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INTERACTION OF QUANTITY, FOOT STRUCTURE, AND STRESS IN THE $2^{ND}/3^{RD}$ SYLLABLE SONORANTS OF SOIKKOLA INGRIAN TRISYLLABLES

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ABSTRACT

The talk describes interaction between phonological quantity (originally, binary) and the compensatory effects of foot structure in sonorants at the 2^{nd} and the 3^{rd} syllable boundary (C_3) in the trisyllabic foot of vanishing Soikkola Ingrian (Finnic). Such interaction had been previously observed as a phonetic effect in the 1^{st} syllable segments and as a phonological impact on the 2^{nd} syllable vowels [1]. C_3 sonorants are also affected, both phonologically and phonetically, and their binary length contrast is almost lost. Depending on the foot structure, original C_3 sonorant geminates are either retained, or nearly or completely shortened to singletons. This result is placed within other results on the trisyllabic foot, which appears to be a coherent metrical unit different from both the disyllabic foot and the bifoot trisyllabic word in Soikkola Ingrian.

Keywords: quantity contrast loss, trisyllabic foot, sonorants, temporal compensation, Soikkola Ingrian.

1. INTRODUCTION[i]

The Soikkola dialect of the Ingrian language (Finnic), spoken at the Russian-Estonian border, manifests the trisyllabic metrical foot, e.g. in *murk̆kina* [ˈmurkˑina] ‘breakfast’. The trisyllabic foot shows phonetic and phonological differences from both the disyllabic foot, e.g. *kurki* [ˈkurg̊i] ‘crane’, and the combination of a disyllabic and a monosyllabic foot, e.g. *murkinā* [ˈmurg̊iˌnaː] ‘breakfast:PRT’. In particular, in a major phonetic study on 22 Soikkola trisyllables [1], the trisyllabic foot showed stronger compensatory effects than the disyllabic foot. Compensatory effects imply a shortening of segments as a function of an increase in the quantity and number of adjacent segments.

In the first syllable segments (V_1 — the 1^{st} syllable vowel, C_2 — a consonant at the 1^{st} and the 2^{nd} syllable boundary, R — an optional sonorant between them, as in *mur***k̆***kina*), all compensatory effects were purely phonetic. However, in the second syllable unstressed vowel (V_2), they led to a merger of the binary length contrast in trisyllables, unlike in the disyllabic foot, which still retains the contrast of short and long V_2.

The present study explores the influence of foot structure on the quantity contrast in C_3 consonants, which follow V_2. In C_2, the quantity contrast of consonants in Soikkola Ingrian is ternary, which is an extreme phonological rarity [2]–[4]: ***kana*** [ˈkanaː] ‘hen’ (singleton) — ***kan̆nā*** [ˈkanˑaː] ‘hen:PRT’ (short geminate) — ***linnā*** [ˈlinːaː] ‘city:PRT’ (long geminate). In C_3, the contrast is only binary (singleton vs. geminate). C_3 geminates historically correspond to C_2 long geminates. Hence the typical transcriptions of the C_3 length contrast in older Soikkola sources [5] as *sūri***ma** ‘grain’ vs. *sūvi***mma** ‘judge:1PL’ (sonorants), *hōva***ta** ‘relax:INF’ vs. *sīvo***tta** ‘cattle’ (stops).

However, geminates in Finnic languages, including Ingrian, are shorter after an unstressed syllable (i.e. as C_3) than after a stressed syllable (i.e. as C_2) [6, p. 274], [7]. Moreover, sonorant geminates differ from stops in that they tend to lose gemination and become singletons in the C_3 position. The shortening of C_3 sonorant geminates has been observed as complete in Estonian and as ongoing in Finnish dialects [6, pp. 273–277] and in Ingrian dialects, including Soikkola Ingrian [8]–[10], but never experimentally studied.

In our dataset from [1][ii], the shortening of C_3 geminate sonorants in Soikkola Ingrian can be studied on the first plural verbal forms with the suffix *-mma/-mmä* and the nominal forms in allative with the suffix *-lle* (or *-lla/-llä*), e.g. *sāta-***mma** ‘get-1PL’, *palka-***lle** ‘salary-ALL’. Original geminate **lː* (160 tokens) can be also directly compared to singleton *l* in forms like *katti***la** ‘cauldron’ (828 tokens). In turn, the forms with original C_3 geminate **mː* (988 tokens) do not have any counterparts with singleton *m* in these data. Datasets on **lː-l* and **mː* are imbalanced also in other respects (see 3.1). However, the overall variety of the structural types represented in these data is still sufficient for making certain conclusions about the process of shortening of the C_3 sonorant geminates.

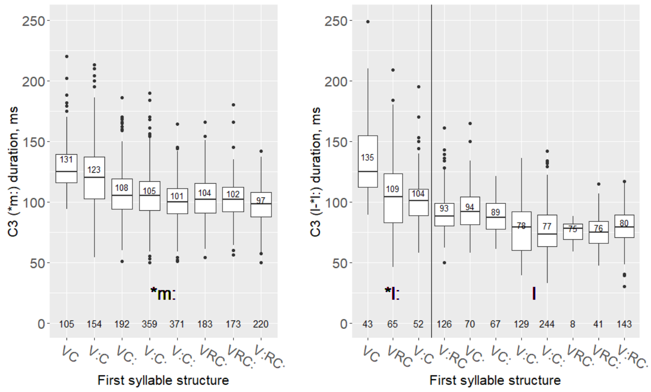
We find that C_3 long sonorants are durationally at most short geminates. We confirm an ongoing merger of C_3 singleton and geminate sonorants. This process has a compensatory nature. It is largely regulated by the 1^{st} syllable structure: the more complex the latter, the shorter any C_3. The C_3 geminates, like the V_2 short vowels, are the longest in the “light” foot with the 1^{st} stressed light syllable (C)V: *otam̆ma* [ˈod**aː**m**ˑ**a]. This is an effect of stress-induced lengthening, untypically located in the 2^{nd} unstressed syllable of the light foot in Finnic languages and affecting also C_3 duration.

2. DATA AND METHODS

Phrase-final tokens from [1], used for this study, were collected in the Kingisepp district (Russia) in 2014-2016 from five female speakers of north Soikkola Ingrian born in 1929-1936. Speakers were presented with a phrase spoken in Russian and asked to translate it into Ingrian. Mixed effects linear regression models are fitted in R with *lme4* on raw durations to study the relations between the structural parameters in the first two syllables of the foot and the duration of C_3 sonorants. The quantity contrast in V_2 has been lost and is excluded from all models. The fixed effects are V_1 length (*V* vs. *V:* — short vowel vs. long vowel), C_2 length (*C* vs. *C˙* vs. *C:* — singleton vs. short geminate vs. long geminate), and the presence of a sonorant R (*yes* vs. *no*), in various interactions. Models also include random by-speaker and by-word intercepts.

3. RESULTS

3.1. Simplification of the datasets on C_3 sonorants



(a) **m: as C_3* (b) **l:-l as C_3*

Figure 1: Mean durations in ms of C_3 (a)**m:* and (b)**l:-l* grouped by the combinations of V_1 length, C_2 length, and the presence of a sonorant R represented in our data.

			(a) *m*-dataset	(b) *l*-dataset	
V_1	**R**	**C_2**	**C_3**	**C_3**	
			***m:**	***l:**	***l***
short	no	sing	105	43	0
		gem	190	0	137
	yes	sing	0	65	0
		gem	358	0	49
long	no	sing	155	52	0
		gem	730	0	373
	yes	sing	0	0	126
		gem	220	0	143

Table 1: Numbers of tokens per combinations of V_1 length, C_2 length (singleton vs. any geminate), and the presence of R in our data on (a)**m:* and (b)**l:-l*.

Figures 1a-b represent the duration of original C_3 geminates **m:* and **l:* and C_3 singletons *l* as a function of combinations represented in the dataset from [1] of the levels of the three fixed effects in the 1st syllable. Raw means are reported within boxes; the number of tokens is given below each box at the bottom.

These data contain structural gaps, because the data from [1] were not intended for studying C_3. However, this can be partially remediated by conflations along certain parameters. Preliminary statistical exploration of data showed that short geminate and long geminate C_2 did not significantly differ in their impact on C_3 duration in any fitted model. In Tables 1a-b, they are, therefore, conflated into one category of geminates (*"gem"*), as opposed to C_2 singletons (*"sing"*).

In the model on **m:* (3.2), also the factor of R is excluded, as it was not significant for those pairs of structures for which it could be studied: V:C˙– V:RC˙, VC: – VRC:, cf. Fig. 1a. This makes the V_1 length * C_2 length matrix of the *m*-dataset full, cf. Table 1a.

In the *l*-dataset, C_3 length (singleton *l* vs. geminate **l:*) is collinear to the unique combinations of the levels of the three structural factors in the 1st syllable. Therefore, the factor of C_3 length itself cannot be included in a model. However, C_3 length can still be explored in the post-hoc pairwise comparisons of means obtained with a model containing the ternary interaction of the factors in the 1st syllable (see 3.3).

3.2. Results of modelling on **m:* (m-dataset)

Fig. 2 shows the results of C_3 **m:* duration modelling according to the following formula: C_3 duration ~ V_1 length * C_2 length + (1 | speaker) + (1 | word), data = 1758 tokens. The interaction is insignificant but is kept in the model, because this helps to study the relationships between the light foot (in bold in Fig. 2) and the heavy foot (any other type of foot).

A post-hoc pairwise comparison of the modelled means in *emmeans* shows no significant differences in C_3 between the structures with a short vs. a long V_1 when C_2 is a singleton: [ˈoda:**m**˙a] — [ˈša:da**m**˙a] (9 ms, SE = 4.6, df = 50, t = 2, p = 0.052; a black line). In both structures, C_3 **m:* still retain gemination.

When C_2 is a geminate, there is also no difference in C_3 between the structures with a short vs. a long V_1 (4 ms, SE = 1.9, df = 53, t = 2, p = 0.06; a red line), but both C_3 **m:* are almost shortened. Their durations of 101 and 106 ms are similar to the duration of word-initial *m* in our dataset (106 ms, 338 tokens). All other differences in Fig. 2 are significant at $p < 0.0001$.

The results on **m:* show that C_3 gemination is kept when C_2 is a singleton, but lost when C_2 is a geminate: *otamma* [ˈoḓa:**m**˙a] 'take:1PL', *sātamma* [ˈša:ḓa**m**˙a] 'get:1PL', but [ˈpałk:ama] 'hire:1PL' (<**palkkāmma*), [ˈłak:ama] 'sweep:1PL' (<**lakkāmma*), [ˈkä:nt˙ima] 'turn:1PL' (<**kāntīmmä*), [ˈšu:t˙ima] 'judge:1PL' (<**suuttīmma*), [ˈleịk:ama] 'cut:1PL' (<**leikkāmma*), [ˈhülk˙äma] 'abandon:1PL' (<**hülkkāmmä*).

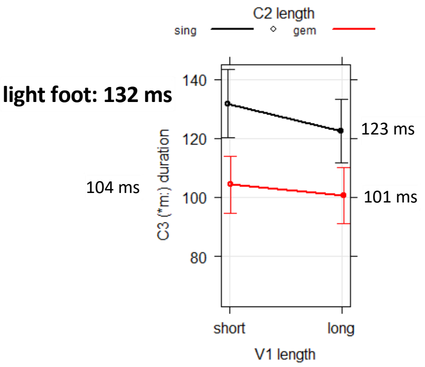


Figure 2: Modelled least squares mean duration of C_3 **m:* as a function of V_1 length and C_2 length (Satterthwaite's approximation of df and a confidence level of 95%).

3.3. Results of modelling on **l:-l* (l-dataset)

Fig. 3 shows the results of C_3 **l:-l* duration modelling according to the following formula: C_3 duration ~ V_1 length * C_2 length * Presence of R + (1 | speaker) + (1 | word), data = 988 tokens. The structures which contain original C_3 **l:* are shaded dark grey, while the structures with original short *l* as C_3 are in light grey.

C_3 **l:*, similarly to **m:*, has the longest duration of 131 ms in the light foot (marked in bold in Fig. 3; *akal̆le* [ˈag̊a:ɫ·e] 'old_woman:ALL'). It is significantly different at $p < 0.0001$ from any other type in Fig. 3.

The remaining two types of **l:* in Fig. 3 (**palkalle* 'salary:ALL' and **koikalle* 'bed:ALL') are shorter: 106 ms and 102 ms. Statistically they do not differ from each other, but differ from all types of originally short **l* as C_3, including durationally the nearest types of **l* in *kattila* [ˈkat:iɫa] 'cauldron' (91 ms) and *kǟntelȫ* [ˈkä:nde̞ˌlö:][iii] (90 ms), although only at $p < 0.05$ or at $p < 0.01$ (cf. also with modelled 89 ms of word-initial *l;* 436 tokens). The difference is anyway too small to be perceived by humans [11], [12]. Gemination of **l:* in these two structures can be, therefore, considered nearly or entirely lost: [ˈpaɫg̊aɫ⁽·⁾e] and [ˈkoig̊aɫ⁽·⁾e].

In the duration of short *l*, we observe the same kind of compensatory trend which distinguished the light foot from the heavy foot in case of **l:*. The duration of 91 ms of *l* in *kattila* with a short V_1 and no sonorant significantly differs from that of *l* in structures with a long V_1 (78 ms; *rītele* [ˈri:t·ele] 'argue:IMP', *Mīkkula* [ˈmi:k:uɫa] 'St. Nicholas'), with a sonorant (78 ms; *kantele* [ˈkant·ele] 'kantele', *küntteli* [ˈkünt:eli] 'candle'), or both (80 ms; *vāntteli* [ˈvä:nt·eli] 'turn:IPF:3SG'), but only at p<0.05 or at p<0.01. C_3 duration before a long vowel in a bifoot structure *kǟntelȫ* 'turn:3SG' (90 ms; cf. Ftn. *ii*) is left aside here.

This is clearly just a phonetic shortening of *l* — a manifestation of how durations in the foot shorten in an inverse relation to the growing number or quantity of segments within the foot, further discussed below.

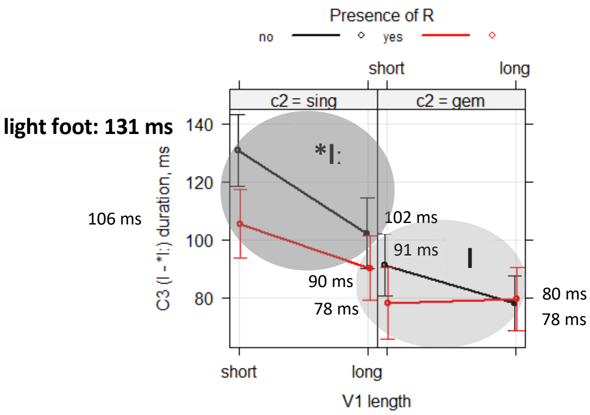


Figure 3: Modelled least squares mean duration of C_3 **l:-l* as a function of V_1 length, C_2 length, and the presence of R (Satterthwaite's approximation of df and a CL of 95%).

4. DISCUSSION

4.1. Similarities and differences between **m:* and **l:-l*

Our data confirm the ongoing shortening of **m:* and **l:* as C_3, i.e. after an unstressed syllable, in the trisyllabic foot. The earliest data from 1884 [8] did not yet report this process. Data from the 1930s [13] did not attest it for **m:* but reported the shortening of **l:* in the allative suffix, although only as C_2 in some personal pronouns (e.g. *miu-lle* ~ *miu-le* 'me:ALL', p. 78). However, the data on the allative suffix and the verbal 1[st] plural from the 1960s [9] and from the 2000s [10] already reflect a wide variation in **m:* and **l:* length as C_3 in the trisyllabic foot (and as C_2 after a long vowel, like in the personal pronouns above). The present data, although limited, allow us to clarify some mechanisms of the shortening of C_3 sonorants.

Geminate sonorants **m:* and **l:* undoubtedly retain gemination in the light foot. However, their duration as C_3 (~130 ms) does not reach the duration even of short geminate stops in C_2 (modelled 177 ms in [1]; cf. with 234 ms for long geminate C_2 stops). Shorter duration of C_3 geminates than of C_2 geminates was expected on the basis of earlier Ingrian and Finnish data. Synchronic C_3 sonorant geminates can be phonologically considered as short geminates /C·/.

In this, they might potentially differ from C_3 stops, which impressionistically do not show any signs of phonological shortening in Soikkola Ingrian (in words like *sīvotta* 'cattle'), but this is yet to be verified on the newly collected data.

In all studied types of heavy foot, **m:* and **l:* have almost or entirely shortened, apart from the type with **m:* and a long V_1 plus singleton C_2 (i.e. "V:C", *sātamma* 'get:1PL'; ~120 ms), where the duration of C_3 **m:* does not significantly differ from that of C_3 **m:* in the light foot. Still, in the same type of foot, **l:* has shortened to ~100 ms (**koikalle* > *koikale*).

To investigate whether the difference in the "V:C" foot between *m: and *l: is systematic or due to some possible gaps in the data, we considered inter-speaker differences in the structures with a singleton C_2 for *m: and *l:. Broadened inter-speaker variability between competing phonological variants is typical of an unfinished sound change [14]. Fig. 4 shows the results of modelling on *m*- and *l*-datasets by a formula: C_3 duration ~ First syllable structure * Speaker + (1 | word). In Fig. 4a, all the types from Fig. 1a where *m: occurs after any type of a geminate are conflated into *"*m:_after_gem"*. In Fig. 4b, all types from Fig. 1b with a short *l* are conflated into *"short_l"*. Fig 4a-b show consistent short geminates in the light foot and fully short consonants in the conflated types. There is, however, a large inter-speaker variability of *m: and *l: in heavy feet with a singleton C_2 (highlighted by circles in Fig. 4). In particular, in the "V:C" foot, C_3 *m: has actually shortened in 2 out of the 5 speakers.

It appears that C_3 *m: and *l: retain gemination in the light foot, are in a process of shortening in heavy feet with singleton C_2, and are (almost) shortened in other heavy feet. C_3 *m: is a bit more conservative than C_3 *l:. In both cases, we anyway see the effects of the general compensatory trend attested also for other foot segments in [1] (see Introduction). In 4.2, we discuss the relevance of our findings on trisyllabic temporal compensation for stress and foot typology.

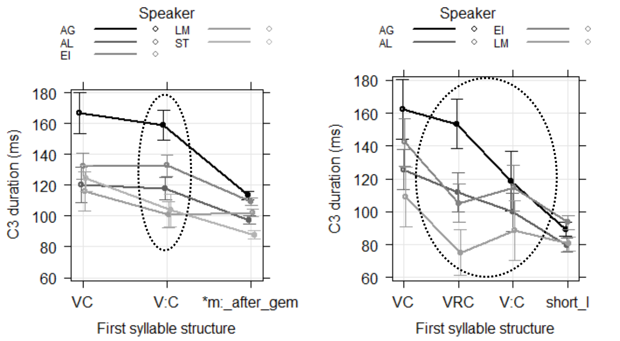


Figure 4: Modelled durations of (a) *m: (left) and (b) *l:-*l* (right) as C_3 with a focus on structures with singleton C_2

4.2. Significance of results for stress and foot typology

Our most robust finding as regards the C_3 geminate sonorants is their clear preservation in the light foot, as opposed to their shortening in the heavy foot. This fact can be also related to a phonetic lengthening of the preceding short V_2 in the light foot (modelled 127 ms — durationally the longest V_2 type in [1]).

This cross-linguistically untypical phenomenon of lengthening of unstressed V_2 rather than of stressed V_1 in the light foot in Finnic languages has been long known as a "half-long vowel" [15], [16]. For Standard Finnish, the "half-long vowel" has been explicitly considered as a manifestation of stress [17].

Our present data show that this lengthening in the 2nd syllable of the light foot spreads not only to the syllable nucleus (i.e. V_2) but also to the coda. In the structures considered, the coda consists of the first part of C_3 geminates, e.g. *o-tam̆-ma* [ˈod̥aːmˑa]. Stress-related lengthening in the 2nd syllable likely prevents C_3 geminates from phonological shortening.

In the heavy foot, which is in turn characterised by the metrical weakening of the 2nd unstressed syllable, both long V_2 [18], [1] and long C_3 shorten, e.g. **lak-kām-ma* > [ˈɬakː**am**a] 'sweep:1PL'. Both processes are observed as still ongoing in Soikkola Ingrian and complete in more prosodically innovative Estonian.

Table 2 draws a comprehensive picture of the compensatory processes affecting segmental duration and quantity within the trisyllabic foot in Soikkola Ingrian on the basis of this study and findings in [1]. Compensatory processes represent an interaction of the foot structure (first of all, light vs. heavy foot, with finer gradations within heavy feet) and segmental quantity. Word-initial consonant C_1 is not affected, neither the 3rd syllable vowel V_3 is. The latter is always short in the trisyllabic foot (trisyllables with long V_3 are bifoot words). Quantity contrasts in the 1st syllable are influenced by compensatory shortening only phonetically. The duration and length of V_2 and C_3 are affected both phonetically and phonologically.

The concept of ternary rhythm is contradictory in modern formal phonology. Some deny its relevance altogether and re-analyse known cases of trisyllabic feet through regular di- and monosyllabic foot types [19]. Others propose a recursive (two-layered) foot, where a "minimal" disyllabic foot is embedded into a "maximal" disyllabic foot [20], [21].

Our phonological and phonetic data on Soikkola Ingrian rather suggest that the trisyllabic foot is a coherent metrical whole in this variety. It is a type of a rhythmic group on its own, different from both the disyllabic foot and the bifoot structure. Especially our present data on C_3 geminate sonorants, which are at the boundary of the 2nd and the 3rd syllable but are still compensatorily affected by the structure of preceding syllables, might pose challenges for the above-mentioned formal accounts on ternary rhythm.

Factor	C_1	V_1	R	C_2	V_2	C_3	V_3
Original length contrast	–	binary	–	ternary	binary	binary	–
Contrast preservation		+		+	–	-/+	
Compensatory impact of the first syllable elements (V_1, R, C_2)	–	phonetic	phonetic	phonetic	phonological, phonetic	phonological, phonetic	–
Affecting compensatory factors		C_2 length (* V_1 length)	V_1 length, C_2 length	V_1 length (* C_2 length), R	V_1 length * R * C_2 length	***m**: — C_2 length; ***l:-l** — V_1 length * R * C_2 length	

Table 1: Prosodic structure of the Soikkola Ingrian trisyllabic foot, as observed in [1] and in this study.

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[i] Author contributions: The design and the background of the study were developed by NK; the data were collected by NK, IB, and EM, segmented by IB with a help of EM, extracted and processed by IB. NK is responsible for the statistical analysis and visualisation of the data presented in this paper. The draft text was written by NK, revised and edited by NK with a help of EM. NK is the corresponding author and responsible for the definitive version of the text.

[ii] The full dataset, including the data used in this paper, will appear at https://osf.io/rbw3m/.

[iii] This type with a final Vː was the only bifoot structure among our original 22 trisyllabic types, to cover the structure “VːRC” absent from the trisyllabic feet with C_2 stops; cf. Footnote (c) to Appendix 1 in [1].