

# AN ACOUSTIC STUDY OF ESTONIAN WORD STRESS

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## Introduction

This study is a part of the **Word Stress Project** which aims to investigate the acoustic correlates of word stress in various languages using unified methodology.



In Estonian, the main word stress is usually **fixed on the first syllable**. The division of the word into feet follows the trochaic rhythm structure. Secondary stresses normally fall on successive odd-numbered syllables.

All primary stressed syllables in Estonian are in one of the **three quantity degrees**: short (Q1), long (Q2) and overlong (Q3). This distinction operates only over a **disyllabic trochaic foot**, and the decisive factor in determining the degree of quantity is **the duration ratio** between the first (stressed) and second (unstressed) syllable, regardless of the stressed syllable structure. An additional cue to the quantity distinction is the **pitch contour**: in Q1 and Q2 is a step down between the two first syllables whereas in Q3 is an early fall in the first syllable.

## Materials

- Spontaneous recordings of 16 native speakers of Estonian (10 females and 6 males, 22–34 years old, students or graduates of the University of Tartu), chosen from the **University of Tartu Phonetic Corpus of Estonian Spontaneous Speech**
- From each recording 15–20 utterances with 1 or 2 target words were chosen. The target words were not preceded or followed by an IP-boundary and were at least two or more syllables long.
- The same 16 speakers were called back to the recording studio to read the utterances and target words as lists (in random order with three repetitions).
- The final data set comprises 276 target words in three different speaking styles: spontaneous speech, phrase reading and word list reading.



|                              |                  |                                 |
|------------------------------|------------------|---------------------------------|
| midagi [ˈmi.ta.ki]           | 'something'      | Q1 (Pri + Uns + Uns)            |
| rongile [ˈron.ki.le]         | 'train AllSg'    | Q2 (Pri + Uns + Uns)            |
| eelmine [ˈee.l.mi.ne]        | 'previous'       | Q3 (Pri + Uns + Uns)            |
| esimene [ˈe.si.me.ne]        | 'first'          | Q1 (Pri + Uns) + Q1 (Pri + Uns) |
| värviliste [ˈvæ.r.vi.lis.te] | 'coloured GenPl' | Q2 (Pri + Uns) + Q2 (Pri + Uns) |
| mesilasse [ˈme.si.lasː.se]   | 'beeyard IllSg'  | Q1 (Pri + Uns) + Q3 (Sec + Uns) |

Table 1: Examples of the target words in three quantity degrees (Pri = primary stressed syllable, Sec = secondary stressed syllable, Uns = unstressed syllable)

## Analysis

The vowels of the target words were manually labelled. The measures of **duration**, **F0 mean**, **F0 standard deviation**, and **spectral emphasis** were extracted using a Praat script. The mean values of the measures were calculated for each speaker for the factors **Style**, **Stress** and **Quantity**. Three-way Anova tests were used to evaluate the significance of the factors.

## Vowel Duration

**Style:** The duration is the longest in word list reading and the shortest in spontaneous speech.

**Interaction of Stress and Quantity:** in Q2 and Q3, vowel duration is the longest in primary stressed syllables and the shortest in unstressed syllables; but in Q1 the unstressed syllables are the longest and the primary stressed syllables the shortest.

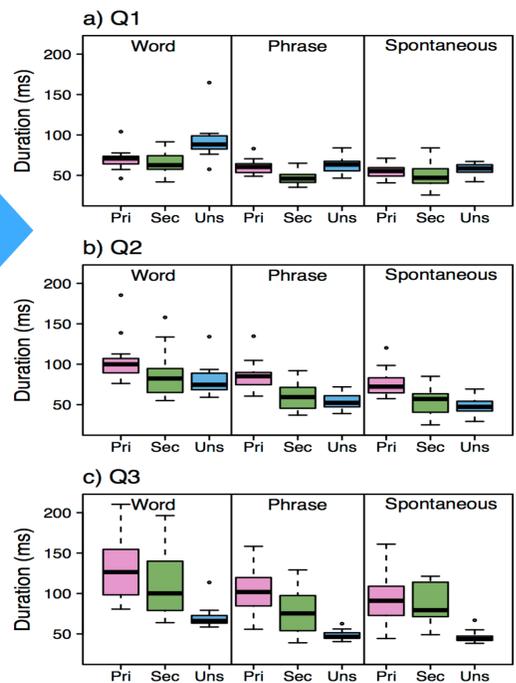


Figure 1: Duration as a function Style (word list reading, phrase reading, spontaneous) and Stress (primary, secondary, unstressed), grouped by Quantity.

## F0 variation

**Male speakers:** **Stress:** F0 variation is greater in primary stressed and unstressed syllables than in secondary stressed syllables.

**Interaction of Stress and Quantity** indicates that the variation of F0 is somewhat different in primary stressed vowels of Q1 vs. Q3.

**Female speakers:** **Stress:** F0 variation is greater in unstressed vowels, and there is no significant difference between primary and secondary stressed vowels.

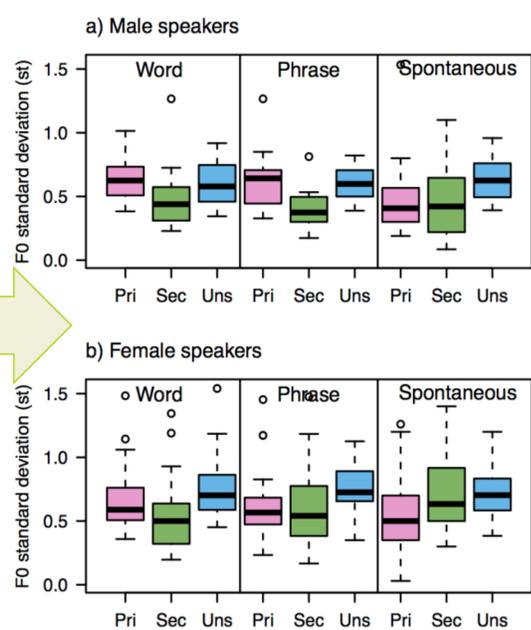


Figure 3: F0 standard deviation as a function Style (word list reading, phrase reading, spontaneous) and Stress (primary, secondary, unstressed), grouped by m/f speakers.

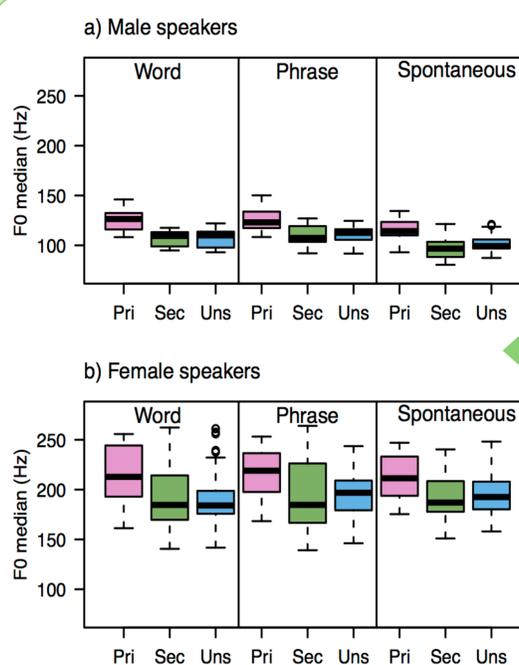


Figure 2: F0 median as a function Style (word list reading, phrase reading, spontaneous) and Stress (primary, secondary, unstressed), grouped by m/f speakers.

## F0 mean

**Stress:** F0 is higher in the primary stressed syllables, but there is no difference between secondary and unstressed vowels.

**Style:** (only male speakers) the F0 mean is higher in read speech than in spontaneous speech, but there is no significant difference between the word list reading and phrase reading.

Unexpectedly, there was no effect of Quantity on the F0 mean, although it is known from previous studies that there is more pitch movement in Q3 primary stressed syllables.

## Conclusions

- Vowel duration was the most important correlate of Style and Stress, but in a strong interaction with Quantity. In Q2 and Q3 the stressed vowels were longer than the unstressed ones, in Q1 the unstressed syllables were the longest.
- The secondary stressed vowels were always shorter than the primary stressed ones.
- The pitch in primary stressed vowels was higher than in secondary and unstressed vowels, while the variation of pitch was high in stressed and unstressed vowels and lower in secondary stressed vowels. Spectral emphasis turned out to be the weakest measure of stress.
- Estonian, a language with fixed word stress and clear phonological rules determining the stress patterns, seems to have fewer and weaker stress correlates. In further work on Estonian word stress also the segmental structure of the foot should be factored in.

## Spectral Emphasis

**Male speakers:** no significant factors.

**Female speakers:** **Style:** spectral emphasis is greater in read as compared to spontaneous speech.

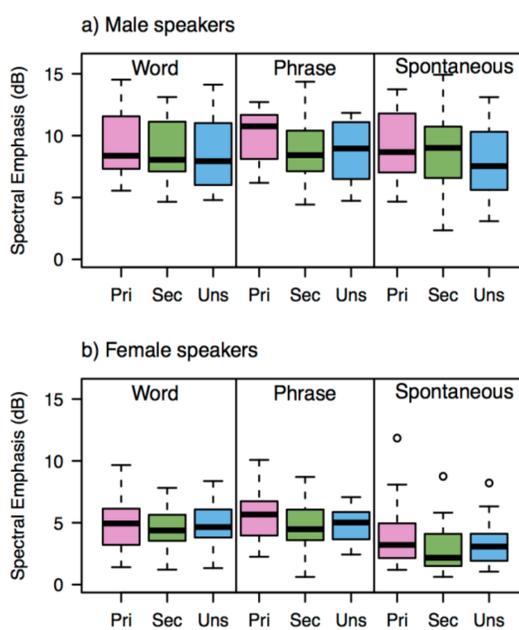


Figure 4: Spectral emphasis as a function Style (word list reading, phrase reading, spontaneous) and Stress (primary, secondary, unstressed), grouped by m/f speakers.