PHONEMIC LENGTH AND PHRASAL ACCENT IN SLOVAK CONSONANTAL AND VOCALIC NUCLEI

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ABSTRACT

Slovak allows us to compare vowels and consonants (/l/ and /r/) in nuclear position for their implementation of phonemic length contrast in stressed as well as unstressed syllables of accented as well as unaccented words. We analyzed the acoustic data of seven speakers for the changes in the duration of the vocalic and consonantal nuclei induced by phonemic length contrast and phrasal accent for both, stressed and unstressed syllables. The difference between long and short nuclei was always robust, while phrasal accent only affected the long nuclei. Whether the nucleus was a vowel or a consonant did not matter except for the long nuclei in the unstressed syllable, where /l/ differed significantly from /e/ or /r/. Results are discussed also by taking into account what is known from the articulatory stand point.

Keywords: Syllabic consonants, Slovak, syllable nuclei, nucleus duration, phrasal accent, word stress

1. INTRODUCTION

The basic issue underlying this paper is the difference between vowels and consonants. There have not been many studies comparing vowels and consonants, simply because not many languages offer the opportunity to do so. Vowels always occupy the nuclear position of a syllable, while consonants usually form the onset or the coda. Languages which allow syllabic consonants are not rare, but in most languages the environment in which they can occur is restricted and predictable from their segmental context: for example they prefer to occur in unstressed syllables [2].

In this regard, Slovak is a very special language. Slovak has two syllabic consonants, /l/ and /r/ which can also occur in lexically stressed positions. Like vowels, when they occupy the nuclear position, they contrast in phonemic quantity (long or short), and follow the same morpho-phonological rules as vowels which trigger length alternations. On the other hand, in onset or coda position, /l/ and /r/ do not show a quantity contrast [13, 11, 3]. Slovak has no true geminates but for a few exceptions, which are commonly produced as singletons in conversational speech.

Given the freedom of context in which syllabic consonants can appear in Slovak, we want to compare the behaviour of vowels and consonants regarding their realization of acoustic duration, in particular:

1. the realization of phonemic length contrast (short/long nucleus),
2. the effect of phrasal accent on the duration,
3. the interaction between the two,
4. the implementation of the effects listed above in stressed, as well as in unstressed syllables.

While phrasal accent and word stress affect all constituents of the syllable, the duration of the nucleus reflects them most prominently [6]. Phrasal accent in Slovak is marked with a rise in pitch, and is also supported by durational modification [9, 14]. We are interested in how this information, usually coded in vowels, is implemented in consonants when they occupy the nuclear position.

In an earlier study it has been shown for Slovak that for vocalic and consonantal nuclei in the stressed syllable which also carry phrasal accent, the phonemic length contrast is robust under speech rate variation and the long nucleus is about twice as long as the short nucleus [5]. In another study in which only vowels were analyzed, it has been shown that long nuclei undergo durational changes caused by word stress, while short nuclei do not [4]. Both studies also looked at the effect of speech rate, and found that long nuclei shorten at faster speech rates while short nuclei do not become shorter at faster speech rates.

The focus of this study is to examine whether consonantal nuclei behave differently from vocalic nuclei regarding their duration when implementing phonemic contrast and phrasal accent. While [5] has previously investigated phonemic quantity contrast and reported no difference in the acoustic duration according to nucleus type, the present study aims to add to this knowledge by additionally examining the effects of phrasal accent and word stress.

2. METHODS

In this paper, read speech of seven native speakers of Slovak (6 female, 1 male) will be analyzed. They were recorded in a soundproof booth with simultaneous recording of their tongue movements by ultrasound, but the articulatory data has not been examined yet. The set of target words consists of disyllabic nonsense words in which the nucleus of the first or second syllable was systematically varied (Table 1). The target nucleus was either vocalic (/e/) or consonantal (/l/ or /r/) and either short or long. Slovak has fixed initial word stress. Therefore, for the stressed condition, the target occurred in the first syllable, while for the unstressed condition the target appeared in the second. Target words were inserted in two carrier phrases in order to elicit the two accentuation patterns:

Pozri, ved' on mi ***pepap*** dal.
(Look, he even gave me pepap.)
Pozri, aj **Ron** mi *pepap* dal.
(Look, also Ron gave me pepap.)

In the first sentence, the target word (in this case *pepap*) is accented, while in the second sentence *Ron* is accented and the target word is not accented (or at least does not carry the primary accent). Since the word stress is fixed in Slovak, it is not possible to compare stressed and unstressed syllables in the same context when it comes to the effect of word boundaries, but we designed the target words and carrier phrase in a way to keep the context of the target nucleus as similar as possible. We chose /i/ as the vowel preceding the target syllable and /a/ as the vowel following the target syllable in order to adequately capture the tongue back movement for /l/ and /r/.

Sentences were presented on a screen one at a time for speakers to read them. The word that was expected to carry the phrasal accent was marked in red. The order of the sentences was always pairwise, as presented above, with the same target word for two carrier phrases. The order of the target words was randomized for each speaker but not for each repetition. Before the recording started, speakers were given the list of sentences to read through aloud once to familiarize themselves with the stimulus material. We recorded five repetitions for five speakers and six repetitions for the other two speakers.

The acoustic data were first automatically segmented using the WebMAUS forced alignment system [8] and then manually corrected.

Table 1: Target words with target nuclei (in bold) in stressed position on top, in unstressed position on bottom, each for short and long nuclei.

		/e/	/l/	/r/
Stressed	short	p**e**pap	p**l**pap	p**r**pap
	long	p**é**pap	p**ĺ**pap	p**ŕ**pap
Unstressed	short	pip**e**p	pip**l**p	pip**r**p
	long	pip**é**p	pip**ĺ**p	pip**ŕ**p

2.1. Statistics

To test the effect of nucleus type, phonemic quantity and sentence accent on the nucleus duration, R [12] and lme4 [1] were used to perform a linear mixed effects analysis. NUCLEUS TYPE (three levels: /e/, /l/, /r/), PHONEMIC QUANTITY (two levels: short, long), PHRASAL ACCENT (two levels: accented, unaccented) and WORD STRESS (two levels: stressed, unstressed) were fixed factors, and SPEAKER was a random facotor (with by-SPEAKER random intercept and slope for NUCLEUS TYPE, PHONEMIC QUANTITY, SENTENCE ACCENT and WORD STRESS). P-values were obtained by a likelihood-ratio-test in which the full model was compared to a model without the effect in question. Because of the large amount of fixed effects, which would complicate the analysis, we decided to split up the data. Since our main interest was to compare the nucleus types, we decided to group further analysis by word stress. This would also allow us to further test for the effect of phrasal accent, which has not been done before. Thus, for the more detailed analysis word stress was removed from the model.

3. RESULTS

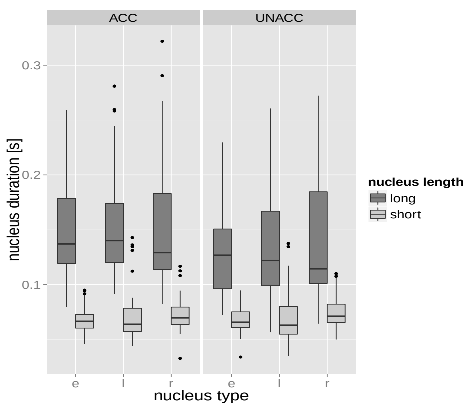
As expected, the statistic analysis revealed that the effects of PHONEMIC QUANTITY ($\chi^2[12] = 54.91, p < 0.001$), PHRASAL ACCENT ($\chi^2[12] = 44.04, p < 0.001$) and WORD STRESS ($\chi^2[12] = 32.03, p < 0.01$) were significant. Surprisingly, NUCLEUS TYPE was also significant ($\chi^2[16] = 31.92, p < 0.05$). Because we were interested in the interactions, we will now present these results in more detail.

3.1. Target syllable in stressed position within the word

First, the words with the target in stressed position within the word will be discussed. Fig. 1 illustrates the nucleus durations for each nucleus type (/e/, /l/ or /r/) and phonemic quantity (long nuclei in dark grey, short in light grey), for accented words in the left panel and unaccented words in the right panel.

As expected, the contrast between the long and short nuclei was present for all nucleus types in accented as well as unaccented words. The nucleus durations were very similar for the three nucleus types and, on average, the long nucleus was 2.2 times longer than the short nucleus for accented words, while for unaccented words, the long/short ratio was about 1.9. The statistics confirm what can be observed in Fig. 1: there were no significant differences between NUCLEUS TYPES ($\chi^2[8] = 4.39, p > 0.5$), while significant effects of PHONEMIC QUANTITY ($\chi^2[6] = 39.5, p < 0.001$) and PHRASAL ACCENT ($\chi^2[6] = 37.98, p < 0.01$) could be shown. The interaction between PHONEMIC QUANTITY and PHRASAL ACCENT was also significant ($\chi^2[5] = 28.98, p < 0.001$) and the post-hoc Tukey test revealed that the effect of PHRASAL ACCENT was significant for long nuclei($p < 0.001$) but not for short.

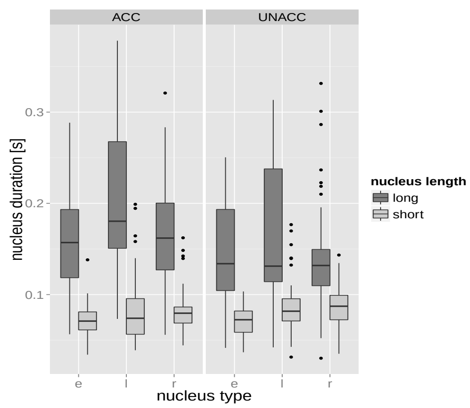
Figure 1: Nucleus durations separately for nucleus types (/e/, /l/, /r/ from left to right) grouped by phonemic length; left panel in accented words, right panel in unaccented words. The target nucleus is in stressed position within the word.



3.2. Target syllable in unstressed position within the word

We now analyze the nucleus durations of words with the target nucleus in unstressed position. The results are visualized in Fig. 2.

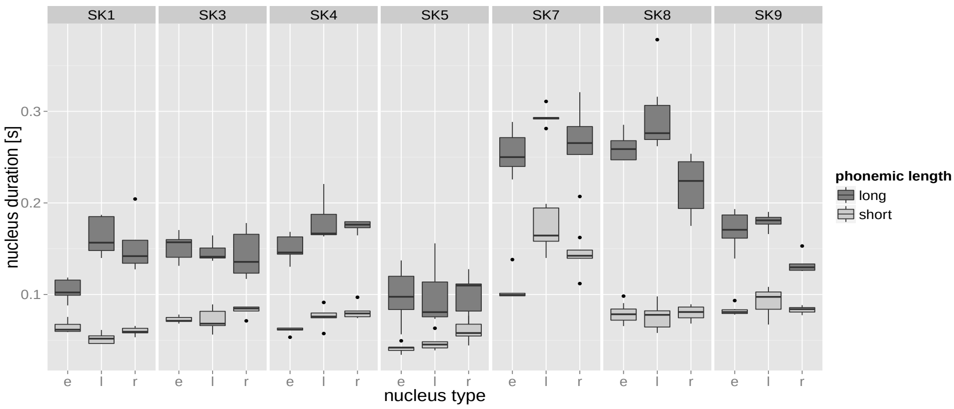
Figure 2: Nucleus durations separately for nucleus types (/e/, /l/, /r/ from left to right) grouped by phonemic length; left panel in accented words, right panel in unaccented words. The target nucleus is in unstressed position within the word.



For unstressed syllables, as for stressed ones, the contrast between long and short nuclei is robust, with the mean long/short ratio of the nucleus duration being 2.2 in accented words and 1.8 in unaccented words. Compared to the results for nuclei in stressed position, in unstressed position there seems to be more difference between nucleus types. The statistical test revealed that unlike for stressed nuclei, in the unstressed case NUCLEUS TYPE did have a significant effect ($\chi^2[8] = 23.50, p < 0.001$). The effects of PHONEMIC LENGTH ($\chi^2[6] = 88.34, p < 0.001$) and PHRASAL ACCENT ($\chi^2[6] = 81.68, p < 0.001$) were also significant. Post-hoc Tukey comparisons revealed that the effect of PHRASAL ACCENT significantly affected the nucleus duration of long nuclei ($p < 0.001$), but not short nuclei ($p > 0.5$). Most interestingly though, nucleus type interacted with phonemic length and phrasal accent in that the duration of long /l/ was longer than /r/ and /e/ in accented words (for both cases $p < 0.05$), while there was no effect of nucleus type for short nuclei or for unaccented nuclei.

We were not primarily interested in speaker variability, but for the accented unstressed nuclei we wanted to have a closer look to see whether there was a stable pattern across individual speakers. Fig. 3 shows nucleus durations for unstressed syllables in accented words separately for each speaker (left panel of Fig. 2). There is no striking pattern but for long nuclei, /l/ shows tendencies to be longer than the other nuclei, or at least is not the shortest. What might also be worth noting is that the long /l/ of speaker SK5 who was speaking with a very fast rate was not longer than /e/ or /r/, while for speaker

Figure 3: Nucleus durations separately for nucleus type by phonemic length in unstressed syllable of the accented word for each speaker.



SK6 who had a very slow speech rate, even the short /l/ was longer than the short /e/ or /r/.

4. DISCUSSION

For the most part consonantal and vocalic nuclei did not differ in acoustic duration. The phonemic quantity contrast was robust, both in accented and unaccented words for stressed and unstressed syllables. As was the case in earlier studies [4, 5], change in duration due to different factors was mainly visible in long nuclei. Thus in accented words, the nucleus durations were longer than in unaccented words for phonemically long nuclei, while the duration remained the same for phonemically short nuclei. It can be assumed that short nuclei are not further compressable which leaves them with less room for variation. Similar effects have been also observed for tense and lax vowels in German [7, 10, 15], where tense vowels, associated with longer duration, showed greater differences over changes in speech rate or different stress positions than lax vowels.

In order to look at the general pattern, we filtered out speaker variability in this study, but trying to understand why long /l/ in the unstressed syllable of the accented word differed from /e/ and /r/, we looked at speaker specific patterns. They were not too revealing, but we could suggest that /l/ coarticulates within the carrier phrase. The target word is followed by the word *dal*, and /d/ is homorganic with /l/, thus speakers keep the tongue in the same position and coarticulate through the /p/. This effect might be stronger on long, accented nuclei in which the tongue tip gesture is stronger articulated and thus most prominent in slow or careful speech. It might be contradictory that it happens in unstressed syllables and not in stressed ones, but it should be kept in mind that stress is controlled by syllable position and only the unstressed syllable, which occupies the final syllable of the target word, neighbours /d/. This assumption needs to be tested on articulatory data.

When comparing Fig. 1 and Fig. 2, unstressed nuclei seemed to be slightly longer than stressed nuclei for both short and long vowels and in accented as well as unaccented words (for example long stressed nuclei in accented position are just below 0.15s long, while unstressed long nuclei in accented position have a mean duration of slightly above 0.15s). It has been observed for some vowels in [4] that the duration of the short nuclei in unstressed position was longer than in stressed position, but this was not the case for long nuclei. Word stress is fixed in Slovak and because it is not important for lexical contrast, it seems to be only weakly implemented. Our results could be interpreted as further evidence for this. It is unlikely that the unstressed syllable is in general longer in Slovak. Instead, it could be the case of phrase-final lengthening since the unstressed syllable was also the penultimate syllable of the phrase.

The comparison of the durations of the nuclei affirmed that syllabic consonants implement phonemic quantity and phrasal accent equally to vowels.

5. ACKNOWLEDGEMENT

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