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RUSSIAN L1 SPEAKERS' PALATALIZATION IN ESTONIAN AND THE EFFECT OF PHONETIC SPEECH TRAINING

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Abstract. The purpose of this paper is to find out whether palatalization contributes to Russian-accented speech in Estonian and whether speech training would help to speak more native-like. Although palatalization is a common feature of both Estonian and Russian, it is more salient in Russian. Since in Estonian palatalization is not marked orthographically and there are typological differences between the two languages, we hypothesized that the Russian L1 learners of Estonian will have difficulties in producing secondary palatalization in a native-like manner. A group of students were tested before and after the training and their results were compared to an Estonian L1 group. We found that Russian L1 speakers did not palatalize word-final consonants as Estonian L1 speakers did but they also did not palatalize word-initial consonants. The training did not have an effect on the production of Estonian palatalization of the Russian L1 speakers.*

Keywords: acoustic phonetics, L2 acquisition, accent, Estonian, Russian

1. Introduction

The purpose of this study is twofold: firstly, we want to find out whether the acoustic properties of palatalization of Russian L1 learners of Estonian deviates from the native Estonian production. Secondly, if it does, we want to know whether speech training helps the students to speak more native-like. The motivation for the study came from the students themselves who reported that they are not comfortable speaking Estonian because of their accent.

The focus of our study is on palatalization. It is a coarticulatory assimilation of a consonant and a neighboring front vowel or the glide /j/ (Kochetov 2011). Although palatalization of consonants occurs in both Estonian and Russian, they can be very

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different in regards to which consonants in which positions are targeted. In Russian, palatalization is very salient and most of the consonants have a palatalized and non-palatalized variant (Howie 2001). Historically, consonants were allophonically palatalized before front vowels, but when these disappeared in certain positions, the palatalization remained (Padgett 2003). For example *дань* sg nom 'tribute' [danʲ] vs. *дан* adj 'given' [danʊ]. The cue for palatalization is written in orthography and word-initial, medial and final consonants are palatalized (Ordin 2010).

In Estonian, only four alveolar consonants /l, n, s, t/ are palatalized. These consonants are allophonically palatalized before the front vowel /i/ or the glide /j/. As a later development, when the word-final /i/ was lost, consonants at the end of nominative nouns with an i-stem are now also palatalized (Kask 1972: 118). For example, *loss* sg nom 'castle' [losʲː]: *lossi* sg gen 'castle' [losʲsi]. Word-initial consonants are not palatalized as they are in Russian. The cue for palatalization is not written in orthography and the reader has to know the pronunciation from the context. Such disharmony between the orthographies of two languages is known to cause problems (Bassetti 2008), as learners' second language (L2) orthographic input affects their acoustic output.

There are similarities between Estonian and Russian palatalization as well. Both languages have secondary palatalization of consonants, which means that the primary place of articulation remains in the same area but simultaneously, a secondary place of articulation is added to the hard palate (Bateman 2007). Previous research on the acoustic features of secondary palatalization has found that when the trigger for palatalization follows the palatalized consonant, the quality of the preceding vowel is affected (Polish – Ćavar 2004; Connemara Irish – Chiosáin, Padgett 2012; Russian – Derkach et al. 1970, Howie 2001, Kochetov 2002, Öhman 1966, Purcell 1979; Korean – Kim 2012; Estonian – Lehiste 1965, Liiv 1965a, 1965b, Teras, Pajusalu 2014, Vihman 1967). There is an increase in the second formant frequency (F2 – associated with expansion of the oral cavity) and decrease in the first formant frequency (F1 – associated with lengthening of the pharyngeal cavity). The same applies to vowels that follow word-initial palatalized consonants. This increase or decrease in formant values can be measured for example by the relative range of movement of the formant values (Fox, Jacewicz 2009).

Palatalization affects not only the spectral properties, but also the temporal properties of speech. It has been established that because of the palatalization gesture, the duration of the vowels is lengthened with palatalization as the body of the tongue has to move up to the hard palate (Bolla 1981, Ćavar 2004, Kavitskaya 2006, Kochetov 2006, Liiv 1965a, Ordin 2010, 2011, Stoll et al. 2015, Teras, Pajusalu 2014, Zsiga 2000).

Palatalization in Estonian should not be a problem for Russian L1 speakers, because as Babel and Johnson (2007) found, Russian L1 speakers should be more sensitive in hearing and discriminating palatalization contrasts. If palatalization is not a feature in L1, the acquisition is problematic. For example English L1 speakers learning Russian struggle with production and perception of the extensive Russian palatalization system (Hacking et al. 2016, Kulikov 2011). On the other hand, if palatalization is a feature in L1 it will be transferred to L2 (Babatsouli, Kappa 2011).

There are three complementary theories which explain second language (L1) acquisition and the underlying reasons for accented speech: the Speech Learning

Model (SLM – Flege 1995, Flege et al. 2003; SLM-r – Flege, Bohn 2021), the Perceptual Assimilation Model (PAM – Best 1995; PAM-L2– Best, Tyler 2007) and the Second Language Linguistic Perception model (L2LP – Escudero 2005, 2009, van Leussen, Escudero 2015). Those models all conclude that native language (L1) affects the way speech sounds are perceived in L2. Moreover, L1 sets the boundaries to the limits in perceiving and producing L2, because learners will perceive sounds in L2 in accordance to their native language. For example Japanese L1 learners of English have trouble differentiating between minimal pairs like *flesh* and *fresh* or *bellies* and *berries* because Japanese speakers perceptually assimilate English liquid consonants [l] and [ɹ] (Aoyama et al. 2004, Shinohara 2014). PAM and L2LP predict that when a sound in L1 is similar to the sound in L2, the learners will have to either create a new category or split their existing L1 category. Although possible, it is implausible that the learners will produce it as speakers of L1 do. If the sound in L2 is a new sound, the learners will have to create a new category altogether which might be easier for the learner. However, the aforementioned theories agree that the earlier you start learning another language, the better you will be.

Phonetic training can help to overcome these discrepancies. Studies have shown that for example English L1 learners of Russian got better at palatalization through training (Hacking et al. 2017). Arabic L1 learners of Finnish improved significantly in their production of Finnish vowels after a short-term phonetic training (Savo, Peltola 2019) and Finnish children were able to produce non-native vowels in pseudowords after a short training (Taimi et al. 2014).

This study addresses the question of how Russian L1 speakers produce Estonian word-final and word-initial consonants compared to the native Estonian group before and after training, whether palatalization contributes to Russian-accented speech in Estonian and whether speech training can help learners to speak more native-like. Based on the previous research it is hypothesized that:

- Russian L1 speakers will not palatalize word-final consonants, because the cue for palatalization is not written in orthography and they might not be proficient enough to recognize that these consonants are palatalized. Thus, the range of F2 values of the vowels that precede consonants will be shorter, the F1 will be longer and the duration will be shorter than in the production of Estonian L1 speakers.
- Russian L1 speakers will palatalize word-initial consonants because they are followed by front vowels which trigger palatalization of word-initial consonants in Russian. We expect that compared to the Estonian L1 production the vowels following initial consonants will have a longer F2 range, shorter F1 range and the duration of the vowels will be longer.
- Based on the findings from PAM (Best 1995, Best, Tyler 2007) and L2LP (van Leussen, Escudero 2015) we hypothesize that as both languages use secondary palatalization, the learners are faced with a new scenario where they have to create a new category or split their existing L1 category. As this can be hard for them, the speakers will produce a consonant that is in between L1 and L2.
- If the Russian L1 group differs from the Estonian L1 group, we expect their productions to become more similar to the L1 group with speech training.

2. Materials and methods

As a pilot project, a 12 week speech training of Estonian (once a week, 1.5 h) was conducted by speech and pronunciation coach Einar Kraut in a Russian-speaking high school in Tallinn. The training consisted of exercises on articulatory movements for setting the quality of Estonian vowels and consonants, stress and quantity system and the correct usage of palatalization. The practical training of articulatory movements during pronunciation of Estonian was improvisational and concentrated on efficiency, broadly following Kraut's handbook (2000) of Estonian pronunciation. The topic of palatalization was covered in two lessons. The training was carried out as follows: the teacher was in front of the class and articulated the words while students followed in a choir. If needed, individual feedback was given in the classroom. The students also had weekly homework assignments and Kraut made instructional YouTube videos on the covered topics for the students to practice on their own.

In order to assess whether the Russian L1 participants use palatalization in the same way as Estonian native speakers and whether the speech training improved the participants' pronunciation of Estonian, a two-part reading test was compiled with a focus on palatalization. The first part consisted of 31 monosyllabic *i*-stemmed test words inserted in a carrier sentence medial position followed by a comma and a word starting with *mi*-. The final consonants were /s, t, n, l/ and the vowels that preceded them were /ɑ, e, i, o, u, ɤ/. E.g. *On olemas ainult üks* ***rass*** [rɑs^{j}ː], *milleks on inimrass*. 'There is only one race and that is the human race'. These word-final consonants are palatalized in standard Estonian. Palatalization is triggered by the stem vowel /i/ which has been language-historically lost in the nominative case.

In the second part, 20 test words were in a carrier sentence medial position. The structure of the carrier sentence was always: *I said x but I meant y*. Test words started with /s, t, n, l/ and were followed by a front vowel /æ, e, i, ø, y/. E.g. *Ütlesin* ***sebra*** [seprɑ], *mõtlesin hobune*. 'I said zebra but I meant horse'. These word-initial consonants are not palatalized in standard Estonian but tend to be palatalized in Russian-accented speech.

30 Russian L1 students attending the final grade in the Russian-speaking high school were recorded before the speech training, but only 8 of them were available for the second recording session after the training as it was hard to get all the students back for another recording. The data from these 8 students (4 male, 4 female speakers, age 17–18) were used in this study. These students reported that they had also gone to a Russian-speaking kindergarten. Besides the training, the students had Estonian classes at school 5 days a week. By the Common European Framework of Reference for Languages (CEFR 2001), Russian L1 students are supposed to acquire B2 level of Estonian by the end of high school (advanced and independent speaker). A control group of 7 Estonian L1 speakers of the same age range and level of education (3 female, 4 male) who did not participate in the training were recorded in an Estonian-speaking high school in Tartu[1].

The Russian students were also asked to fill out a short self-assessment questionnaire in Russian before and after the training. The results showed that the ratings on their proficiency in Estonian did not change substantially, yet they gave the course a favorable grade.

[1] As the study was carried out at the University of Tartu, it was easier to find test subjects there. We do not expect significant dialectal variability in the production of the test words between the high school students of Tallinn and Tartu.

The acoustic recordings were made with a Mixpre 6 USB sound device and a condenser microphone Micpro8 (Tallinn) and Beyerdynamic MC 930 (Tartu). The carrier sentences were presented in a randomized order on a laptop screen in an empty classroom and the audio was recorded with the Speechrecoder software (Draxler, Jänsch 2018). The students were not introduced to the test material prior to the recording session and had to read the sentences as they appeared on the screen in their own pace. In the case of disfluencies the students were given the chance to repeat the sentence.

The recordings were automatically segmented with an ASR-based force aligner (Alumäe et al. 2018) and manually checked for possible misalignments of the phoneme boundaries. The formant values and segmental durations were measured in Praat (Boersma, Weenink 2019). 30 equidistant F1 and F2 values of vowels were extracted using a script inspired from the Optimal Formant Ceiling (Escudero et al. 2009) method. Optimal formant ceilings and trajectories for each vowel that had the least variation and durations were extracted and analyzed. As the data were sparse, we transformed the formant values to z-scores in order to normalize for the differences in vocal tract length between genders. The number of analyzed tokens per vowel is presented in Table 1.

Table 1. Number of vowels preceding word-final and following word-initial consonants analyzed and uttered by L1 and L2 groups (pre and post-test) in the study

Preceding word-final C			Following word-initial C		
Vowel	**L1**	**L2**	**Vowel**	**L1**	**L2**
/ɑ/	84	192	/e/	28	64
/o/	49	112	/æ/	28	64
/u/	42	96	/i/	28	64
/i/	7	16	/y/	28	64
/ɤ/	14	32	/ø/	28	64
/e/	14	32			
Total	210	480		140	320

In order to measure the range of the movement of F1 and F2 values, we calculated the standard deviation (SD) from 30 measurement points within each individual vowel. This measure describes the trajectory range, but instead of calculating the difference between the starting point and the end point of the formant trajectory, using standard deviation reduces the effect of each individual measurement point. Higher standard deviation or longer range of each vowel's F1 and F2 shows that there is more movement in the formant values during the vowel and thus it is more likely that the subject was palatalizing the consonant.

A Linear Mixed Model (LMM) was used in R (R Core Team 2020) with *lmer4* package (Bates et al. 2015) to estimate the effect of vowel and trial (pre-test, post-test and control group) on the standard deviations of normalized F1 and F2 values (z-score) within the 30 measurement points and on the duration of vowels. A Benjamini-Hochberg corrected Tukey post hoc test was also conducted for a pairwise comparison in R with the *multcomp* package (Hothorn et al. 2008).

3. Results

3.1. Quality of vowels preceding word-final consonants

Figure 1 shows the formant movement from the beginning to the end of the vowels in the formant space. There is a clear distinction between the F2 values of the control group and the two L2 trials. With the vowels /ɑ, e, ɤ, u, o/, the F2 value moves more towards /i/ during the vowel in the control group than in the trials of the L2 group. With the vowel /i/, the L2 group had higher F2 values both pre- and post-test than the control group. The F2 values between the trials of the L2 group are very similar, which suggests that the effect of the speech training was not significant.

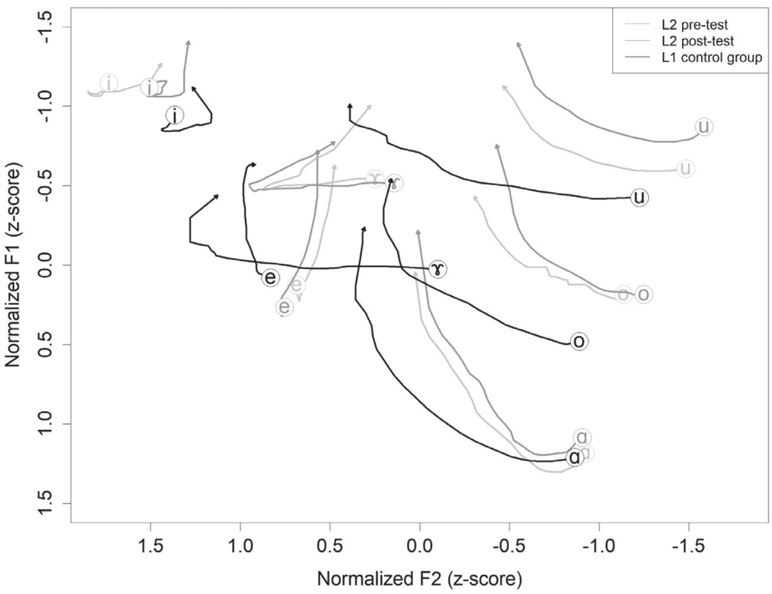

Figure 1. The movement of vowel formants preceding word-final consonants in F2~F1 space. The vowel symbols represent the beginning of the vowel and the arrows indicate the end. The colors on the plot are coded as follows: black – control group; light gray – recording made before the training; dark gray – recordings made after the training

The movement in the F1 value over the course of duration of the vowel does not show a systematic pattern (figure 2). F1 of the L2 group is similar to the control group. To test these assumptions, we looked at the standard deviation of the range of formant values within the 30 measurement points of each vowel production.

Figure 2 shows that although the median values were somewhat different, the distribution of the data was similar across the three groups. A post-hoc test of the LMM (table 2) where we compared the pair-wise differences by vowels and groups confirmed that the range of F1 of the L2 group was not significantly different from the control group and the training did not affect those values either.

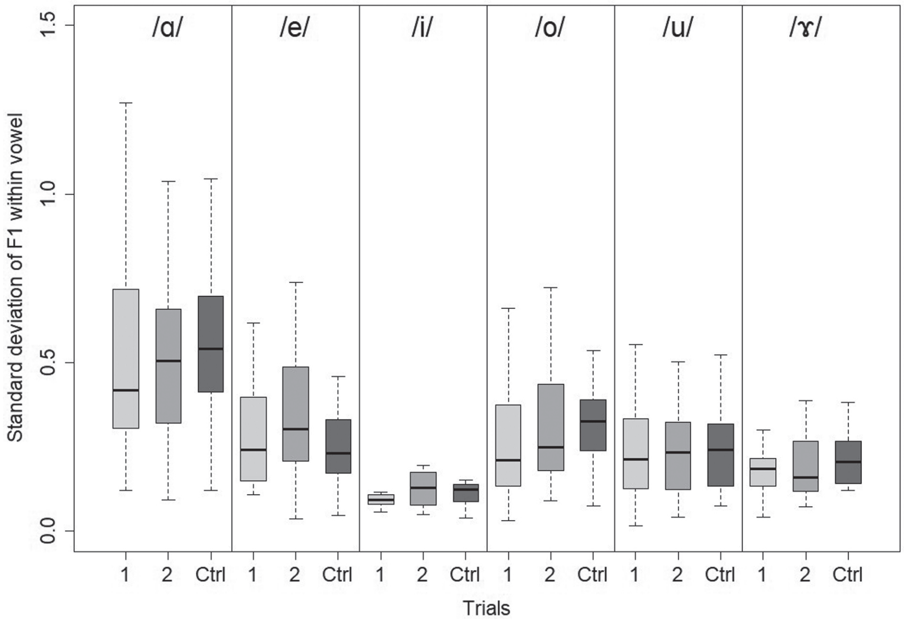

Figure 2. Standard deviations of F1 range within each vowel preceding palatalized word-final consonants. Light gray: 1 – recordings made before the speech training; gray: 2 – recordings made after the training; dark gray: Ctrl – recordings of the control group

Table 2. The summary of output of the post-hoc LMM model for the vowels' standard deviations of F1 range with pair-wise comparisons of values for each vowel before (1), after (2) and of the control group (ctrl). The table presents the estimates (Est.) of F1 standard deviations of the vowels' formant range preceding word-final consonants, the standard error (St. err.), the difference (Diff.) between the groups and the p-value of the significance of the difference (Benjamini and Hochberg corrected)

Vowel	Group	Est.	St. err.	Est.	St. err.	Diff.	p
/ɑ/	1 vs 2	0.519	0.288	0.513	0.028	–0.006	0.834
	1 vs ctrl	0.519	0.288	0.561	0.042	0.042	0.322
	2 vs ctrl	0.513	0.028	0.561	0.042	0.048	0.261
/e/	1 vs 2	0.289	0.052	0.341	0.068	0.051	0.451
	1 vs ctrl	0.289	0.052	0.268	0.077	–0.202	0.790
	2 vs ctrl	0.341	0.052	0.269	0.077	–0.072	0.350
/i/	1 vs 2	0.097	0.071	0.140	0.097	0.043	0.651
	1 vs ctrl	0.097	0.071	0.215	0.105	0.011	0.911
	2 vs ctrl	0.141	0.071	0.109	0.105	–0.032	0.760
/o/	1 vs 2	0.287	0.033	0.319	0.036	0.032	0.371
	1 vs ctrl	0.287	0.033	0.332	0.048	0.045	0.352
	2 vs ctrl	0.320	0.033	0.332	0.048	0.013	0.792
/u/	1 vs 2	0.241	0.033	0.236	0.036	–0.005	0.879
	1 vs ctrl	0.241	0.033	0.246	0.048	0.005	0.903
	2 vs ctrl	0.236	0.033	0.247	0.048	0.011	0.814
/ɤ/	1 vs 2	0.182	0.052	0.198	0.068	0.016	0.807
	1 vs ctrl	0.182	0.052	0.229	0.077	0.047	0.542
	2 vs ctrl	0.198	0.052	0.228	0.077	0.031	0.694

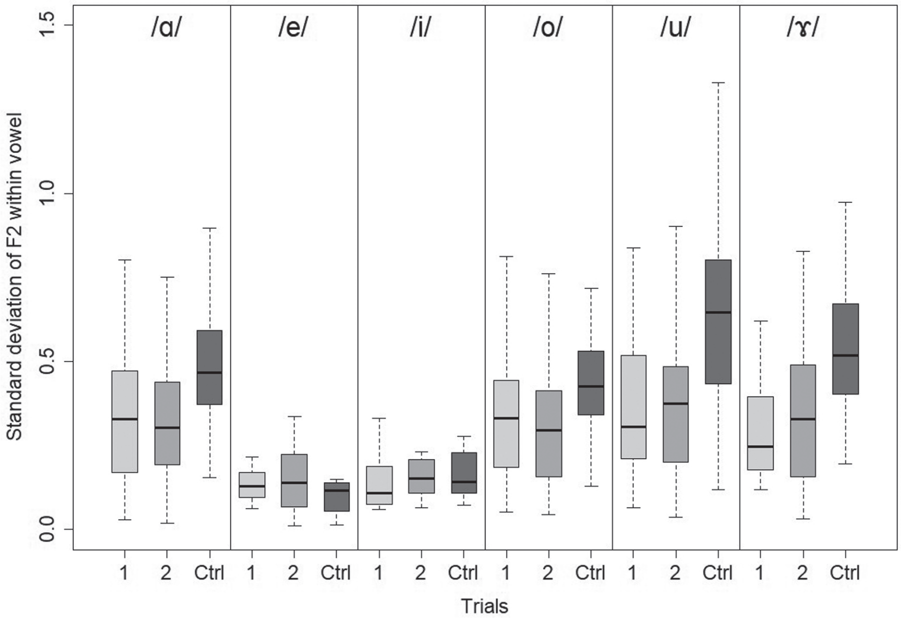

Figure 3. Standard deviations of F2 range within each vowel preceding palatalized word-final consonants. Light gray: 1 – recordings made before the speech training; gray: 2 – recordings made after the training; dark gray: Ctrl – recordings of the control group

Figure 3, where the standard deviations of each vowels' F2 range are plotted, shows that the median values in the L2 group are similar, but there is a difference with the control group where the values of the back vowels are higher. A post-hoc test of the LMM confirmed (table 3) that the training did not affect the F2 range of vowels preceding palatalized consonants of the L2 group, but their productions had a shorter formant range than the control group recordings did. As the training did not affect the F2 values of the L2 group significantly, we will only report the results of the comparison of the post-test with the control group. The range of F2 of /ɑ/ of the L2 group was 0.146 shorter compared to the L1 group ($p = 0.013$); /o/ was 0.142 shorter ($p = 0.026$); /u/ was 0.254 shorter ($p < 0.001$) and /ɤ/ was 0.181 shorter ($p = 0.048$) F2 range.

Table 3. The summary of output of the post-hoc LMM model for the vowels' standard deviations of F2 range with pair-wise comparisons of values for each vowel before (1), after (2) and of the control group (ctrl). The table presents the estimates (Est.) of F2 standard deviations of the vowels' formant range preceding word-final consonants, the standard error (St. err.), the difference (Diff.) between the groups and the p-value of the significance of the difference (Benjamini and Hochberg corrected)

Vowel	Group	Est.	St. err.	Est.	St. err.	Diff.	p
/ɑ/	1 vs 2	0.311	0.032	0.334	0.027	0.003	0.918
	1 vs ctrl	**0.311**	**0.032**	**0.461**	**0.047**	**0.149**	**0.012**
	2 vs ctrl	**0.334**	**0.033**	**0.480**	**0.047**	**0.146**	**0.013**
/e/	1 vs 2	0.141	0.054	0.152	0.068	0.011	0.871
	1 vs ctrl	0.141	0.054	0.152	0.067	0.011	0.872
	2 vs ctrl	0.151	0.054	0.113	0.079	–0.038	0.631
/i/	1 vs 2	0.141	0.078	0.186	0.094	0.045	0.635
	1 vs ctrl	0.141	0.078	0.166	0.105	0.025	0.808
	2 vs ctrl	0.186	0.072	0.167	0.105	–0.019	0.854
/o/	1 vs 2	0.331	0.036	0.313	0.035	–0.017	0.632
	1 vs ctrl	**0.331**	**0.036**	**0.456**	**0.053**	**1.256**	**0.049**
	2 vs ctrl	**0.314**	**0.036**	**0.456**	**0.053**	**0.142**	**0.026**
/u/	1 vs 2	0.398	0.036	0.385	0.035	–0.012	0.725
	1 vs ctrl	**0.398**	**0.036**	**0.639**	**0.053**	**0.242**	**< 0.001**
	2 vs ctrl	**0.386**	**0.036**	**0.640**	**0.053**	**0.254**	**< 0.001**
/ɤ/	1 vs 2	0.332	0.054	0.383	0.067	0.051	0.449
	1 vs ctrl	**0.332**	**0.054**	**0.563**	**0.079**	0.231	0.019
	2 vs ctrl	0.382	0.054	0.562	0.079	0.181	0.048

3.2. Quality of vowels following word-initial consonants

Figure 4 shows the formant trajectories of the vowels that followed word-initial consonants plotted in the formant space. Again, there is a clear distinction between the values of the L2 group and of the control group. With the vowels /æ, e, i, y/ the F1 values are higher and F2 values are lower in the control group. With the vowel /ø/, the L2 group had lower F1 and F2 values than the control group. The recordings made before the speech training are distinct from the recordings made after the training, having a lower F2 and higher F1 after the training and moving closer to the values of the control group, suggesting that the effect of the training was significant.

Figure 5 shows that the range of F1 in the L2 group varied more after the training and the length of it is shorter in the control group. A post-hoc test of the LMM (table 4) where we made a pair-wise comparison between vowels and test groups shows that the training only affected the F1 of /e/ of the L2 group, where the range was 0.129 shorter before the training ($p = 0.005$). Compared to the control group the F1 values had a longer range in the L2 group. The learners' range of F1 of /æ/ was 0.177 longer compared to the L1 group ($p < 0.001$); /e/ was 0.192 longer ($p < 0.001$) and /ø/ was 0.104 longer ($p = 0.053$).

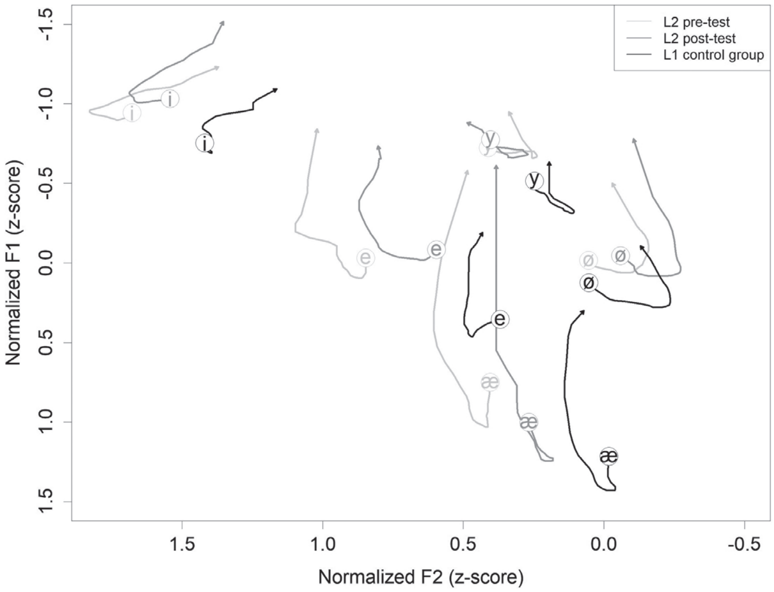

Figure 4. The movement of vowel formants following word-initial consonants in F2~F1 space. The vowel symbols represent the beginning of the vowel and the arrows indicate the end. The colors on the plot are coded as follows: black – control group; light gray – recording made before the training; dark gray – recordings made after the training

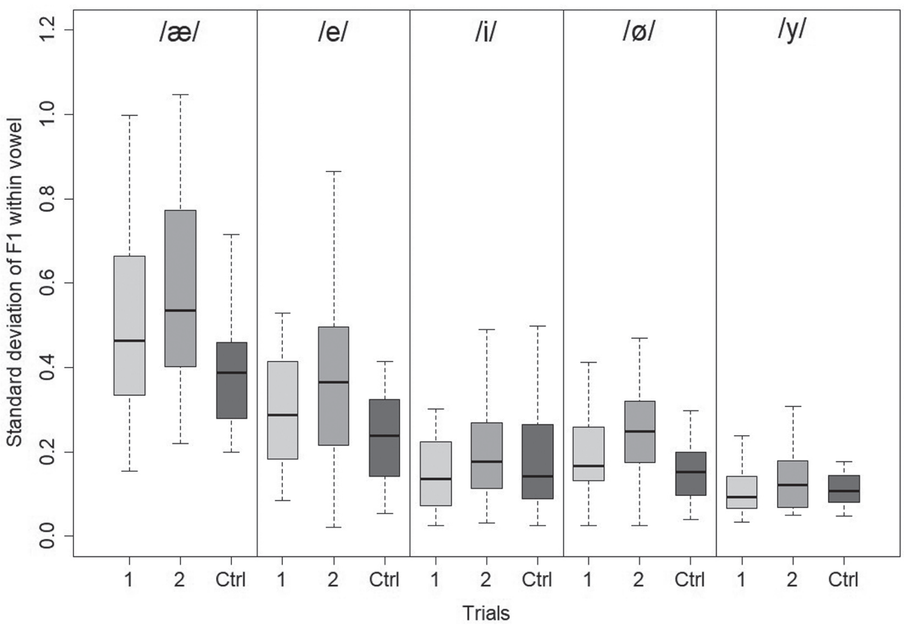

Figure 5. Standard deviations of F1 range within each vowel following word-initial consonants. Light gray: 1 – recordings made before the speech training; gray: 2 – recordings made after the training; dark gray: Ctrl – recordings of the control group

Table 4. The summary of output of the post-hoc LMM model for the vowels' standard deviations of F1 range with pair-wise comparisons of values for each vowel before (1), after (2) and of the control group (ctrl). The table presents the estimates (Est.) of F1 standard deviations of the vowels' formant range following word-initial consonants, the standard error (St. err.), the difference (Diff.) between the groups and the p-value of the significance of the difference (Benjamini and Hochberg corrected). Significant differences are marked in bold

Vowel	Group	Est.	St. err.	Est.	St. err.	Diff.	p
/æ/	1 vs 2	0.506	0.034	0.578	0.043	0.072	0.106
	1 vs ctrl	**0.506**	**0.034**	**0.401**	**0.049**	**–0.104**	**0.040**
	2 vs ctrl	**0.578**	**0.034**	**0.401**	**0.049**	**–0.177**	**< 0.001**
/e/	**1 vs 2**	**0.311**	**0.034**	**0.440**	**0.043**	**0.129**	**0.005**
	1 vs ctrl	0.311	0.034	0.248	0.049	–0.062	0.081
	2 vs ctrl	**0.441**	**0.034**	**0.249**	**0.049**	**–0.192**	**< 0.001**
/i/	1 vs 2	0.154	0.034	0.189	0.043	0.035	0.414
	1 vs ctrl	0.154	0.034	0.186	0.049	0.032	0.512
	2 vs ctrl	0.191	0.034	0.187	0.049	–0.003	0.945
/ø/	1 vs 2	0.193	0.034	0.261	0.043	0.068	0.118
	1 vs ctrl	0.193	0.034	0.157	0.049	–0.035	0.467
	2 vs ctrl	**0.262**	**0.034**	**0.157**	**0.049**	**–0.104**	**0.053**
/y/	1 vs 2	0.119	0.034	0.137	0.043	0.189	0.664
	1 vs ctrl	0.119	0.034	0.123	0.049	0.004	0.931
	2 vs ctrl	0.138	0.034	0.123	0.049	–0.014	0.764

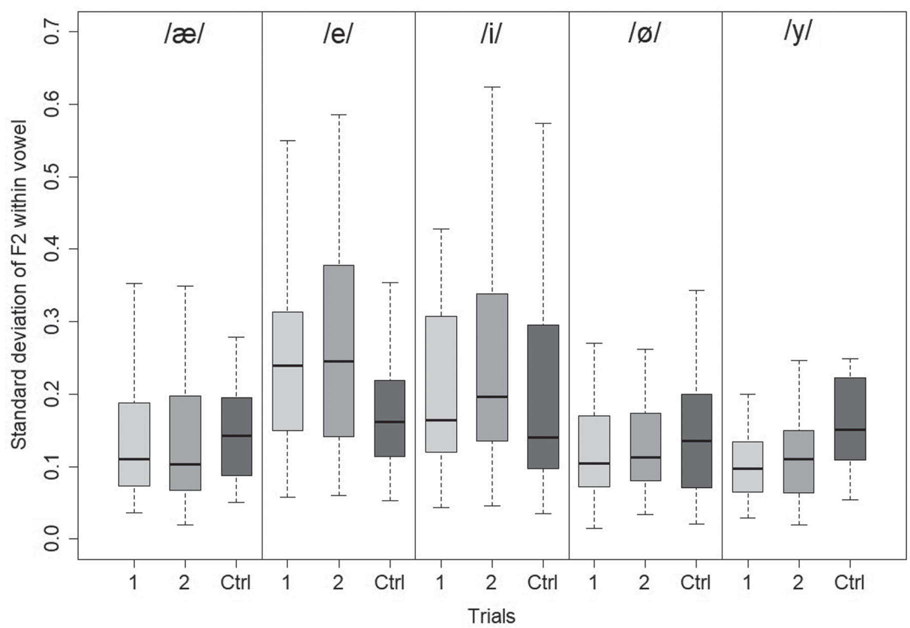

Figure 6. Standard deviations of F2 range within each vowel following word-initial consonants. Light gray: 1 – recordings made before the speech training; gray: 2 – recordings made after the training; dark gray: Ctrl – recordings of the control group

Figure 6 shows that the range of the F2 values in the L2 group and in the control group is similar. A post-hoc test of the LMM (table 5) shows that the training did not affect the F2 range of the L2 group's vowels following the word-initial consonants. Compared to the control group, the learners' F2 range of /e/ was 0.079 longer after the training (p = 0.018). With all the other vowels, the L2 group was not different from the control group.

Table 5. The summary of output of the post-hoc LMM model for the vowels' standard deviations of F2 range with pair-wise comparisons of values for each vowel before (1), after (2) and of the control group (ctrl). The table presents the estimates (Est.) of F2 standard deviations of the vowels' formant range following word-initial consonants, the standard error (St. err.), the difference (Diff.) between the groups and the p-value of the significance of the difference (Benjamini and Hochberg corrected). Significant differences are marked in bold

Vowel	Group	Est.	St. err.	Est.	St. err.	Diff.	p
/æ/	1 vs 2	0.151	0.022	0.161	0.026	0.009	0.713
	1 vs ctrl	0.151	0.022	0.145	0.031	–0.005	0.861
	2 vs ctrl	0.161	0.021	0.145	0.031	–0.015	0.629
/e/	1 vs 2	0.256	0.022	0.264	0.026	0.007	0.777
	1 vs ctrl	**0.256**	**0.022**	**0.183**	**0.031**	**–0.072**	**0.034**
	2 vs ctrl	**0.263**	**0.021**	**0.183**	**0.032**	**–0.079**	**0.018**
/i/	1 vs 2	0.209	0.022	0.236	0.027	0.027	0.302
	1 vs ctrl	0.209	0.022	0.187	0.032	–0.021	0.509
	2 vs ctrl	0.236	0.022	0.187	0.032	–0.048	0.161
/ø/	1 vs 2	0.132	0.022	0.133	0.027	0.001	0.962
	1 vs ctrl	0.132	0.022	0.143	0.032	0.011	0.728
	2 vs ctrl	0.134	0.022	0.144	0.032	0.009	0.758
/y/	1 vs 2	0.107	0.022	0.225	0.027	0.011	0.686
	1 vs ctrl	0.107	0.022	0.165	0.032	0.058	0.116
	2 vs ctrl	0.118	0.022	0.165	0.032	0.047	0.139

3.3. Duration of vowels preceding word-final consonants

Figure 7 shows that the duration of the vowels in the L2 group was longer before the training, with the exception of (/ɤ/). A post-hoc test of the LMM (table 6) where we made a pair-wise comparison between vowels and groups showed that there were no significant temporal differences in the vowels between the groups.

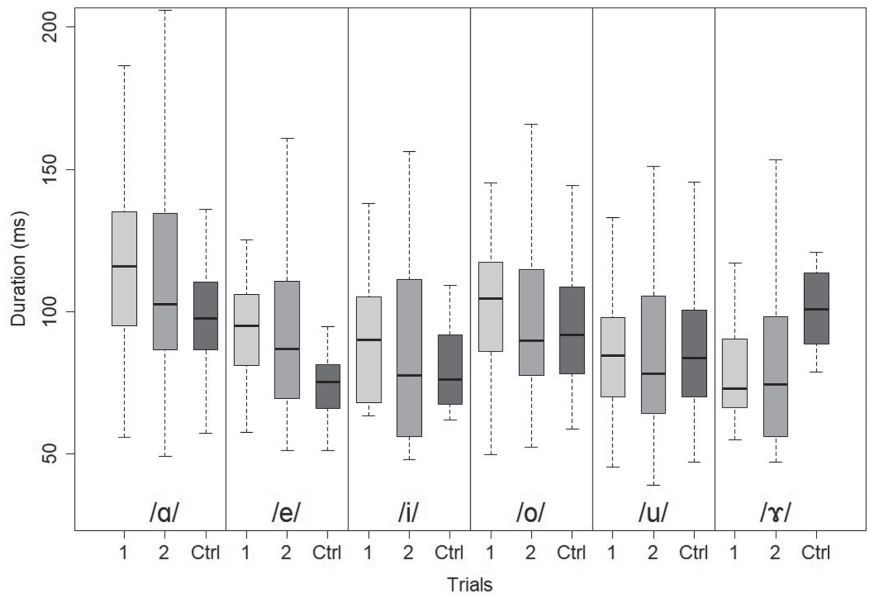

Figure 7. Durations (in milliseconds) of the vowels preceding word-final palatalized consonants. Light gray: 1 – recordings made before the speech training; gray: 2 – recordings made after the training; dark gray: Ctrl – recordings of the control group

Table 6. The summary of output of the post-hoc LMM model for the vowel duration with pair-wise comparisons of values for each vowel before (1), after (2) and of the control group (ctrl). The table presents the estimates (Est.) of duration (in milliseconds) of the vowels following word-initial consonants, the standard error (St. err.), the difference (Diff.) between the groups and the p-value of the significance of the difference (Benjamini and Hochberg corrected). Significant differences are marked in bold

Vowel	Group	Est.	St. err.	Est.	St. err.	Diff.	p
/ɑ/	1 vs 2	115	6.4	112	3.0	–3	0.346
	1 vs ctrl	115	6.4	100	9.4	–15	0.119
	2 vs ctrl	112	6.4	100	9.4	–12	0.197
/e/	1 vs 2	92	8.0	91	7.3	–1	0.922
	1 vs ctrl	92	8.0	73	11.7	–19	0.117
	2 vs ctrl	92	8.0	74	11.7	–18	0.131
/i/	1 vs 2	91	9.5	87	10.4	–4	0.689
	1 vs ctrl	91	9.5	81	13.9	–10	0.472
	2 vs ctrl	87	9.5	81	13.9	–6	0.672
/o/	1 vs 2	102	6.7	97	3.9	–5	0.224
	1 vs ctrl	102	6.7	93	18.1	–9	0.349
	2 vs ctrl	98	6.7	93	9.7	–5	0.644
/u/	1 vs 2	87	6.7	83	3.9	–4	0.341
	1 vs ctrl	87	6.7	88	9.7	1	0.956
	2 vs ctrl	83	6.7	87	9.7	4	0.665
/ɤ/	1 vs 2	78	8.0	83	7.3	5	0.459
	1 vs ctrl	78	8.0	101	11.7	23	0.116
	2 vs ctrl	83	8.0	101	11.7	18	0.131

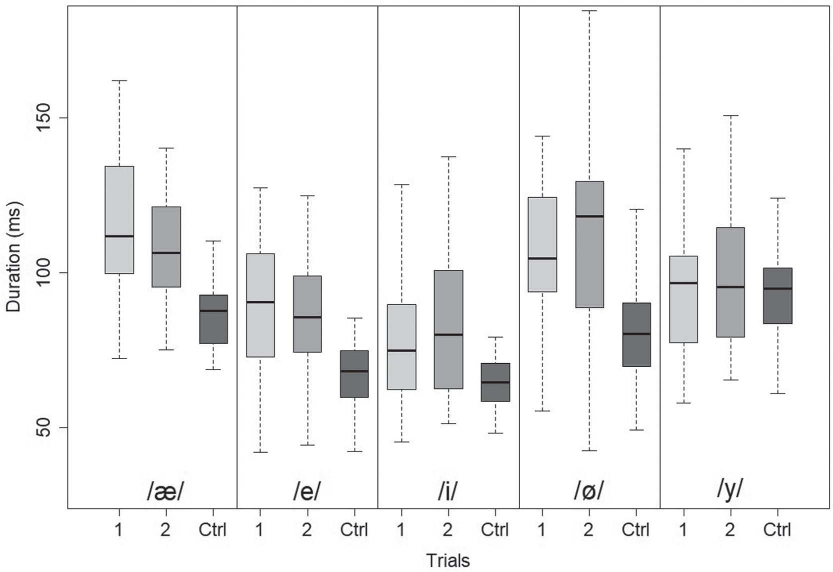

Figure 8. Durations (in milliseconds) of the vowels following word-initial consonants. Light gray: 1 – recordings made before the speech training; gray: 2 – recordings made after the training; dark gray: Ctrl – recordings of the control group

Table 7. The summary of output of the post-hoc LMM model for the vowel duration with pair-wise comparisons of values for each vowel before (1), after (2) and of the control group (ctrl). The table presents the estimates (Est.) of duration (in milliseconds) of the vowels following word-initial consonants, the standard error (St. err.), the difference (Diff.) between the groups and the p-value of the significance of the difference (Benjamini and Hochberg corrected). Significant differences are marked in bold

Vowel	Group	Est.	St. err.	Est.	St. err.	Diff.	p
/æ/	1 vs 2	115	5.2	108	5.1	–7	0.172
	1 vs ctrl	**115**	**5.2**	**87**	**7.6**	**–28**	**0.001**
	2 vs ctrl	**108**	**5.2**	**87**	**7.6**	**–21**	**0.014**
/e/	1 vs 2	90	5.2	87	5.1	–3	0.561
	1 vs ctrl	**90**	**5.2**	**67**	**7.6**	**–23**	**0.007**
	2 vs ctrl	**87**	**5.2**	**66**	**7.6**	**–21**	**0.018**
/i/	1 vs 2	78	5.2	83	5.1	5	0.314
	1 vs ctrl	78	5.2	65	7.6	–13	0.108
	2 vs ctrl	**83**	**5.2**	**64**	**7.6**	**–19**	**0.033**
/ø/	1 vs 2	108	5.2	110	5.2	2	0.739
	1 vs ctrl	**108**	**5.2**	**84**	**7.6**	**–24**	**0.005**
	2 vs ctrl	**110**	**5.2**	**84**	**7.6**	**–26**	**0.002**
/y/	1 vs 2	101	5.2	98	5.1	–3	0.532
	1 vs ctrl	101	5.2	94	7.6	–7	0.328
	2 vs ctrl	98	5.2	94	7.6	–4	0.571

3.4. Duration of vowels following word-initial consonants

Figure 8 shows that the duration of the vowels in L2 group is similar between the two trials, but compared to the control group the vowels /æ/, /e/ and /ø/ are longer. A post-hoc test of the Linear Mixed Model shows that the training did not affect the duration of the vowels in the L2 group (table 7). Compared to the control group, the durations of the L2 group vowels were longer. The duration of /æ/ was 21 ms longer after the training ($p = 0.014$); the duration of /e/ was 21 ms after the training ($p = 0.018$); the duration of /i/ was 19 ms longer before the training ($p = 0.033$) and the duration of /ø/ was 26 ms longer after the training ($p = 0.002$).

4. Discussion

This article looked at whether palatalization contributes to the accent in the Estonian produced by Russian L1 speakers and whether speech training helps them to speak more native-like. We looked at the standard deviations of the formant values within the vowel productions to compare the relative range of the F1 and F2 movements.

We hypothesized that Russian L1 speakers will not palatalize the Estonian word-final consonants in the nominative forms of *i*-stemmed words because the cue for palatalization is not written in the orthography. The results showed that the length of their F1 range was similar to L1 Estonian speakers, but their F2 range was shorter. Although the main correlate of palatalization is the rise in F2 in vowels preceding the consonants, it is usually accompanied by the lowering of the F1 as well. This was not observed in the L2 learners' group. Previous research has shown that the vowels preceding palatalized consonants are longer in duration. We found that there were no temporal differences in the vowels between the L2 and L1 groups. We conclude that the learners do sometimes palatalize word-final consonants, but with regard to the extent of F2 movement, the range is shorter compared to the Estonian L1 group. We hypothesized based on L2LP and PAM that this might happen, because the two categories in both languages are similar and L2 speakers will produce a category that is between L1 and L2. We also hypothesized that if L2 and L1 groups differ, speech training would help the L2 group to produce more native-like categories. Based on our results we conclude that the speech training did not affect the production of their word-final consonants.

We hypothesized that the L2 learners would palatalize word-initial consonants, because they were followed by front vowels that usually trigger palatalization in the word-initial consonant in their L1. We expected to see an /i/-like transition in the beginning of the vowel resulting in shortening of F2 range, lengthening of F1 range and a longer duration of the vocalic segment. The results showed that the F2 range of the L2 group both before and after the training was similar to the control group, but the F1 range of the L2 group tended to have more variability. The duration of the vowels of the L2 group was longer than that of the control group. As we consider the rise in F2, or the longer range of the movement, to be the main correlate of palatalization, we cannot confirm that the word-initial consonant was palatalized. Still, the L2 production deviated from the control group in regard to both F1 and duration. L2LP and PAM predicted that the learners might have a problem acquiring this new scenario in which the categories are similar in both languages. It is possible that they produced a category between L1 and L2. However, the speech training had no effect as the difference from the control group remained after the training.

The reason why the speech training did not have an effect on the speakers' pronunciation could be because the length and the frequency of the course was not sufficient for showing a significant effect in the fine phonetic detail. Moreover, the size of the group (8 participants) was insufficient for the effects to reach statistical significance over the individual variability. As we cannot draw definitive conclusions regarding the training, we believe that the main contribution of our study is showing that palatalization can be a contributing factor in Russian-accented speech in Estonian.

5. Conclusions

The purpose of this study was to investigate whether the Russian L1 learners of Estonian palatalize word-final and word-initial consonants and whether Estonian speech training helped them to speak more native-like. The students were asked to participate in a voluntary reading test before and after the speech training. The length of their F1 and F2 range and the durations of vowels preceding the palatalized word-final consonants and following the palatalized initial consonants were compared to the Estonian L1 control group that did not participate in the training.

Russian L1 speakers' F2 range was shorter compared to the L1 group and we concluded that they tended not to palatalize word-final consonants. The duration of the vowels was similar between the L2 and L1 groups. The range of the F2 values of the vowels that followed word-initial consonants was similar to that of Estonian L1 speakers, but the durations of their vowels were longer and the F1 range was longer as well.

The current study provides invaluable insight and empirical evidence that, although palatalization is a common feature of Russian, acquiring the similar feature in a different language (Estonian) can be difficult for Russian L1 learners and it contributes to their accented speech in Estonian. As this study had a limited number of participants, more data is needed to draw any final conclusions.

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VENE EMAKEELEGA EESTI KEELE ÕPPIJATE PALATALISATSIOON JA HÄÄLDUSTREENINGU MÕJU SELLELE

Anton Malmi, Pärtel Lippus
Tartu Ülikool

Artiklis uurime, kas vene emakeelega õppijad kasutavad eesti keeles palatalisatsiooni samamoodi nagu emakeelsed kõnelejad. Kui õppijate kasutus erineb emakeelsetest kõnelejatest, tahame teada, kas kõnetreening aitab erinevusi vähendada. Salvestasime Tallinna Linnamäe Vene Lütseumi 12. klassi õpilasi enne ja pärast nende initsiatiivil korraldatud hääldustreeningut. Treeningu viis läbi kõne- ja hääldusõpetaja Einar Kraut, see kestis 12 nädalat (1,5 tundi nädalas). Mõlemal salvestussessioonil (enne ja pärast treeningut) osales kaheksa õpilast. Kontrollgrupiks salvestasime sama materjali seitsmelt murdetaustata Tartu keskkooli õpilaselt, kes ei osalenud treeningus.

Vene ja eesti keeles realiseerub palatalisatsioon erinevalt. Vene keeles hõlmab see peaaegu kõiki konsonante, ka sõna alguses, ning seda märgitakse ortograafias. Eesti keeles sõna alguses kontrastiivset palatalisatsiooni ei esine, palataliseeruvad ainult konsonandid /s, t, n, l/, aga ortograafias seda ei märgita.

Teise keele omandamisel tugineb õppija suuresti oma emakeelele ning produtseerib õpitavat keelt emakeelest lähtuvalt. Leidsime, et vene emakeelega õppijad ei palataliseeri sõnalõpulisi konsonante ühesilbilistes *i*-tüvelistes sõnades, nagu eesti emakeelega kõnelejad, ilmselt kuna seda pole ortograafias märgitud. Oletasime ka, et nad palataliseerivad sõnaalgulisi konsonante nii nagu vene keeles, kui neile järgnevad eesvokaalid. Sellele me kinnitust ei leidnud. Leidsime, et vene emakeelega õppijad ei ole täielikult omandanud eesti keele palatalisatsiooni ja kasutavad vahekeelt, kus on omadusi nii ühest kui ka teisest keelest. Hääldustreening ei andnud mõõdetavat efekti osalejate eesti keele palatalisatsiooni hääldusele.

Katse tulemust mõjutas kindlasti see, et hääldustreening ei keskendunud konkreetselt palatalisatsioonile, vaid kattis erinevaid teemasid. Edaspidi võiks treeningul võtta fookusesse korraga ainult ühe teema või treeningu mõju analüüsil katta kõiki läbitud teemasid. Treeningu efekt võis käesoleval juhul andmete vähesuse tõttu jääda ka individuaalse varieeruvuse varju, mistõttu tuleks tulevikus püüda kaasata suuremat katseisikute rühma, et leida kinnitust siinse uurimuse tulemustele.

Võtmesõnad: akustiline foneetika, teise keele omandamine, aktsent, eesti keel, vene keel