

# Pause Duration at Syntactic Boundaries\*

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## 1 Introduction

Any speech synthesis and speech recognition system has the algorithm which defines pause duration. A pause is an important member of prosodic cues used among other components – pitch changes, prepausal lengthening, declination reset – for boundary marking and thus for structuring the text into intonation units. We know that the speakers use variable combination of prosodic cues to mark boundaries between different syntactic or discourse units. What prosodic cues are of primary importance for the speaker to mark boundaries of different strength and to highlight the structural make up of the sentences in the text – these issues have been the subject of intensive research. Some studies have shown that syntactic boundaries are characterized mostly by pauses [1], [2], [3] and lengthening [2], [3], [4], [5], [6], sometimes also pitch [7], some claim that the interaction of prosodic cues is a more complex one [8].

In this study we investigated the role of a pause as one of the prosodic cues used in marking syntactic boundaries in the Russian text.

## 2 Subjects

5 female and 3 male speakers of Russian participated in this study, all students of Saint-Petersburg State University. Their age ranged from 17 to 20 years old at the time of recording.

## 3 Material and procedure

A phonetically balanced text [9] was recorded individually with a Sony DAT recorder. Total recording time is about 30 minutes. The text contained syntactically simple, compound and complex sentences; various types of sentences – declarative, interrogative and imperative – were presented as well. It was read by each speaker in the most appropriate and natural manner. Intonation transcription in which prosodic boundaries were marked was manually performed by the experimenter. Since the subjects read a prepared text, in a great majority

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of cases prosodic boundaries coincided with the boundaries between syntactic units.

The recordings were then digitized, the beginning and the end of each intonation unit was determined at the on-set and off-set of the acoustic signal on the oscillogram. The oscillograms and the waveforms were obtained using the EDS program. Duration of pauses at perceived boundaries was measured in several steps. First, each pause of 250 ms duration was automatically indicated in the spectrogram of the analyzed signal by a mark of a selected color. Second, the results of the automatic phrasing were then compared with the results of manual intonation transcription. Pauses which were shorter than 250 ms, and those of longer duration were marked on the oscillogram by hand.

At the third step the segmentation files were exported into the specifically structured text file which was treated using the EXEL for MS Office 97.

## 4 Analysis of Results

Table 1 presents the number of intonation units obtained as a result of intonation transcription of the recorded material, the number and average duration of pauses marked automatically.

**Table 1.** Number of units, number of pauses <250 ms and >250 ms and their average duration values

| Speaker | Number of units | Number of pauses <250 ms | Average duration of pauses <250 ms | Number of pauses >250 ms | Average duration of pauses >250 ms |
|---------|-----------------|--------------------------|------------------------------------|--------------------------|------------------------------------|
| S. 1    | 127             | 61                       | 157                                | 55                       | 557                                |
| S. 2    | 134             | 65                       | 159                                | 68                       | 551                                |
| S. 3    | 138             | 70                       | 177                                | 67                       | 636                                |
| S. 4    | 127             | 43                       | 188                                | 83                       | 543                                |
| S. 5    | 128             | 51                       | 180                                | 76                       | 541                                |
| S. 6    | 136             | 53                       | 174                                | 82                       | 481                                |
| S. 7    | 121             | 61                       | 174                                | 59                       | 566                                |
| S. 8    | 130             | 25                       | 179                                | 105                      | 557                                |

The analysis of the data showed that pauses with duration of over and under 250 ms were observed at the boundaries of both major and minor syntactic units. The average value of all pauses under 250 ms is 173,5 ms. Taking into consideration the results of some previous research on perceived pause duration we can regard most these pauses as "psychological". To get a more clear picture of the prosodic role of pause duration in marking syntactic boundaries of different syntactic units we decided to perform a more detailed study of pause duration with regards to the type of the syntactic phrase.

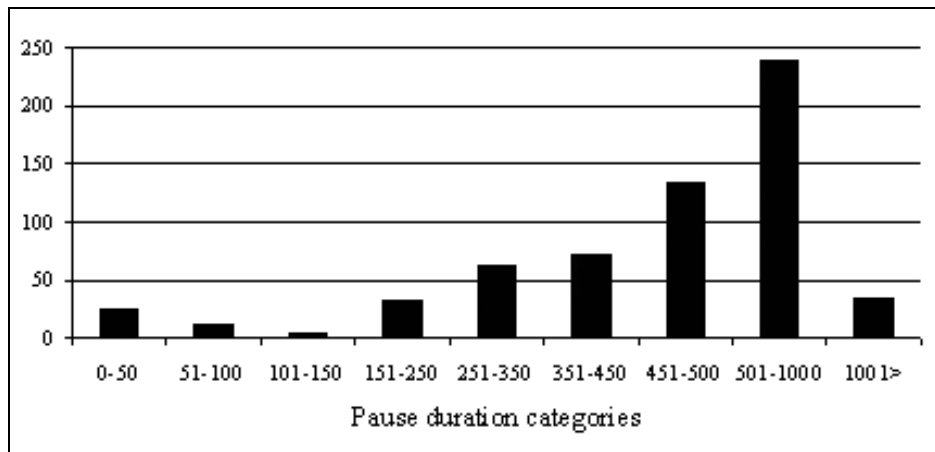
The results obtained are presented in Tables 2 and 3 and figures 1, 2.

**Table 2.** Number and duration categories of pauses at major syntactic boundaries for 8 speakers

| Category<br>ms | S. 1 | S. 2 | S. 3 | S. 4 | S. 5 | S. 6 | S. 7 | S. 8 | Total |
|----------------|------|------|------|------|------|------|------|------|-------|
| 0- 50          | 8    | 1    | 2    | 1    | 4    | 1    | 7    | 1    | 25    |
| 51- 100        | 0    | 3    | 0    | 2    | 2    | 1    | 3    | 0    | 11    |
| 101- 150       | 2    | 1    | 0    | 0    | 0    | 0    | 1    | 0    | 4     |
| 151- 250       | 7    | 6    | 7    | 5    | 5    | 0    | 1    | 1    | 32    |
| 251- 350       | 9    | 6    | 4    | 10   | 8    | 13   | 9    | 4    | 63    |
| 351- 450       | 11   | 9    | 8    | 8    | 7    | 11   | 9    | 8    | 71    |
| 451- 500       | 9    | 3    | 6    | 4    | 7    | 6    | 6    | 3    | 134   |
| 501-1000       | 18   | 34   | 33   | 28   | 28   | 32   | 25   | 40   | 238   |
| > 1001         | 4    | 3    | 6    | 6    | 2    | 4    | 4    | 5    | 34    |

## 5 Major syntactic boundaries

As it follows from the Table 2, though pause duration at major syntactic boundaries varies, the differences have a vary narrow range : 88% of all pauses are over 250 ms, most of them though, 450–1000 ms (see Figure 1). Pauses with duration over 1000 ms are those which mark the end of a paragraph.



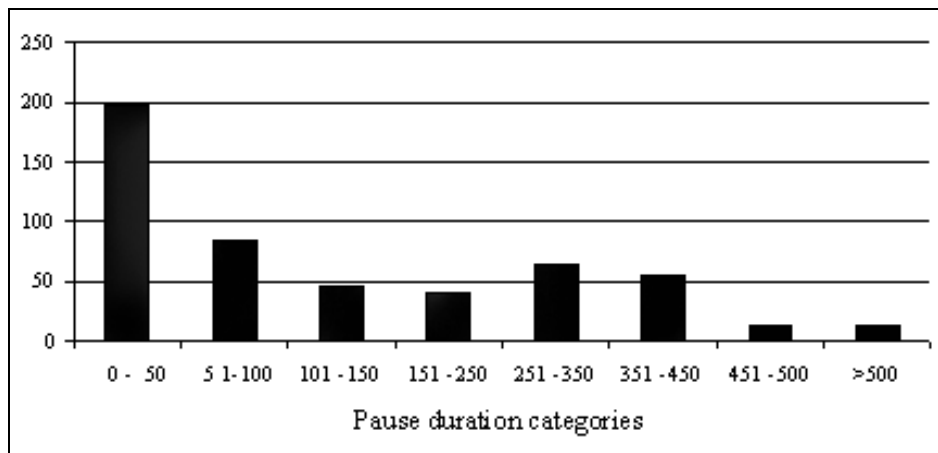
**Fig. 1.** Number of observations for 9 pause categories (in ms) for major syntactic boundaries in the read text

## 6 Minor syntactic units.

72 % of all pauses found at minor syntactic boundaries have duration values below 250 ms. As it follows from Table 3, most of them are less than 50 ms. Pauses with duration under 100 ms constitute 55 % of the whole number (see also Figure 2). This data leads to the conclusion that minor syntactic boundaries in the read text are marked by a set of prosodic cues of which a pause is not of primary value. The force of this prosodic marker in demarcating syntactic units is debatable.

**Table 3.** Number and duration categories of pauses at major syntactic boundaries for 8 speakers

| Category<br>ms | S. 1 | S. 2 | S. 3 | S. 4 | S. 5 | S. 6 | S. 7 | S. 8 | Total |
|----------------|------|------|------|------|------|------|------|------|-------|
| 0 – 50         | 33   | 24   | 36   | 14   | 9    | 31   | 37   | 14   | 198   |
| 51– 100        | 13   | 17   | 7    | 11   | 8    | 11   | 11   | 6    | 84    |
| 101– 150       | 9    | 10   | 10   | 4    | 8    | 3    | 0    | 1    | 45    |
| 151– 250       | 1    | 3    | 8    | 6    | 15   | 5    | 1    | 2    | 41    |
| 251– 350       | 1    | 8    | 6    | 13   | 9    | 11   | 4    | 12   | 64    |
| 351– 450       | 2    | 4    | 5    | 10   | 8    | 6    | 2    | 18   | 55    |
| 451– 500       | 0    | 1    | 0    | 2    | 2    | 1    | 1    | 5    | 12    |
| > 500          |      |      |      | 0    | 4    |      |      | 9    | 13    |



**Fig. 2.** Number of observations for 9 pause categories (in ms) for minor syntactic boundaries in the read text

## 7 Conclusion

The data obtained from the study performed thus challenges the results reported in some other studies, according to which a speaker primarily adapts the duration of pauses and secondarily chooses a particular type of melodic boundary marker. This is not the case at least for the boundaries marking minor syntactic units. It is more in agreement with those who state the priority of pitch changes without a pause rather than a pause plus melodic changes. Observations show that prepausal lengthening is not characteristic for non-final intonation units (minor syntactic unit) in Russian either due to very fast and sharp pitch changes. But experimental evidence for this claim is the aim of our future studies.

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