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PROMINENCE AND GEMINATION IN INGRIAN*

Abstract. This paper reports results of an acoustic study of stress and length patterns in Ingrian, a Finnic language closely related to Finnish. Primary stressed syllables were found to have higher fundamental frequency than both secondary stressed and unstressed syllables. Intensity and duration played a limited role in signaling stress. In keeping with published descriptions, consonants preceding a long vowel in the second syllable of the primary stress foot were lengthened. The lengthening effect was greater in consonants targeted by the process of primary gemination (Finnish *yleisgeminaatio*), i.e. those in CVCVV feet in disyllabic words, than those affected by other gemination phenomena applying in Ingrian.

Keywords: Ingrian, phonetics, stress, duration, gemination.

1. Introduction

Recent literature has seen a number of quantitative studies of prominence and duration in Finnish (e.g. Suomi, Toivanen, Ylitalo 2003; Suomi 2005; 2007; Myers, Hansen 2007; Nakai, Kunnari, Turk, Suomi, Ylitalo [to appear]). Relatively understudied from a quantitative phonetic standpoint has been the closely related language of Ingrian (Porkka 1885; Sovijärvi 1944; Лаанест 1966; Palander 1987) spoken along coastal areas of Northeastern Russia. The present paper seeks to contribute to the literature on prosody in Finnic languages by presenting results of a quantitative study of stress and duration in Ingrian.

Of particular interest in the present work are two topics. First, the paper examines the phonetic correlates of both primary and secondary stress in Ingrian. Second, the paper presents results of a durational study of some of the various consonant lengthening phenomena characteristic of Ingrian. Examination of consonant duration in Ingrian not only contributes to our

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descriptive understanding of lengthening patterns found in Finnic but also potentially sheds light on theoretical issues concerning the analysis of prosodic structure in Ingrian and other Finnic varieties.

2. Background

2.1. Lengthening patterns

Ingrian displays various lengthening processes targeting vowels and consonants that were etymologically short and remain short in standard Finnish. The target of lengthening, the context in which it occurs and the degree of lengthening varies from dialect to dialect within Ingrian. Furthermore, the description of lengthening in Лаанест 1966 suggests that it is not a consistent feature within individual dialects.

The most pervasive type of lengthening in Ingrian and one that is reported for all varieties targets consonants between a short vowel in the first syllable and a long vowel or diphthong in the second syllable. For example, standard Finnish *kalaa* 'fish, part. sg.' is realized as *kallaa* in Ingrian. This phenomenon of lengthening (Finnish *yleisgeminaatio* or, as it typically loosely translated into English, *primary gemination*) is found in many Finnic varieties, including certain Southern Estonian dialects (Kettunen 1962), Eastern Votic (Kettunen 1930), several Finnish dialects, including Häme, Savo, Ala-Satakunta, and Central and North Pohjanmaa (Kettunen 1940; Mielikäinen 1981; Paunonen 1973; Nahkola 1987), and Livonian historically (see below). Examples of primary gemination appear below in (1a). Ingrian also has undergone additional lengthening processes that are either absent from other Finnic languages or less widespread. The first of these lengthening phenomena (Finnish *erikoisgeminaatio* or, as it typically loosely translated into English, *secondary gemination*) is a more recent phenomenon than primary gemination and targets consonants after a heavy (CVV or CVC) first syllable before a long vowel or diphthong in the second syllable. Outside of Ingrian, secondary gemination is limited to a portion of the Savo and Ostrobothnian dialect regions (Kettunen 1940; Mielikäinen 1981; Palander 1987). Examples of secondary gemination affecting intervocalic consonants after long vowels and closed syllables appear below in (1b) and (1c), respectively. Ingrian also displays lengthening of consonants between the first and second vowel of trisyllabic words, where it is most pervasive if the first syllable is open and contains a short vowel (1d) but is also observed occasionally if the first syllable is heavy (1e).

(1) Consonant lengthening in Ingrian (examples from Лаанест 1966 using his transcriptions except that length is marked uniformly for consonants and vowels through orthographic doubling of the lengthened sound):

(a) *varria* 'hot, part. sg.', *sinnua* 'you, part.sg.', *sikkaa* 'pig, part. sg.', *vettee* 'water, ill. sg.', *pallaa* 'it burns', *rahhaa* 'money, part. sg.', *sullaa* 'it melts' (Лаанест 1966 : 22)

(b) *maittoo* 'milk, part. sg.', *poikkaa* 'boy, part. sg.', *leippää* 'bread, part. sg.', *päivvää* 'day, part. sg.', *vootteen* 'year, ill. sg.' (Лаанест 1966 : 25)

(c) *nälkkää* 'hunger, part. sg.', *olkkea* 'straw, part.sg.', *jalkkaa* 'leg, part. sg.' (Лаанест 1966 : 25)

(d) *heppoizen* 'horse, gen. sg.', *lässiivä* 'sick', *mattaala* 'ow', *orraavad* 'squirrels' (Лаанест 1966 : 26)

(e) *jalkkoja* 'leg, part. pl.', *kärppäizen* 'fly, gen. pl.', *küünneled* 'tears' (Лаанест 1966 : 30)

While the long vowels and diphthongs triggering lengthening in disyllables and many of the trisyllabic cases are either etymologically long (as in the case of many diphthongs) or have arisen through intervocalic consonant loss, many cases of lengthening in trisyllables have been triggered by spontaneous lengthening of the second vowel, e.g. *mattaala*, *ommeena*. In many forms, the length in the vowel has subsequently been lost.

According to A. Laanest (Лаанест 1966), dialects of Ingrian show variation in both the environments in which lengthening occurs and the degree of lengthening. For example, the Lower Luga dialect lacks secondary gemination, i.e. it does not lengthen consonants following a heavy initial syllable, and it does not display lengthening in trisyllabic words. Furthermore, the Hevaha variety displays greater lengthening in primary gemination contexts, i.e. in consonants following a short vowel in disyllables, than other Ingrian dialects.

A. Laanest (Лаанест 1966) transcribes four degrees of length: short (indicated as a single consonant with no diacritics, e.g. *p*), lengthened (marked with a grave accent, e.g. *p̀*), short geminate (indicated as a double consonant with a breve mark over the first consonant, e.g. *p̆p*), and full geminate (transcribed as a double consonant, e.g. *pp*). The amount of lengthening is subject to variation conditioned by dialect, context, and other factors that A. Laanest alludes to but does not explicitly describe. These factors produce skewed distributions in the amount of lengthening. Thus, the term *gemination* is misleading in some cases and could thus more safely be replaced by the cover term *lengthening*.

One robust generalization that emerges, however, is that lengthening is characteristically greater following short vowels than following either long vowels (including diphthongs) or closed syllables. Thus, in the Soikkola dialect, virtually all (17 of 20 distinct lexical items) of the lengthening examples cited by A. Laanest following a long vowel or a closed syllable are transcribed with lengthened (i.e. non-geminated) consonants and those few transcribed with geminates (3 cases) are transcribed as being short geminates. This contrasts with intervocalic consonants following short vowels, which are uniformly transcribed by A. Laanest with either short or full geminates. Furthermore, as mentioned earlier, lengthening occurs asymmetrically after short vowels but not long vowels or closed syllables in the Lower Luga dialect.

2.2. The metrical analysis of lengthening

Following P. Kiparsky's (2006) analysis of Livonian, which historically underwent lengthening processes similar to those found in disyllabic Ingrian words (Kettunen 1938), the various gemination processes in Ingrian may be viewed as a strategy to improve the structure of the trochaic (strong-weak) feet characteristically employed by Finnic languages. This account is most straightforwardly illustrated by words containing a short vowel in an open first syllable followed by a long vowel or diphthong in the second syllable. In such words, the short, i.e. monomoraic, syllable together forms a foot with the second syllable, which is bimoraic by virtue of containing a long vowel. A foot of this type consisting of a stressed monomoraic syllable followed by an unstressed bimoraic syllable is potentially undesirable because the unstressed syllable is heavier than the stressed syllable. While standard Finnish tolerates these light plus heavy feet, termed "resolved trochees" by P. Kiparsky, Ingrian and other Finnic varieties displaying lengthening before long vowels repair this ill-formed foot type by beefing up the first syllable through gemination of the intervocalic consonant. This process is illustrated in Figure 1.

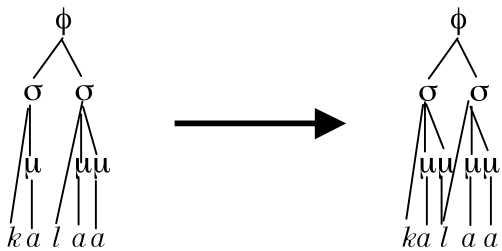

Figure 1. **Gemination as mora addition in CVCVV feet.**

A chronologically later process of vowel reduction targeting the second vowel in the foot subsequently obscured the conditioning context driving this foot repair process in Livonian (and sometimes in Ingrian trisyllables) but not in Ingrian or Finnish disyllabic words. In his account of lengthening in Finnish dialects, H. Paunonen (1973) adopts essentially this same analysis of foot optimization, in which the long vowel arising in the second syllable of the foot through consonant syncope disrupts the original prosodic profile of the foot, thereby triggering consonant lengthening in order to restore the balance between the two syllables. M. Gordon (1998) also pursues this approach in his fortition-based account of consonant gradation in Finnic and Sámi.

P. Kiparsky's account of Livonian differs, however, from other analyses in the foot structure that he assumes to be the final output of gemination. Whereas it is traditionally assumed that the feet resulting from gemination are trochees consisting of two heavy syllables, P. Kiparsky suggests that the two heavy syllables split into two separate feet, each consisting of a single heavy syllable. These feet are termed "moraic trochees" since they canonically consist of two moras, unlike "syllabic trochees" which are composed of two syllables regardless of their internal weight (see Hayes 1995 for an overview of this distinction). The moraic trochee structure assumed by P. Kiparsky (2006) to result from gemination is contrasted with the traditional syllabic trochee analysis of gemination in Figure 2.

P. Kiparsky's (2006) account makes interesting predictions about lengthening and stress. First, his account draws a distinction between phonetic and phonological lengthening, only the latter of which is reflected in moraic structure. In his analysis, true phonological lengthening occurs in two contexts. First, intervocalic consonants are phonologically geminated after short vowels, e.g. *kalaa* → *kallaa* 'fish, part. sg.'. Second, he assumes that

Figure 2. **The moraic trochee and the syllable trochee analyses of the Finnic foot.**

a coda consonant in the first syllable is underlyingly non-moraic and receives a mora through phonological lengthening before a long vowel in the second syllable. This latter type of lengthening historically targeted the sonorant in sonorant plus obstruent clusters in Livonian (Kettunen 1938), but is absent in Ingrian, which instead lengthens the obstruent, e.g. *jalkaa* 'leg, part. sg.' → *jalkkaa* not **jallkaa* (cf. Livonian *jal̄gə*).

This leaves one context in which lengthening is inarguably phonetic and not phonological, i.e. non-moraic: following a long vowel or diphthong (e.g. *maitoo* 'milk, part. sg.' → *maittoo*) Lengthening in this context is found in Ingrian, though not as pervasively as the lengthening found following a light (CV) syllable (see section 2.1). It may be noted that it is also possible to analyze the coda consonant in closed syllables as moraic in Ingrian, in which case the lengthening of the second member of consonant clusters, e.g. *jalkaa* → *jalkkaa* 'leg, part. sg.', could be interpreted as being phonetic rather than mora adding.

2.3. Stress

P. Kiparsky's account also makes the interesting prediction that the syllable immediately following an initial syllable that has been phonologically beefed up through lengthening may potentially (depending on one's interpretation of the relationship between foot structures and stress) carry secondary stress since it belongs to a different foot from the first syllable. An analysis that assumes a syllable trochee consisting of two heavy syllables, on the other hand, does not predict secondary stress on the vowel following the lengthened consonants since it belongs to the same foot as the first syllable.

The predictions about stress cannot readily be tested for Livonian since the etymological long vowels triggering gemination later reduced quantitatively and qualitatively to schwa. However, in Ingrian, most of the long vowels (especially those in disyllabic words) triggering lengthening have been preserved. It is thus possible to check Ingrian for both a potential distinction between phonetic and phonological lengthening as well as for the presence of secondary stress in the syllables containing the long vowels triggering lengthening of the preceding consonant.

Stress in Ingrian has been subject to very little investigation, though it is either implied (e.g. Laanest 1975) or stated explicitly (Porkka 1885) that it follows the alternating pattern characteristic of Finnish, whereby the primary stress in native words falls on the first syllable with odd-numbered non-final syllables carrying secondary stress. A. Laanest (1975 : 91) suggests that Ingrian conforms to the Finnish pattern and provides forms illustrating the alternating stress pattern and the rejection of stress by a final light syllable: *nai·zel-li:gaz* 'married man', *a·bula:issia* 'assistant, part.pl.' (where · indicates primary stress and *:* secondary stress). However, there are no quantitative phonetic studies of Ingrian stress to confirm the pattern reported for standard Finnish. It is thus unclear whether secondary stress might vary in its location depending on vowel length as potentially predicted by the moraic trochee analysis proposed by P. Kiparsky (2006) for Livonian.

3. Present study

The present study is a phonetic investigation of length patterns and stress in Ingrian. It has three goals. First, it seeks to broaden our understanding of stress patterns in Finnic languages by examining data from a less widely studied Finnic language. The paper further hopes to determine the acoustic correlates of primary and secondary stress in Ingrian. A final goal of the study is to assess the phonetic and phonological nature of lengthening in Ingrian. Some questions that will be addressed in the study of length patterns are the following:

• Is primary gemination associated with greater phonetic duration than other lengthening phenomena, i.e. is lengthening greater after a light (CV) syllable in disyllabic words than in trisyllables and after a heavy (CVV or CVC) syllable in disyllables, as A. Laanest's description (Лаанест 1966) suggests?
• Are there four discrete categories of length as implied by A. Laanest's transcriptions or does length vary gradiently?
• Are lengthened consonants in any (or all) contexts equivalent in duration to underlying geminates?

3.1. Methodology

The data considered in this study are drawn from an acoustic recording of a narrative recorded in 1964 by R. E. Nirvi from a female speaker (born in 1907) of the Soikkola dialect from the village of Saarove. The recording was made using a reel-to-reel recorder, and was transferred to an analog cassette. In preparation for analysis, the recording was then digitized as a .wav file at a sampling rate of 44.1. The data analysis was performed using Praat (www.praat.org).

A total of 408 words occurring in a 12 minute span of the narrative were analyzed. Only disyllabic and longer words were included since only they contain consonants in environments targeted by lengthening and since only they possess syllables differing in stress that can be compared. Furthermore, words in utterance final position were excluded since they were subject to final lengthening and, in many cases, devoicing. Of the 408 words measured, 301 were disyllabic, 78 were trisyllabic, and 29 contained four or more syllables. Of this last group, a majority (23 of 29) were four syllables long.

The following measurements were taken. The duration of vowels and consonants was measured from a waveform in conjunction with a time-aligned spectrogram. The vowel was measured from the onset of the second formant to the offset of the second formant, and the measurement of consonant duration encompassed the constriction, excluding the release burst and any positive voice-onset-time in the case of stops. Furthermore, the fundamental frequency and the intensity of vowels were averaged over each vowel as determined from the duration measurement. Results were logged using Praat and imported into a spreadsheet for coding followed by statistical analysis using SPSS (www.spss.org). Vowels were coded according to their phonemic length and their stress level. Primary stress was assumed to fall on the first syllable (excluding some unassimilated loanwords of the type that did not occur in the examined data) following the pervasive pattern found throughout Finnic and impressionistically observed in the Ingrian data as well. Secondary stress was coded according to the pattern reported in Laanest 1975, whereby secondary stress falls on odd-numbered non-final syllables. Secondary stress was also coded a second way following the Finnish weight-sensitive pattern, whereby stress falls on a final odd-numbered syllable if it is heavy and on an even-numbered heavy syllable following a light odd-numbered syllable. The two different ways of coding stress yielded virtually identical results with respect to the acoustic correlates of stress.

3.2. Results: Acoustic correlates of stress

3.2.1. Fundamental frequency

Figure 3 plots the fundamental frequency of vowels occurring in primary stressed syllables, secondary stressed syllables, and all unstressed syllables regardless of their position in the word. An analysis of variance (ANOVA) indicated a significant effect of stress level on fundamental frequency: F

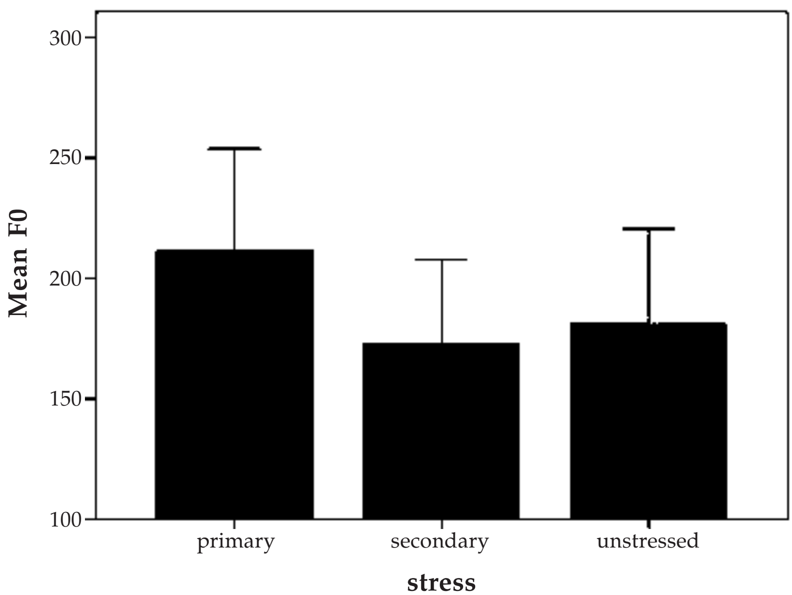

Figure 3. **Average fundamental frequency (in Hertz) of primary stressed, secondary stressed, and unstressed vowels. Whiskers indicate one standard deviation from the mean.**

(2, 952) = 72.836, p < 0.001. Scheffe's posthoc tests indicated a significant difference between primary stressed (212 Hz on average) and both secondary stressed (173 Hz) and unstressed (181 Hz) syllables at p < 0.001. However, secondary stressed syllables did not reliably differ from unstressed syllables in fundamental frequency.

3.2.2. Intensity

Figure 4 plots the intensity (in decibels) of vowels occurring in primary stressed syllables, secondary stressed syllables, and all unstressed syllables.

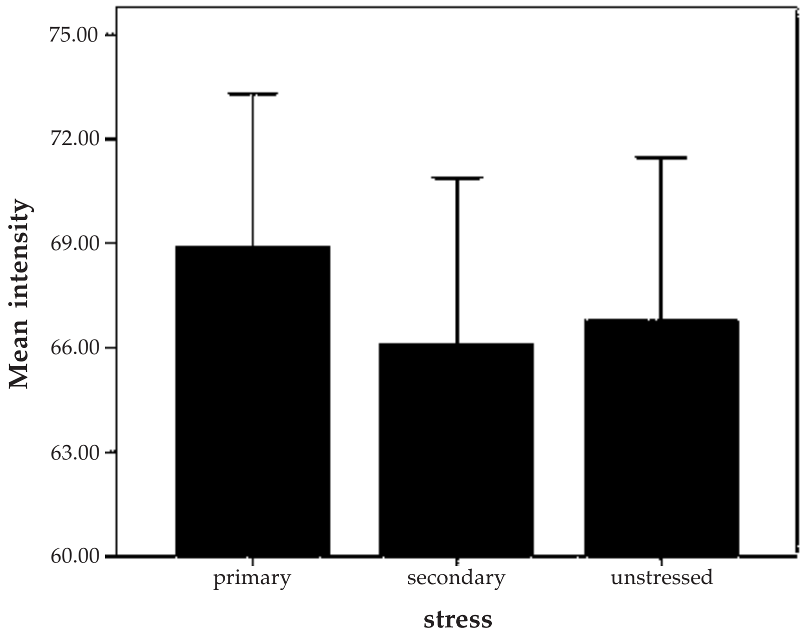

Figure 4. **Average intensity (in decibels) of primary stressed, secondary stressed, and unstressed vowels. Whiskers indicate one standard deviation from the mean.**

An analysis of variance (ANOVA) indicated a significant effect of stress level on fundamental frequency: F (2, 954) = 27.909, p < 0.001. Scheffe's posthoc tests revealed a significant difference between primary stressed (68.9 dB on average) and both secondary stressed (66.1 dB) and unstressed (66.8 dB) vowels at p < 0.001. Though the intensity difference between primary stressed and other vowels is relatively small (2—3 dB), it should be borne in mind that the ear is sensitive to small differences in the logarithmic decibel scale. For example, a difference of only 3 dB is perceived as roughly a 50% difference in loudness (Warren 1970). As with fundamental frequency, secondary stressed syllables did not reliably differ from unstressed syllables in intensity.

3.2.2. Duration

The analysis of duration is complicated somewhat by the phonemic contrast in vowel length that exists in Ingrian. Separate analyses for short and long vowels were thus conducted. An analysis of variance conduced for the short vowels did not indicate any effect of stress on duration values. Vowels were almost equivalent in length in syllables with differing levels of stress: primary stressed vowels = 89 milliseconds on average, secondary stressed vowels = 78 milliseconds, unstressed vowels = 88 milliseconds.

For phonemic long vowels, however, there was a significant effect of stress level on duration: $F(2, 281) = 26.775$, $p < 0.001$. Figure 5 plots duration for long vowels in syllables with different degrees of stress. Posthoc tests indicated that there was a difference between primary stressed vowels (140 milliseconds on average) and both secondary stressed (106 milliseconds) and unstressed (109 milliseconds) vowels at $p < 0.001$.

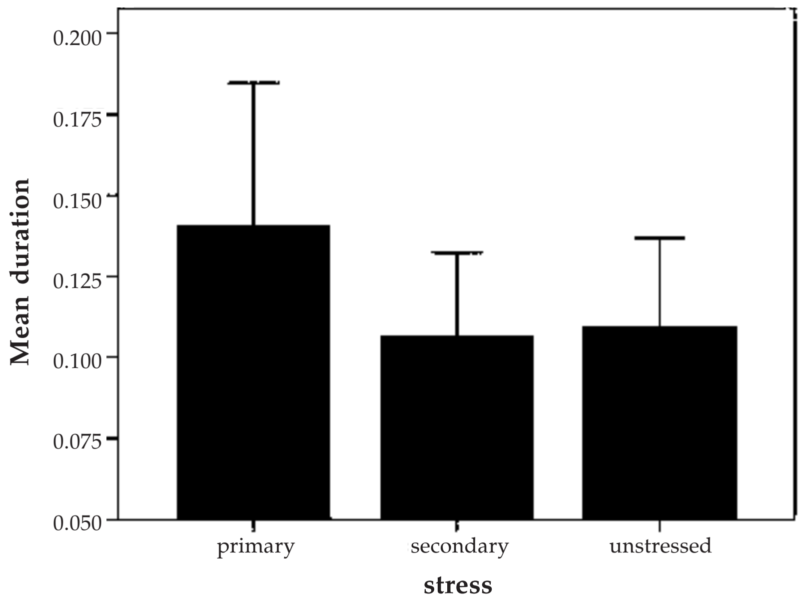

Figure 5. **Duration (in seconds) of primary stressed, secondary stressed, and unstressed long vowels. Whiskers indicate one standard deviation from the mean.**

Analyses were also performed excluding final vowels, since they could plausibly be subject to the cross-linguistically common phenomenon of final lengthening (Wightman, Shattuck-Hufnagel, Ostendorf, Price 1992), which could obscure the overall duration results for stress. Even when final vowels were excluded, an ANOVA failed to indicate any effect of stress level on duration for the short vowels. In fact, duration values remained virtually unchanged when final vowels were omitted: secondary stressed non-final vowels = 85 milliseconds on average compared to 78 milliseconds when both final and non-final vowels are included; unstressed non-final vowels = 91 milliseconds compared to 88 milliseconds when both final and non-final vowels are included (primary stressed vowels do not occur in final position in the data set, which did not contain any monosyllables). As expected, an ANOVA comparing final and non-final short vowels failed to indicate any difference when collapsed across stress conditions: non-final vowels = 89 milliseconds vs. final vowels = 87 milliseconds.

The length of long vowels and diphthongs was also compared in a t-test. There was a very small, but not statistically reliable, difference in mean duration for the two categories (diphthongs = 127 milliseconds vs. long monophthongs = 119 milliseconds). Long vowels and diphthongs grouped together, however, did display a length asymmetry between final and non-final syllables according to a t-test, t (1, 282) = 5.257, $p < 0.001$ Interestingly, vowels were s h o r t e r in final syllables than in non-final syllables: 110 milliseconds vs. 132 milliseconds. Excluding final vowels from an ANOVA testing the effect of stress level on the duration of long vowels did not affect results substantially relative to the ANOVA including both final and non-final long vowels: F (2, 110) = 7.933, p = 0.001. Primary stressed vowels (140 ms) differed substantially from both secondary stressed (92 ms) and unstressed (108 ms) vowels ($p < 0.05$), while secondary stressed and unstressed vowels did not differ from each other.

Figure 6 plots vowel length in stressed (dark bars) and unstressed (light bars) syllables of word-initial disyllabic feet in words of two and three syllables. An Ingrian word exemplifying each foot type is given alongside the schematic foot shape. It may be noted that the schematic foot shapes reflect phonemic duration, i.e. excluding the gemination effects triggered by a following long vowel, whereas the Ingrian examples are transcribed with lengthened consonants before long vowels. Long vowels and diphthongs are plotted separately with long vowels indicated by V: and diphthongs by VV to illustrate their near equivalence in duration in most foot types.

Comparison of vowel length patterns indicates the occurrence of vowel lengthening in the second syllable of disyllabic feet whose syllable is light

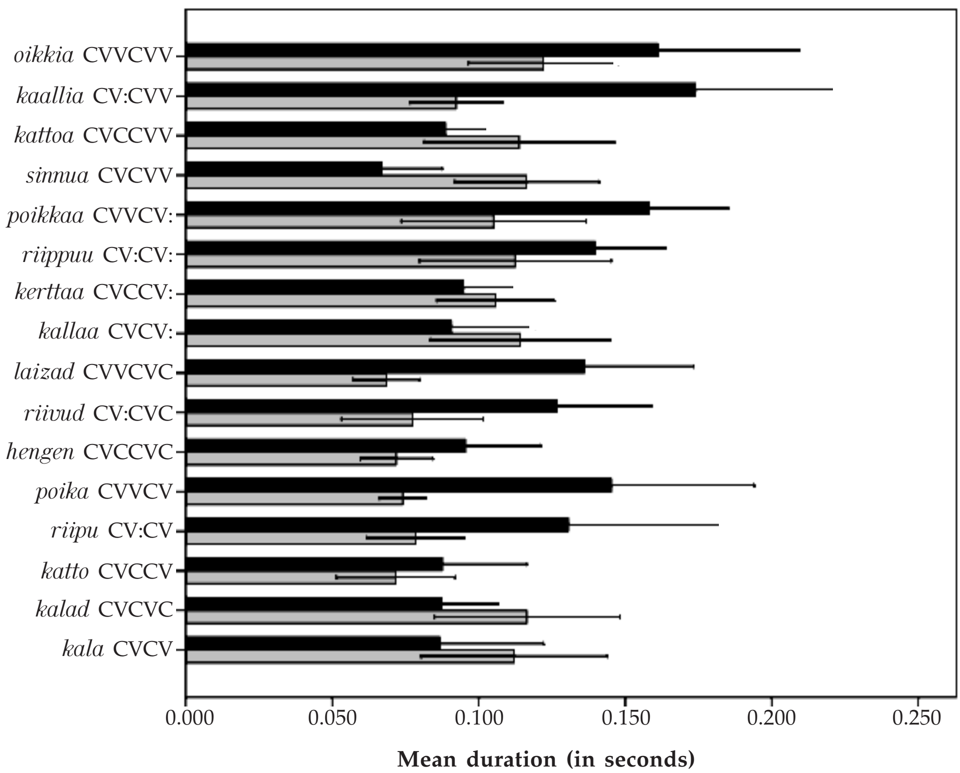

Figure 6. **The duration of stressed (dark bars) and unstressed (light bars) vowels in different word-initial foot types in Ingrian. Whiskers indicate one standard deviation from the mean.**

(CV), i.e. in the bottom two foot types in Figure 6. This phenomenon of the ”half-long” vowel is observed in phonemic short vowels in both open and closed syllables and is pervasive in many Finnic languages, including Ingrian’s close relative Finnish (Wiik, Lehiste 1968; Lehtonen 1970; Suomi, Toivanen, Ylitalo 2003; Suomi, Ylitalo 2004; Suomi 2005; 2007). The extent of this lengthening is particularly striking in the data examined here: the lengthened vowels are equivalent in length to phonemic long vowels and diphthongs in the same position (the top 8 foot types in Figure 6). This result is consistent with A. Laanest’s observation that the second vowel in CVCV feet in trisyllabic words has become long in many words (Лаанест 1966 : 26). Based on the examined data, it appears to be a relatively pervasive effect not only in trisyllabic words but also in disyllabic words in Ingrian. A comparison of the second vowel in CVCV feet in disyllabic and trisyllabic words indicated virtually no difference in length as a function of number of syllables in the word: the mean was 116 milliseconds in disyllables and 114 milliseconds in trisyllables.

The neutralization of phonemic vowel length contrasts in foot-final syllables with a light foot-initial syllable means that the phenomenon of consonant lengthening before unstressed long vowels bears the burden of conveying the contrast in vowel length in CVCV(C) feet: consonant lengthening applies before phonemic long vowels but not before phonemic short vowels that have been lengthened foot-finally in CVCV and CVCVC feet.

3.2.4. Stress on long vowels triggering gemination

Data were also coded according to the stress algorithm predicted by an account positing moraic rather than syllabic trochees, i.e. if secondary stress is assumed to fall on the long vowels triggering lengthening of the preceding consonant, e.g. *síkkàa* and *póikkàa* rather than *síkkaa* and *póikkaa*, respectively. Results remained unchanged under this stress system. Both fundamental frequency and intensity were affected by stress level: for fundamental frequency: $F (2, 828) = 61.731$, $p < 0.001$; for intensity, $F (2, 830) = 23.793$, $p < 0.001$. Primary stressed vowels differed from both secondary stressed and unstressed vowels in both fundamental frequency and intensity ($p < 0.001$) but secondary stressed and unstressed vowels still did not differ in either property. The duration of short vowels was not affected by stress, but the duration of long vowels was: $F (2, 255) = 19.210$, $p < 0.001$. This overall result was again attributed to a difference between primary stressed and both secondary stressed and unstressed vowels ($p < 0.01$) but not between secondary stressed and unstressed vowels.

3.2.5. Effects of stress on consonant duration

Consonant duration was also examined to determine whether consonants in either onset or coda position were lengthened under stress. Only singleton consonants were examined since geminates cannot reliably be divided into coda and onset phases. This parameter was tested since studies have shown that increased consonant duration is a cue to stress in certain Finnic languages. For example, I. Lehiste (1966) found that consonants in the onset of primary stressed syllables, the initial syllable, were much longer than onsets of word-medial syllables in Estonian. J. Lehtonen (1970), K. Suomi, J. Toivanen and R. Ylitalo (2003), and K. Suomi (2005) made a similar finding for Finnish. M. Gordon (1997) replicated I. Lehiste's finding of primary stressed onset lengthening in his study of Estonian and also found that most reliable acoustic correlate to secondary stress in Estonian was the lengthening of the onset consonant. J. Lehtonen (1970), K. Suomi and R. Ylitalo (2004), and K. Suomi (2005) found that coda consonants in primary stressed syllables are also lengthened in Finnish, but that this lengthening is limited to voiced codas.

For the examined Ingrian data, no effect of stress level on the duration of coda consonants was found, either voiced or voiceless. Coda consonants were marginally longer in primary stressed (80 ms) and unstressed (77 ms) syllables relative to secondary stressed (66 ms) syllables, but these differences were not statistically reliable. Onset consonants differed only negligibly between the three stress levels: primary stressed = 82 ms vs. secondary stress = 75 ms vs. unstressed = 79 ms. However, if voiceless onsets are excluded, a significant effect of stress on consonant duration emerges: according to an ANOVA, $F(2, 433) = 6.513$, $p = 0.002$. Both primary stressed (71 milliseconds) and secondary stressed (73 milliseconds) onsets are longer than unstressed onsets (63 milliseconds) at $p < 0.05$ according to a Scheffe's posthoc test.

3.2.6. Summary: Acoustic correlates of stress

Fundamental frequency and intensity were found to be reliable correlates of stress in the examined data, whereas only the duration of long vowels and voiced onsets was reliably linked to stress. However even fundamental frequency and intensity only differentiated primary stressed vowels from secondary stressed and unstressed vowels, but failed to distinguish primary stress from secondary stress. Similarly, long vowels were only lengthened in primary stressed syllables and not secondary stressed syllables. The only property which distinguished secondary stressed syllables from unstressed syllables was lengthening of voiced onsets. However, this feature failed to distinguish primary stress from secondary stress. Results did not change according to whether secondary stressed was assumed to fall on the vowels triggering lengthening in the preceding consonant or not. There was thus no support from stress patterns in the examined data for adopting a moraic trochee analysis over the traditionally assumed syllabic trochee analysis.

3.3. Results: Lengthening

The next phase of the study examined the various lengthening processes targeting consonants between the vowel in the first syllable and a long vowel in the second syllable of disyllabic and trisyllabic words. As a starting point, consonants were coded according to the structure of the foot in which they occurred. Following traditional accounts, which were supported by the acoustic results in section 3.2, it was assumed that the consonants targeted by lengthening occurred in the middle of disyllabic feet consisting of the first two syllables in the word. There are 13 types of foot structures encompassing the first and second syllables: CVCV, CVC_1C_1V, CVC_1C_2V, CVVCV, CVCVC, CVC_1C_1VC, CVC_1C_2VC, CVV(C)CVC, CVCVV(C),

$CVC_1C_1VV(C)$, $CVC_1C_2VV(C)$, CVV(C)CVV(C), $CVVC_1C_1VV(C)$, where C and V stand for phonemically short segments, VV represents phonemically long vowels or diphthongs, C_1C_1 stands for a geminate, and C_1C_2 stands for a consonant cluster. Since these schematic types are based on phonemic categories, the phonetically lengthened consonants occurring before long vowels are treated as phonemically short.

3.3.1. Consonant duration

Figure 7 compares the duration of consonants affected by the various lengthening processes in the first foot of two- and three-syllable words of various shapes. Two- and three-syllable words are compared for feet differing in whether the first syllable is light (CV) or heavy (CVC or CVV). There were no trisyllabic forms in which the lengthened consonant was preceded by a CVV first syllable. It may be noted that CVV stands for both long monophthongs and diphthongs, which were shown to be durationally equivalent in the last section.

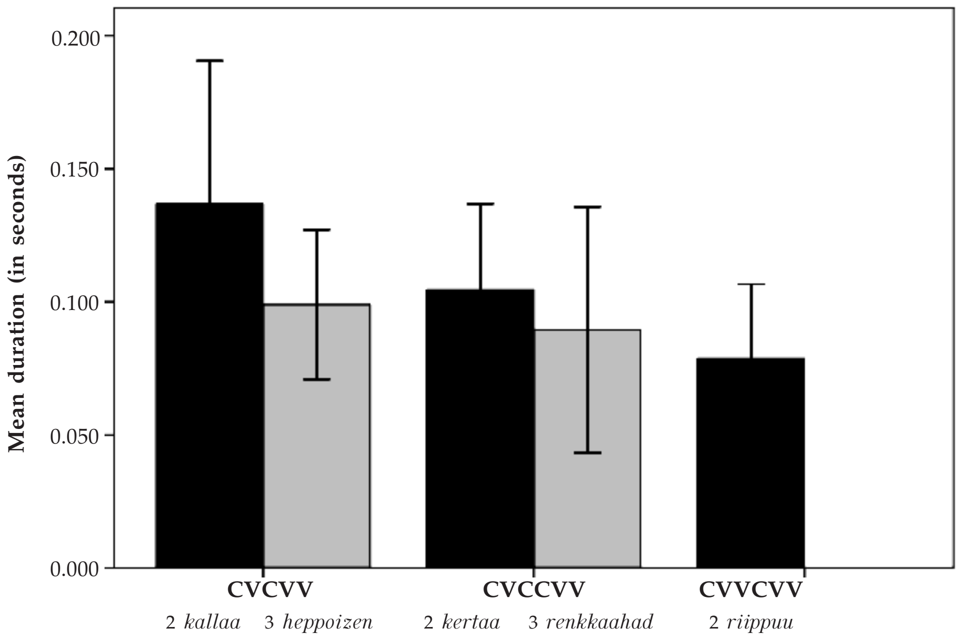

Figure 7. **Duration of lengthened consonants in the onset of the second (unstressed) syllable of different word-initial foot types in disyllabic and trisyllabic words.**

As the figure shows, an interesting interaction emerged between word length and the syllable preceding the lengthened consonant. The lengthened consonants occurring after a light (CV) syllable in disyllabic words were substantially longer than all other lengthened consonants. These consonants most affected by lengthening are those targeted by the historically earlier process of primary gemination that is also found in many Finnish dialects. Consonants undergoing lengthening processes other than primary gemination are far shorter than those lengthened by primary gemination. This result is consistent with M. Palander's (1987) phonetic results for certain (but not all) speakers of Eastern Finnish dialects displaying both primary and secondary gemination. The duration difference in the present study between consonants targeted by primary lengthening and those targeted by other lengthening phenomena was confirmed in an analysis of variance with word length (two vs. three syllables) and preceding syllable type (CV vs. CVC vs. CVV) as independent variables. There was neither an effect of word length or preceding syllable on consonant duration, but there was an interaction between the two factors reflecting the greater lengthening effect observed in disyllabic words following a light (CV) first syllable: $F\ (2, 120)=3.508$, $p = 0.033$.

Figure 8 plots the duration of phonemically short consonants occurring in the onset of the second syllable in the various foot types encompassing the first two syllables of the word. The data in the figure is limited to disyllabic words since there were relatively few tokens of trisyllabic words containing lengthened consonants before a CVV second syllable (7 beginning with CV syllables and 4 with CVC syllables). The consonants targeted by lengthening occur before the second vowel in the CV**C**VV(C), CVC**C**VV(C), and CVV(C)**C**VV(C) feet. There were insufficient numbers of words longer than three syllables to test differences in consonant length between words containing at least four syllables and words containing fewer than four syllables.

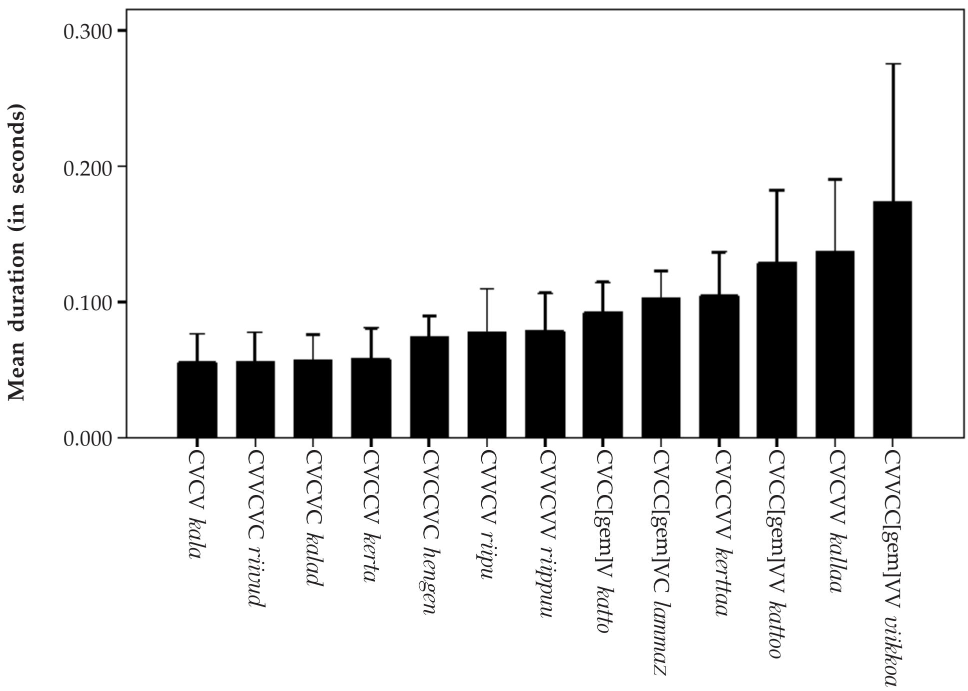

Figure 8. **Duration of consonants in the onset of the second (unstressed) syllable of different word-initial foot types. Whiskers indicate one standard deviation from the mean.**

An ANOVA indicated a significant effect of foot type on the duration of the foot-medial consonant: $F\ (12, 371) = 22.897$, $p < 0.001$. As the figure shows, the duration of all of the consonants targeted by lengthening are longer than all the phonemic short consonants not occurring in a lengthening environment. Furthermore, all the phonemic geminates are longer than all the single consonants. There is variation in length, however, both among the phonemic geminates and the lengthened consonants. Pairwise results of Scheffe's posthoc tests comparing foot-medial consonant length in different foot types are presented in table 1. Asterisks indicate differences that are significant at minimally $p < 0.05$.

Table 1

Pairwise posthoc results for consonant duration in the onset of the unstressed syllable of the word-initial foot

		Short						**Leng-thened**			Geminate			
		CVCV	CVCVC	CVCCV	CVCCVC	CVVCV	CVVCVC	**CVCVV**	**CVCCVV**	**CVVCVV**	CVCC[gem]V	CVCC[gem]VC	CVCC[gem]VV	CVVCC[gem]VV
Short	CVCV							*	*				*	*
	CVCVC							*	*				*	*
	CVCCV							*					*	*
	CVCCVC							*						*
	CVVCV							*						*
	CVVCVC							*	*				*	*
Leng-thened	**CVCVV**									*				
	CVCCVV													
	CVVCVV													*
Geminate	CVCC[gem]V													
	CVCC[gem]VC													
	CVCC[gem]VV													
	CVVCC[gem]VV													

None of the phonemic short consonants occurring in non-lengthening contexts, i.e. before short vowels, differed reliably from each other in duration. The longest category of consonants consists of geminates occurring between long vowels ($CVVC_1C_1VV$). Scheffe's posthoc tests indicated that geminates in this environment were longer than all phonemic short consonants except for the phonetically lengthened one in CVCVV feet, but were not longer than any of the other geminates. The longest of the lengthened consonants, the one in CVCVV feet arising through primary gemination, differed from all other phonemic short consonants, but did not differ from any of the phonemic geminates. It is thus clear that the lengthened consonant in CVCVV is best transcribed as a true geminate. The second longest lengthened consonant, the one in CVCCVV feet, differs from some of the phonemic short consonants but not all and it does not differ from any of the phonemic geminates. It thus occupies a middle ground in terms of duration, resembling a phonemic geminate but not completely distinguishable from short consonants. The most ambiguous case involves the lengthened consonant in CVVCVV feet. On the one hand, it is shorter than any of the other lengthened consonants or geminates and it does not differ from any of the short consonants statistically. On the other hand, it only differs from the geminate in $CVVC_1C_1VV$.

The absence of a length difference between the lengthened consonant in CVCVV and the underlying geminate in CVC_1C_1VV means that these structures are durationally undifferentiated. On the other hand, lengthening of the consonant in CVCVV serves as the sole property distinguishing CVCV from CVCVV, since the second vowel of the CVCV foot has been lengthened to the point where it is equivalent in length to a phonemic long vowel (see section 3.2.3). If consonant gemination was originally motivated by considerations of contrast maintenance as suggested by H. Paunonen (1973), this goal is only partially achieved in Ingrian: CVCVV differs from CVCV through the lengthened intervocalic consonant in CVCVV but this lengthening leads to neutralization of CVCVV with CVC_1C_1VV.

3.3.2. Durational correlations between the lengthened consonant and neighboring sounds

Regression analyses were performed on the consonants occurring in the three lengthening contexts in order to see whether there was a correlation, either positive or negative, between the amount of lengthening and the duration of neighboring sounds. It would not be surprising to find a correlation between consonant duration and the duration of the following vowel if lengthening is viewed as a strategy for balancing the duration of the two syllables in a foot. Furthermore, a correlation between consonant duration and the duration of the preceding rime might also be expected since A. Laanest's (Лаанест 1966) description suggests a greater lengthening effect after light CV syllables than after heavy (CVC or CVV) syllables (see section 2.1).

Looking first at the lengthened consonant in CVCVV feet, there was no reliable correlation between the duration of the consonant and the duration of the preceding vowel (r = 0.126). There was a moderate correlation, however, between consonant duration and the duration of the following vowel (r = 0.413), such that a longer following vowel was associated with a longer consonant.

In CVCCVV feet, there was no virtually no correlation between consonant duration and the duration of the preceding rime (r = 0.201). However, there was a moderate inverse correlation between consonant duration and the duration of the immediately preceding coda consonant (r = 0.279), such that the consonant was longer following a shorter preceding consonant and shorter following a longer consonant. This type of correlation is consistent with the tendency for consonants to undergo more lengthening after light (CV) syllables than after heavy (CVV and CVC) syllables, which are phonetically longer. There was virtually no correlation between the consonant duration and the duration of the following vowel (r = 0.185).

For CVVCVV feet, the duration of the preceding rime was correlated moderately (r = 0.366) with the duration of the intervocalic consonant. The correlation was an inverse one, such that the consonant was longer following a shorter preceding rime and longer following a shorter one. There was no correlation between the consonant duration and the duration of the following vowel (r = 0.039).

3.3.3. Summary: consonant lengthening

The descriptions of lengthening occurring before long vowels that are reported in Лаанест 1966 were confirmed by the data. The present data suggest a continuum of lengthening with the greatest effect in CVCVV feet, the smallest effect in CVVCVV feet, and an intermediate one in CVVCCVV feet. The sharpest division within this continuum falls between CVCVV and the other two foot types, i.e. between consonants targeted by primary gemination and those affected by later lengthening processes. Only in the case of consonants targeted by primary gemination is the lengthened consonant of a duration that falls within the range of durations found for true phonemic geminates and clearly outside of the range of durations found for phonemic short consonants. The lengthened consonant in CVCCVV is shorter and less clearly a geminate, though it is closer in duration to geminates than to phonemic short consonants. The lengthened consonant in CVVCCVV feet is shorter than any of the other lengthened consonants (or geminates) and does not reliably differ from the short consonants.

Regression analyses also pointed to a difference between the nature of lengthening in CVCVV and lengthening in the other two foot types. An inverse correlation between consonant duration and the duration of the immediately preceding segment, the first vowel in CVVCVV feet and the first syllable's coda in CVCCVV feet, is not observed in CVCVV feet but is found in other foot types.

The difference in consonant lengthening patterns in different foot is at least partially consistent with an analysis, *à la* P. Kiparsky's (2006) account of Livonian, that assumes a distinction between phonological and phonetic lengthening. According to such an account, the stressed first syllable in CVCVV feet is monomoraic and thus in need of lengthening before the bimoraic unstressed syllable. In keeping with the phonological nature of lengthening in CVCVV, the intervocalic consonant displays the greatest amount of lengthening in this foot type. At the other end of the spectrum, in feet with a long vowel in the first syllable, there is no need for mora addition since the first syllable is already heavy. Any lengthening of the consonant in this context may thus be assumed to be phonetic rather than phonological in nature. Accordingly, in the present study, the lengthened consonant in CVVCVV feet is shorter than other lengthened consonants. The lengthened consonant in CVCCVV occupies a durational middle ground, being longer than its counterpart in CVVCVV feet but shorter than its analog in CVCVV feet. Depending on one's assumptions about the moraic status of coda consonants and where one draws the durational dividing line between phonetic and phonological lengthening, the intermediate lengthening effect found in CVCCVV feet is potentially compatible with its phonological or phonetic status.

4. Conclusions

The present study of Ingrian examined acoustic manifestations of stress and various lengthening phenomena. In the realm of stress, a clear distinction between primary stressed vowels and other vowels emerged, whereby primary stressed vowels had greater intensity and higher fundamental frequency than either secondary stressed or unstressed vowels. Secondary stressed vowels were not differentiated from unstressed syllables in either intensity or fundamental frequency. Duration was a less robust correlate of stress than either intensity or fundamental frequency. Long vowels but not short vowels were lengthened in primary stressed syllables relative to both secondary stressed and unstressed syllables. The only cue to secondary stress found in the data was lengthening of voiced (but not voiceless) onsets in both primary stressed and secondary stressed syllables. This study thus failed to find any phonetic property that distinguished all three levels of stress.

The relatively low reliability of duration as a cue to stress is perhaps not surprising given the existence of quantity contrasts in both stressed and unstressed syllables in Ingrian. There are thus many words in which a short vowel in a stressed syllable is followed by a long vowel in an unstressed syllable. The existence of words of this type makes it impossible to assume that stressed vowels will be longer than unstressed vowels, a property shared with Finnish.

This does not mean that duration plays no role in the signaling of prominence in Ingrian. Long vowels were longer in both primary stressed and secondary stressed syllables relative to unstressed syllables. The asymmetric lengthening of long but not short vowels accords with results for Finnish (Lehtonen 1970; Suomi, Ylitalo 2004), although the Ingrian data differs from results from standard Finnish (Lehtonen 1970; Suomi, Ylitalo 2004; Suomi 2005) in failing to displaying lengthening of codas, either voiced or voiceless, in stressed syllables. Suomi, Ylitalo 2004, Suomi 2005, Suomi, Toivanen, Ylitalo 2007 interpret the lengthening of long vowels and coda consonants in stressed syllables as lengthening of the second mora, The lengthening of long but not short vowels plausibly also has a functional explanation: long vowels are free to lengthen without disturbing a phonemic contrast in duration whereas short vowels could infringe on the durational space of phonemic long vowels if they were to lengthen.

The lengthening of voiced onsets in stressed syllables distinguishes stressed from unstressed syllables paralleling results from Finnish (Lehiste 1965; Suomi, Toivanen, Ylitalo 2003; Suomi 2005) and Estonian (Lehiste 1966; Gordon 1997). As in Estonian (Gordon 1997), onset lengthening also was found to be the only property distinguishing secondary stressed from unstressed syllables.

The use of fundamental frequency to cue prominence is consistent with literature on Finnish. Recent work on Finnish (Suomi, Toivanen, Ylitalo 2003) has shown that fundamental frequency is actually a property of phrase level accents and is not reliably used as a correlate of word-level stress (see Slujter, van Heuven 1996 on the distinction between word-level stress and phrase-level accent). Syllables that carry word-level stress are eligible to receive phrase-level accents. The present study of Ingrian, which was based on data from a narrative, did not differentiate between word-level and phrasal prominence. The extent to which raised fundamental frequency is associated with word-level as opposed to phrase-level prominence in Ingrian must thus await future study. It also remains to be determined whether intensity is a robust correlate of word-level stress or is also a feature of phrase-level accent. What is clear, however, is that initial syllables in Ingrian are associated with word-level stress, which makes them eligible to receive phrase-level accents.

The lengthening patterns reported for Ingrian in the literature were robustly confirmed in the present study. Lengthening was greatest for consonants targeted by primary gemination, i.e. the intervocalic consonant in CVCVV feet in disyllabic words, where the lengthened consonant's duration fell squarely within the range of durations found for phonemic geminates. In disyllabic words, the lengthening effect was smaller in CVCCVV feet, and still smaller in CVVCVV feet. Furthermore, there was less lengthening in the intervocalic consonant in CVCVV feet in trisyllabic words than in the equivalent foot type in disyllables. This difference also corresponds to a difference between primary gemination affecting disyllabic words and the chronologically later lengthening process applying to trisyllabic words.

The reduced lengthening observed in the consonant following a CVV initial syllable in disyllabic words is consistent with the view that lengthening in this case is phonetic, unlike the phonological lengthening observed in CVCVV (and possibly CVCCVV) feet, where lengthening is associated with an additional mora in the first syllable following P. Kiparsky's (2006) analysis of Livonian. However, there was no evidence from secondary stress for splitting of the first foot into two monosyllabic feet, each of which is bimoraic. Rather, it seems at least on the basis of stress data that Ingrian adheres to the syllabic trochee template even in cases where both syllables in the trochee are heavy.

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ВЫДЕЛЕННОСТЬ И ГЕМИНАЦИЯ В ИЖОРСКОМ ЯЗЫКЕ

В статье излагаются результаты акустического изучения ударения и длительности в ижорском языке. Установлено, что слоги, на которые падает главное ударение, имеют более высокую основную частотность, чем слоги с второстепенным ударением и безударные слоги. Интенсивность и продолжительность как признаки ударения играют ограниченную роль. По опубликованным данным, согласные, предшествовавшие долгому гласному второго слога ударной стопы, удлиняются. Удлинение более ощутимо у согласных, испытавших первичную геминацию (т. е. в ступе CVCVV двухслоговых слов), чем у согласных, которые подверглись геминации других типов, присущих ижорскому языку.