NON-MODAL PHONATION ASSOCIATED WITH STØD VOWELS IN LIVONIAN

Uldis Balodis
University of Latvia and the Western Institute for Endangered Language Documentation

Abstract. Livonian is unique among the Finnic languages in possessing a two-way tonal contrast in primary stressed syllables. Observed already in the earliest linguistic descriptions of Livonian, this two-way contrast between stressed syllables with stød (also called broken tone) and plain tone closely resembles the tonal system of Latvian with which Livonian has been in close long-term contact. This paper describes a pilot study, which used six measurements of spectral tilt (h1-h2, h1-F1, h1-F2, h1+h2/2-F1, h1-F3, F2-F3) to determine whether Livonian stød was associated with any non-modal phonation, specifically creaky voice. Spectral tilt is the degree to which intensity decreases as frequency increases (Gordon and Ladefoged 2001). Earlier researchers (e.g., Vihman 1971) have noted that stød vowels tend to be laryngealised, therefore, creaky voice is a likely candidate for non-modal phonation associated with stød. The method in this study is based on that used by Esposito (2004) in her similar study of Santa Ana del Valle Zapotec. The study used data from archival recordings of Pētõr Damberg, a speaker of the East Dialect of Courland Livonian from the village of Sīkrõg, and focused on measurement of CVV syllables containing either [ǭ] or [ō] (IPA: [o̞ː] and [oː]).

Keywords: tone, stød, broken tone, phonation, spectral tilt, creaky voice, Livonian language

DOI: https://doi.org/10.12697/jeful.2018.9.2.08

1. Introduction

Tone and pitch accent are known to occur in conjunction with characteristic phonation in many languages elsewhere in the world, far away from the Livonian Coast and the Baltic region. In Tibetan, for example, low-toned vowels are pronounced with a breathy phonation (DeLancey 2003). Elsewhere more complex systems exist, such as that found in Jalapa Mazatec, an Oto-Manguean language spoken in Mexico. In Jalapa Mazatec, words are contrasted not only for tone but also phonation (Gordon 2001).

The Nordic-Baltic region has long been observed as an area rich with languages possessing tonal features. Roman Jakobson (1931) spoke of a Baltic Sprachbund containing the Livonian and Estonian (Finnic), Latvian and Lithuanian (Baltic), North Kashubian (Slavic), and Swedish, Norwegian (except north-western dialects), Danish (most dialects), and northern German (some dialects) (Germanic) languages.

This paper describes a pilot study, which used six measurements of spectral tilt (h1-h2, h1-F1, h1-F2, h1+h2/2-F1, h1-F3, F2-F3) to determine whether Livonian stød was associated with any non-modal phonation, specifically creaky voice. Spectral tilt is the degree to which intensity decreases as frequency increases (Gordon and Ladefoged 2001). Earlier researchers (e.g., Vihman 1971) have noted that stød vowels tend to be laryngealised, therefore, creaky voice is a likely candidate for non-modal phonation associated with stød. This study focused on measurement of CVV syllables with and without stød containing either [ǭ] or [ō] (IPA: [o̜ː] and [oː], respectively).

This paper is divided into four main sections after the introduction. Section 2 focuses on background for the study and includes a description of Livonian, a brief comparison of Danish and Livonian stød, and a description of Livonian stød and the prosodic system as a whole with some information on the historical evolution of the understanding of stød. Section 3 provides information on the materials and methods used in this study and includes a description of the data with a background of Pētõr Damberg, the Livonian speaker whose speech was analysed for this study, the criteria used for token selection, and the methodology applied in this study. Section 4 describes the results of this study. Section 5 summarises the conclusions of this study and proposes directions for future research based on this study.

2. Background

2.1. Description of Livonian

Livonian, a critically endangered Finnic language (Moseley 2010), is spoken today primarily as a second language by Livonian community members as well as linguists. Until the 1860s, Livonian was spoken on both sides of the Gulf of Rīga with a small community of speakers living on the eastern coast of the gulf near the village of Svētciems. However, after that time and until the mid-twentieth century, Livonian was only spoken as a language of daily interaction in a string of villages along the coast of northern Courland in western Latvia. Livonian ceased to be used in daily life when Livonian speakers gradually left the villages of their native coast as a result of coastal and sea access restrictions and militarisation imposed during the Soviet period, which deprived them of their traditional fishing-based livelihood. In the present day, Livonian continues to be learned by descendants and individuals from outside of the community. Language revitalisation efforts are also continuing on an ongoing basis.

As shown in Figure 1, Courland Livonian is divided into two dialects – West and East Livonian – with a transitional form sharing features of both dialects historically spoken in Īra village[1]. Dialect differences are most evident in the vowel inventories of each dialect. West Livonian has 6 short (*a, ä*, *e*, *i*, *o*, *u*) and 6 long (*ā, ǟ*, *ē*, *ī*, *ō*, *ū*) vowels, East Livonian has 8 short (*a, ä*, *e*, *i*, *o*, *ȯ*, *õ*, *u*) and 9 long vowels (*ā, ǟ*, *ē*, *ī*, *ō*, *ǭ*, *ȱ*, *ȭ*, *ū*) with some vowels absent from the inventories of Kūolka (*ǭ* is absent) and Mustānum villages (*ǭ*, *ȯ*, *ȱ* are absent), while the transitional Īra dialect has 8 short (*a, ä*, *e*, *i*, *o*, *ȯ*, *õ*, *u*) and 8 long vowels (*ā, ǟ*, *ē*, *ī*, *ō*, *ȱ*, *ȭ*, *ū*) (Tuisk 2016).

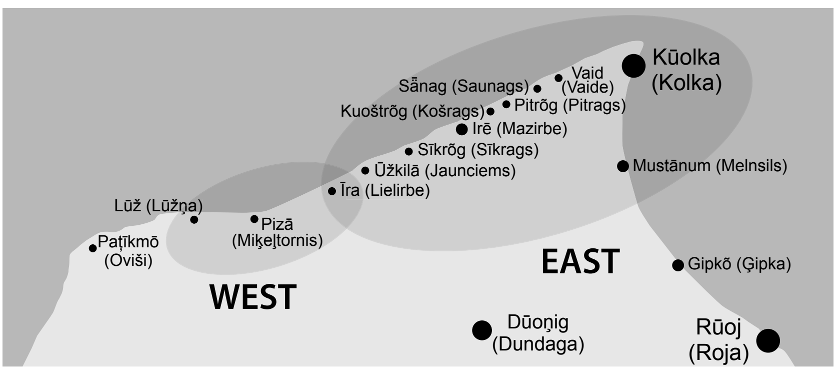

Figure 1. Courland Livonian dialects, also showing the transitional dialect area in Īra village (Latvian place names appear in parentheses following Livonian names).

1 For more on the Livonian dialects and their differences see Tuisk 2016. For more on the transitional form of Livonian spoken in Īra, sometimes called the "Central Dialect", see Viitso 1999.

2.2. Livonian and Danish stød

Livonian stød, also known as *broken tone*, takes its name from the Danish feature which is also called stød. Danish linguist Vilhelm Thomsen (1890) first noted the similarity between this Livonian prosodic feature and Danish stød. Since then *stød* has been one of the terms used to refer to this Livonian prosodic feature. Danish and Livonian stød were compared by Vihman (1971) in her doctoral dissertation.

Danish stød has been extensively studied (e.g., Fischer-Jørgensen 1989, Grønnum & Basbøll 2007, Grønnum et al 2013, Hansen 2015). Grønnum et al. 2013 tested two hypotheses regarding the nature of Danish stød: (1) that stød is an "autonomous laryngeal syllable prosody" or (2) it is the result of a HL tonal pattern being compressed into a single syllable. The authors found that while stød patterns were similar regardless of the regional variety of Danish being examined, tonal patterns were highly variable and stød could occur with any kind of tonal configuration. Similarly, Grønnum (2014) found that laryngealisation appears to be the characteristic perceptual cue for Danish stød, while pitch variations were not always present. She writes: "Laryngealization is the articulatory, acoustic, and perceptual constant in stød production, F0 perturbation is not."

This is the opposite situation from Livonian stød (Tuisk 2016). A unique tonal contour (rising-falling or sometimes falling across the entire stød syllable) and laryngealisation are both features of Livonian stød, but for Livonian stød the characteristic pitch contour is among the most reliable perceptual cues, while laryngealisation is not always present. Danish stød (e.g., Fischer-Jørgensen 1989) and Livonian stød (e.g., Tuisk 2016) do, however, share a characteristic variation in intensity.

2.3. The Livonian Prosodic System and the Characteristics of Stød

Prosodic phenomena relating to stød have been noted already since the very first extensive modern documentation of Livonian conducted by Johann Anders Sjögren and Ferdinand Wiedemann and described in *Joh. Andreas Sjögren's Livische Grammatik nebst Sprachproben* (Joh. Andreas Sjögren's Livonian Grammar with language samples). As Viitso (2008a) observes, Wiedemann noted a perceived difference in vowel length and the length of geminate consonants in certain minimal or near-minimal pairs of words. The following is my translation of the original German[2]. I have updated the orthography to that used for modern Livonian and italicised the Livonian words:

> With respect to vowel length, the Livonians also distinguish two different degrees. They distinguish, for example *pīlõb* (from *pīl*) and *pīņ* with a greater length for i from *pīlõb* (from *pill*) and *pīn*. Something quite similar to this is also seen in liquids, where a continuous pronunciation, that is, a lingering of the voice not on the vowel of the syllable but instead on the consonant itself, is especially evident in a great and audible length difference, for example, in *buļļõ* (from *buļļ*, pl. *būlid*) one lingers longer on the ļ than in *buļļõ* (from *buļ*, pl. *bulīd*) … (Wiedemann 1861: 11)

As noted by Viitso (2008a), the difference in vowel length and “lingering” on the geminate liquid at the syllable boundary noted by Wiedemann coincide perfectly with the presence and absence of stød. Thus, in the first two example pairs, *pīlõb* ‘s/he wastes, discards’ and *pīņ* ‘misery, agony’ do not have stød, while *pī’lõb* ‘s/he stands’ and *pī’n* ‘braid’ do have stød. Likewise, the first example *buļļõ* ‘bull (part.sg.)’ does not have stød, while the second example *bu’ļļõ* ‘water bubble (part.sg.)’ does have stød.

The first mention of Livonian stød as a unique prosodic feature came approximately thirty years later (Thomsen 1890), when Vilhelm Thomsen, a Danish-speaking linguist, encountered a Livonian-speaking fisherman in Copenhagen and immediately noticed a prosodic feature in the man’s speech very similar to the stød feature found in Danish (Kiparsky 2006).

Kettunen (1938) conducted acoustic phonetic studies and described stød in terms of the Latvian tone system with three tones: *stossintonation* ‘push intonation’ or *bruchintonation* ‘break intonation’ referring to stød, *gedehnte intonation* ‘stretched intonation,’ *fallende intonation* ‘falling intonation.’ Posti (1942) used a similar approach and terms categorising Livonian tones as *Stossintonation*, which is stød, *fallende intonation* which is the falling intonation, and *steigende intonation*, or

2 The original text reads: “In der Dehnung der Vocale unterscheiden die Liven noch zwei Stufen. Sie unterscheiden z.B. pīlọ̤b (von pīl) und pīń durch grössere Länge des i von pīlọ̤b (von pill) und pīn. Etwas diesem ganz Aehnliches ist noch, dass sie auch in den Liquiden, welche einer continuirlichen Aussprache, d.h. eines Verweilens der Stimme nicht auf dem Vocal der Sylbe sondern auf diesem Consonanten selbst, besonders fähig sind, eine grössere und geringere Länge unterscheiden, z.B. bei bul´l´ọ̤ (von bul´l´ pl. būlid) länger auf dem l´ verweilen als bei bul´l´ọ̤ (von bul´ pl. bulīd) …”

rising intonation, instead of Kettunen's *gedehnte intonation*. Significant work on the acoustic properties of stød was conducted several decades later by Vihman (1971) for her doctoral dissertation.

As noted by Tuisk (2012), the Livonian prosodic system combines features of both the Latvian and Estonian systems. Thus, the Livonian tonal system is similar to that of Latvian (see Kariņš 1996, Markus & Bond 2010 for a description of the Latvian tonal system), while the Livonian quantity system is similar to that of Estonian.

Livonian contrasts length for vowels and consonants, and has diphthongs, triphthongs as well as a long and short forms of some diphthongs and triphthongs. Primary stress[3] is fixed on the initial syllable. As noted by Tuisk (2016), stød can only occur if there is a minimum amount of voiced material in the syllable rhyme. This unit, called the *stød basis*, consists of a primary-stressed syllable containing a long vowel, diphthong, or triphthong, or a primary-stressed syllable with a short vowel preceding a voiced geminate or consonant cluster. A non-contrastive stød-like pitch contour can also occur on half-long vowels in even-numbered syllables in Eastern Livonian. (Kettunen 1925, Posti 1942)

While Livonian is the only Finnic language to contrast stressed stem-initial syllables for tone (Tuisk 2016), stød has been found in or conjectured to have existed in several other Finnic languages, which have been in long-standing contact with Latvian[4]. These include Salaca Livonian (Winkler 1999, Winkler 2010), Krevin Votic (Winkler 1997), Leivu South Estonian (Teras 2010), and Lutsi South Estonian (Balodis et al. 2016).

While stød is not distinguished in the Livonian orthography, it is marked[5] in Livonian linguistic texts with an apostrophe following a short or long vowel or before the next to last vowel in polyphthongs in stød syllables (e.g., *mȭ* 'earth' : *mȭ'* 'downward', *lēḑ* 'sphere' : *lē'ḑ* 'leaf', *kallõ* 'island' (part.sg.) : *ka'llõ* 'fish' (part. sg.), *kuonnõ* 'frog' (part.sg.) : *ku'onnõ* 'at home', *jūodõ* 'to drink' : *jū'odõ* 'to lead').

3 For a discussion of Livonian secondary stress, see Tuisk 2015a.

4 The influence between Latvian and Livonian, of course, runs both ways, as Viitso (2008c: 233) notes: "mõtlõmõst, ku pāina um leţkīel sõņši ežmiz zilb pǟl sīepierāst, ku sǟl se um vȯnd jõvā vāldamiersūomõ ja germān kēļši." (my English translation: it can be conjectured that stress in Latvian is on the first syllable, because that's where it also has been in the Finnic and Germanic languages)

5 The minimal pair examples are taken from Kiparsky 2006.

Syllables with stød or broken tone have a rising-falling or falling tonal contour and these contrast with syllables with plain tone, which are either level or rising (Tuisk 2015b). Stød is characterised by more than just one feature and not all of these features always occur for every stød syllable; however, the most stable and characteristic features of stød are, according to Tuisk (2016), “an early location for the F0 turning point and intensity turning point within the stressed syllable along with the characteristic shape of the pitch and intensity contours”. Also, as noted by Lehiste et al (2008), stød may be disappearing as its characteristic features are less evident in younger Livonian speakers.

Still, it is important to note the richness of acoustic properties associated with stød. Characteristics of stød syllables (as noted by Vihman 1971, Suhonen 1982, Pajupuu and Viitso 1986, Wiik 1989, Kiparsky 2006, Viitso 2008b, Lehiste et al 2008, Teras and Tuisk 2009, Tuisk 2015a, Tuisk 2015b, Tuisk 2016) can generally be described as:

(1) a rising-falling or predominantly falling pitch contour
(2) an early pitch peak or falling pitch across the entire stød syllable
(3) some variation in intensity
(4) possible difference in rhyme duration compared to plain-toned syllables
(5) the presence of laryngealisation

During the last decade, studies have significantly expanded into comparing the acoustic properties of stød in read and spontaneous speech (e.g., Teras and Tuisk 2009, Tuisk 2015b, Tuisk 2016). Tuisk (2016) notes that the characteristic patterns of stød, such as those noted above, are more typical for stød syllables in read rather than spontaneous speech. Still, stød syllables show unique properties also in spontaneous speech. Table 1 compares the properties of stød in read and spontaneous speech. Tuisk (2016) notes that there may be a difference between first and second syllable duration between words with an initial syllable either with or without stød, and this information is also included in the table below.

Table 1. A comparison of the acoustic properties of stød in read and spontaneous speech.

Acoustic Property	Read Speech	Spontaneous Speech
Pitch	Pitch peak occurs earlier in stød syllables than in syllables with plain tone (Tuisk 2016).	Pitch peak occurs earlier in stød syllables than in syllables with plain tone (Tuisk 2016).
Larynge-alisation	More likely to occur in read speech (Tuisk 2016). Occurs 87% of the time (Teras and Tuisk 2009).	Less likely to occur or be weaker in spontaneous speech (Tuisk 2016). Occurs 34% of the time, rhyme is longer when laryngealisation is present. (Tuisk 2015b).
Duration	S1: Shorter duration for stød syllables (Teras and Tuisk 2009). S2: Duration the same in syllables with plain and broken tone (Tuisk 2016).	S1: Duration differences between stød- and plain-toned syllables neutralised (Tuisk 2016). S2: Significant decrease in duration in words with stød compared to those with plain tone (Tuisk 2016).
Intensity	Earlier intensity turning point in stød syllables than in plain-toned syllables (Teras & Tuisk 2009).	Irregular intensity movement in stød syllables, more stable intensity in plain-toned syllables (Tuisk 2015b).

3. Materials and Methods

3.1. Description of Data and Background of Consultant

The data used for this study were taken from a series of recordings[6] (total length: 3h 47m 15s) of Livonian speaker Pētõr Damberg (1909–1987) made by University of Tartu linguist Tiit-Rein Viitso[7] in Tartu

6 The specific recordings used are indexed as SUHK0445-01, SUHK0445-02, SUHK0500-01, SUHK0503-01, SUHK0504-01, SUHK0505-01. My deepest thanks and appreciation to archive director Tuuli Tuisk for making these recordings available to me for use in this study and also for sharing the Praat text grids she had prepared for a different study of her own, which helped me find some of the words used in this study.

7 See the article by Pajusalu and Tuisk on Tiit-Rein Viitso's lifelong work on Livonian in this volume.

in 1986. The recordings are housed at the University of Tartu Archives of Estonian Dialects and Kindred Languages. The Livonian speech in these recordings is largely monologic, with Viitso making only brief and infrequent comments to the speaker, though some portions also involve repetition by Damberg of particular Livonian words and phrases. For this study, I only used the portions which contained natural speech and in these Damberg is generally telling stories and recounting memories of various aspects of life in the Livonian-speaking villages of northern Courland.

Pētõr Damberg, a native speaker of the East Dialect of Courland Livonian, was born at Kielk (Latvian: *Keļķi*) homestead in the Livonian-speaking village of Sīkrõg (Latvian: *Sīkrags*) located near the centre of the string of historically Livonian-speaking villages along the north-western coast of Latvia (See Figure 1 for a map of the Livonian villages and dialects).

Damberg was an excellent and insightful speaker of Livonian, but also exceptional among his generation of Livonian speakers due to the work he did relating to Livonian. He wrote and translated poetry and other literature into Livonian, he collected Livonian folklore, and continued to work on developing the Livonian written language. Prior to World War II, he was one of the Livonian young people who attended university in order to return and teach Livonian in the coast villages (Damberg attended the Jelgava Teachers' Institute). During that time, he helped with the establishment of the Livonian-language newspaper "Līvli" (The Livonian), he compiled the first Livonian school reader *Jemakīel lugdõbrāntõz skūol ja kuod pierast* (Mother tongue reader for school and home), and sang in the Livonian folk ensemble "Līvlist" (The Livonians).

During the late 1930s, while he worked as the school principal in Pizā (Latvian: *Miķeļtornis*), he worked with students to create an album containing photographs and drawings of Livonian daily life, which was only discovered approximately 70 years later and published in 2007. Following World War II, he ultimately settled in the town of Ādaži located approximately 25 km east of Rīga. Damberg continued to work as a consultant for many linguists and compiled Livonian dictionaries including (along with Hilda Grīva and Ints Čače) a Livonian-Latvian-Esperanto conversational dictionary as well as a second, as of yet unpublished, Livonian reader. Some of Damberg's poetry can be found in the 1998 Livonian-Latvian poetry anthology *Ma akūb sīnda vizzõ, tūrska!* (I'm craftier than you are cod!) (Karma 1994:128, Damberg 1978, Ernštreit 1998:129, Ernštreits 2013)

3.2. Criteria for Selection of Tokens for Phonation Study

A total of 52 tokens (26 with stød, 26 without stød) were selected for this study based on their suitability for comparison between CVV syllables with and without stød. As some of the spectral tilt calculations involved measurements of F1 and F2, the tokens also had to be limited depending on the vowel forming the nucleus of each syllable. I chose to focus on CVV syllables containing the mid-high rounded back vowel [ō] (IPA: [oː]; e.g., in *lōda* 'table') and the low rounded back vowel [ǭ] (IPA: [o̞ː]; e.g., in *mǭ* 'earth, land'). As noted by Tuisk (2016), these vowels are distinct in East Courland Livonian (with the exception of that spoken in Kūolka and Mustānum) and, therefore, would also have been distinct in the Sīkrõg speech of Pētõr Damberg. However, these vowels are phonetically close and so in order to increase the number of tokens that could be used in the study, tokens with either vowel were included.

While in an earlier phase of the study, an attempt was made to also control for position within an intonation unit (IU), ultimately, as a restriction had already been placed on the particular vowels in the first syllable of each token, a further restriction on IU position made it too difficult to find sufficient tokens with stød. Thus, position within an IU was not taken taken into account in this study.

3.3. Methodology

This study was based on the study of phonation associated with tone for Santa Ana del Valle Zapotec (SADVZ) conducted by Esposito (2004). In her study, Esposito uses six measurements of spectral tilt in order to determine whether vowels differing in tone in SADVZ also differ in phonation type. Spectral tilt measures the degree to which intensity decreases as frequency increases and has been a reliable method for measurement of phonation in a number of languages including Jalapa Mazatec, !Xóõ, Gujarati, and Tsonga (Gordon and Ladefoged 2001).

Of course, not all measurements of spectral tilt are equally effective for all languages. For Livonian a reliable measure of spectral tilt would be expected to consistently give a lower value for creaky vowels than for modal vowels (Esposito 2004). In other words, if vowels in stød syllables are pronounced with creaky voice, but vowels in syllables without stød are not, then vowels in stød syllables should consistently show a lower value for a reliable measure of spectral tilt than vowels in syllables without stød. A non-reliable measure for such phonation would not show this correlation between relative spectral tilt value and the presence or absence of stød in a syllable.

For this study I tested the tokens in the data sample using the same six spectral tilt measures used by Esposito (2004) in her study of SADVZ; these are: h1-h2, h1-F1, h1-F2, h1+h2/2-F1, h1-F3, F2-F3. As this is a pilot study, the main reason for choosing these six methods for calculating spectral tilt was that they constituted a fairly large array of possible ways to accurately arrive at a result for Livonian that would show characteristic phonation associated with stød (presumably creaky voice).

Tokens were analysed and measured using the Praat acoustic phonetics program (Boersma & Weenink 2018). The boundaries of a vowel were determined by analysing boundaries observable in spectrograms. Measurements were taken at the beginning, middle, and end of the first syllable vowel in each token. In order to compare sections of like size in a similar relative position within the vowel across all tokens, a 60 ms slice was taken 10 ms from the beginning and end of the vowel. The midpoint of the vowel was calculated manually by dividing the duration in half and adding it to the start time of the vowel. The 60 ms slices taken from the middle of the vowel extended for 30 ms to each side from the midpoint of the vowel. Of the syllables selected for use in this study, the mean duration of the vowels in stød syllables was 267 ms and that of vowels in non-stød syllables was 287 ms.

A Fast Fourier Transform (FFT) or spectral slice was calculated using Praat and then I manually measured h1, h2, F1, F2, and F3 on the resulting image in Praat. Figure 2 shows how h1, h2, F1, F2, and F3 appear in an example spectral slice taken from 60 ms in the middle of the first-syllable vowel in *mǭ'zõ* ‘downward’. After that I performed each of the above calculations for each of the three positions within each vowel and then, adding up the number of positive, negative, and zero results I had for each calculation at each position, determined whether any of these calculations showed the expected pattern for creaky voice, i.e., negative values for stød syllables, but positive values for non-stød syllables.

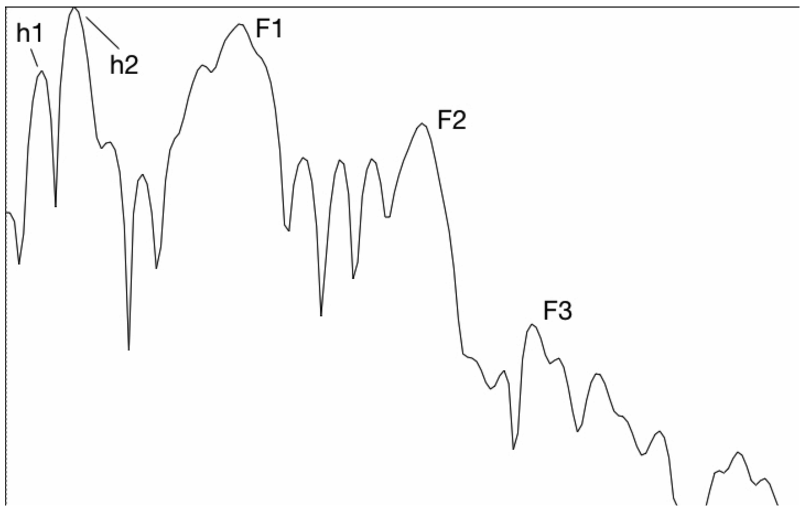

Figure 2. Example of the identification of h1, h2, F1, F2, F3 in a spectral slice taken from the middle 60 ms of the first-syllable vowel in *mǭ'zõ* 'downward'.

This method is similar to that used by Esposito in her original study, but not identical, as she had access to speakers of SADVZ and could elicit minimal triplets for which tone was a contrasting feature. As this study utilises existing spontaneous speech data, pair-wise comparison for phonation between stød/non-stød minimal pairs was not possible

4. Results

According to Esposito's study (2004), for creaky voice one would expect negative values for vowels with creaky phonation and positive values for modal vowels. Only one of the six calculations appeared to show this expected result, but even then that result was not entirely conclusive. For h1-h2, while non-stød syllables were generally positive, suggesting they had modal phonation, stød syllables tended to be negative, which corresponds to the expectation that vowels in stød syllables are creaky due to the laryngealisation characteristic of stød. This negative value occurred most often for vowels in stød syllables measured at their midpoint and end.

Likewise, the fact that the h1-h2 test showed positive values earlier in the vowel, but was more likely to show negative values later on in the vowel, also possibly points to an increasing creakiness over the course of the stød vowel. However, the correlation was not absolute, as there were also a number of cases where this test failed to show creaky voice in vowels in stød syllables. This might be explained by the fact that, as noted in earlier studies (Teras & Tuisk 2009, Tuisk 2015b, 2016), laryngealisation does not always occur in vowels in stød syllables and it is also less commonly found (34% vs. 87%, respectively, as shown in Table 1) in spontaneous rather than read speech. So, it actually is not surprising that creaky voice does not appear to always occur in stød syllables.

The other five calculations (h1-F1, h1-F2, h1+h2/2-F1, h1-F3, F2-F3) yielded similar results for vowels in both stød and non-stød syllables, which suggests that these do not correlate with creaky phonation for Livonian.

Figures 3–8 show the mean values with standard error for each calculation at the start, middle, and end of the vowel in each syllable where measurements of h1, h2, F1, F2, F3 were taken. Tables 2–7 show the number of times a positive or negative result was obtained for each calculation at each measurement spot across the entire data set (zero results are not included).

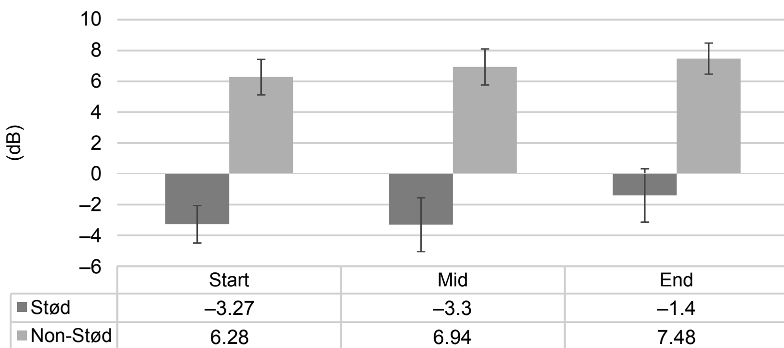

Figure 3. Mean values for h1-h2 with standard error.

Table 2. Number of instances of positive/negative results for h1-h2 (zero values eliminated).

h1-h2	**Stød**		**Non-stød**	
	positive	*negative*	*positive*	*negative*
start	10	16	24	2
mid	6	19	22	4
end	8	18	24	2

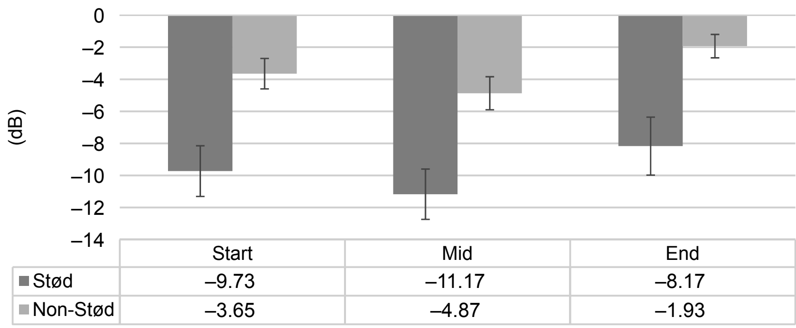

Figure 4. Mean values for h1-F1 with standard error.

Table 3. Number of instances of positive/negative results for h1-F1 (zero values eliminated).

h1-F1	Stød		Non-stød	
	positive	*negative*	*positive*	*negative*
start	10	16	7	19
mid	6	20	4	21
end	6	19	7	18

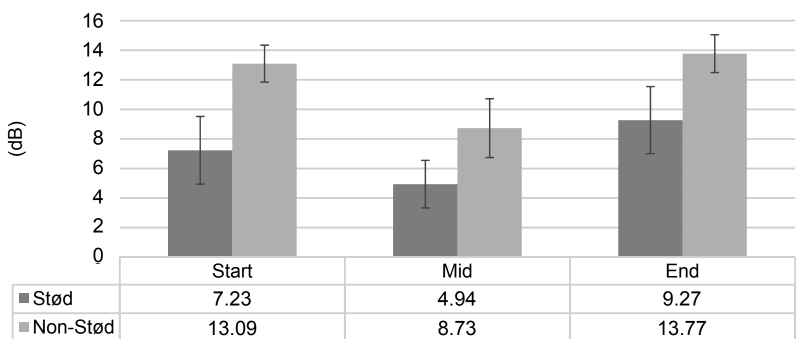

Figure 5. Mean values for h1-F2 with standard error.

Table 4. Number of instances of positive/negative results for h1-F2 (zero values eliminated).

h1-F2	Stød		Non-stød	
	positive	*negative*	*positive*	*negative*
start	17	9	26	0
mid	19	7	23	2
end	18	8	26	0

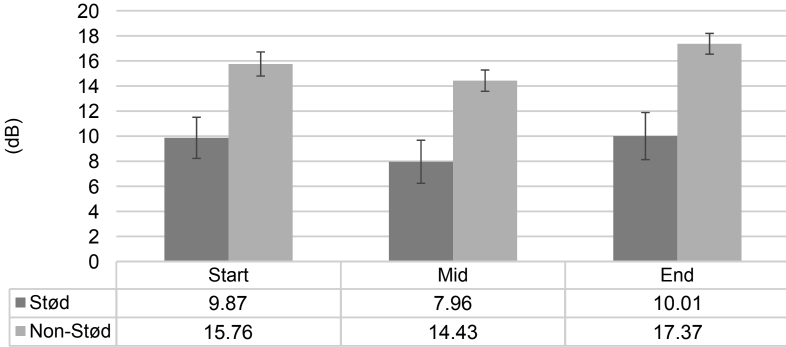

Figure 6. Mean values for h1+h2/2-F1 with standard error.

Table 5. Number of instances of positive/negative results for h1+h2/2-F1 (zero values eliminated).

h1+h2/2-F1	**Stød**		**Non-stød**	
	positive	*negative*	*positive*	*negative*
start	21	5	26	0
mid	22	3	26	0
end	21	5	26	0

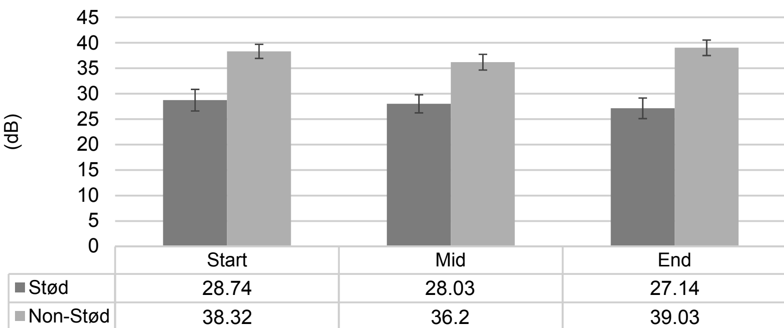

Figure 7. Mean values for h1-F3 with standard error.

Table 6. Number of instances of positive/negative results for h1-F3 (zero values eliminated).

h1-F3	**Stød**		**Non-stød**	
	positive	*negative*	*positive*	*negative*
start	26	0	26	0
mid	26	0	26	0
end	26	0	26	0

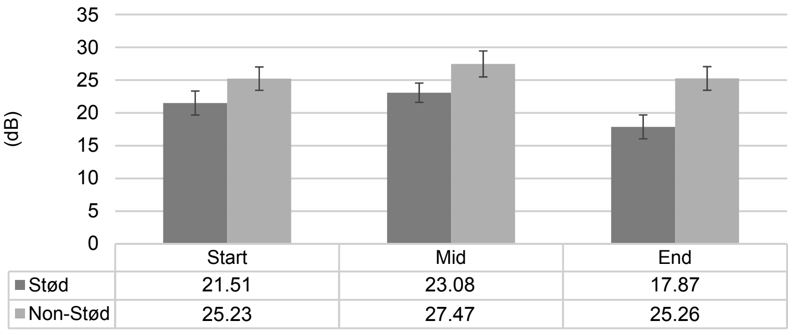

Figure 8. Mean values for F2-F3 with standard error.

Table 7. Number of instances of positive/negative results for F2-F3 (zero values eliminated).

F2-F3	Stød		Non-stød	
	positive	*negative*	*positive*	*negative*
start	25	1	26	0
mid	26	0	25	1
end	25	1	26	0

In order to test for statistical significance, a Fisher exact test, which was available online (GraphPad 2018), was used to calculate p-values for the number of positive and negative results for each calculation occurring for vowels in stød and non-stød syllables (i.e., the numerical values shown in Tables 2–7 above). The Fisher exact test was used instead of a usual chi-square test, due to the presence of zero values for some of the results. For each calculation, separate tests were run for the results at each position where measurements were taken (i.e., a separate test was run for each of the start, mid, end rows in each table).

For the h1-h2 calculation, the p-value was less than 0.0001 at the start, mid, and end points of the calculation and so the association between the occurrence of stød and the negative values for h1-h2 can be considered extremely statistically significant.

Nearly all of the other calculations were found to not be statistically significant. The p-values for h1-F1 were 0.5551 (start), 0.7265 (mid), 1.0000 (end). The p-values for h1+h2/2-F1 were 0.0506 (start), 0.1104 (mid), 0.0506 (end). The p-values for h1-F3 were 1.0000 (start), 1.0000 (mid), 1.0000 (end). The p-values for F2-F3 were 1.0000 (start), 1.0000 (mid), 1.0000 (end).

For h1-F2, however, the calculation at the start and end of the vowel was found to be very statistically significant with p-values of 0.0017 (start) and 0.0042 (end), which are still of lesser statistical significance than those found for the results of h1-h2. The calculation at the midpoint of the vowel was not found to be statistically significant with a p-value of 0.1400 (mid).

5. Conclusion

This paper describes a pilot study, which used six measurements of spectral tilt (h1-h2, h1-F1, h1-F2, h1+h2/2-F1, h1-F3, F2-F3) to determine whether Livonian stød was associated with any non-modal phonation, specifically creaky voice. Spectral tilt is the degree to which intensity decreases as frequency increases (Gordon and Ladefoged 2001). Earlier researchers (e.g., Vihman 1971) have noted that stød vowels tend to be laryngealised, therefore, creaky voice is a likely candidate for non-modal phonation associated with stød. The method in this study is based on that used by Esposito (2004) in her similar study of Santa Ana del Valle Zapotec. The study used data from archival recordings of Pētõr Damberg, a speaker of the East Dialect of Courland Livonian from the village of Sīkrõg, and focused on measurement of CVV syllables containing either [ǭ] or [ō] (IPA: [o̞ː] and [oː], respectively). A total of 52 tokens were examined (26 with stød, 26 without stød). A Fast Fourier Transform (FFT) or spectral slice was calculated using Praat for sections 60 ms in length at the start, middle, and end of each vowel. h1, h2, F1, F2, and F3 were measured manually on the resulting image in Praat and then the six aforementioned calculations were performed. The total number of negative and positive results for the calculations were tallied and are given in Tables 2–7. A Fisher exact test was performed for each of these results in order to test for statistical significance.

Taking into account all the obtained results in this study, it can be said that (1) h1-h2 can be used to test for creaky voice in Livonian, as it appears to correlate with the expected result (i.e., negative values for creaky voice, positive values for modal voice) and (2) that the p-values obtained for the h1-h2 results indicate that this distribution of negative vs. positive values is extremely statistically significant. The fact that h1-h2 appeared to show that, as would be expected, creaky voice never occurs with vowels in non-stød syllables, but only showed creaky voice occurring in about 2/3 to 3/4 of the vowels in stød syllables (as shown in Table 2) can be explained by the fact that while laryngealisation is a recognised characteristic of vowels with stød, it does not occur in all vowels in stød syllables and occurs less frequently in spontaneous than read speech.

This study charts the course for many future lines of inquiry. First, and perhaps most obviously, it should be expanded to a larger data set, which also incorporates all of the other types of syllables that have stød: short vowels in closed syllables, short and long polyphthongs in open syllables. Additionally, since Tuisk (2016) has observed that duration of not only the first, but also the second, syllable can be affected by the presence of stød, a future more extensive study should examine whether creaky voice is in any way affected by the length of the word in which it occurs (e.g., is creaky voice more prevalent in a word with a fewer rather than greater number of syllables). Also, a much larger study would make it possible to control for IU position, which could then show whether this has any effect on the prevalence of creaky voice in Livonian stød syllables. Likewise, a future study could incorporate read speech data and contrast it with spontaneous speech, in order to determine whether creaky voice is more prevalent in one or the other type of speech (presumably it would be more prevalent in read speech, as laryngealisation is more prevalent in read speech). Additionally, as Lehiste et al. (2008) note that stød seems to be less prevalent among younger speakers of Livonian, it would be valuable to compare the prevalence of creaky voice in the language of younger and older speakers (in practical terms, living speakers vs. recorded data from speakers who were born much longer ago).

Esposito (2004) found in her study that different spectral tilt calculations (i.e., those used in her study and also in this one) gave different results for male and female speakers, that is, some calculations were better at identifying a particular phonation type in female rather than male speakers, and vice versa. Thus, an expanded version of this study should use not only data from additional speakers, but also examine data from both male and female speakers to see whether any such differences also exist for Livonian.

Beyond this, there are several other interesting avenues of inquiry that could be pursued. Posti (1942) notes that some second-syllable half-long vowels show a stød-like pitch contour. Vowels identified as having this stød-like quality could also be measured in the manner done in this study to check for the presence of creaky voice. Likewise, it would be interesting to expand this study to data from Lutsi and Leivu South Estonian, both of which also have stød, though not to the same extent as Livonian. The smaller amount of available recordings and the lower prevalence of stød in these languages makes it a more difficult phenomenon to study and quantify, but it is worth investigating nevertheless, in order to better understand the features that stød has in the languages of Latvia where it is known to exist and for which there are recordings (i.e., Livonian, Latvian, Leivu, Lutsi).

This study, in addition to showing one way of identifying creaky voice in Livonian stød syllables, also opens the way for a number of interesting future studies yet to be conducted – not only in Livonian, but also in other languages spoken in Latvia.

Acknowledgements

This study was supported by the Latvian Ministry of Education and Science State research programme "Latvian language" (VPP-IZM-2018/2-0002). I would also like to sincerely thank Prof. Matt Gordon (University of California, Santa Barbara) for providing the guidance and advice in the original study on which this article is based and Prof. Karl Pajusalu (University of Tartu) for his support and encouraging me to revise and publish my original study. I would like to especially thank Dr. Tuuli Tuisk (University of Tartu) for her guidance, insightful comments, and advice on how to approach my study based on the most recent understanding of stød – without her insight, this study would not have been possible. I would also like to thank Dr. Valts Ernštreits (University of Latvia) for his help in understanding certain Livonian lexical items and Dr. Pärtel Lippus (University of Tartu) for his help and advice regarding the statistical analysis in this article. I would also like to thank the anonymous reviewer whose comments were very helpful and valuable.

Addresses:

Uldis Balodis
Livonian Institute
University of Latvia
Kronvalda Blvd 4-220, Riga
LV-1010, Latvia
E-mail: ubalodis@lu.lv
Western Institute for Endangered Language Documentation
7414 Magnolia Ave., #3
Riverside, CA 92504, USA
E-mail: ubalodis@wieldoc.org

References

Balodis, Uldis, Karl Pajusalu, and Pire Teras (2016) "Broken tone in South Estonian dialects in Latvia". *Linguistica Lettica* 24, 98–114.

Boersma, Paul and David Weenink (2018) *Praat: doing phonetics by computer* [Computer program]. Version 6.0.43. Available online at <http://www.praat.org/>. Accessed on 08.09.2018.

Damberg, Pētõr (1978) "Liivi keelekorraldusest". *Emakeele Seltsi aastaraamat* 23, 71–81.

DeLancey, Scott (2003) "Lhasa Tibetan". In Graham Thurgood and Randy J. LaPolla, eds. *The Sino-Tibetan languages*, 270–286. London and New York: Routledge.

Ernštreit, Valt, ed. (1998) *Līvõ lūolkub: Ma akūb sīnda vizzõ, tūrska! Lībiešu dzejas izlase: Es viltīgāks par tevi, menca!* Rīga: Līvõ Kultūr sidām.

Ernštreits, Valts (2013) "Lībiešu Literatūra". In Renāte Blumberga, Tapio Mekeleinens, and Karls Pajusalu, eds. *Lībieši: Vēsture, valoda un kultūra*, 417–431. Rīga: Līvõ Kultūr sidām.

Esposito, Christina M. (2004) "Santa Ana del Valle Zapotec phonation". *UCLA Working Papers in Phonetics* 103, 71–105.

Fischer-Jørgensen, Eli (1989) *A phonetic study of the stød in standard Danish*. Turku: University of Turku.

Gordon, Matthew (2001) "Linguistic aspects of voice quality with special reference to Athabaskan". *Proceedings of the 2001 Athabaskan Languages Conference*, 163–178.

Gordon, Matthew and Peter Ladefoged (2001) "Phonation types: a cross-linguistic overview". *Journal of Phonetics* 29, 383–406.

GraphPad (2018) *QuickCalcs: Analyze a 2x2 contingency table.* Available online at <https://www.graphpad.com/quickcalcs/contingency1.cfm>. Accessed 06.11.2018.

Grønnum, Nina (2014) "Laryngealization or pitch accent – the case of Danish stød". In Nick Campbell, Dafydd Gibbon, and Daniel Hirst, eds. *Speech Prosody 7 – Proceedings of the 7th international conference on Speech Prosody: Social and Linguistic Speech Prosody,* 804–808. Dublin.

Grønnum, Nina and Hans Basbøll (2007) "Danish stød: phonological and cognitive issues". In Maria-Josep Solé, Patrice Speeter Beddor, Manjari Ohala, eds. *Experimental Approaches to Phonology*, 192–206. Oxford University Press.

Grønnum, Nina, Miguel Vazquez-Larruscaín, and Hans Basbøll (2013) "Danish stød: laryngealization or tone". *Phonetica* 70, 66–92.

Hansen, Gert Foget (2015) *Stød og stemmekvalitet. En akustik-fonetisk undersøgelse af ændringer i stemmekvaliteten i forbindelse med stød*. Ph.d.-afhandling. Det Humanistiske Fakultet, Københavns Universitet.

Jakobson, Roman (1931) "Über die phonologischen Sprachbünde". *Travaux du Cercle linguistique de Prague* 4, 164–183.

Kariņš, Krišjānis (1996) *The prosodic structure of Latvian*. Unpublished Ph.D. Dissertation. University of Pennsylvania.

Karma, Tõnu (1994) “Lībiešu kultūras darbinieki savai jūrmalai un Latvijai”. In Kersti Boiko, ed. *Lībieši*. Rīga: Zinātne.

Kettunen, Lauri (1925) *Untersuchung über die livische Sprache, Phonetische Einführung, Sprachproben*. Tartu: E. K. Ü. “Postimehe” trükk.

Kettunen, Lauri (1938) *Livisches Wörterbuch mit grammatischer Einleitung*. Helsinki: Suomalais-Ugrilainen Seura.

Kiparsky, Paul (2006) *Livonian stød*. Unpublished manuscript. Stanford University.

Lehiste, Ilse, Pire Teras, Valts Ernštreits, Pärtel Lippus, Karl Pajusalu, Tuuli Tuisk, and Tiit-Rein Viitso (2008) *Livonian prosody*. Helsinki: Suomalais-ugrilainen Seura.

Markus, Dace and Zinny Bond (2010) “Continuing research on Latvian syllable intonations”. *Žmogus ir žodis. Mokslo darbai* 12,1, 52–61. Vilnius: Vilniaus pedagoginis universitetas.

Moseley, Christopher, ed. (2010) *Atlas of the world's language in danger.* 3rd ed. Paris: UNESCO Publishing. Available online at: <http://www.unesco.org/culture/en/endangeredlanguages/atlas>. Accessed 30.07.2018.

Pajupuu, Hille and Tiit-Rein Viitso (1986) “Livonian polyphthongs”. In Arvo Eek, ed. *Estonian papers in phonetics 1984–1985*, 96–130. Tallinn.

Posti, Lauri (1942) *Grundzüge der livischen Lautgeschichte*. Helsinki: Suomalais-ugrilainen seura.

Suhonen, Seppo (1982) “Über die Quantität der livischen Vokale”. In A. Iivonen, S. Suhonen, P. Virtaranta, eds. *Voces amicorum Sovijärvi. In Honorem Antti Sovijärvi septuagesimum annum agentis die XXII mensis aprilis anno MCMLXXXII*, 295–306. (Mémoires de la Société Finno-Ougrienne, 181.) Helsinki.

Teras, Pire (2010) “Quantity in Leivu”. *Linguistica Uralica* 46, 1, 1–16.

Teras, Pire and Tuuli Tuisk (2009) “The characteristics of stød in Livonian”. In Martti Vainio, Reijo Aulanko, Olli Aaltonen, eds. *Nordic Prosody: Proceedings of the Xth Conference, Helsinki 2008.* Vol. 10, 217–226.

Thomsen, Vilhelm (1890) *Berøringer mellem de finske og de baltiske (litauisk-lettiske) Sprog, En sproghistorisk Undersøgelse*. Copenhagen: Bianco Lunos Kgl. Hof-Bogtrykkeri (F. Dreyer).

Tuisk, Tuuli (2012) “Tonal and Temporal characteristics of disyllabic words in spontaneous Livonian”. *Linguistica Uralica* 48, 1, 1–11.

Tuisk, Tuuli (2015a) “The temporal structure of livonian tri-, tetra- and pentasyllabic words”. *Linguistica Uralica* 51, 3, 177–195.

Tuisk, Tuuli (2015b) “Acoustics of stød in Livonian”. In *Proceedings of the 18th International Congress of Phonetic Sciences,* 356, 1–5. Glasgow: University of Glasgow. Available online at <http://www.icphs2015.info/pdfs/Papers/ICPHS0356.pdf>. Accessed 08.09.2018.

Tuisk, Tuuli (2016) “Main features of the Livonian sound system and pronunciation”. *Journal of Estonian and Finno-Ugric Linguistics* (*ESUKA – JEFUL*) 7, 1, 121–143.

Vihman, Marilyn (1971) *Livonian phonology, with and appendix on stød in Danish and Livonian*. Unpublished Ph.D. Dissertation. University of California, Berkeley.

Viitso, Tiit-Rein (1986) Field recordings of Livonian speaker Pētõr Damberg. Referenced as SUHK0445-01, SUHK0445-02, SUHK0500-01, SUHK0503-01,

SUHK0504-01, SUHK0505-01 at the Archives of Estonian Dialects and Kindred Languages at the University of Tartu. Available online at <http://www.murre.ut.ee/arhiiv/index.php>. Accessed 08.10.2018.
Viitso, Tiit-Rein (1999) "Keskliivi". In Karl Pajusalu and Tõnu Tender, eds. *Õdagumeresoomõ veeremaaq. Läänemeresoome perifeeriad*, 158–169. (Publications of Võro Institute, 6.) Võro: Võro Instituut´.
Viitso, Tiit-Rein (2008a) "Ferdinand Joh. Wiedemann ja 135-aastane liivi grammatika". *Liivi keel ja läänemeresoome keelemaastikud*, 261–263. Tartu, Tallinn: Eesti Keele Sihtasutus.
Viitso, Tiit-Rein (2008b) "Survey of Previous Research on Livonian Prosody". *Liivi keel ja läänemeresoome keelemaastikud*, 289–293. Tartu, Tallinn: Eesti Keele Sihtasutus.
Viitso, Tiit-Rein (2008c) "Līvõ kēļ munt vāldamiersūomõ kīeld siegās". *Liivi keel ja läänemeresoome keelemaastikud*, 233–237. Tartu, Tallinn: Eesti Keele Sihtasutus.
Wiedemann, Ferdinand (1861) *Livische Grammatik nebst Sprachproben*. St. Petersburg: Commissionäre der Kaiserlichen Akademie der Wissenschaften (Eggers et Comp).
Wiik, Kalevi (1989) *Liivin katko*. Turku: Turun Yliopisto.
Winkler, Eberhard (1997) *Krewinisch, zur Erschließung einer ausgestorbenen ostseefinischen Sprachform*. Wiesbaden: Harrassowitz Verlag.
Winkler, Eberhard (1999) "Katkeintonatsiooni tekkimisest läänemeresoome keeltes". In Karl Pajusalu and Tõnu Tender, eds. *Õdagumeresoomõ veeremaaq. Läänemeeresoome perifeeriad*, 201–206. (Publications of Võro Institute, 6.) Võro: Võro Instituut´.
Winkler, Eberhard (2010) "Katketooni märkimisest vanades läänemeresoome allikates". In Jüvä Sullõv, ed. *Väikuq keeleq mitmõkeelitsen ütiskunnan. Väikesed keeled mitmekeelses ühiskonnas*, 68–78. (Publications of Võro Institute, 24.) Võro: Võro Instituut´.

Kokkuvõte. Uldis Balodis: Mittemodaalne fonatsioon liivi keele katketooniga sõnade vokaalides. Liivi keel on läänemeresoome keelte seas mõneti ainulaadses olukorras, kuna sõnade pearõhulistes silpides ilmneb tonaalne vastandus. Juba varasemad liivi keele kirjeldused on näidanud, et selles vastanduvad katketoon ehk *stød* ja püsitoon. Toonisüsteemi poolest on liivi keel sarnane läti keelega, millega liivi keel on olnud pikaajalises kontaktis. Käesolevas artiklis uuritakse, kas liivi *stød* on seotud mittemodaalse fonatsiooniga, eriti nn käriseva häälega (*creaky voice*). Selle kindlaks tegemiseks mõõdeti spektrikallet (*spectral tilt*) kuuest punktist (h1-h2, h1-F1, h1-F2, h1+h2/2-F1, h1-F3, F2-F3). Spektrikalle on aste või punkt, kuhu intensiivsus võib sageduse suurenedes tõusta (Gordon and Ladefoged 2001). Käesolevas uurimuses kasutatud meetod põhineb samal meetodil, mida kasutas Esposito (2004) oma uurimuses Santa Ana del Valle Zapotec kohta. Ainestik on pärit idaliivi keelejuhilt Pētõr Dambergilt (Kuramaalt Sīkrõgi külast). Analüüsitud materjal sisaldas CVV esisilbiga sõnu, kus esinesid pikad vokaalid [ǭ] või [ō] (IPA: [ǫ:] ja [o:]). Varasemad uurimused (nt Vihman 1971) on näidanud, et

*stød*iga vokaalid kalduvad olema larüngaliseeritud, mistõttu võib *stød*i puhul kärisevat häält seostada mittemodaalse fonatsiooniga, seda osutavad ka selle artikli tulemused.

Märksõnad: toon, *stød*, katketoon, fonatsioon, spektrikalle, kärisev hääl, liivi keel

Kubbõvõttõks. Uldis Balodis: **Līvõ kīel īžkillijizt äbmodāli fonātsij katkāndõksõks sõņši.** Līvõ kēļ um īžki vāldamiersūomõ kīeld siegās, sīest ku sīe ežmis zilbsõ võib vȱlda kakš tūoņõ (katkāndõks agā murdtõd tūoņ ja tazzi/nūziji tūoņ). Siedā kūlizt jõvā ežmizt līvõ kīel tuņšlijizt. Līvõ kīel ja leţkīel tūoņõd sistēmõd ātõ väggi ītizt, sīest ku nänt rõkāndijizt ātõ kōgiņ jellõnd īdtuoiz kūoral. Sīes tuņšlimizõs um kȱlbatõd kūd spektõr vändit (engliš kīels *spectral tilt*) aigõ (h1-h2, h1-F1, h1-F2, h1+h2/2-F1, h1-F3, F2-F3). Sīen um sēļţamõst, või līvõ kīel katkāndõks um mingi eņtšvīţi fonātsij tīp. Spektõr vändit um āiga, mis nägţõb, kui pǟgiņ kildzit sadāb, až sagdit nūzõb (Gordon ja Ladefoged 2001). Jedmilizt tuņšlimizt (ngţ. Vihman 1971) ātõ nägţõnd, ku katkāndõksõks īžkillijizt jūs um lieudtõb laringalizātsij, ja keržiji ēļ sugūb äbmodālizõst fonātsijst. Sīe tuņšlimiz pierāst kȱlbatõd metod um seļļi īž nemē Esposito (2004) kȱlbatiz Santa Ana del Valle zapotek kīel tunšlimiz pierāst. Tuņšlimiz materjalõks ātõ Kurāmō idālīvõ murd rõkāndijiz Pētõr Damberg tekstõd (Damberg vòļ Sīkrõg kilāst). Analīz pierāst sait võttõd sõnād CVV ežmiz zilbõks, missõs āt pitkād īžkillijizt [ǭ] agā [ō] (IPA: [o̰ː] ja [oː]).