Final Lengthening in Russian: a Corpus-based Study

Tatiana Kachkovskaia, Nina Volskaya, Pavel Skrelin

Saint Petersburg State University, Russia
tania.kachkovskaya@gmail.com, volni@phonetics.pu.ru, skrelin@phonetics.pu.ru

Abstract
The paper presents the results of a corpus-based study of final lengthening in Russian. The Corpus of Russian Professionally Read Speech (CORPRES) was used to investigate the degree of word and vowel lengthening as a function of prosodic factors, including prosodic boundary type and phrase or utterance pitch pattern. The results show that the degree of both word and vowel lengthening depends on the boundary depth and the location of the word within the intonation contour, as well as on the presence of a pause. Our data are only partly in line with the data previously obtained in a controlled experiment.

Index Terms: final lengthening, pre-boundary lengthening

1. Introduction
Final lengthening in many languages including Russian has proved to be a complex phenomenon influenced by a number of factors, both segmental and prosodic. It has been shown that boundary depth has a significant effect on the degree of final lengthening [1] [2] [3], and so does the type of the intonation used [4]. For Russian there are very few publications on the subject [5] [6].

In this paper we present the results of two corpus-based experiments. In Experiment 1 we analyzed word duration in different prosodic contexts. In Experiment 2 we focused on the lengthening of the vowel /a/ in open syllables near prosodic boundaries of different types.

When analyzing the effects of boundary depth on the word and vowel duration, we distinguish between two types of intonational units containing nuclear stress: a non-sentence-final unit (prosodic phrase, or p-phrase) and a sentence-final unit (intonational phrase, or i-phrase). Thus, an intonational phrase may consist of more than one prosodic phrase, but not vice versa. Since the experimental material used is read speech recordings, the boundary type is defined purely on syntactic grounds.

CORPRES [7] developed at the Department of Phonetics, St. Petersburg State University, is a fully-annotated corpus of Russian speech where texts of different speaking styles were recorded from 4 male and 4 female speakers. The annotation covers phonetic and prosodic information including the type of pitch movement, boundary type, and various degrees of prominence. The results reported in this paper are based on the data obtained from a part of this corpus described as “an action-oriented fiction narrative resembling conversational speech” [7].

2. Experiment 1

2.1. Material
In order to find out how different prosodic factors influence word duration, we have chosen “Ludmila” (a proper name) as a target word since in one of the CORPRES texts it appears in 100 different contexts. The text was recorded from 4 (2 male and 2 female) speakers. Thus, in this experiment we analyzed 400 realizations of the target word.

2.2. Method
Since the corpus contains a multi-level segmentation and prosodic annotation, for each occurrence of the target word we have calculated its absolute duration and extracted information about its position within the p-phrase and the i-phrase along with the type of intonation contour and the localization of the intonation center (nuclear stress). The data were subjected to statistical analysis using ANOVA. For pairwise comparison two-tailed Welch’s t-test was used.

2.3. Results
Figure 1 shows the duration of the word “Ludmila” depending on the boundary type for Speaker C. The results look similar for all four speakers, but with some difference in scale (see Figure 2).

Mean word durations in p-medial position differ significantly from p-final and i-final positions before a pause for all 4 speakers (excluding p-final position before a pause for
Speaker M, where the data were scarce and therefore could not provide reliable results). This lengthening is probably due to the final position of the word, but we should bear in mind that in our data final position is also the intonation center.

Our data show that before a pause word duration values are higher for p-final position than for i-final for all 4 speakers, but the effect is significant only for Speaker C ($p = 0.021$). This is remarkable since i-final boundaries are deeper and therefore expected to provide more lengthening, as shown in some previous studies for other languages [1] [2]. These results are also not consistent with what was found for the Russian language in a controlled experiment [5]. However, similar results were obtained for German and French [8], and for Dutch this was found to be speaker-specific [9].

These results could be explained by the difference in realizations of intonation contours in i-final vs. p-final positions. In Russian most types of pitch movement can be used in both positions (for example, the rising-falling contour is used in i-final position for general questions and in p-final position when expressing non-finality), and in that case the realizations may differ in the speed of pitch change, pitch range, and vowel length. Thus for some intonation contours the durational differences between p-final and i-final stressed vowels may be due to the features typical for the variant of the intonation contour used rather than final lengthening. To confirm or reject this claim, more research is to be conducted, with each type of pitch movement treated separately.

The data also show that the presence or absence of a pause at the end of the unit in question has an effect on word duration, which has not been reported in previous studies for the Russian language. However, very similar results we obtained for Spanish [10].

In our data, for 3 of 4 speakers the target word is longer when followed by a pause, although the difference is significant only for speakers A ($p = 0.008$) and C ($p < 0.001$). For speaker M mean word duration is lower before a pause, but the difference is very slight and statistically non-significant. Our data seem to provide an explanation for this inconsistency between the speakers: in p-final position with no pause following, speakers A, C, and K use only non-final rising contours, while speaker M also uses a specific falling contour with special emphasis used in vocatives and exclamations.

Thus, the tendency for the target word to be longer before a pause can be explained by the difference in intonation contours used (see above). To clarify the issue, more research is to be done.

The difference in vowel duration between p-medial and p-final positions not followed by a pause is found non-significant for 3 of 4 speakers ($p_A = 0.19, p_C = 0.074, p_K = 0.15, p_M = 0.03$). Still, the mean word duration values in final position are consistently higher for all speakers.

### 3. Experiment 2

#### 3.1. Material

Here we observe relative duration values of the vowel /a/ in two positions: penultimate stressed open syllable and ultimate unstressed open syllable. The choice was based on the results of a previous study [5] where final lengthening was found not only in final syllables, but also in the last stressed syllable (which is true for other languages as well [11]).

In this experiment we analyze the data obtained for one speaker. Note that all vowels observed here are taken from words immediately preceding prosodic boundaries.

#### 3.2. Method

Vowel duration values were extracted from the corpus based on their position in the prosodic phrase. For this purpose we provided each prosodic phrase with inverse allophone numeration, so that each p-final allophone was numbered 1. This is the position we used to obtain data for ultimate unstressed /a/. In the analyzed text we found 824 allophones of this kind.

For penultimate stressed /a/ we chose position 3, in order to...
decrease segmental influence and minimize manual work. Thus, the vowel could be followed by either a consonant plus an unstressed vowel, or an unstressed vowel plus a consonant, or two consonants. Contexts of the latter type were removed from the dataset to make sure all the target vowels are taken from penultimate syllables. The total amount of allophones of this kind in the analyzed text was 344.

For the purposes of our study, we measured vowel duration relative to the mean duration for this type of allophone, which is calculated over the whole corpus. The mean duration of unstressed /a/ is 66 ms, of stressed /a/ — 104 ms.

All the data were subjected to statistical analysis using ANOVA. For pairwise comparison we used two-tailed Welch’s t-test.

3.3. Results

3.3.1. Boundary type

Figures 3–4 show relative duration values of the target vowels in words immediately preceding prosodic boundaries, but not carrying nuclear stress, which means we might eliminate (at least partly) the influence of the intonation contour used.

For the stressed /a/ (Figure 3) boundary type does not reveal a strong effect on vowel duration ($p = 0.042$, which is close to the 5% limit), but the lengthening varies from 6% in p-final position to 28% in p-final position before a pause, which means that most of the time the vowel is lengthened. The difference between the mean values reveals the same tendencies as in the Experiment 1, but to a lesser extent.

As for the unstressed /a/ in ultimate open syllables (Figure 4), the difference between the mean values is more substantial, and it is statistically significant ($p < 0.001$). The mean lengthening ranges from −13% in p-final position to 29% in p-final position before a pause. Thus, what we observe in p-final position can be explained only by the absence of a pause. The difference between the lengthening in p-final and i-final positions before a pause is not statistically significant ($p = 0.129$), although shows the same tendencies as in the Experiment 1.

Figures 5–6 show relative duration values of the target vowels in words immediately preceding prosodic boundaries and carrying nuclear stress. Thus, a stronger lengthening effect in these data could imply that the effect of final lengthening and nuclear lengthening is additive.

For both the stressed /a/ (Figure 5) and the unstressed /a/ in ultimate open syllables (Figure 6), the difference between the mean values is statistically significant ($p < 0.001$ in both cases). For all boundary types these values are higher than those in the position without nuclear stress.

In general, these values look very similar to the respective values of /a/ in words without nuclear stress, but the variance is higher. A possible explanation is that the presence of nuclear stress adds much variation, since different intonation contours have a different lengthening effect on the vowels.

As we can see in Figures 3–6, in the position before a pause the ultimate unstressed vowels /a/ show a higher variation than the penultimate stressed vowels /a/. However, the variation is about the same if there is no pause following. This is probably due to the influence of the intonation contours used by professional speakers to convey different shades of meaning. In that case the ultimate vowel is more likely to get lengthened since there are no other phonemes following it.

3.3.2. Type of pitch movement

In an attempt to answer the question whether the type of pitch movement has an influence on vowel lengthening, and whether this influence differs across prosodic boundaries, we have analyzed relative vowel duration values using ANOVA. Our dataset provided enough data to estimate this influence for two types of boundaries: p-final before a pause and i-final before a pause. Note that in the Russian language there is a difference in intonation contours typical for these positions (see above).

It is worth mentioning here that in Russian timing is based on stress accent, i.e. on lexically defined local prosodic promi-
The main phonetic correlates of stress accent in Russian are vowel duration and vowel quality. Thus, we expected to find a stronger influence of pitch movement type on vowel lengthening for the stressed /a/ than for the unstressed /a/.

For the p-final position before a pause our dataset contained both rising and falling contours expressing non-finality. After eliminating those with emphatic accent (since they are beyond the scope of this study), we performed t-tests to find out whether the direction of pitch movement influences vowel lengthening. For the vowel /a/ in ultimate unstressed open syllables this difference is statistically significant ($p < 0.001$), and the relative vowel duration is higher for the rising contours. However, for the vowel /a/ in penultimate stressed open syllables we observe the opposite: the difference is non-significant ($p = 0.059$), and the mean relative vowel duration is lower for the rising contours. This might imply that different contours affect stressed and post-stressed vowels differently.

For the i-final position the influence of the intonation contour is non-significant ($p = 0.268$) for final unstressed /a/. The degree of lengthening is at about the same level for all types of pitch movement. However, for the stressed /a/ in penultimate open syllables this influence is statistically significant ($p < 0.001$), and the values for some of the contours differ markedly from the others. The rising-falling contour used in general questions shows very slight vowel lengthening, while the average lengthening across all contours is 32 %. The vowel duration values for the falling contour used for the author’s words after direct speech are also lower (14 %), which might be due to the tempo reduction typical for remarks. The falling contour used in vocatives and exclamations shows a higher lengthening effect (47 %) compared to the average value (32 %), which is not surprising since these realizations are usually emphasized. Thus, for i-final position our data seem to confirm the assumption that pitch movement type has a stronger effect on the lengthening of the stressed vowels /a/ than for the unstressed.

4. Conclusions

- Our data have shown similar tendencies for both the word “Ludmila” and the vowel /a/ in ultimate unstressed open syllables and penultimate stressed open syllables. The degree of final lengthening is influenced by:
  - the boundary depth (it is higher for p-final than for i-final position);
  - the presence or absence of a pause (it is higher before a pause).

Both of these tendencies have not been reported on in previous studies for the Russian language. A possible explanation is based on the fact that in Russian the intonation contours used in p-final position are not exactly the same as in i-final, even though the pitch pattern might be the same. The presence or absence of a pause is also related to the pitch movement type: our data show that only some contours can be used without a following pause.

- The lengthening of the vowel /a/ in ultimate unstressed open syllables (relative to the mean duration calculated for this type of allophone over the whole corpus):
  - without nuclear stress: 6 % in p-final position, 28 % in p-final position before a pause, and 21 % in i-final position before a pause (the influence of boundary type is close to the limit of significance, $p = 0.042$);
  - under nuclear stress: 18 % in p-final position, 33 % in p-final position before a pause, and 34 % in i-final position before a pause (the influence of boundary type is significant, $p < 0.001$).

- The lengthening of the vowel /a/ in penultimate stressed open syllables (relative to the mean duration calculated for this type of allophone over the whole corpus):
  - without nuclear stress: −13 % in p-final position, 29 % in p-final position before a pause, and 15 % in i-final position before a pause (the influence of boundary type is significant, $p < 0.001$);
  - under nuclear stress: −5 % in p-final position, 42 % in p-final position before a pause, and 18 % in i-final position before a pause (the influence of boundary type is significant, $p < 0.001$).

- The type of pitch movement has an effect on:
  - the lengthening of the vowel /a/ in ultimate unstressed open syllables ($p < 0.001$), but not on the lengthening of the vowel /a/ in penultimate stressed open syllables ($p = 0.059$) in p-final position before a pause;
  - only the lengthening of the vowel /a/ in penultimate stressed open syllables in i-final position before a pause ($p < 0.001$). For some types of pitch movement the degree of vowel lengthening in i-final position differs markedly from that of the other types.

- Our data seem to contribute to the idea that final lengthening is universal across languages [12].

5. Acknowledgements

The authors acknowledge Saint Petersburg State University for a research grant (31.0.145.2010).
6. References


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