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PRODUCTION OF ESTONIAN QUANTITY CONTRASTS BY JAPANESE SPEAKERS

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Abstract. Estonian and Japanese are quantity languages both exploiting the duration cue to implement phonological contrasts. However, the quantity systems of the two languages are different – Estonian features a three-way quantity contrast while Japanese has a binary contrast. This paper studies how L2 subjects with Japanese-language background (L2-JP) produce the Estonian quantity contrasts. For the acoustic analysis the speech recordings by six L2-JP subjects and 12 native Estonian (L1-EE) subjects were used. The material analyzed consists of read sentences comprising triplets of segmentally identical disyllabic target words in the quantities Q1 (short), Q2 (long) and Q3 (overlong). In their production, the L2-JP subjects successfully produced the Q1/Q2 contrast but failed in contrasting vocalic Q2 and Q3 (CVVCV *vs.* CVV:CV) oppositions; however, the subjects managed to produce the Q2/Q3 consonantal quantity contrasts (CVCCV *vs.* CVC:CV). The L2-JP subjects' segment durations differing from those of the L1-EE subjects, reveal the role of native durational patterns on the acquisition of Estonian quantity oppositions.

Keywords: Estonian, Japanese, L2 speech, phonological length, quantity contrasts

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1. Introduction

Language-specific differences in the phonological systems of a subject's native language and a foreign language emerge in the production and perception of a foreign language, especially in adult learners. Besides general theoretical models focusing on the perception and production of second language (L2) sounds, e.g., the Perceptual Assimilation Model (PAM and PAM-L2, Best, 1995, Best and Tyler 2007) and the Speech Learning Model (SLM, Flege 1995), there are two models that specifically address the role of duration in L2 speech. Namely, (1) the Desensitization Hypothesis which states that duration cues are easy to access whether or not listeners have had previous linguistic experience with them (Bohn 1995), and (2) the Feature Hypothesis which claims that learning L2 durational contrasts is likely to be connected

with the role of the duration feature in learner's native language (L1) (McAllister et al. 2002).

In this paper we will study how L2 subjects with Japanese-language background (L2-JP) produce the Estonian quantity contrasts. In both Estonian and Japanese, the acoustic duration of speech segments plays an important role in manifesting phonological contrasts. While Estonian has a three-way quantity system in a disyllabic foot (Lehiste 1997, Lehiste 2003, Eek and Meister 1997, Krull and Traunmuller 2000), referred to as short (Q1), long (Q2), and overlong (Q3), Japanese quantity system is binary: short and long (Han 1962).

In Estonian, the three-way quantity contrasts occur in both vowels and consonants as shown in the following examples:

(1) word structures with vocalic quantity contrast:
Q1 (short): *sada* /sa.ta/ 'hundred', nominative singular;
Q2 (long): *saada* /saa.ta/ 'to send', singular imperative;
Q3 (overlong): *saada* /saa:.ta/ 'to get', *da*-infinitive;

(2) word structures with consonantal quantity contrast:
Q1 (short): *lugu* /lu.ku/ 'story' nominative singular;
Q2 (long): *luku* /luk.ku/ 'lock' genitive singular;
Q3 (overlong): *lukku* /luk:.ku/ 'lock' partitive singular.

The examples of Japanese binary quantity contrast in both vowels and consonants are:

(1) in vowels:
short: /kado/ 'corner'
long: /ka:do/ 'card'; /kado:/ 'floral art'

(2) in consonants:
short: /kata/ 'shoulder'
long: /kat:a/ 'bought'

In Estonian, a vocalic quantity contrast is possible in stressed syllables only; the duration of the vowel in the unstressed syllable following the stressed syllable is longer in Q1 words than in Q2 and Q3 words; however, vowels in unstressed syllables are classified as phonologically short. In Japanese, the short/long contrast in vowels is possible in any syllable (see examples above). In addition, the two languages are different in the light of the isochrony theory (Pike 1945, Abercrombie 1967). Estonian is considered a 'syllable-timed' language (Eek and Help 1987) and manifests a tendency to foot-isochrony (Lehiste and Ross 2001, Nolan and Asu 2009), while Japanese is categorized as a 'mora-

timed' language (Warner and Arai 2001, Bloch 1950). Japanese is also known as a 'pitch-accent' language exploiting tones for distinguishing same-sounding words (Hasegawa 1999). For example, /kat:a/ with L-H pitch pattern means 'to buy' (past tense) and with H-L pattern it means 'to win'. Also in Estonian, pitch has been found to play the role of a secondary cue, especially in distinguishing Q2 and Q3 words (Lehiste 1960; Liiv 1961, Eek 1980).

As pooled over several studies (Liiv 1961, Eek 1974, Krull 1997, Eek and Meister 1998, Eek and Meister 2003, Asu et al. 2009), in Estonian native speech, the mean duration of short stressed vowels measured in Q1 words is 93 ms (sd = 23 ms) and the duration of long stressed vowels in Q2 and Q3 is 175 ms (sd = 43 ms) and 228 ms (sd = 67 ms), respectively. The rather large variation of vowel durations is explained by the variable prosodic context of measured words (sentence-initial, sentence-final, focus, non-focus), variable speech style (read speech, spontaneous speech), and variable articulation rate (fast, moderate, slow) analyzed in different studies. Despite the large variations in vowel duration, the mean long/short duration ratio remains rather stable across all variables and equals 1.9 (sd = 0.2) when comparing Q2 vs. Q1 words, and 2.5 (sd = 0.3) when comparing Q3 vs. Q1 words.

In the word structures with consonantal quantity the intervocalic consonant at the syllable boundary manifests a singleton vs. geminate contrast. As reported in Suomi et al. (2013), the mean duration of a singleton consonant in Q1 structure is 71 ms (sd = 10 ms), and the mean duration of a geminate consonant is 140 ms (sd = 33 ms) and 173 ms (sd = 32 ms) in the structures Q2 and Q3, respectively. The mean geminate/singleton duration ratio is 2.0 (sd = 0.2) for Q2 vs. Q1, and 2.4 (sd = 0.1) for Q3 vs. Q1 comparison.

In Japanese, long vowels are 2.4–3.2 times longer than short vowels in minimal pair words (e.g. Han 1962, Ueyama 2000). Hirata (2004) studied vowel durations and long/short duration ratios in two-syllable non-words spoken at slow, normal and fast articulation rate. In normal speech, the mean durations of accented vowels were 82 ms and 209 ms for short and long vowels, respectively. The mean long/short duration ratio 2.55 was maintained across all speaking rates. Similar results have been reported by Isei-Jaakkola (2004): the mean duration of a short vowel /a/ in variable consonantal context was 84.8 ms (sd = 16.7 ms), and that that of a corresponding long vowel 211.0 ms (sd = 16.7 ms); the long/short duration ratio equals to 2.5.

For the singleton vs. geminate contrast in Japanese variable results have been reported. Homma (1981) measured the Japanese short and

long plosives (closure part + VOT) in a carrier sentence and reported the mean duration for a singleton as 66.7 ms and 176 ms for a geminate, resulting in the geminate/singleton ratio 2.6. A more recent study by Hirata and Whiton (2005) reports, for a singleton plosive (closure part + VOT), the mean duration of 93 ms, and 235 ms for a geminate plosive; however, the geminate/singleton ratio 2.5 is in line with Homma's results. For more data from different studies see Isei-Jaakkola (2004).

To achieve native-like production of Estonian quantity contrasts it is not enough to distinguish the short/long contrast in stressed (typically word-initial) syllable only, but also to produce adequate temporal relations of stressed and unstressed syllables. Foot isochrony implies that the duration of an unstressed second-syllable vowel (V2) must vary inversely with the duration of the stressed syllable vowel (V1). In Estonian native speech, the syllable duration ratio (V1/V2) introduced by Lehiste (1960) to distinguish the three quantity oppositions is 0.6 – 0.8 (mean = 0.7) for Q1, 1.4 – 2.0 (mean = 1.6) for Q2, and 2.0 – 3.9 (mean = 2.8) for Q3, as pooled over several studies for vocalic quantity contrast (Liiv 1961, Eek 1974, Krull 1997, Eek and Meister 1998, 2003, Asu et al. 2009). A more recent paper (Lippus et al. 2013) studied the quantity-related variations of duration, pitch and vowel quality in spontaneous Estonian and reported the characteristic duration ratios for both vocalic and consonantal quantity contrasts for disyllabic words in accented and unaccented positions. The mean duration ratio for Q1 words was 0.7, for Q2 words 1.6 and 2.2, and for Q3 words 2.4 and 3.0 for vocalic and consonantal quantity contrasts, respectively.

Our former studies on the production of Estonian quantity contrasts by L2 subjects with Russian, Finnish, and Latvian language backgrounds have shown that L2 subjects successfully produced the Q1/Q2 contrast, but had difficulties to produce distinct patterns for Q2 and Q3 regardless of variable use of the duration cue in their native language (Finnish and Latvian use the duration cue for phonological contrasts and Russian does not) (Meister and Meister 2012a, 2013ab, 2014ab). It was found that Q2 and Q3 temporal patterns by Finnish (L2-FI) and Latvian (L2-LV) L2 subjects are close to the native Estonian (L1-EE) Q3 pattern while L2 subjects with Russian language background (L2-RU) produce durational patterns close to Estonian Q2.

The results above suggest that L2 subjects with Japanese language background may also have problems in distinguishing the Q2 and Q3 patterns and will produce both Q2 and Q3 words with the durational pattern typical of Q3. In both Japanese vowels and consonants the typical long/short (geminate/singleton) ratio is around 2.5 which is close

to the typical ratios for Estonian Q3 (2.4 – 2.5), and the native short/long patterns may hinder the formation of new temporal patterns for Estonian Q2 (long/short ratio 1.9 – 2.0). However, an L2 quantity study comparing American English and Japanese has shown that some L2 subjects with Japanese background successfully produced an English-like pattern for English tense and lax vowels (tense/lax duration ratio 1.3) whereas some L2 subjects produced their native short/long pattern (Ueyama 2000). Interestingly, there was no correlation with L2 proficiency.

In this paper we aim to study how L2 subjects with Japanese-language background produce the Estonian quantity contrasts by comparing the durations of segments in disyllabic target words involving vocalic and consonantal quantity contrast produced by the L1-EE and the L2-JP subject groups. Considering the role of duration in the two languages and the earlier findings discussed above, we will make the following hypotheses for the current study:

(1) In line with the Feature Hypothesis (McAllister et al. 2002), Japanese subjects benefit from the short/long contrast existing in their native phonology and are expected to successfully produce Estonian Q1/Q2 contrasts;
(2) For the distinction of Estonian Q2/Q3 three alternatives should be considered:
   a) L2-JP subjects will have difficulty to distinguish the Estonian Q2/Q3 contrast since it involves new temporal patterns not available in Japanese,
   b) L2-JP subjects will rely on the short/long contrast existing in their native phonology and may be able to produce different patterns for Q2 and Q3, as suggests the Feature Hypothesis (McAllister et al. 2002),
   c) L2-JP subjects may be able to easily adapt to salient duration differences existing in Q2 and Q3 and therefore be able to produce different patterns for Q2 and Q3, as the Desensitization Hypothesis (Bohn 1995) suggests.

2. Method

2.1. Subjects

The native subject group (L1-EE) includes 12 native speakers of Estonian (6 male, 6 female). The L1-EE subjects (age 21–54, median 26.5) were from monolingual Estonian-speaking families living in the

capital area. All L1-EE subjects have acquired or were acquiring a university degree. They represent standard Estonian pronunciation.

Six native speakers of Japanese (3 male, 3 female) served as the L2-JP group. The L2-JP subjects (age 32–45, median 36.5) came from monolingual Japanese-speaking families living in Japan. They were educated in different high schools or universities in Japan, they started to study Estonian after arriving to Estonia at the age of 19–43 (median 27.5). They have stayed in Estonian for several years and use Estonian daily. In self-assessment two subjects rated his/her proficiency in Estonian as "intermediate" and four subjects as "advanced".

2.2. Speech material

All subjects participated in the recordings of the Estonian Foreign Accent Corpus (Meister and Meister 2012b, 2013c, 2015), in which disyllabic target words representing quantity oppositions in sentence context are included. During the recordings, the subjects read an Estonian text corpus including 140 sentences containing the main phonological oppositions of Estonian, two short passages, and in order to elicit spontaneous speech, the subjects introduced themselves and described three photos. All subjects were recorded in the recording studio of the Laboratory of Phonetics and Speech Technology, Tallinn University of Technology. All recordings were carried out using the same microphones and high quality recording equipment (sampling frequency 44.1 kHz, resolution 16 bit).

For this study, we use a subset of the corpus that contains 27 segmentally identical disyllabic target words (9 triplets) representing the vocalic quantity contrast Q1 (CV.CV), Q2 (CVV.CV), and Q3 (CVV:.CV), and 27 disyllabic target words (9 triplets) representing the consonantal quantity contrast Q1 (CV.CV), Q2 (CVC.CV), and Q3 (CVC:.CV). The target words were embedded in short meaningful sentences of similar structure.

A small Japanese corpus was recorded by the same Japanese subjects (referred as L1-JP) when reading the story "The North Wind and the Sun" in Japanese, and 20 phonetically rich Japanese sentences. This corpus was important as a reference for native Japanese duration and for comparing native Japanese quantity with their L2 Estonian duration.

All recordings were manually segmented using Praat (Boersma and Weenink 2015) on lexical and segmental levels.

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 distinguishing the three quantity oppositions was calculated. In the case of a vocalic quantity contrast, the 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 target words with a consonantal quantity contrast, the duration ratio is calculated as the duration of Syllable 1 rhyme divided by the duration of Syllable 2 nucleus (V2). An approach from Eek and Meister (2004) has been adopted for splitting the word-medial geminate consonant into the coda of the first syllable and the onset of the second syllable: in CVC.CV (Q2) structures, the intervocalic geminate is equally divided into two parts, in CVC:.CV (Q3) structures, two-thirds of the geminate's duration is attributed to the first syllable coda and one-third to the second syllable onset. Then the duration of Syllable 1 rhyme is found as the sum of duration of V1 and the duration of the first syllable coda. Note that syllable-initial consonants do not participate in the quantity opposition.

3. Results

3.1. Words with a vocalic quantity contrast

Table 1 shows average segment durations and duration ratios of the word structures with a vocalic quantity contrast (L1-EE: 12 subjects x 27 words = 324 words, L2-JP: 6 subjects x 27 words = 162 words) in Q1 (CV.CV), Q2 (CVV.CV), and Q3 (CVV:.CV), the corresponding boxplots are presented in Figure 1. Analysis of variance (ANOVA) with factors Subject group (L1-EE and L2-JP) and Quantity (Q1, Q2, Q3) and TukeyHSD post-hoc test were applied for statistical analysis using R (R Core Team 2014). The ANOVA results comparing each segment of L1-EE and L2-JP are also given in Table 1.

Comparing L1-EE vocalic segments to those of the L2-JP group, no significant difference is observed in the case of Q1. However, large differences exist between the two groups in the case of Q2 and Q3 in V1, V2, and consequently, in V1/V2 ratio ($p < 0.001$ for V1 in Q2 and Q3, V2 in Q3, V1/V2 in both Q2 and Q3, and $p < 0.01$ for V2 in Q2). While L1-EE subjects produce three different durations for both V1

and V2 in the three quantity degrees ($p < 0.001$), the L2-JP subjects produce different V1 and V2 durations for Q1 and Q2 (V1: $p < 0.001$; V2: $p < 0.05$) but not for Q2 and Q3 (V1: $p=0.96$; V2: $p=0.98$) words. Consequently, the V1/V2 duration ratio in the L1-EE group results in three well-distinguished patterns ($p < 0.001$) while in the case of L2-JP group Q2 and Q3 patterns do not differ ($p=0.85$). There is no difference between the two groups in the case of Q1 ($p=0.2$), but the production of both Q2 and Q3 words by the L2-JP subjects deviates from the L1-EE group ($p < 0.001$). The mean values of the V1/V2-ratio for Q2 (2.4) and Q3 (2.3) of the L2-JP group lay between the corresponding values of the L1-EE group (1.8 and 2.8 for Q2 and Q3, respectively).

Table 1. Mean durations (in ms) and standard deviations (in parenthesis) of C1, V1, C2, V2, and V1/V2 duration ratios of the three word structures representing the vocalic quantity contrasts Q1, Q2 and Q3 read by L1-EE and L2-JP subjects (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$)

Qs	Subjects	C1	V1	C2	V2	V1/V2
Q1	L1-EE	81 (21)	81 (15)	81 (16)	111 (27)	0.8 (0.2)
	L2-JP	104 (41)	90 (45)	63 (32)	121 (51)	0.8 (0.4)
	p	***				
Q2	L1-EE	85 (19)	143 (28)	58 (11)	85 (24)	1.8 (0.4)
	L2-JP	120 (42)	189 (55)	63 (32)	100 (44)	2.4 (1.8)
	p	***	***		**	***
Q3	L1-EE	78 (21)	171 (30)	59 (12)	63 (13)	2.8 (0.7)
	L2-JP	117 (39)	192 (46)	57 (21)	98 (38)	2.3 (1.2)
	p	***	***		***	***

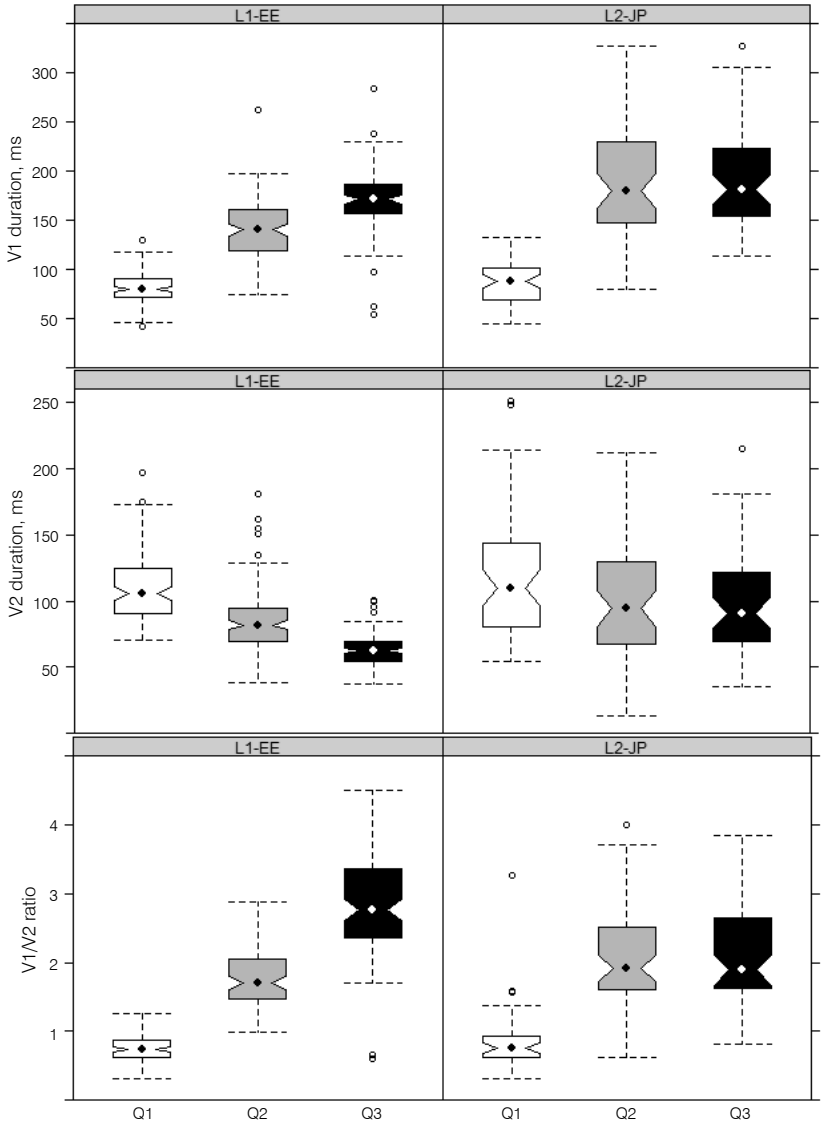

Figure 1. Boxplots of V1 duration (top), V2 duration (middle), and V1/V2 duration ratio (bottom) in Q1 (white), Q2 (grey), and Q3 (black) in the target words with vocalic quantity contrast produced by L1-EE (left) and L2-JP (right) subjects.

The mean long/short duration ratio in the L1-EE group is 1.8 and 2.1 when comparing Q2 vs. Q1 and Q3 vs. Q1, respectively. The L2-JP group has produced equal values of the long/short duration ratio 2.1 for both Q2 vs. Q1 and Q3 vs. Q1.

Significant differences between the two groups are observed in the case of C1 duration in all quantity degrees; however, word-initial consonants do not participate in quantity oppositions.

3.2. Words with a consonantal quantity contrast

Table 2 provides mean segment durations of word structures with a consonantal quantity contrast in Q1 (CV.CV), Q2 (CVC.CV), and Q3 (CVC:.CV) produced by the two subject groups, the corresponding boxplots are presented in Figure 2. The Consonant set includes duration data measured from 252 words (12 subjects x 21 words) produced by the L1-EE group and 162 words (6 subjects x 27 words) by the L2-JP group. The consonants occurring in the intervocalic position are: /k/, /p/, /t/, /l/, /m/, /n/, and /s/.

In the word structures with a consonantal quantity contrast significant differences in duration of vocalic segments in the two groups are found in V1 ($p < 0.05$) in the case Q1, and in V2 ($p < 0.001$) in the case Q3. C1 and C2 exhibit differences between the groups. However, as mentioned above, C1 has no contrastive role in distinguishing quantity oppositions; instead, C2 is the main segment manifesting quantity-related contrasts. Both subject groups produce C2 with different durations for the three quantity degrees (L1-EE: $p < 0.001$ for all contrasts, L2-JP: $p < 0.001$ for Q1 vs. Q2 and $p < 0.05$ for Q2 vs. Q3). In both groups, there is no quantity-related difference in V1. V2 duration varies reversely to C2 duration, resulting in three patterns ($p < 0.001$ for all quantity contrasts) in the case of L1-EE group, but only two patterns in the case of L2-JP group ($p < 0.01$ for Q1 vs. Q2 and $p=0.7$ for Q2 vs. Q3). Both subject groups exhibited distinct S1/S2 values for the three quantity contrasts ($p < 0.001$ for all contrasts), the differences between the groups are minor and significant in the case of Q3 only ($p < 0.05$).

The mean geminate/singleton duration ratios are comparable in the both groups: 1.8 in the L1-EE group and 2.0 in the L2-JP group when comparing Q2 vs. Q1, and 2.5 in the L1-EE group and 2.3 in the L2-JP group when comparing Q3 vs. Q1.

Table 2. Mean durations (in ms) and standard deviations (in parenthesis) of C1, V1, C2, V2, and duration ratios of Syllable 1 rhyme and Syllable 2 nucleus (S1/S2) in target words representing the consonantal quantity contrasts Q1, Q2 and Q3 read by L1-EE and L2-JP subjects (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$)

Qs	Subjects	C1	V1	C2	V2	S1/S2
Q1	L1-EE	75 (22)	80 (16)	68 (18)	96 (28)	0.9 (0.3)
	L2-JP	103 (40)	87 (20)	78 (39)	104 (44)	0.9 (0.3)
	p	***	*			
Q2	L1-EE	69 (22)	84 (21)	120 (21)	78 (19)	1.9 (0.5)
	L2-JP	95 (29)	84 (27)	153 (52)	84 (34)	2.2 (0.9)
	p	***		***		
Q3	L1-EE	65 (23)	85 (24)	169 (38)	58 (14)	3.6 (0.9)
	L2-JP	98 (33)	86 (26)	178 (63)	78 (27)	3.1 (1.9)
	p	***			***	*

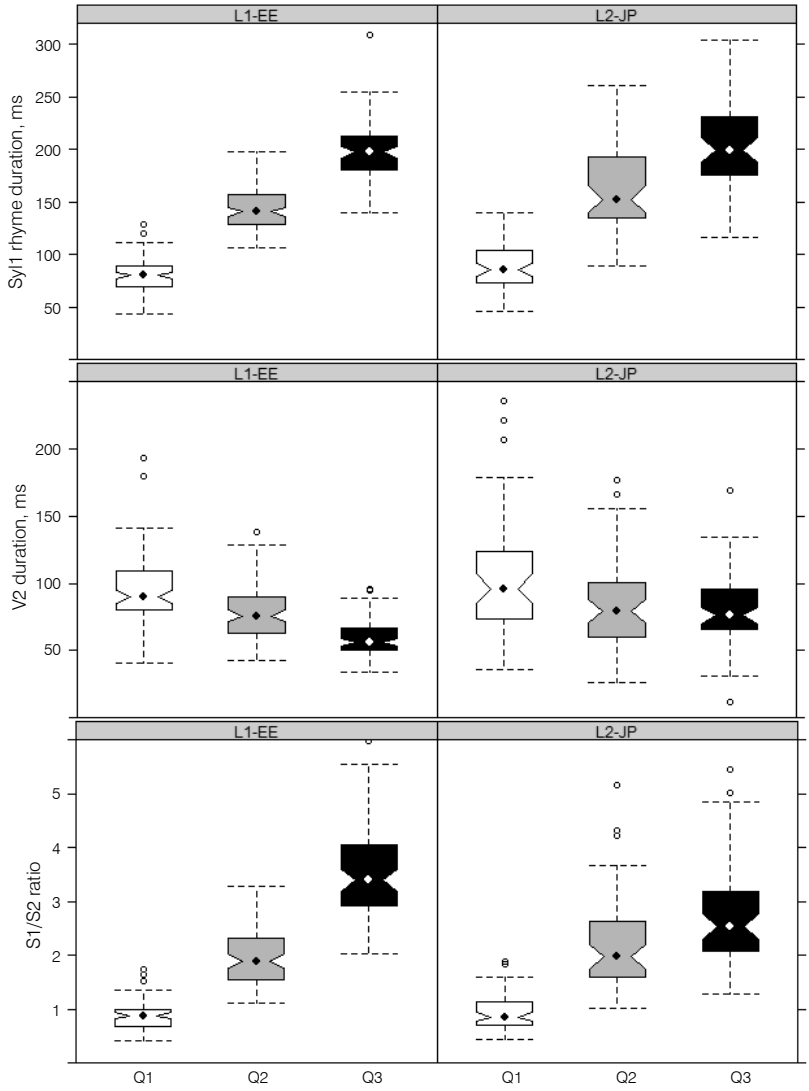

Figure 2. Boxplots of Syllable 1 rhyme duration (top), V2 (=Syllable 2 nucleus) duration (middle), and Syll1/Syll2 duration ratio (bottom) in Q1 (white), Q2 (grey), and Q3 (black) words with consonantal quantity contrast produced by L1-EE (left) and L2-JP (right) subjects.

3.3. Segment durations in L1-JP

Table 3 provides mean durations of Japanese vowels and consonants measured from the small Japanese corpus recorded by the same Japanese speakers. It serves as a reference for comparing native Japanese durations with their L2 Estonian durations. The mean durations of native Japanese short/long segments and the long/short duration ratio are close to the results reported in previous studies (e.g. Hirata 2004, Isei-Jaakkola 2004).

Table 3. Mean durations (in ms) and standard deviations of native Japanese vowels and consonants, and long/short duration ratios. (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$).

Segment	Quantity	Duration	Sd	Long/short ratio
Vowels	Short	78.9	30.1	2.1
	Long	167.0	34.8	
	p	***		
Consonants	Short	90.5	31.6	2.1
	Long	194.2	39.1	
	p	***		

4. Discussion and conclusions

The results of this study show that L2 subjects with Japanese language background produce the Estonian quantity contrasts variably: in the word structures with a vocalic quantity contrast they successfully produce the Q1/Q2 contrast, but do not distinguish the Q2 and Q3 patterns, whereas in the word structures with a consonantal quantity contrast they manage to produce separate patterns for all three quantities.

In L2-JP speech, the long/short duration ratio in vowels (cf. Table 1, V1 duration in Q2, Q3 vs. Q1) is exactly the same (2.1) as in their native speech (cf. Table 3). Hence, the L2-JP subjects exploit their native duration contrast also for Estonian, resulting in the identical patterns for Q2 and Q3. The difficulty to distinguish the vocalic Q2 and Q3 patterns can be explained by the fact that the Q2 and Q3 structures with the vocalic quantity contrast, representing different grammatical words, are not distinguished in the orthography. This may lead the L2-JP subjects

to use the same pattern for the production of both Q2 and Q3 words. As our former studies have shown, L2 subjects with Russian (L2-RU), Finnish (L2-FI) and Latvian (L2-LV) language backgrounds have a similar inability to distinguish vocalic Q2 and Q3 structures (Meister and Meister 2012a, 2013b, 2014a, 2014b). However, L2 subjects with different language backgrounds produce different durational patterns – L2-RU subjects produce both Q2 and Q3 words as Estonian Q2 words, L2-FI and L2-LV subjects as Estonian Q3 words, and L2-JP subjects in-between Estonian Q2 and Q3.

In the production of consonantal quantity contrasts, the L2-JP subjects successfully distinguished all three structures; however, their Q3 pattern deviates significantly from the corresponding L1-EE pattern (see Figure 2, bottom). For the native Estonian listeners, it may result in an ambiguous perception of Q3 words produced by L2-JP subjects since Estonian listeners expect much higher Q3 syllable duration ratio than that produced by L2-JP subjects. In the case of target words involving plosives in the intervocalic position, the Q1 – Q2 – Q3 contrasts are expressed orthographically (see Introduction for examples), but not in the case of other intervocalic consonants (e.g., Q1: *kanu* /ka.nu/ 'chicken', part.pl.; Q2: *kannu* /kan.nu/ 'kettle', gen.sg.; Q3: *kannu* / kan:.nu/ 'kettle', part.sg.). However, no effect of the type of intervocalic consonant was found. It might be that the orthographic manifestation of quantity contrasts in the case of plosives has contributed to the acquisition of the appropriate durational patterns in all consonantal quantity contrasts. Formerly, it has been found that L2 orthography contributes to the target-like production of consonant-peaked quantity oppositions in L2-RU and L2-FI subjects (Meister and Meister 2014a).

The results of the study indicate well how the L2 subjects with Japanese language background could achieve more native-like production of Estonian quantity contrasts. In the words with vocalic quantity contrast, shortening of a long vowel in Q2 stressed syllable (V1) and of a short vowel in Q3 unstressed syllable (V2) by ca 40–50 ms will result in native-like syllable duration ratios for Q2 and Q3, respectively (see Figure 1). In the words with consonantal quantity contrast, the reduction of a short vowel in Q3 unstressed syllable (V2) by ca 20 ms will result in more natural-sounding Q3 words (see Figure 2).

The first hypothesis posed for the study was supported by the results – the L2-JP subjects distinguished the Estonian Q1 and Q2 words well, as predicted by the Feature Hypothesis (McAllister et al. 2002). As far as the alternatives considered in the second hypothesis are concerned, only the first alternative was supported by the results. Both

the Feature Hypothesis (McAllister et al. 2002) and the Desensitization Hypothesis (Bohn 1995) failed to predict the difficulty to distinguish the Estonian Q2/Q3 vocalic contrast by the L2-JP subjects. However, the subjects did manage to produce the Q2/Q3 consonantal quantity contrasts, probably due to the fact that the plosive quantity differences are revealed in the orthography. The Q2/Q3 contrast involves new temporal patterns not available in Japanese; in addition, Q2/Q3 words with the vocalic contrast are not distinguished orthographically which makes the learning of the new L2 patterns even more difficult. Use of the duration cue in Estonian quantity contrasts is by far too complex to be easily accessed even by subjects whose native language employs the duration cue contrastively. The durational relations in Estonian quantity contrasts are not easy to acquire by the L2-JP subjects since their native binary contrast may hinder the formation of new temporal patterns, and a simple matching of the Japanese binary contrast to the ternary contrast in Estonian cannot be a successful strategy.

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References

Abercrombie, David (1967) *Elements of general phonetics*. Edinburgh: Edinburgh University Press.

Asu, Eva Liina, Pärtel Lippus, Pire Teras, and Tuuli Tuisk (2009) "The realization of Estonian quantity characteristics in spontaneous speech". In M. Vainio, R, Aulanko,

O. Aaltonen, eds. *Nordic prosody: proceedings of the Xth conference,* 49–56.Frankfurt, Berlin, and New York: Peter Lang.

Best, Catherine T. (1995) "A direct realist view of cross-language speech perception". In W. Strange, ed. *Speech perception and linguistic experience: issues in cross-language research,* 171–204. Timonium, MD: York Press.

Best, Catherine T. and Michael D. Tyler (2007) "Nonnative and second language speech perception: commonalities and complementarities". In M. J. Munro and O.-S. Bohn, eds. *Second language speech learning: the role of language experience in speech perception and production*, 13–34. Amsterdam: John Benjamins.

Boersma, Paul and David Weenink (2015) *Praat: doing phonetics by computer [computer program]*. Version 5.4.22. Available online at <http://www.praat.org/>. Accessed on 09.10. 2015.

Bloch, Bernard (1950) "Studies in colloquial Japanese IV: phonemics". *Language* 26, 86–125.

Bohn, Ocke-Schwen, (1995) "Cross-language perception in adults: first language transfer doesn't tell it all". In W. Strange ed. *Speech perception and linguistic experience: issues in cross-language research,* 379–410. Timonium, MD: York Press.

Eek, Arvo (1974) "Observations on the duration of some word structures: I". *Estonian papers in phonetics*, 18–31. Tallinn.

Eek, Arvo (1980) "Further information on the perception of Estonian quantity". *Estonian papers in phonetics*, 31–57. Tallinn.

Eek, Arvo and Toomas Help (1987) "The interrelationship between phonological and phonetic sound changes: a great rhythm shift of Old Estonian". *Proceedings of the 11th ICPhS*, 6, 218–233. Tallinn, Estonia: Academy of Sciences of the Estonian S.S.R.

Eek, Arvo and Einar Meister (1997) "Simple perception experiments on Estonian word prosody". In I. Lehiste and J. Ross, eds. *Estonian prosody: papers from a symposium*, 71–99. Tallinn: Institute of Estonian Language.

Eek, Arvo and Einar Meister (1998) "Quality of standard Estonian vowels in stressed and unstressed syllables if the feet in three distinctive quantity degrees". *Linguistica Uralica* 34, 3, 226–233.

Eek, Arvo and Einar Meister (2003) "Foneetilisi katseid ja arutlusi kvantiteedi alalt (I). Häälikukestusi muutvad kontekstid ja välde". *Keel ja Kirjandus* 46, 11–12, 815–837, 904–918.

Eek, Arvo and Einar Meister (2004) "Foneetilisi katseid ja arutlusi kvantiteedi alalt (II): Takt, silp ja välde". *Keel ja Kirjandus* 47, 4, 251–271.

Flege, James Emil (1995) "Second language speech learning: theory, findings, and problems". In W. Strange ed. *Speech perception and linguistic experience: issues in cross-language research,* 233–275. Timonium, MD: York Press.

Han, Mieko (1962) "The feature of duration in Japanese". *Onsei no kenkyu* 10, 65–80.

Hasegawa, Yoko (1999) "Pitch accent and vowel devoicing in Japanese". *Proceedings of the 14th International Congress of Phonetic Sciences*, 523–526.

Hirata, Yukari (2004) "Training native English speakers to perceive Japanese length contrasts in word versus sentence contexts". *The Journal of the Acoustical Society of America* 116, 2384–2394.

Hirata, Yukari and Jacob Whiton (2005). “Effects of speaking rate on the single/geminate stop distinction in Japanese”. *Journal of the Acoustical Society of America* 118, 3, 1647–1660.

Homma, Yayoi (1981). “Durational relationship between Japanese stops and vowels”. *Journal of Phonetics* 9, 273–281.

Isei-Jaakkola, Toshiko (2004) *Lexical quantity in Japanese and Finnish*. Ph.D. Dissertation. University of Helsinki, Helsinki, Finland.

Krull, Diana (1997) “Prepausal lengthening in Estonian: evidence from conversational speech”. In I. Lehiste and J. Ross, eds. *Estonian prosody: papers from a symposium,* 136–148. Tallinn: Institute of Estonian Language.

Krull, Diana and Hartmut Traunmüller (2000) “Perception of quantity in Estonian”. *Proceedings of fonetik 2000*, 85–88.

Lehiste, Ilse (1960) “Segmental and syllabic quantity in Estonian”. *American Studies in Uralic Linguistics* (Bloomington: Indiana University) 1, 21–82.

Lehiste, Ilse (1997) “Search for phonetic correlates in Estonian prosody”. In I. Lehiste and J. Ross, eds. *Estonian prosody: papers from a symposium,* 11–35. Tallinn: Institute of Estonian Language.

Lehiste, Ilse (2003) “Prosodic change in progress: from quantity language to accent language”. In P. Fikkert and H. Jakobs, eds. *Development in prosodic systems*, 47–65. (Studies in Generative Grammar.) Berlin, New York: Mouton de Gruyter.

Lehiste, Ilse and Jaan Ross (2001) *The temporal structure of Estonian runic songs*. Berlin and New York: Mouton de Gruyter.

Liiv, Georg (1961) “Eesti keele kolme vältusastme vokaalide kestus ja meloodiatüübid”. *Keel ja Kirjandus* 7: 412–424 and 8:480–490.

Lippus, Pärtel, Eva Liina Asu, Pire Teras, and Tuuli Tuisk (2013). “Quantity-related variation of duration, pitch and vowel quality in spontaneous Estonian”. *Journal of Phonetics* 41, 1, 17–28.

McAllister, Robert, James E. Flege, and Thorsten Piske (2002) “The influence of L1 on the acquisition of Swedish quantity by native speakers of Spanish, English and Estonian”. *Journal of Phonetics* 30, 229–258.

Meister, Lya and Einar Meister (2012a) “The production and perception of Estonian quantity degrees by native and non-native speakers”. In *Interspeech 2012: 13th annual conference of the International Speech Communication Association*, 886–889. Portland, Oregon.

Meister, Lya ja Einar Meister (2012b). “Aktsendikorpus ja võõrkeele aktsendi uurimine”. *Keel ja Kirjandus* 55, 8–9, 696–714.

Meister, Einar and Lya Meister (2013a) “Native and non-native production of Estonian quantity degrees: comparison of Estonian, Finnish and Russian subjects”. In E. L. Asu and P. Lippus, eds. *Nordic prosody: proceedings of the Xith conference*, 235–243. Frankfurt am Main: Peter Lang Verlag.

Meister, Einar and Lya Meister (2013b) “Production of Estonian quantity contrasts by native speakers of Finnish”. In *Interspeech 2013: 14th annual conference of the International Speech Communication Association*, 330–334. Lyon, France: International Speech Communication Association.

Meister, Lya and Einar Meister (2013c) "The Estonian foreign accent corpus". In *Book of abstracts. PPLC13: phonetics, phonology, languages in contact: contact varieties, multilingualism, second language learning*, 141–143. Paris, France.

Meister, Einar and Lya Meister (2014a) "Estonian quantity degrees produced by Latvian subjects". *Linguistica Lettica* 22, 85–106.

Meister, Einar and Lya Meister (2014b) "L2 production of Estonian quantity degrees". In D. Gibbon, N. Campbell, and D. Hirst, eds. *Speech prosody 7: proceedings of the 7th international conference*, 929–933. Dublin: International Speech Communication Association.

Meister, Einar and Lya Meister (2015) "Development and use of the Estonian L2 corpus". In J. Trouvain, F. Zimmerer, M. Gosy, and A. Bonneau, eds. *Book of extended abstracts. Workshop on phonetic learner corpora*, 45–47. Satellite workshop of the 18th International Congress of Phonetic Sciences.

Nolan, Francis and Eva Liina Asu (2009) "The pairwise variability index and coexisting rhythms in language". *Phonetica* 66, 1–2, 64–77.

Pike, Kenneth L. (1945) *Intonation of American English*. Michigan: Ann Arbor Press.

R Core Team (2014) *R: a language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Available online at <http://www.R-project.org/>. Accessed on 31.08.2015.

Suomi, Kari, Einar Meister, Riikka Ylitalo, and Lya Meister (2013). "Durational patterns in Northern Estonian and Northern Finnish". *Journal of Phonetics* 41, 1, 1–16.

Ueyama, Motoko (2000) *Prosodic transfer: an acoustic study of L2 English vs. L2 Japanese*. Ph.D. Dissertation. University of California, Los Angeles.

Warner, Natasha and Takayuki Arai (2001) "Japanese mora-timing: a review". *Phonetica* 58, 1–25.

Kokkuvõte. Einar Meister, Rena Nemoto, Lya Meister: Eesti välted jaapani emakeelega keelejuhtide häälduses. Eesti ja jaapani keel on kvantiteedikeeled, st mõlemad keeled kasutavad kestust fonoloogiliste vastanduste väljendamiseks. Kvantiteedisüsteemid kahes keeles on siiski erinevad – eesti keelt iseloomustab kolmene vältevastandus, jaapani keeles on kestusvastandus binaarne. Artiklis uuriti eesti väldete hääldust jaapani emakeelega keelejuhtide kõnes ja võrreldi seda eesti emakeelega keelejuhtide hääldusega. Akustiliseks analüüsiks kasutati kuue eesti keelt võõrkeelena kõneleva jaapanlase ja 12 eesti emakeelega keelejuhi etteloetud lausete salvestusi, milles esinesid vältevastandusi kandvad kahesilbilised sõnad. Tulemused näitasid, et jaapani keelejuhid häälдasid kontrastiivselt esma- ja teisevältelisi sõnu, kuid ei eristanud teise- ja kolmandavältelisi vokaalikeskse vastandusega (CVVCV *vs* CVV:CV) sõnu. Samas hääldasid nad erinevalt teise- ja kolmandavältelisi konsonandikeskse vastandusega (CVCCV *vs* CVC:CV) sõnu. Leitud segmendikestuste erinevused jaapanlaste ja eestlaste kõnes peegeldavad emakeelsete kestusmustrite erinevusi kahes keeles.

Märksõnad: eesti keel, jaapani keel, aktsendiga kõne, fonoloogiline kestus, välted