

ACOUSTICS OF STØD IN LIVONIAN

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ABSTRACT

The paper focuses on the phonetic realisation of the Livonian stød. An investigation of the temporal and tonal characteristics of words with and without stød consisting of a long first syllable and a short second syllable in spontaneous speech was carried out. The changes in pitch alignment, durations and duration ratios of the syllables in disyllabic words were analysed and the role of intensity was studied. The analysis revealed a difference in the observed acoustic characteristics in words with and without stød. The duration of the first syllable is more neutralised in both groups. In tonal characteristics two distinct patterns are evident. In words with stød, the pitch peak in the stressed syllable is earlier than in words without stød. The intensity in the first syllable is similar in both groups, but there is a difference in the interaction between the first and second syllable.

Keywords: stød, fundamental frequency, intensity, quantity, Livonian.

1. INTRODUCTION

Livonian is the southernmost Finnic language, once spoken in Latvia. There are currently no native speakers left. As far as it is known, the last native speaker of Livonian died in 2013. Nowadays the descendants of Livonian speakers speak it as a second or third language, or learn it as a foreign language.

Acoustic-phonetic studies have shown that the quantity system of Livonian has similarities with that of Estonian [6, 7, 8, 9]. The tonal system shares similar characteristics with Latvian but also Danish [2, 3, 10, 11, 16, 18]. Livonian is the only Finnic language that differentiates two tones in stressed stem-initial syllables. The *plain tone* is characterised as level or rising and the *broken tone* or stød as rising-falling. Livonian stød can be defined as a phonological unit, which on the suprasegmental level has particular characteristic features. The most typical aspect is a specific shape of pitch excursion, which sometimes can be accompanied by laryngealization.

In orthography, stød is usually left unmarked, but in transcriptions it is marked with an apostrophe.

In the current paper, the glottal consonant symbol [ʔ] is used following the conventions of IPA transcription. In Livonian, the so-called *stød-basis* is a long stressed syllable with a long vowel, diphthong, triphthong, or a short vowel followed by a voiced geminate consonant or consonant cluster (e.g. [rɔ:ʔdɤ] ‘money, PSg’, [ti:ʔedɤ] ‘to do, Inf’, [kuoʔigɤ] ‘ship, PSg’, [saʔddɤ] ‘to rain, Inf’). The prominence of this phenomenon must not be ignored, as stød has a phonological role in differentiating meaning (e.g. [kuonnɤ] ‘frog, PSg’ vs. [kuoʔnnɤ] ‘at home’) [5]. Similarly to Danish, Livonian stød is to a large extent predictable from syllabic and morphological structure.

The Livonian prosodic system became the object of international discussion for the first time in the 19th century. The special status of the Livonian words was first noticed by the Estonian linguist Wiedemann [19], who clearly recognized the existence of different tones but explained them as specific vowel or consonant lengths similar to quantity contrasts in Estonian. A few decades later, stød was first described by the Danish linguist Thomsen [16] who noticed its similarities with the Danish stød. The first experimental studies of Livonian pronunciation were initiated in the 1920s, mainly due to interest in stød [4].

2. PHONETIC FEATURES OF STØD

Previous descriptions reveal a certain degree of agreement among researchers who have studied Livonian stød.

The studies have pointed out that the fundamental frequency peak occurs late in the syllable where stød is not expected and much earlier in the syllable where it is expected [8, 12, 13, 18]. In addition to the characteristic tone contour, stød is realised as a change in the phonation pattern – irregular vibrations of the vocal folds, i. e. laryngealization or glottalization. The location of the laryngealization in a syllable rhyme can appear in the beginning, middle or at the end of the first syllable [8, 15, 18]. There are also descriptions of an abrupt drop of F0 when laryngealization begins [14].

It has also been shown how the situation of the language critically changed at the end of the 20th century. For example, laryngealization is not

realised by all speakers in all the words where it is expected and young speakers do not produce laryngealization at all [8].

The analysis of words pronounced in minimal pairs have shown that the words with *stød* are differentiated from words without *stød* first and foremost by laryngealization, and by an early F0 peak followed by a fall in F0 [15]. In Livonian spontaneous speech [17] laryngealization in *stød* words occurs rather rarely. In fact, it is the peak or turning point of the F0 curve that is dominant in differentiating words with and without *stød*. It has been shown that *stød* tends to shorten long vowels and diphthongs [15].

The general contour of intensity has been found to be different in words with and without *stød* [18]. A decrease of intensity during laryngealization has been also described [12]. It has been shown [15] that in spontaneous speech the most characteristic tends to be earlier intensity peak in words with *stød*, while in words without *stød* the peak is later. The question of mean intensity values in both syllables of a word, and their comparison with each other or the surrounding segments has not been studied so far.

The present paper deals primarily with the following questions: (1) How stable are the main phonetic characteristics of *stød* in spontaneous Livonian? (2) What is the role of intensity in characterising Livonian *stød*? Considering previous studies, it is hypothesised that there is a variation in tonal characteristics and intensity between words with and without *stød*, but temporal features are more neutralised in spontaneous speech. It is also assumed that not only the acoustic characteristics of the first syllable but also the second syllable should receive greater attention.

3. RESEARCH MATERIAL AND METHOD

The spontaneous speech data used in the study comes from the University of Tartu Archives of Estonian Dialects and Kindred Languages. The analysed words are from six native Livonian speakers (three females and three males), who were recorded in the 1970s and 1980s. The speakers were born between 1889 and 1921 and come from the villages that belong to the Eastern and Central part of the Livonian Coast.

Table 1: Number of tokens used in the analysis.

	Number of speakers	Words without <i>stød</i>	Words with <i>stød</i>
Female	3	84	57
Male	3	99	62
Overall	6	183	119

A total of 302 disyllabic words were analysed (see Table 1). Words without *stød* and with *stød* are treated separately and compared to each other. The material consists of disyllabic words with a long first syllable containing a long monophthong, diphthong or triphthong and a short vowel in the second syllable, e.g. [mø:dʏ] ‘land, PSg’ vs. [mø:ʔzʏ] ‘down, Adv’, [ti:edʏ] ‘work, PSg’ vs. [ti:ʔedʏ] ‘to do, Inf’. Only phrase-internal words were analysed, as this position could be considered neutral. The words in this position formed the most complete set of data. All test words were in a stressed position.

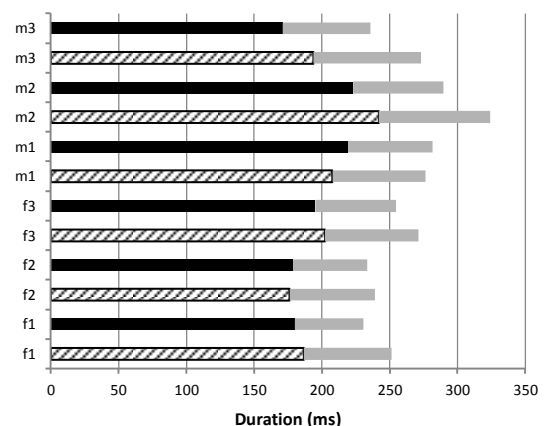
The test words and phoneme boundaries were manually tagged using Praat [1], after which segment durations, pitch values and intensity values were extracted from the annotated TextGrid using a script. The location of the F0 peak or turning point relative to the beginning of the first syllable was also manually annotated. By turning point, the point where there is a noticeable change in the direction of the F0 contour in the first syllable from rising or level to falling is meant. The mean intensity was calculated for both voiced syllable rhymes.

4. RESULTS AND DISCUSSION

4.1. Temporal characteristics

The mean segment durations of the first and second syllable in words without *stød* and with *stød* are presented in Figure 1.

Figure 1: Mean rhyme durations for the first and second syllable (grey bar) measured for six speakers (f=female, m=male) for words without *stød* (hatched bar) and with *stød* (black bar).



Comparison of the two word groups shows that the duration of the first syllable rhyme (S1) is similar in both groups. The mean S1 rhyme duration in words without *stød* is 204 ms and in words with *stød* 193 ms. A one-way ANOVA test reveals that the duration difference of the S1 rhyme between two

groups is not significant [$F(1,299) = 2.69, p=0.10$]. The mean second syllable rhyme (S2) duration is decreased in words where *stød* is expected: in the group without *stød*, $\bar{x}=72$ ms, and in the group with *stød*, $\bar{x}=60$ ms. The difference between two groups is highly significant [$F(1,299) = 38.65, p<0.001$].

The ratio of syllable rhyme durations for the group where *stød* is not expected is 2.96 and 3.37 for the group where *stød* is expected, revealing a significant difference [$F(1,299) = 10.13, p<0.01$].

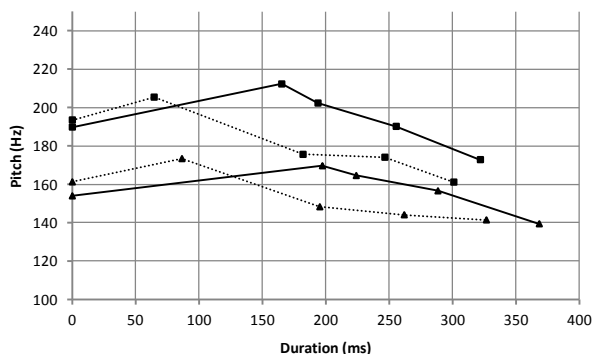
Results obtained from read speech [15] as well as spontaneous speech [17] have shown that the S1 durations in these word groups are significantly different. The duration of the S1 rhyme was shorter in words where *stød* is expected. However, the current results from spontaneous speech show that the S1 durations are quite similar for both groups. The difference in the duration of the first syllable tends to get more neutralised, but it is maintained in the duration of the second syllable rhyme.

Laryngealization is not always realised in spontaneous speech. However, if present, it is clearly heard. A laryngealization period occurred in approximately 34% of the words with *stød*. The duration of laryngealization varies between 19–179 ms. The location of laryngealization also varies, but is usually located in the middle of the S1 rhyme. The duration of the S1 rhyme of words with *stød* is significantly longer when laryngealization is present [$F(1,117) = 22.92, p<0.001$].

4.2. Tonal characteristics

Words with an H*L pitch accent comprised the most complete set of data. A few words with a rising F0 in both syllables of a word were omitted from the analysis. It can be seen in Fig. 2 that two clear patterns of pitch alignment appear.

Figure 2: Fundamental frequency (in Hz) in words without *stød* (solid line) and with *stød* (dashed line) for three female speakers (black squares) and three male speakers (black triangles). The five points are at the S1 rhyme beginning, F0 peak, S1 rhyme end, S2 rhyme beginning and S2 rhyme end.



The most characteristic feature in differentiating the two word groups appears to be the location of the pitch peak or turning point. In words without *stød* the F0 peak is near the end of the S1 rhyme (at 84–88% of the rhyme) or in some cases in the beginning of S2. In words with *stød* the F0 peak is usually in the first half of the S1 rhyme (at 34–41% of the rhyme). Also, the F0 can sometimes fall from the beginning of the S1 rhyme throughout the whole syllable. This result is in sound with the previous findings concerning both spontaneous and read speech [15, 17], but differs from several findings concerning read speech [8].

There is no significant difference in F0 peak values in the two groups [$F(1,260) = 0.06, p=0.81$]. Characteristically, the fall of F0 from its peak to the end of S1 is bigger in words with *stød*. Similarly to the earlier results [15, 18] the pitch in the second syllable is somewhat lower in words with *stød* than in words without *stød*.

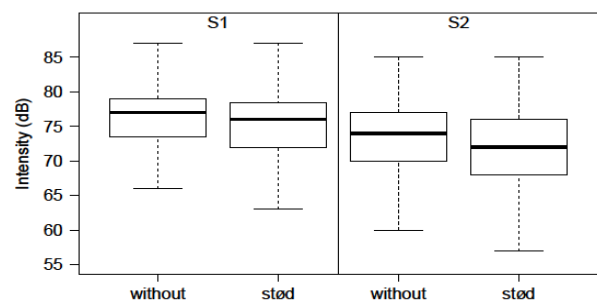
In the case of laryngealization the F0 peak is usually within the laryngealization or before it. There were some cases where it was impossible to get any F0 values due to the irregular vibration of the vocal folds.

4.3. Intensity

The question of the role of intensity in the two word groups is treated with slight caution, since intensity is very “sensitive” to many aspects, including segment quality. In the current material, the great majority of words had the vowel [ɤ] in the second syllable and only voiced consonants between two syllable rhymes.

For intensity analysis, first, the mean intensity of S1 and S2 for both word groups was measured. The boxplots for intensity are presented in Figure 3. The mean intensity of S1 for words without *stød* is 76 dB and for words with *stød* 75 dB, while in S2 the values were 73 dB and 72 dB respectively.

Figure 3: Boxplots for intensity values (in dB) in S1 and S2 in words without *stød* and words with *stød* for six speakers.

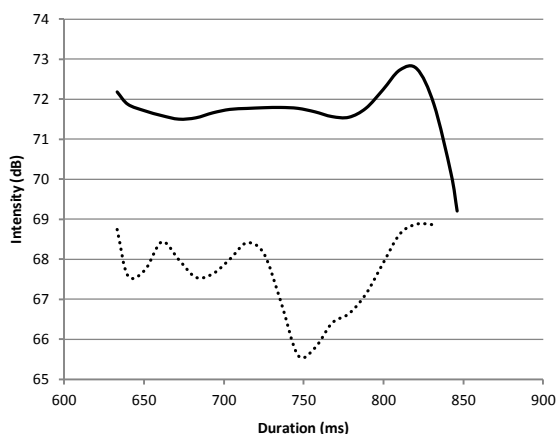


As for the interaction, the intensity of S1 and S2 is significantly different in words with stød and words without stød [$F(1,601) = 34.4, p < 0.001$]. There is no difference between words with stød and words without stød in the mean intensity of the first syllable [$F(1,300) = 0.44, p = 0.5$]. Intensity of the second syllable differed significantly between words with and without stød [$F(1,300) = 5.01, p < 0.01$]. Hence, the interaction between the two syllables is examined a little further.

For each token, the S2 mean intensity in dB was then subtracted from the S1 mean intensity's value to find how much lower or higher the intensity level of the S1 was relative to the S2. These values were then averaged. The mean difference between two syllables was significantly smaller for words without stød and bigger for words with stød [$F(1,300) = 7.81, p < 0.01$]. The results suggest that not only the syllable carrying stød but also the following syllable might cue the difference between the two word groups.

Still, the most characteristic appears to be the irregularity in the intensity contour within the S1 rhyme. In words with stød there is a variation in intensity, while in words without stød the intensity is more stable. Figure 4 illustrates the intensity contours in the S1 rhyme in a word without stød and in a word with stød.

Figure 4: Intensity contours (in dB) in S1 in the word [mø:ðʏ] 'land, PSg' (solid line) and in the word [mø:ʒʏ] 'down, Adv' (dashed line) from one female speaker.



In the case of laryngealization there is always an irregular movement of the intensity contour. More specifically, there is a sudden dip or drop in intensity.

5. CONCLUSIONS

The current study shows that there are acoustic differences in Livonian in words without stød and

words with stød. The temporal characteristics of the first syllable tend to get neutralised in spontaneous speech, but not the following syllable. The longer second syllable keeps the word with and without stød apart. The tonal characteristics vary systematically in words with and without stød. The F0 peak in S1 in words with stød occurs earlier than in words without stød. The role of intensity should not be overlooked. Irregular intensity movement in S1 is the most characteristic aspect of the words with stød. In addition to the intensity in the syllable carrying stød, surrounding segments must be also considered. The S1 intensity in words without stød and with stød is the same, but the difference becomes evident in the interaction of S1 and S2 in the two groups. For further analysis, it would be intriguing to study the quality of segments.

Livonian stød combines temporal, tonal and intensity characteristics that should always be considered together.

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