Vowel length affects pre-boundary lengthening in Czech

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Abstract

This study investigates the patterns of pre-boundary lengthening (PBL) in Czech, a language with phonemic length distinctions. Studies on Finno-Ugric languages found that PBL can be restricted or absent on vowels for which a corresponding longer phoneme with the same quality exists in the inventory. The present study provides the first investigation of a Slavic language in this regard. A production experiment was conducted that tested for an impact of vowel length on the presence and amount of PBL in trisyllabic words with antepenultimate stress.

The results showed that short and long vowels undergo lengthening in all positions, but short vowels in pre-final syllables tend to involve a smaller amount of relative lengthening than long vowels. Furthermore, the results are compatible with the assumption that the initiation of PBL is linked to the stressed syllable, as has been observed in Germanic languages. The initiation point, however, shifts to the following syllable if the distance between the stressed syllable and the end of the word is increased.

Index Terms: Prosody, pre-boundary lengthening, final lengthening, phonemic vowel length, Czech

1. Introduction

An important cue to prosodic phrasing is the lengthening of material immediately preceding the prosodic boundary, referred to as pre-boundary lengthening (henceforth, PBL). That is, segments occurring in phrase-final position are produced with longer duration than the same segments in phrase-medial position, all else being equal. This effect has been attested in a large variety of languages, which suggests that it might be a universal phenomenon (see, e.g., [1] for an overview). Most commonly, PBL occurs on the rime of the phrase-final syllable; yet, in some languages, including English, it has been found that PBL also affects earlier syllables and then retains until the end of the prosodic phrase (e.g., [2]). The sequence of segments that is affected by lengthening is henceforth referred to as PBL domain. The beginning of this domain has been found to align with the syllable that bears main word stress (e.g., [2,3] for English; [4,5] for German, which establishes a connection between the prosodic structure and the initiation of PBL. Furthermore, it has been observed that the initiation of PBL occurs at a fixed distance to the prosodic phrase boundary so that additional material at the end of the phrase-final word leads to later initiation of PBL (e.g., [6,7] for English; [5,9] for German). In [6,7,8], this is accounted for by a clock-slowing gesture of fixed duration, called π-gesture, which is active at prosodic phrase boundaries.

The segments contained in the PBL domain show specific temporal dynamics. It has been observed across languages that the relative amount of lengthening on the individual segments increases gradually from left to right until the phrase boundary is reached (e.g., [3,4,5,6]). The largest amount of PBL commonly occurs on the segments included in the final rime whereas the amount on earlier segments is considerably lower (e.g., [4,5,10]). For example, in a production study on American English [3], it was found that the amount of PBL on the onset consonant of the final syllable involved a mean increase of 15 percent whereas the following vowel involved a mean increase of 71 percent.

In languages with phonemic length distinctions (so-called quantity languages), it has been found that vowels are restricted with regard to PBL if a corresponding longer phoneme exists in the inventory (see, e.g., [11] for the general claim; see [12] for Estonian, [13,14] for Hungarian, and [15] for Northern Finnish). An early claim was that quantity languages do not exhibit a PBL effect on such vowels in order to keep them distinguishable from the corresponding longer phoneme (e.g., [11]). Later studies, however, found that PBL does apply to such vowels in quantity languages, yet in a restricted manner. Estonian, for example, shows a relatively smaller amount of PBL on long vowels in pre-final syllables in order to keep them distinguishable from long vowels [12]. Similarly, it was found for Northern Finnish that the relative amount of PBL is smaller on half-long vowels than on long vowels in the final syllable [15]. Furthermore, it has been observed in Hungarian that short vowels reject PBL in the penultimate syllable (but not in the final syllable) whereas long vowels undergo PBL in this position [4]. Note that all of the languages investigated in this respect are Finno-Ugric languages. The present study provides the first investigation of PBL and vowel length in a Slavic quantity language.

Slavic languages are generally understudied with respect to PBL (except for Russian; e.g., [16]). It has been found that PBL occurs in Czech [17]; yet, to our knowledge, the details on its domain and temporal dynamics have not been investigated so far. Czech is particularly interesting in this regard because it is a quantity language whose vowel inventory is organized in pairs of short and long monophthongs with identical quality. This allows for minimal pairs such as let (lit. ‘light’) vs. led (lit. ‘summer’), differing only as to the length feature of the vowel. It has not been investigated so far if phonemically short vowels undergo PBL in Czech and, in case they do, if lengthening restrictions apply in order to keep them distinguishable from long vowels. The present study addresses these aspects. The literature suggests two hypotheses in this regard: First, PBL applies to short and long vowels, but the relative amount of lengthening is smaller on short vowels than on long vowels (as found for Northern Finnish); and, second, PBL applies to long vowels, but not to short vowels (all else being equal). Furthermore, the present study addresses the initiation of PBL with respect to the patterns observed in Germanic languages, that is, (a) a connection between PBL initiation and word stress and (b) the possibility that PBL is initiated at a fixed distance from the phrase boundary.
2. Methods

A production experiment was conducted, which is described in the following. The experiment involved the audio-recording and analysis of read speech in a laboratory setting.

2.1. Materials

The stimuli used for elicitation were controlled with regard to the presence of long and short vowels and the occurrence of a following prosodic boundary. The target words were trisyllabic proper names in their diminutive form, involving the diminutive suffix -ka. This had the advantage that words with the same syllabic structure could be controlled with regard to the presence and position of long and short vowels. The basic structures of the target words and corresponding examples are given in (1), where short vowels are represented as V and long vowels as VV. The structure in (1a) only contains short vowels and served as the baseline structure for comparison. The structure in (1b) differs from the baseline structure in that it has a long vowel in the antepenultimate syllable and the structure in (1c) differs from the baseline structure in that it has a long vowel in the penultimate syllable. We employed six names for each structural condition. One of the names with a long vowel in penultimate syllable (Štepánka) deviated from the structure in (1c) in that it contained a consonant cluster in word-initial position.

(1) a. CV.CV.CV (e.g., Romanka)
   b. CV.CV.CV.CV (e.g., Řuženka)
   c. CV.CV.CV.CV (e.g., Rosálka)

Furthermore, we included six proper names with a long vowel in final position, which did not have the diminutive suffix and varied as to the number and structure of syllables (e.g., Novotná, Salomé). This added some variation to the stimuli and outbalanced the positions of long vowels. These words were also used to obtain data for long vowels in final position.

The presence/absence of a prosodic boundary after the target word was elicited by means of structurally ambiguous lists of the type [N1 or N2 and N3], where the target word was in position N2. These lists can either be interpreted as having a left-branching structure [[N1 or N2] and [N3]] or a right-branching structure [[N1] or [N2 and N3]]. Prior studies showed that this ambiguity is resolved by inserting a prosodic boundary after N2 in the left-branching case and after N1 in the right-branching case (e.g., [3,5,9,18,19]). The lists were embedded in carrier sentences, which followed a short context scenario. We created six different scenarios and carrier sentences, henceforth referred to as items. Each item contained one of the six target words for each structure presented in (1) and one of the words with a long vowel in final position. Each sentence was elicited once with the left-branching and once with the right-branching structure. Thus, each item involved eight different expressions (4 target words × 2 branching structures), which yielded 48 different expressions in total (6 items × 8 expressions). The lists were set in boldface and the branching structure was indicated by means of parentheses around the respective constituents. An example is given in (2).

(2) a. Myslím ze (Nad’ a a Romanka) nebo (Alexandr)
   vyřesí úlohu

   b. Myslím ze (Nad’ a a Romanka nebo Alexandr)
   vyřesí úlohu

   ‘I think that Nad’a and Romanka or Alexandr will solve the task.’

We created two blocks of stimuli for each subject: The 48 slides with the target stimuli were pseudo-randomized and interspersed with filler slides. Each block involved a different pseudo-randomized order. Thus, each subject produced each stimulus twice, which yielded 96 target expressions per subject.

2.1.1. Subjects and procedure

The data set included the audio-recordings of five Czech native speakers whose age ranged from 25 to 50 years. The subjects audio-recorded themselves following detailed instructions. The instructions included a description and examples of the involved ambiguity and told the subjects to pronounce the sentences (without the context scenario) in such a way that the intended meaning of the list was expressed. In case of mispronunciations, they were asked to repeat the sentence. They were also told that a person would have to listen to their recorded productions off-line and decide which meaning was intended for each sentence. This was supposed to make the subjects produce the prosodic cues for disambiguation more reliably. The recordings were made with the software Praat [20]. The subjects received detailed instructions on how to install and set up the software, switching to mono sound, 44.1 kHz sampling frequency, and 16-bit resolution. They were instructed to use a headset and to do the recording in a quiet room without interruption.

2.2. Analysis

In total, 480 productions entered the analysis (5 subjects × 96 expressions). The recorded productions were checked as to the presence/absence of prosodic phrase boundaries at the locations of interest. Prior studies showed that silent pauses are regularly realized at prosodic boundaries employed to resolve the structural ambiguity in lists of the type used here (e.g., [19] for German). We therefore used the presence/absence of a period of silence of at least 20 ms after the target word as an indicator for the presence/absence of a prosodic boundary. Across subjects and conditions, a pause was present after the target word in 98.8 percent of instances from the left-branching condition and in 0.8 percent of instances from the right-branching condition. This distribution reflects the intended phrasing patterns.

The segment boundaries in the target words were manually annotated using Praat [20]. The annotation procedure followed the guidelines in [21]. Consonant boundaries were identified based on abrupt spectral changes indicating the onsets and releases of constriction gestures. Regarding boundaries between a vowel and a following consonant, the offset of F2 energy was also taken into account. The exceptional consonant cluster in the first syllable of Štepánka was treated as a single segment. In the target words with a word-final long vowel, which varied with regard to syllable structure, only the boundaries of the final vowel were annotated. The duration values of the segments were extracted by an automated procedure.

For statistical analysis, we used the software environment R [22] and the lme4 package [23]. Separate linear mixed effects regression models were fitted to the data for each segment position of the word forms in (1). The models accounted for DURATION as a function of PROSOCIC BOUNDARY and WORD FORM (with interaction term). Furthermore, a separate linear mixed effects regression model was fitted to the data of the long vowel in the final syllable obtained in word forms that differed from those in (1). This model accounted for DURATION as a function of PROSOCIC BOUNDARY. All models included random intercepts for SPEAKER, WORD, and REPETITION. P-values were obtained by post-hoc comparisons using the multcomp package.
3. Results

Figure 1 presents the duration differences for each segment in the target words without a long vowel (e.g., Romanka). The green boxes show the duration data in phrase-medial position (produced in the right-branching structures) and the yellow boxes show the duration data in phrase-final position (produced in the left-branching structures). C1 and V1 refer to the onset consonant and nuclear vowel of the antepenultimate syllable; C2, V2, and C3 refer to the onset consonant, nuclear vowel, and coda consonant of the penultimate syllable; and C4 and V3 refer to the onset consonant and nuclear vowel of the final syllable. The codes above the plots indicate the significance level of the p-values. Significant effects were found for all segment positions. The duration of the initial onset consonant (C1) is slightly shorter in phrase-final position than in phrase-medial position ($\beta=-4$, SE=1.7, t=-2.4, p=.0142). The duration of all following segments is longer in phrase-final position than in phrase-medial position (V1: $\beta=5$, SE=2.5, t=2.1, p=.0396; C2: $\beta=4$, SE=2.5, t=1.8, p=.0412; V2: $\beta=15.8$, SE=2.5, t=-6.3, p<.001; C3: $\beta=38.3$, SE=2.8, t=13.8, p<.001; C4: $\beta=18.2$, SE=2.3, t=7.9, p<.001; V3: $\beta=108.1$, SE=2.7, t=40.3, p<.001).

4. Discussion and conclusions

The results suggest that short vowels do lengthen in all positions in Czech, but tend to involve a smaller amount of lengthening than long vowels when they occur in the antepenultimate syllable.
antepenultimate syllable. This restriction might be due to the phonemic length distinction of vowels, as a stronger lengthening effect on short vowels might have brought them close to the duration of (unlengthened) long vowels in the same position. This pattern is similar to the one found for Estonian, which restricts the amount of PBL on long vowels in pre-final syllables in order to keep them distinguishable from overlong vowels [12]. A similar effect, yet on the final syllable, also occurs in Northern Finnish [15]. Czech short vowels did not show a restriction of PBL in the final syllable, but showed a considerably larger amount of lengthening than long vowels in this position. This might be due to a ceiling effect: Long vowels might not have as much room for lengthening as short vowels do before a maximum level is reached. The patterns found for Czech in the present study differ from those found for Hungarian, which involves no difference in the amount of PBL between short and long vowels in the final syllable and rejects PBL altogether in the penultimate syllable [14]. The difference between Czech and Hungarian might be due to differences in functional load, which should be addressed in future research. Altogether, Czech shows similarities and differences with regard to the Finno-Ugric languages discussed here. It remains to be seen how other Slavic languages with phonemic vowel length, such as Slovenian and Croatian, behave in this regard.

As for the initiation and domain of PBL, we found the patterns illustrated in (3), where the domain is indicated by underlining. PBL was initiated on the vowel of the antepenultimate syllable in words without a long vowel (3a) and in words with a long vowel in the antepenultimate syllable (3b) and lasted until the end of the word. The antepenultimate syllable is also the one that carried word stress. Thus, the finding that PBL is initiated on the antepenultimate syllable is compatible with the assumption that the last main stress syllable preceding the boundary triggers the initiation of PBL (e.g., [2,3,5]). As Czech has fixed word stress on the word-initial syllable, it was not possible to test different positions of word stress in the same word.

\[ \text{(3)} \]
\[ \begin{align*}
\text{a.} & \quad \text{CVCVC.CV (e.g., Romanka)} \\
\text{b.} & \quad \text{CVV.CVC.CV (e.g., Kőzenka)} \\
\text{c.} & \quad \text{CVVCVC.CV (e.g., Rosálka)}
\end{align*} \]

In the words with a long vowel in the penultimate syllable (3c), PBL was not initiated on the vowel of the antepenultimate syllable, but on the following consonant. Thus, the initiation of PBL is shifted to the right, away from the stressed syllable, if a long vowel instead of a short vowel followed. This pattern can straightforwardly be explained by means of the distance to the phrase boundary. As outlined earlier, a common assumption in this regard is that PBL is initiated at a fixed distance to the phrase boundary and may shift if material is added to the final portion of the word (e.g., [5,6,7,8,9]). The structure in (3c) contains the same number of segments as the baseline structure in (3a). It differs, however, as to the number of V positions since the long vowel is represented as VV, capturing its difference to short vowels in regard to duration. Thus, the structure in (3c) can be understood as containing more material than the structure in (3a). As a result, the distance between the stressed/antepenultimate syllable and the end of the word might be too large and the point of PBL initiation shifts from the default initiation point to the following consonant. Note that the PBL domain in both structures (3a and c) contains the same number of C and V positions (yet in part distributed over different syllables).

The word-initial onset consonant was not affected by PBL, but showed a tendency for shortening in phrase-final words. This effect was significant in words without a long vowel (e.g., Romanka) and nearly significant in words with a long vowel in the penultimate syllable (e.g., Rosálka). A similar effect has been observed in Seoul Korean [25], showing PBL on the final syllable and shortening of the initial consonant in a test word containing four syllables. In [25], this is regarded as a consequence of the speech planning process in compensation of the shortening that followed in the final syllable. A similar effect was also found in American English, showing shortening of the onset consonant in the final syllable followed by a large amount of PBL on the final rime [26]. Further research is needed in this regard, addressing the possibility that material preceding the PBL domain may undergo compensatory shortening.

In conclusion, the patterns of PBL in Czech largely resemble those observed in other languages. Phonemically short vowels undergo PBL in all syllable positions in trisyllabic words. In pre-final syllables, the amount of lengthening is smaller on short vowels than on long vowels, which might result from a strategy to keep the vowel phonemes distinguishable. In the final syllable, the amount of PBL is larger on short vowels so that the phonemic distinction is not retained. The initiation patterns observed in the present study are compatible with the assumption that the PBL domain is anchored to the main stress syllable. The point of PBL initiation may however shift to later material in order to keep a fixed distance to the phrase boundary. Future research should address the perceptual relevance of these patterns.

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6. References


