories of the eighties and nineties shed new light on PBL. It is now widely accepted that there is a

phonological hierarchy of prosodic constituents separate from the surface syntactic structure. In these studies PBL is argued to be a signal for the boundaries of prosodic constituents (e.g. [10], [6]).

Our study follows recent work on PBL in assuming prosodic constituents separate from syntactic constituents. Since prosodic constituents have not previously been studied independently from the syntactic structure in Hungarian, we used acoustic correlates typical of prosodic constituent boundaries in other language to identify such boundaries in our corpus (see section 3).

2.3. PBL in Finno-Ugric languages

While PBL has been claimed to be universal [21], some studies argue that PBL is nonexistent or perceptually irrelevant in languages where length is phonemic. For Finno-Ugric languages, a number of sources have been repeatedly cited in support of this interpretation (see [19]; [21]). However, by returning to these studies, we found that they either do not mention phonetic lengthening at all [11], or they dismiss its existence based evidence we find questionable [7] [8].

In more recent work, McRobbi [15] [16] argues that PBL is nonexistent in the Finno-Ugric language Skolt-Sami. However, her study of duration in boundary signalling in that language does not seem to provide sufficient evidence for her conclusion that the language does not have PBL. Although her data indicates some durational decrease in paragraph final sentences, which might be taken as evidence against PBL, we found that the lack of statistical significance or of perceptual experiments makes the significance of this decrease difficult to estimate. Another result of her study, used as an argument against PBL, is that disyllabics in paragraph-final position undergo vowel reduction or drop. However, this pattern of reduction only holds for words read in sentence frames and not for her larger corpus of spontaneous conversations.

Studies of Hungarian, the Finno-Ugric language our study is concerned with, have not argued against the existence of final lengthening. On the contrary, present-day and historical data indicate some amount of lengthening at the boundaries of syntactic constituents in the language [7] [8]. However, this lengthening was systematically dismissed, because the authors concluded that it is not perceptually relevant. Kassai [7] [8], for instance, shows that vowels and consonants are longer at the end of words and sentences. She even states that durational differences between segments in sentence-initial and sentence-final positions are the only non-negligible difference in her corpus. However, she also seems to conclude that this amount of lengthening is not perceptually relevant, because

the listener tends to compare sentence-final durational cues to their sentence-medial (and not sentence-initial) counterparts ([8], p. 136). We do not think this assumption about the mechanism of perceptual processes is correct. In the following sections, we argue that the amount of lengthening we observe in our data must be perceptible.

3. CORPUS AND DATA

The data for this study comes from a corpus of approximately 3 hours of restricted spontaneous speech transcribed, digitized and analyzed by the authors, using Entropics' acoustic analysis software. Two native Hungarian speakers (one male and one female) from Budapest were taped in a quiet room, using head mounted directional microphones, while exchanging information about the actions and characters in simple computer animations. The speakers were recorded in three dialog situations, representing decreasing control of the investigator over the speech material: question-answer, directed description and undirected description (see [5] for more detail). There were two sequences of 24 animations used as stimuli in recording the participants. Data for this study came from each participants' directed and undirected descriptions, and from their answers in a question-answer task.

As opposed to previous studies using read-aloud speech produced in laboratory conditions (see 2.), our corpus has the advantage of a controlled situation and of spontaneous speech production: the speakers were engaged in a constrained task, but they spoke spontaneously within the context of performing the task. The restricted context and limited vocabulary provided many occurrences of identical words uttered in different prosodic positions by both speakers. 130 pairs of words were selected from this corpus. These target words were paired according to their occurrences in each of two prosodic positions: (i) Intonational Phrase-final (IPF) and (ii) Intonational Phrase-medial (IPM). To insure clear cases of IPF words, we only considered the last word of turn-final utterances followed by major pitch movements, pauses or hesitations, i.e. any one or more of prosodic features typically associated with major prosodic boundaries. For IPM words, we excluded all items preceded or followed by any such boundary cues. The following utterances show the target word *esernyő* 'umbrella' in the two prosodic positions:

Intonational Phrase Medial (IPM):

A zöld esernyő nekiütközik a fekete lakatnak.

'The green umbrella (with)hits the black padlock(with)'

(h-aja-t2s1, anim. 20, Line 169)

Intonational Phrase Final (IPF):

A fekete lakatnak ütközik a fehér esernyő.

'The black padlock(with) hits the white umbrella'

(h-aja-t2s1, anim. 20, Line 174)

The animation corpus provided multiple instances of various nouns, adjectives, adverbs, verbs and particles in both IPM and IPF positions. Out of the 130 matched pairs of words, 58 pairs were produced by the female speaker, and 72 pairs by the male speaker.

Durations of IPM and IPF words were measured. Since the corpus of IPM and IPF items did not contain utterance-initial words, silent periods of stop consonants in both positions could be measured accurately. We also measured individual vowels in order to compare the long to short vowel ratios in our corpus to previous reports of these ratios for Hungarian. Vowels were measured from the onset to the offset of voicing, bursts of stop consonants were excluded from vowel durations. If two adjacent vowels or vowels and glides occurred, the segmentation was decided on the basis of formant transitions and perceptual judgements. Further measurements were made of the syllable and phone durations of the items used in the matched pairs of words.

4. RESULTS AND DISCUSSION

The result of our matched pair analysis, shown graphically in figure 1, is the finding that intonational phrase-final tokens of words are systematically longer than their intonational phrase-medial partners. This result is significant at $p < .0001$, using the Wilcoxon signed rank test. It is clear from the scatterplot in figure 1 that the significance of the result comes more from consistency of the phenomenon rather than from huge differences in duration between intonational phrase-final and intonational phrase-medial items. In other words, while the difference in duration between IPM and IPF items may not always be large, the IPF words are almost always longer. Contrary to what might have been expected, it appears that Hungarian speakers are consistently using increased duration to mark phrase boundaries in the same way that speakers do in other languages, such as English. This result clearly contradicts previous assumptions about the absence of PBL in languages with phonemic length, and it supports the hypothesis that PBL is likely to be universally used by languages to cue major prosodic boundaries.

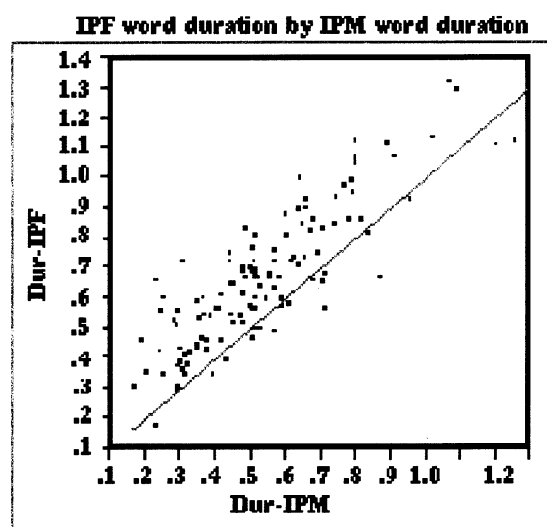


Figure 1. Word durations in two prosodic positions: intonational phrase medial (Dur-IPM) and intoantional phrase final (Dur-IPF)

This result is consistent with earlier studies on Hungarian that also showed systematic lengthening of vowels and consonants in final position. However, these

studies claimed that the lengthening they observed is not perceptually relevant and on this basis PBL was rejected as a legitimate boundary cue. The lack of perceptual experiments in the literature led us to wonder if this is simply speculative, and to ask what type of data could address the question of perceptual relevance. We decided to compare the difference in duration between IPF and IPM items with a durational difference known to be crucial in the language. Hence we compared the differences in IPF and IPM durations to those of long and short vowels. We measured the duration of individual vowels within the target words, and then calculated: 1) the ratios of long to short vowels, and 2) the ratios of IPF to IPM vowels. We did not distinguish between vowels in different positions within the word or between syllable-types. Our hypothesis was that if we found that the IPF/IPM ratio was as large or larger than the long/short ratio, we could conclude that the IPF/IPM distinction must be perceptually relevant. If this is the case, then it seems likely that speakers and hearers of Hungarian can use PBL as a distinction since it is as noticeable as the phonemic length.

Table 1 shows that in fact our hypothesis seems to be correct. There are IPF/IPM ratios that are bigger than long/short ratios.

Table 1: Duration ratios for long/short and IPF/IPM distinctions.

Vowel	long/short	IPF/IPM	N (IPM/IPM pairs)
i	1.52:1	1.13:1	46
i:		1.04:1	9
e	1.47:1	1.18:1	131
e:		1.25:1	37
y	no data	0.99:1	13
y:		-	-
u	no data	0.99:1	14
u:		-	-
ø	1.81:1	1.37:1	31
ø:		1.52:1	22
o	1.66:1	1.10:1	64
o:		2.27:1	7
a	1.78:1	1.21:1	37
a:		1.36:1	18

For example, the IPF/IPM ratio for /ø:/ is as big as the long/short ratio for /i/ and larger than the long/short ratio for /e/. The IPF/IPM ratio for /o:/ is larger than any of the long/short ratios including the long/short ratio between /o:/ and /o/. It seems unreasonable to assume that speakers would be able to perceive a 1.66:1 difference between /o:/ and /o/ but not a 2.27:1 difference between /o:/ in IPF and IPM positions. This is particularly significant in light of the fact that we did not control for position of the vowel within the word, and controlling for position in the word is likely to make the ratios even larger in the same direction.

Table 2 shows vowel length ratios in our corpus compared to two previous studies. Meyer and Gombóc's historical data were taken from [7]. The ratios shown for Kassai [7] were calculated by the second author, based on the

tables Kassai provides. We have sufficient data for comparison of 5 of the 7 long/short vowel pairs. As might be expected for a corpus of spontaneous speech as opposed to read minimal pairs, the ratios in our corpus show less variation. It has been claimed that high vowel ratios should be bigger than the ratios for lower vowels, but this is not supported by either our ratios or the ratios we calculated from Kassai's data. For example the ratio of /i:/ to /i/ is 1.52:1 for us and 1.28:1 for Kassai. This is smaller than the ratios for /a:/ to /a/ in both studies: 1.78:1 in our corpus, and 1.82:1 in Kassai's corpus. The claim that vowel ratios should be larger for vowels distinguished only by length is also not supported (see appendix for vowel chart). The same comparison between i:/i and a:/a just discussed also demonstrates this point. The most important point is that in spite of the difference in speech style (spontaneous vs. read) our vowel ratios are sufficiently similar to previously reported vowel ratios that our results on PBL cannot be discounted as a peculiarity of our corpus.

Table 1: Ratios of long to short vowels in three studies.

Vowel	H & F (1998)*	Kassai (1979)**	Meyer & Gombóc (1925)***
i:/i	1.52:1	1.28:1	2.11:1
e:/e	1.47:1	1.25:1	1.69:1
y:/y	no data	1.79:1	1.97:1
u:/u	no data	2.00:1	2.02:1
ø:/ø	1.81:1	1.60:1	1.86:1
o:/o	1.66:1	1.89:1	2.11:1
a:/a	1.78:1	1.82:1	1.78:1

* spontaneous speech, all types of syllables, 1-6 syllable words

** minimal pairs, open syllables, 1-4 syllable words

*** minimal pairs, all syllables, one-syllable words

In order to address the question of where within words that PBL occurs we also examined syllables and phones in our data. Using the Wilcoxon signed rank test we found that final syllables of polysyllabic words were longer in IPF position ($p < .0001$). Medial syllables were also longer in IPF position ($p < .009$). A closer look at the medial syllables showed that the penultimate syllables were responsible for this difference in length between IPF and IPM items while syllables further from the ends of words did not show this difference. Initial syllables did not exhibit significant difference in length between the IPF and IPM positions.

Within the final syllables, we found that for CV syllables the lengthening affected the rhyme of the final syllable, which is consistent with similar findings in English [22] and in Dutch [1]. In word final CVC syllables, coda consonants had longer durations than their IPM counterparts ($p < .0001$) and also accounted for a larger portion of their syllable's duration than the coda consonants in IPM position ($p < .0001$). Rhymes in these CVC syllables had slightly longer duration on average in IPF position than in IPM position. However, unlike the coda consonants IPF rhymes constituted a smaller portion of their syllable's duration than IPM rhymes. Onset consonants in IPF and IPM positions did not differ significantly in duration but IPF onset consonants were

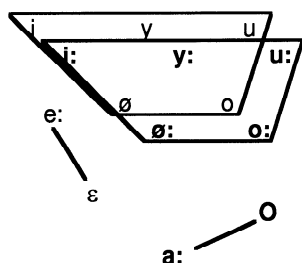
responsible for a smaller portion of their syllable's duration than their IPM counterparts. It appears that within final CVC syllables, the rhyme may get some lengthening but the majority of the PBL occurs on the final consonant.

5. CONCLUSION

In this paper we have shown that Hungarian, a language with phonemic length also has consistent preboundary lengthening. Contra previous work which also noted this lengthening but claimed that it was not perceptually relevant, we presented evidence that PBL is as great or greater than differences in length between short and long vowels. Since it is clear that native speakers of Hungarian are able to perceive the difference between long and short vowels, we conclude that it is highly likely that they are also able to perceive PBL. This suggests that the use of phonemic length in a language does not preclude the use of PBL and that Hungarian does not seem to be an exception to the universality of PBL.

6. APPENDIX

Vowels of Hungarian: 5 pairs of vowels are distinguished by length only, 2 pairs of vowels differ both in length and in quality.



NOTES

1. The carat sign (˘) stands for double-bar accent used in the spelling of long labial vowels.

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