L2 production of Estonian quantity degrees

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Abstract

The Estonian quantity system involves three contrastive patterns referred to as short (Q1), long (Q2) and overlong (Q3) quantity degrees. Our previous studies have shown that for L2 learners the distinction between Q2 and Q3 is a difficult task in both production and perception. While Q1 and Q2 structures are always distinguished in the orthography, this is not the case in most Q2 and Q3 words excluding the words with plosives between first and second syllable vowels (see examples later in the text). Thus, the orthography might be the reason for the use of the same L2 production pattern for both Q2 and Q3.

The current paper studies the role of L2 orthographic input on the L2 production of Estonian quantity degrees by two groups of subjects with different language backgrounds: Finnish and Russian. The material used in the study involves word structures with and without orthographic manifestation of quantity contrasts.

The results confirm the role of Estonian orthography on the L2 pronunciation, however, the two L2 subject groups show different prosodic patterns.

Index Terms: L2 speech, Estonian, Finnish, Russian, quantity opposition

1. Introduction

The domain of the Estonian quantity degrees is a disyllabic foot – a sequence consisting of the stressed syllable and the following unstressed syllable, e.g. [1], [2], [3], [4]. In the vowel-peaked structures (Q1: CV.CV; Q2: CVV.CV; Q3: CVV:.CV) the quantity contrast manifests mainly in vowels and diphthongs of the stressed syllable, e.g.: Q1: *sada* /sa.ta/ 'hundered', nom.sg.; Q2: *saada* /saa.ta/ 'to send', sg.imperat.; Q3: *saada* /saa:.ta/ 'to get'; Q2: *koera* /koe.ra/ 'dog', gen.sg.; Q3: *koera* /koe:.ra/ 'dog', part.sg.. In the consonant-peaked structures (Q1: CV.CV, Q2: CVC.CV, Q3: CVC:.CV) quantity oppositions occur in consonants and consonant clusters between the first and second syllable vowels, e.g.: Q1: *kala* /ka.la/ 'fish', nom.sg.; Q2: *kalla* /kal.la/ 'arum', nom.sg.; Q3: *kalla* /kal:.la/ 'pour', 2.sg. imperat.; Q2: *lehma* /leh.ma/ 'cow', gen.sg.; Q3: *lehma* /leh:.ma/ 'cow', part.sg..

Phonetically, the duration of a stressed syllable vowel (V1) in the vowel-peaked structures is shortest in Q1 and longest in Q3 – V1 duration in Q2 is ca 1.9 and in Q3 ca 2.5 times longer than in Q1 (as pooled from several studies [5]); the duration of intervocalic consonant (C2) in the consonant-peaked structures increases in a similar amount – ca 1.8 and ca 2.5 times in Q2 and Q3, receptively [6]. The duration of an unstressed syllable vowel (V2) varies inversely to the duration of V1 (or C2) being in Q2 ca 0.8 and in Q3 ca 0.6 times shorter than V2 in Q1 [5], [6]. Despite large variations of V2 duration, no quantity contrast exists in unstressed syllable and V2 is defined phonologically "short". Also, a consonant quantity contrast in word-initial position is not possible.

In addition to the inversely proportional durational relations within a foot, F0 contour is a complementary cue distinguishing the quantity oppositions – in Q1 and Q2 the F0-peak is located close to the end of V1, in Q3 it is located within the first half of V1 eg. [7], [8].

Lehiste [7] has introduced the syllable duration ratio as a characteristic feature distinguishing the three quantity degrees. The typical duration ratio for Q1 is 2:3, for Q2 3:2, and for Q3 2:1; similar ratios have been reported in numerous subsequent studies for both read [2], [8], [9], [10], [11] and spontaneous speech [12], [13].

As our previous studies [6], [14], [15], [16], [17] have shown, for L2 learners with Finnish- and Russian-language backgrounds the distinction between vowel-peaked Q2 and Q3 contrasts is a difficult task in both production and perception. It can be partly explained by the fact that in the orthography, vowel-peaked Q2 and Q3 structures, representing different grammatical words, are not distinguished (see examples above).

In our recent paper [5], we have addressed the role of L2 orthography on the production of Estonian quantities by focusing on consonant-peaked target words manifesting the Q1 – Q2 – Q3 contrast orthographically, i.e. the words with plosives between first and second syllable vowels, e.g.: Q1: *kade* /ka.te/ 'envious', nom.sg.; Q2: *kate* /kat.te/ 'cover', nom.sg.; Q3: *katte* /kat:.te/ 'cover', gen.sg.; Q1: *lugu* /lu.ku/ 'story', nom.sg.; Q2: *luku* /luk.ku/ 'lock', gen.sg.; Q3: *lukku* /luk:.ku/ 'lock', part.sg.; Q1: *leba* /le.pa/ 'lay', 2.pers.sg.imperat.; Q2: *lepa* /lep.pa/ 'alder', gen.sg.; Q3: *leppa* /lep:.pa/ 'alder', part.sg.

Notice that, in Estonian orthography, the letters <bdg> and <ptk> denote short and long voiceless plosives, respectively.

The findings confirmed the effect of L2 orthography – L2 subjects with Finnish-language background produced different patterns for Q2 and Q3 structures in the case of target words with plosives, but not in the case of words with non-plosives.

In the current paper we study the role of L2 orthographic input on the L2 production of Estonian quantity oppositions by two groups of subjects with different language backgrounds: Finnish and Russian. The speech material analyzed in the study involves vowel-peaked and consonant-peaked words with and without orthographic manifestation of quantity contrasts.

2. Method

2.1. Subjects

The L2-FI group involves subjects (age 21-49, median 36) from the Helsinki, Turku and Oulu areas born in monolingual Finnish speaking families. They started to study Estonian at the age 18-35 at university and have studied it for 1-5 years; six subjects

use Estonian frequently (daily or weekly), other six rarely.

The L2-RU subjects (age 21-33, median 24.5) were born in monolingual Russian speaking families living in the north-east of Estonia or in the capital area. Most of the L2 subjects started to learn Estonian in school at the age of 6-13, one subject at the age of 16 and one at the age of 20. All (except one) L2-RU subjects communicate at home in Russian, but outside they use Estonian almost every day.

The L1-EE group of native speakers (age 21-54, median 26.5) came from monolingual Estonian-speaking families and represent the pronunciation of standard Estonian.

All subject groups have equal number of subjects balanced by sex (6 male, 6 female); none of the subjects reported any language impairment.

2.2. Speech material

A subset of the Estonian Foreign Accent Corpus [18], [19] involving disyllabic target words representing quantity oppositions in sentence context was used in the study. L2-FI subjects from Helsinki and Oulu were recorded in the recording studios of Helsinki and Oulu universities, the subjects from Turku in a quiet lecture room at Turku University. L2-RU and L1-EE subjects were recorded in the recording studio of the Laboratory of Phonetics and Speech Technology, Tallinn University of Technology. For all recordings the same microphones and high quality recording equipment (sampling frequency 44.1 kHz, resolution 16 bit) were used.

From each subject 48 words were analyzed, including nine triplets of vowel-peaked structures (CV.CV; CVV.CV; CVV:.CV) (referred later as Vowel set) and seven triplets of consonant-peaked structures (CV.CV, CVC.CV, CVC:.CV). Among the latter, three triplets (referred to as Plosive set) involved plosives /k/, /p/ and /t/ between first and second syllable vowels, in four triplets (referred to as Non-plosive set) the consonants /m/, /n/, /s/, and /l/ were present. All target words have been manually segmented and labeled on word and phone levels using Praat [20].

2.3. Measurements

The durations of all constituent segments (C1, V1, C2, V2) in each target word were measured using a Praat-script and the syllable duration ratio was calculated as the duration of the first (stressed) syllable rhyme divided by the duration of the second (unstressed) syllable nucleus [21].

In the case of vowel-peaked quantity contrast (i.e. target words CV.CV, CVV.CV and CVV:.CV) the characteristic duration ratio is calculated as the duration of the stressed syllable vowel (V1) divided by the duration of the unstressed syllable vowel (V2). In the case of consonant-peaked target words (CVC.CV and CVC:.CV) the calculation of duration ratio is more complicated since it involves splitting of the word-medial geminate consonant into two segments: the coda of the first syllable and the onset of the second syllable. For splitting a simple approach from [21] has been adopted. In Q2 (CVC.CV) the intervocalic geminate is divided into two parts of equal duration, in Q3 (CVC:.CV) the second syllable onset is taken equal to one-third of the duration of the intervocalic geminate, and two-thirds of geminate's duration is attributed to the first syllable coda.

Notice that syllable-initial consonants do not participate in forming quantity contrasts, thus they are left out of further analysis. However, durations of C1 and C2 are given in Table 1 and 2 for the reader's interest.

3. Results

3.1. Vowel-peaked structures

Table 1 provides mean segment durations and syllable duration ratios of the Vowel set (36 subjects x 27 words = 972 words) representing the vowel-peaked word structures in Q1, Q2, and Q3 produced by subjects in three groups. ANOVA with factors Subject group and Quantity, and TukeyHSD post-hoc test were applied for statistical analysis. Box plots (Figure 1) and scatter plots (Figure 2) demonstrate variations in V1/V2 ratio, and V1 and V2 duration produced by the three subject groups.

As expected, the segment durations and syllable duration ratios of the L1-EE subject group are in line with those reported in many earlier studies (e.g. [2], [4], [5], [13], and others). Quantity effects durations of V1 [$F_{(2, 321)} = 350.5$; $p < 0.001$] and V2 [$F_{(2, 321)} = 131.6$; $p < 0.001$], and consequently also V1/V2 ratios [$F_{(2, 321)} = 503$; $p < 0.001$], among different quantity degrees.

In the L2-FI group, Quantity has a strong effect on V1 [$F_{(2, 321)} = 210$; $p < 0.001$] and V2 [$F_{(2, 321)} = 92$; $p < 0.001$] duration, and V1/V2 ratio [$F_{(2, 321)} = 248.5$; $p < 0.001$]. However, the post-hoc test confirmed differences in these parameters among Q1 and Q2 ($p < 0.001$), but not between Q2 and Q3. Comparing L2-FI vocalic segments to those of the L1-EE group, there are no significant differences in the case of Q1 and Q3, but large differences exist between the two groups in the case of Q2 in V1, V2, and in V1/V2 ratio ($p < 0.001$). L2-FI subjects do not distinguish the Q2 and Q3 temporal patterns and produce them both similarly to the Q3 pattern of the native group. Notice the almost perfect match of Q2 and Q3 in L2-FI group in Figure 1 and 2 (mid).

Table 1: *Mean duration (in ms) and standard deviation (in parenthesis) of C1, V1, C2, V2, and V1/V2 duration ratio in the three word structures representing the quantity contrasts Q1, Q2 and Q3 read by L1-EE, L2-FI and L2-RU subjects.*

Group	Qs	C1	V1	C2	V2	V1/V2
	Q1	**81**	**81**	**61**	**111**	**0.8**
		(20.1)	(15)	(15.7)	(26.9)	(0.2)
L1-EE	Q2	**85**	**143**	**58**	**85**	**1.8**
		(19.4)	(28.2)	(10.8)	(23.8)	(0.4)
	Q3	**78**	**171**	**59**	**63**	**2.8**
		(21.5)	(30.4)	(11.9)	(12.9)	(0.7)
	Q1	**94**	**74**	**71**	**114**	**0.7**
		(25.2)	(22)	(24.9)	(35.9)	(0.2)
L2-FI	Q2	**106**	**170**	**60**	**66**	**2.8**
		(25.9)	(48.2)	(17.5)	(25.7)	(1)
	Q3	**96**	**173**	**60**	**66**	**2.8**
		(27.4)	(44.8)	(15.7)	(27.7)	(0.9)
	Q1	**99**	**98**	**63**	**100**	**1.1**
		(32.4)	(30)	(19.2)	(38.7)	(0.5)
L2-RU	Q2	**108**	**153**	**61**	**90**	**1.8**
		(28.8)	(35.7)	(16.1)	(33.3)	(0.6)
	Q3	**106**	**155**	**62**	**91**	**1.8**
		(40.2)	(40.6)	(16.6)	(30.8)	(0.6)

In the L2-RU group, in vocalic segments, Quantity has a strong effect on V1 [$F_{(2, 321)} = 88.8$; $p < 0.001$], and on V1/V2 ratio [$F_{(2, 321)} = 61.8$; $p < 0.001$], but a rather weak effect on V2 [$F_{(2, 321)} = 2.8$; $p = 0.06$]. The post-hoc test revealed differences in V1 and in V1/V2 ratio ($p < 0.001$) in Q1 and Q2, but not in Q2 and Q3; Quantity had no effect on V2 duration.
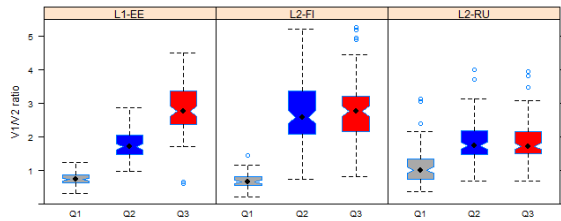
Figure 1: *Box plots of V1/V2 duration ratio in Q1 (gray), Q2 (blue) and Q3 (red) produced by L1-EE (left), L2-FI (mid) and L2-RU (right) subject groups.*
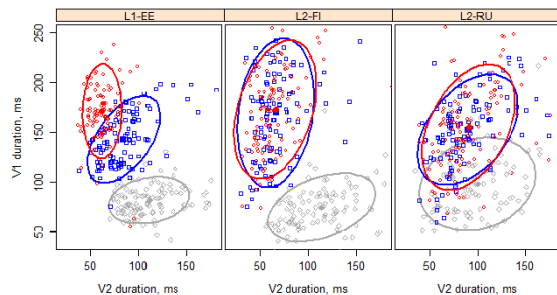

Figure 2: *Scatter plots of V1 and V2 durations in Q1 (gray), Q2 (blue) and Q3 (red) produced by L1-EE (left), L2-FI (mid) and L2-RU (right) subject groups.*

Compared with the L1-EE group, L2-RU vocalic segments deviate in Q1 (p <0.001 in the case of V1 and V1/V2 ratio, p <0.05 in the case of V2) and in Q3 (p <0.001 in the case of V2 and V1/V2 ratio, p <0.01 in the case of V1); no difference between the two groups was found in Q2. Similarly with the L2-FI group, the L2-RU group produces a single temporal pattern for both Q2 and Q3, but it coincides with Q2-pattern of the L1-EE group (see Figure 1 and 2, right).

3.2. Consonant-peaked structures

Table 2 provides mean segment durations of the consonant-peaked word structures in Q1, Q2, and Q3 produced by subjects in the three groups. Part A includes duration data of the Non-plosive set (36 subjects x 12 words = 432 words), and part B of the Plosive set (36 subjects x 9 words = 324 words). Variations in Syl1 rhyme/V2 ratio and Syl1 rhyme and V2 durations are shown in box plots (Figure 3) and scatter-plots (Figure 4).

In the L1-EE group, Quantity strongly effects the duration of Syl1 rhyme in both the Non-plosive [F(2, 141) = 212; p <0.001] and in the Plosive [F(2, 105) = 382.7; p <0.001] sets. Also V2 duration differs significantly among quantities in the Non-plosive [F(2, 141) = 26.6; p <0.001] and the Plosive [F(2, 105) = 43.2; p <0.001] sets. As a result, the characteristic duration ratio Syl1 rhyme/V2 reliably separates the three quantity degrees in both sets (Non-plosive set: [F(2, 141) = 160.5; p <0.001], Plosive set [F(2, 105) = 326.2; p <0.001]). Comparing L1-EE segment durations in the Non-plosive set to those of the Plosive set, differences in most segments emerge. However, these differences are natural due to the variable phonemic identity of the segments. It is important to notice that in both sets segment durations manifest quantity related patterns similar to

the vowel-peaked structures: Syl1 rhyme duration is proportional to the quantity degree (shortest in Q1 and longest in Q3) and V2 duration is inversely proportional (longest in Q1 and shortest in Q3).

Table 2: *Mean duration (in ms) and standard deviation (in parenthesis) of C1, Syl1 rhyme (S1-rh), C2-s2, V2, and Syl1 rhyme/V2 duration ratio (S1-rh/V2) in the three word structures representing the quantity contrasts Q1, Q2 and Q3 in words in the Non-plosive (A) and the Plosive (B) sets read by L1-EE, L2-FI and L2-RU subjects.*

A: Non-plosive set						
Group	Qs	C1	S1-rh	C2-s2	V2	S1-rh/V2
	Q1	**87**	**85**	**63**	**93**	**1.0**
		(17.7)	(13.4)	(20.4)	(29.8)	(0.28)
L1-EE	Q2	**78**	**152**	**55**	**78**	**2.0**
		(18.7)	(19.1)	(10.1)	(17.4)	(0.49)
	Q3	**77**	**191**	**55**	**61**	**3.3**
		(18.9)	(37.3)	(10.1)	(14.5)	(0.93)
	Q1	**106**	**73**	**69**	**97**	**0.8**
		(20.5)	(15.4)	(17.7)	(23.9)	(0.22)
L2-FI	Q2	**98**	**154**	**67**	**71**	**2.4**
		(17.1)	(36.3)	(19.7)	(26.4)	(0.83)
	Q3	**96**	**159**	**67**	**65**	**2.6**
		(19.3)	(37.8)	(19.7)	(18.1)	(0.91)
	Q1	**111**	**95**	**77**	**79**	**1.4**
		(26)	(18.7)	(28.2)	(32)	(0.63)
L2-RU	Q2	**108**	**157**	**61**	**81**	**2.1**
		(24.3)	(22.3)	(16.3)	(30.6)	(0.6)
	Q3	**107**	**155**	**61**	**63**	**2.7**
		(18.8)	(37)	(16.3)	(20.9)	(1.12)
B: Plosive set						
	Q1	**58**	**74**	**74**	**100**	**0.8**
		(14.6)	(16.9)	(12.3)	(25.2)	(0.18)
L1-EE	Q2	**57**	**132**	**67**	**77**	**1.8**
		(19.2)	(12.1)	(6.7)	(18.4)	(0.52)
	Q3	**49**	**199**	**67**	**55**	**3.8**
		(16.3)	(25.7)	(6.6)	(13.5)	(0.68)
	Q1	**60**	**65**	**92**	**107**	**0.7**
		(20.4)	(13.9)	(23.8)	(41.6)	(0.28)
L2-FI	Q2	**58**	**134**	**75**	**74**	**2.4**
		(16.7)	(34.6)	(29.5)	(36)	(1.36)
	Q3	**56**	**187**	**75**	**64**	**3.2**
		(15.7)	(43.9)	(29.5)	(22.4)	(1.3)
	Q1	**71**	**91**	**69**	**95**	**1.1**
		(24.5)	(29.5)	(14.3)	(41.1)	(0.53)
L2-RU	Q2	**74**	**138**	**67**	**65**	**2.2**
		(20)	(21.3)	(16.5)	(16.2)	(0.49)
	Q3	**63**	**180**	**67**	**58**	**3.3**
		(16.3)	(40.6)	(16.5)	(18.3)	(1.15)

Quantity effects Syl1 rhyme and V2 durations, and also their ratios in both L2 groups, however, differences from the native group exist. In the L2-FI group, in the Non-plosive set, Quantity has strong effect on Syl1 rhyme [F(2, 141) = 111.8; p <0.001]); however, Syl1 rhyme differs only among Q1 and Q2 (Q1: 73 ms, Q2: 154 ms; p <0.001), but not in Q2 and Q3 (Q2: 154 ms, Q3: 159 ms; p = 0.7). In the Plosive set, L2-FI subjects produce different Syl1 rhyme durations in the three quantity degrees [F(2, 105) = 121.8; p <0.001], the mean durations for Q1 are: 65 ms, for Q2: 134 ms, and for Q3: 187 ms. V2 duration
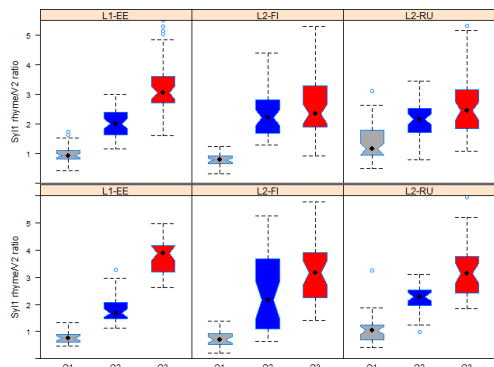
Figure 3: *Box plots of Syl1 rhyme/V2 duration ratio in Q1 (gray), Q2 (blue) and Q3 (red) of Non-plosive (top) and Plosive (bottom)sets produced by L1-EE (left), L2-FI (mid) and L2-RU (right) subject groups.*
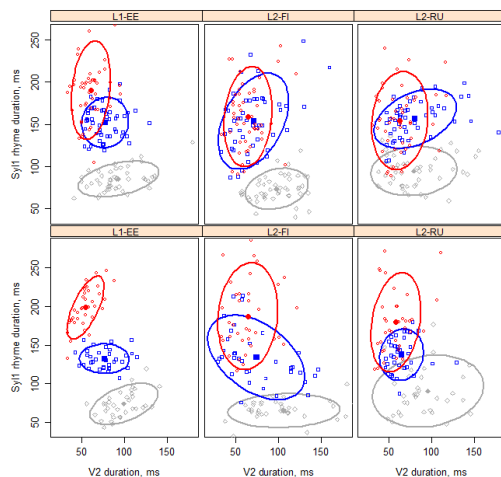

Figure 4: *Scatter-plots of Syl1 rhyme and V2 durations in Q1 (gray), Q2 (blue) and Q3 (red) of Non-plosive (top) and Plosive (bottom) sets produced by L1-EE (left), L2-FI (mid) and L2-RU (right) subject groups.*

has similar patterns in both word sets: V2 duration differs only between Q1 and Q2 (p <0.001), but not between Q2 and Q3. As a result, the Syl1 rhyme/V2 ratio in the Non-plosive set is 0.8 for Q1, 2.4 for Q2, and 2.6 for Q3; these ratios differ between Q1 and Q2 (p <0.001), but not between Q2 and Q3 (p = 0.2). In the Plosive set, the duration ratios are 0.7, 2.4, and 3.2, respectively, and provide a reliable difference between all quantity degrees (p <0.001).

For the L2-RU group, Quantity has a similar effect as in the case of L2-FI group for Syl1 rhyme which differs in the Non-plosive set between Q1 and Q2 only (Q1: 95 ms, Q2: 157 ms; p <0.001), and not between Q2 and Q3 (Q2: 157 ms, Q3: 155 ms; p = 0.9), and in the Plosive set, it differs among all quantities [F(2, 105) = 72.2; p <0.001]), the mean durations are 91 ms, 138 ms, and 180 ms for Q1, Q2 and Q3, respectively. V2 duration shows different patterns: in the Non-plosive set it is almost the same in Q1 and Q2 (Q1: 79 ms, Q2: 81 ms; p = 0.96), but it differs between Q2 and Q3 (Q2: 81 ms, Q3: 63 ms;

p <0.01); in the Plosive set V2 duration differs between Q1 (95 ms) and Q2 (65 ms) (p <0.01), but not between Q2 and Q3 (58 ms) (p = 0.6). Consequently, Syl1 rhyme/V2 duration ratio is distinctive among all quantity degrees in both word sets: in the Non-plosive set Q1: 1.4 vs. Q2: 2.1 (p <0.001) and Q2: 2.1 vs. Q3: 2.7 (p <0.01); in the Plosive set Q1: 1.1 vs. Q2: 2.2 vs. Q3: 3.3 (p <0.001).

4. Discussion

The languages involved in the study differ in the way the duration cue is exploited in phonological contrasts. Estonian and Finnish are quantity languages, both exploiting the duration cue contrastively, while Russian is a non-quantity language lacking duration-based phonological oppositions. There are two theoretical models addressing the role of duration in L2 speech: (1) the *Feature Hypothesis* states that "L2 features not used to signal phonological contrasts in L1 will be difficult to perceive for the L2 learner and this difficulty will be reflected in the learner's production" [22], (2) the *Desensitization Hypothesis* states that duration cues are easy to access whether or not listeners have had specific linguistic experience with them [23].

The first model predicted an advantage for the L2-FI group over the L2-RU group since L2-FI subjects can exploit the binary contrasts available in Finnish. The second model suggested that also L2-RU subjects should be able to distinguish Estonian quantity contrasts even though there is no corresponding prosodic pattern in Russian to rely on. The Q1 vs. Q2 results support the second hypothesis since both L2 groups were successful in producing the Q1 vs. Q2 opposition. With respect to the Q2 vs. Q3 results, neither hypothesis can be favored (more space would be needed to elaborate on theoretical implications).

The most surprising result was that the L2-RU group outperformed the L2-FI group in producing distinct Q2 and Q3 patterns in the Non-plosive set. This may have to do with the fact that our Finnish speakers had learned Estonian as adults while the Russian speakers mostly in childhood, in addition, the exposure to and use of Estonian is much more frequent in the case of the L2-RU group. Also, the methods how the Estonian quantity contrasts have been taught might effect the results.

5. Conclusions

In the paper we studied the effect of L2 orthographic input on L2 pronunciation of vowel-peaked and consonant-peaked quantity contrasts. Only in the Plosive set the quantity contrasts are explicitly expressed in the orthography, unlike the Vowel set and the Non-plosive set. The results confirmed the role of L2 orthographic input in the case of the L2-FI group – in the Plosive set the L2-FI subjects produced different patterns for Q2 and Q3 structures, but not in the other sets. However, the role of orthography can not be conclusive in the case of the L2-RU subjects since they produced different patterns for Q2 and Q3 structures also in the Non-plosive set.

6. Acknowledgements

7. References

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