

# THE PRODUCTION OF ESTONIAN VOWELS IN THREE QUANTITY DEGREES BY SPANISH L1 SPEAKERS

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## ABSTRACT

This paper studies the production of Estonian vowels in three quantity degrees by Spanish L1 learners of Estonian. The Estonian vowel system includes 9 vowels /i, y, e, ø, æ, a, o, ɤ, u/ while the Spanish vowel system has 5 /i, e, a, o, u/. Estonian has a rather complex three-way quantity system whereas in Spanish there are no phonological length oppositions.

Twenty-two native speakers of Spanish participated in a reading task. As a control group ten native speakers of Estonian were recorded.

The results showed that Spanish speakers did not distinguish between Estonian close-mid vowels (/ø, ɤ/) but produced instead an ambiguous mid-vowel. Also, the Estonian vowels /æ/ and /a/ were merged into Spanish /a/. The results improved with more exposure to the target language. Additionally, the vowels produced by Spanish speakers were significantly longer.

**Keywords:** Estonian vowels, Spanish, L2, duration.

## 1. INTRODUCTION

Second language (L2) acquisition theories suppose that L1 has an important role in language acquisition. According to the Speech Learning Model (SLM) acquiring L2 categories that are new compared to L1 is easier than acquiring those that are similar to the L1 categories [1], [2]. Also, the Perceptual Assimilation Model (PAM) relies on the phonetic similarity in order to make predictions about the acquisition of L2 contrasts [3]. Furthermore, the Native Language Magnet (NLM) theory proposes that L1 categories are represented in long-term memory as prototypes and in case of L2 acquisition the L1 categories act as perceptual magnets by assimilating nearby categories [4], [5].

Spanish has 5 vowels /i, e, a, o, u/. The Estonian vowel system is more crowded, including 9 vowels /i, y, e, ø, æ, a, o, ɤ, u/. The vowels /i, u, e, o/ are identical in both languages, while Estonian /æ/ and /a/ are similar to Spanish /a/, and Estonian /y, ø, ɤ/ do not have counterparts in Spanish [6], [7].

Estonian has a complex three-way quantity system consisting of short (Q1), long (Q2) and overlong (Q3)

quantity degrees. The Estonian quantity combines the segmental duration and tonal features while Spanish does not have a phonological length opposition. The Estonian quantity can be described by the duration ratios of the first and second syllable which typically are 2/3 in a Q1 foot, 3/2 in a Q2 foot, and 2/1 in a Q3 foot [7]–[11]. The quantity also has an effect on vowel quality which ranges from more central in Q1 to more peripheral in Q2 and Q3 [12], [13].

The Spanish speakers' production of L2 vowels has been studied based on different languages but the main focus has been on English. It was found in [2] that Spanish speakers produced English /ɛ/ and /æ/ as Spanish /e/ and /a/. The production of English /i/ and /ɪ/ was shown to be difficult for Spanish speakers regardless of their experience with English [2], [14], [15].

In addition to the acquisition of L2 vowels the acquisition of prosodic contrasts has been studied as well. A study conducted by [16] showed that Spanish speakers were less successful in perceiving the Swedish quantity than the Estonian and English speakers.

Studies on the acquisition of Estonian vowels by L2 speakers have shown that the production of /y, ø, ɤ, æ, a/ is problematic for L2 speakers of Estonian (for more details see [17], [18]). The results of a previous study [19] showed that Spanish speakers have difficulty producing the vowels /ø/ and /ɤ/ which were produced as an ambiguous mid-vowel. Also, /æ/ and /a/ were assimilated into one category and produced as Spanish /a/. However, the longer the Spanish speakers had studied Estonian the closer their vowels were to the Estonian L1 speakers' production.

It is hypothesized that Spanish speakers with a shorter length of residence (LOR) reduce all Estonian vowels to the Spanish vowel categories and those with a longer LOR are capable of creating new categories. However, the acquisition of new categories might be difficult due to similarities between the new and existing categories (e.g. /ø, ɤ/, /æ, a, a/). Additionally, it is expected that Spanish speakers find it difficult to produce durational distinctions of the Estonian vowels.

## 2. MATERIALS AND METHODS

A reading task was carried out using SpeechRecorder software [20] in a soundproof recording booth at the phonetics lab of the University of Tartu. The reading task formed part of a larger experiment. Another part of the experiment has been reported in [21].

### 2.1. Participants

Twenty-two native speakers of Spanish (11 females and 11 males) from different Spanish speaking countries (Spain (11), Colombia (5), Mexico (4), Honduras (2)) participated in the experiment. The Spanish L1 participants were between 20 and 46 years old (mean 30.45). They had learned Estonian and lived in Estonia from one month to 16 years (mean duration of studies 1.9 years, mean length of residence 3.2 years).

Due to the small number of Spanish L1 learners of Estonian, it was impossible to control the duration of study, LOR and country of origin of the participants. The whole Spanish speaking community of Tartu participated in the experiment. As the quality of vowels is remarkably stable in different dialects of Spanish [7], [22], the varying dialectal background of the participants was not considered a problem.

As a control group 10 native speakers of Estonian (5 females and 5 males) were recorded. The Estonian L1 participants were between 23 and 55 years old (mean 29.5). All Estonian participants spoke standard Estonian.

### 2.2. Test procedure

The participants were asked to read sentences from the computer screen. Every sentence included a CV(:)CV structured test word (see Table 1). The sentences were presented to the participants in random order. In total 81 sentences were recorded (9 vowels x 3 quantity degrees x 3 test words for each category). The first syllable vowel of the test word was analysed.

### 2.3. Data analysis

A Praat script based on the method described in [23] was used to measure the first three formants of the central 60% of the vowel. The formant values were determined 201 times in 10 Hz steps between 4500-6500 Hz for women and between 4000-6000 Hz for men. Grouping by speaker and vowel, the ceiling with the lowest variation was chosen to be the optimal ceiling. The formant values were log-scaled and normalized to z-scores.

The statistical analysis was carried out in R using lme4 [24]. The Euclidean distance was measured to evaluate the acquisition of vowel categories (see Section 3.2.). Linear mixed-effects models were fitted to analyse the effect of language experience (see Table 2) and the acquisition of duration patterns (see Section 3.3).

**Table 1:** An example of the sentences presented to the participants in the reading task.

Test word	Sentence
sada [sata] 'hundred'	Mehel on sada eurot. 'The man has a hundred euros'
saada [sa:ta] 'to send' 2SG, IMP	Palun saada talle sõnum. 'Please send him/her a message'
saada [sa::ta] 'to become' INF	Tüdruk tahab saada politseinikuks. 'The girl wants to become a police officer'

## 3. RESULTS

### 3.1. Vowels in F1-F2 space

There are no significant differences between the two groups of participants in the production of /i, u, e, o/ which are identical categories in both languages (see Figure 1). Greater variation can be seen in the production of /y, ø, æ, a, ɤ/.

Spanish L1 speakers have created a new mid-vowel for the Estonian /ø/ and /ɤ/ which is different from any Spanish vowel category. Within this new category Spanish L1 speakers do not distinguish /ø/ and /ɤ/ in the production and there is some overlap with /o/. A similar tendency can be seen in case of /æ/ and /a/ which are merged into Spanish /a/. The greatest variation occurs in the production of /y/ where the ellipse extends from /i/ to /u/.

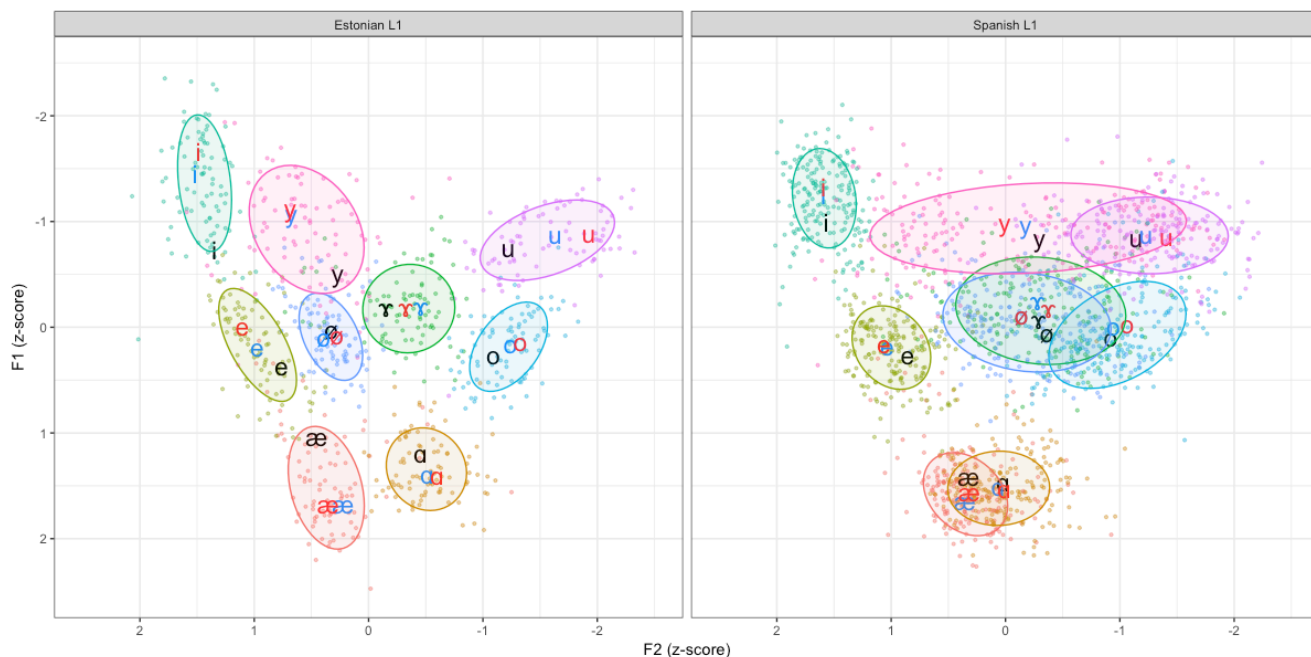
The short vowels produced by the Estonian L1 speakers are located in the more central and the long and overlong vowels more peripheral area of the vowel space (see Figure 1). No such tendency occurs in the production of the Spanish L1 speakers.

### 3.2. Length of residence (LOR) and L2 use

The Euclidean distance of Spanish speakers' vowels from Estonian speakers' mean values was calculated in order to measure how well the Spanish speakers have obtained the Estonian vowel categories.

A linear mixed-effects model was fitted to analyse the effect of L2 use, the duration of study and LOR on the vowel production.

**Figure 1:** Estonian vowels produced by Estonian L1 and Spanish L1 speakers grouped by mother tongue. The points marked as vowels are the means, the colour of the vowel marks the quantity (black – Q1, blue – Q2, red – Q3), the ellipse shows standard deviation.



Prior to the analysis the participants were divided into two groups according to their L2 use: those who use Estonian daily and those who do not.

The optimal model evaluates the distance of L2 production from the L1 groups' as a function of the vowel (only new vowel categories were included /æ, α, r, ø, y/) and L2 use (yes/no) (see Table 2). The effect of the speaker was added as a random factor. The intercept of the model corresponds to the distance of vowel /æ/ of the Spanish speaker who does not use Estonian daily. Factors such as test word, gender, duration of study and LOR were not significant and were therefore excluded from the model. Although L2 use as a main factor was not significant, the interaction of L2 use and vowel was the strongest compared to the interactions of duration of study and vowel, and LOR and vowel. Therefore, L2 use was included in the optimal model.

Figure 2 shows the effect of L2 use on the production of new vowel categories. The production of the participants who use Estonian daily is closer to the target vowels than the production of those who do not use Estonian daily. The greatest effect is seen in case of /α/, /ø/ and /y/ which also have the strongest interaction according to the model.

### 3.3. Vowel duration

The duration of stressed syllable vowels in the three quantity degrees was measured. A linear mixed-effects model was fitted to evaluate the effect of L1 and quantity on vowel duration.

**Table 2:** Linear mixed-effects model evaluating the distance of L2 production from that of the L1 group.

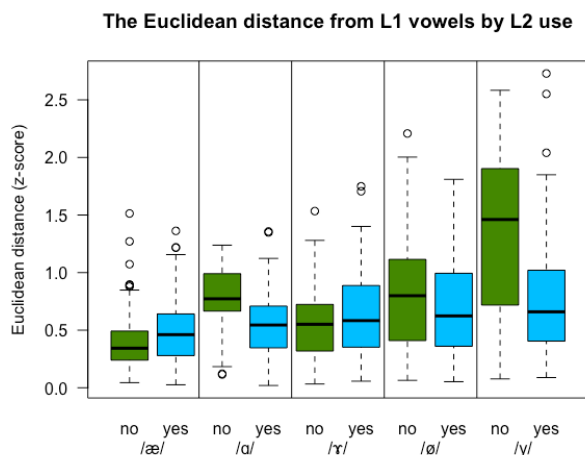
Fixed effects	Estimate	Std. Error	t value	Pr(> t )
Intercept	0.404	0.063	6.39	< 0.001
Vowel /α/	0.369	0.054	6.81	< 0.001
Vowel /s/	0.154	0.054	2.82	< 0.01
Vowel /ø/	0.405	0.054	7.48	< 0.001
Vowel /y/	0.926	0.054	17.1	< 0.001
L2 use yes	0.093	0.09	0.99	0.33
Vowel /α/: L2 use yes	-0.321	0.077	-4.19	< 0.001
Vowel /s/: L2 use yes	0.001	0.077	0.01	0.99
Vowel /ø/: L2 use yes	-0.192	0.077	-2.51	< 0.05
Vowel /y/: L2 use yes	-0.630	0.077	-8.22	< 0.001

L1 has a statistically significant effect on the vowel duration ( $F(1, 30) = 20.5, p < 0.001$ ): the vowels produced by the Spanish L1 speakers have a significantly longer duration and there is more variation compared to the Estonian L1 speakers.

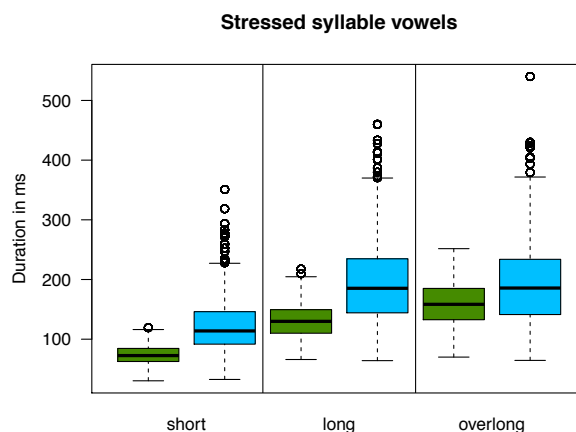
Also, the quantity ( $F(2, 77717) = 17914.1, p < 0.001$ ) and the interaction of L1 and quantity ( $F(2, 77717) = 528.6, p < 0.001$ ) turned out to be statistically significant factors.

Another linear mixed-effects model was fitted to analyse the effect of language experience on Spanish

**Figure 2:** Euclidean distance from L1 vowels grouped by L2 use (green – do not use Estonian daily, blue – daily users of Estonian) and vowel.



**Figure 3:** The duration of stressed syllable vowels grouped by mother tongue (green – Estonian L1, blue – Spanish L1) and quantity degree.



speakers' results. Factors such as duration of study, L2 use and LOR were not significant.

The Spanish L1 speakers distinguish between two categories of length: short (mean duration 123 ms) vs long (Q2 194 ms, Q3 194 ms), whereas the Estonian speakers have three clear categories: short (73 ms) long (130 ms), and overlong (158 ms) (see Figure 3). All the vowels produced by the Spanish speakers are significantly longer compared to the Estonian L1 productions.

#### 4. DISCUSSION

Previous studies have shown that Spanish learners find it difficult to acquire new L2 vowel categories [2], [14], [15]. The results of this study are in line with previous results [19]: for a Spanish L1 speaker the most difficult categories to acquire are the Estonian /y, ø, æ, a, ɤ/.

The vowels produced by Spanish L1 speakers seem to cluster around the five Spanish vowel categories as predicted by the Native Language Magnet theory [4], [5]. There is some overlap of /ø, ɤ/ with /o/, /æ, a/ with /a/ and /y/ with /i, u/. With respect to the acquisition of new categories the vowel /y/ appears to be the first new category that Spanish L1 speakers start to produce (see the stretched ellipse in Figure 1). The production of vowels /ø/ and /ɤ/ seems to be the most difficult for Spanish speakers as the ellipses overlap greatly.

As Estonian is a quantity language, the duration of vowels is influenced by the quantity. The Spanish speakers differentiate short vowels from long and overlong but compared to Estonian speakers the vowels are longer. As expected, the Spanish speakers do not distinguish long and overlong vowels as these were produced with a similar duration which is in line with the results of a previous perception test [21].

The quantity also has an effect on the vowel quality, the short vowels produced by the Estonian L1 speakers are located in the more central, and the long and overlong vowels in the more peripheral area of the vowel space, as also found in [12], [13].

The results of [19] showed a positive effect of duration of study on the production of Estonian vowels. In the present paper, the duration of study and LOR were not generally statistically significant factors. However, L2 use had a significant effect only on some of the vowels (/a/, /ø/ and /y/). It is shown in [25] that across different studies the effect of LOR varies and in about half of the studies LOR did not have an effect on the results. Also, it is argued that LOR might affect some aspects of language more than others (for more details see [25]).

#### 5. CONCLUSIONS

The results of a production experiment testing the acquisition of Estonian vowel categories showed that the Spanish L1 speakers do not distinguish Estonian vowels /ø/ and /ɤ/ and produce instead an ambiguous mid-vowel. Also, the production and differentiation of /æ/ and /a/ was problematic and these vowels were merged into Spanish /a/.

To some extent, the Spanish L1 participants with greater experience of Estonian produced vowels closer to the Estonian L1 target vowels. The language experience did not have an effect on the production of durational distinctions.

#### 6. ACKNOWLEDGEMENTS

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## 7. REFERENCES

- [1] J. E. Flege, 'Second-language Speech Learning: Theory, Findings, and Problems.', *Speech Perception and Linguistic Experience: Issues in Cross-language research. Timonium, MD: York Press*, no. In W. Strange (Ed), pp. 233–277, 1995.
- [2] J. E. Flege, O.-S. Bohn, and S. Jang, 'Effects of experience on non-native speakers' production and perception of English vowels', *Journal of Phonetics*, vol. 25, no. 4, pp. 437–470, Oct. 1997.
- [3] C. T. Best and M. D. Tyler, 'Nonnative and second-language speech perception: Commonalities and complementarities.', in *Language Experience in Second Language Speech Learning: In Honor of James Emil Flege*, Amsterdam: John Benjamins Publishing, 2007, pp. 13–34.
- [4] P. K. Kuhl, 'Human adults and human infants show a "perceptual magnet effect" for the prototypes of speech categories, monkeys do not', *Perception & Psychophysics*, vol. 50, no. 2, pp. 93–107, Mar. 1991.
- [5] P. K. Kuhl, B. T. Conboy, S. Coffey-Corina, D. Padden, M. Rivera-Gaxiola, and T. Nelson, 'Phonetic learning as a pathway to language: new data and native language magnet theory expanded (NLM-e)', *Philos Trans R Soc Lond B Biol Sci*, vol. 363, no. 1493, pp. 979–1000, Mar. 2008.
- [6] E. L. Asu and P. Teras, 'Illustrations of the IPA: Estonian', *Journal of the International Phonetic Association*, vol. 39, no. 3, pp. 367–372, 2009.
- [7] J. I. Hualde, *The Sounds of Spanish with Audio CD*. Cambridge University Press, 2005.
- [8] I. Lehiste, 'Segmental and syllabic quantity in Estonian', in *American Studies in Uralic Linguistics*, Bloomington: Indiana University Publications, 1960, pp. 21–82.
- [9] I. Lehiste, 'Search for phonetic correlates in Estonian Prosody', in *Estonian prosody: Papers from a symposium*, I. Lehiste and J. Ross, Eds. Tallinn: Institute of Estonian Language, 1997, pp. 11–35.
- [10] I. Lehiste, 'Prosodic change in progress: From quantity language to accent language.', in *Development in prosodic systems, Studies in Generative Grammar*, Berlin, New York: Mouton de Gruyter, 2003, pp. 47–65.
- [11] T. Navarro, *Studies in Spanish phonology*. Coral Gables: University of Miami Press, 1968.
- [12] A. Eek and E. Meister, 'Quality of standard Estonian vowels in stressed and unstressed syllables of the feet in three distinctive quantity degrees', *LU*, vol. 34, no. 3, pp. 226–233, 1998.
- [13] P. Lippus, E. L. Asu, P. Teras, and T. Tuisk, 'Quantity-related variation of duration, pitch and vowel quality in spontaneous Estonian', *Journal of Phonetics*, vol. 41, no. 1, pp. 17–28, Jan. 2013.
- [14] R. A. Fox, J. E. Flege, and M. J. Munro, 'The perception of English and Spanish vowels by native English and Spanish listeners: A multidimensional scaling analysis', *A multidimensional scaling analysis. Journal of the Acoustical Society of America*, 97, pp. 2540–2551, 1995.
- [15] P. Escudero and P. Boersma, 'Bridging the gap between L2 speech perception research and phonological theory', *Studies in Second Language Acquisition*, vol. 26, no. 04, Dec. 2004.
- [16] R. McAllister, J. E. Flege, and T. Piske, 'Regular Article: The influence of L1 on the acquisition of Swedish quantity by native speakers of Spanish, English and Estonian', *Journal of Phonetics*, vol. 30, pp. 229–258, Apr. 2002.
- [17] L. Meister and E. Meister, 'Production and Perception of Estonian Vowels by Native and Non-Native Speakers', *NTERSPEECH-2011*, pp. 1145–1148, 2011.
- [18] R. Nemoto, E. Meister, and L. Meister, 'Production of Estonian vowels by Japanese subjects', *ICPhS 2015 : 18th International Congress of Phonetic Sciences, 10-14 Aug 2015 SECC Glasgow UK, Proceedings*, pp. 1–5, 2015.
- [19] K. Leppik and P. Lippus, 'A comparative study of Estonian and Spanish vowels in L1 and L2 production.', *XXVIII Fonetikan päivät. Turku 25.-26. lokakuuta 2013. Konferenssijulkaisu. Turku: Turun yliopisto*, pp. 19–26, 2014.
- [20] C. Draxler and K. Jänsch, 'SpeechRecorder - a Universal Platform Independent Multi-Channel Audio Recording Software', in *Proceedings of the Fourth International Conference on Language Resources and Evaluation (LREC'04)*, Lisbon, Portugal, 2004.
- [21] K. Leppik, P. Lippus, and E. L. Asu, 'The perception of Estonian quantity degrees by Spanish listeners', in *Proc. 9th International Conference on Speech Prosody 2018*, 2018, pp. 478–482.
- [22] P. Ladefoged, *Vowels and Consonants*, vol. second edition. University of California, Los Angeles: Blackwell Publishing, 2005.
- [23] P. Escudero, P. Boersma, A. S. Rauber, and R. A. H. Bion, 'A cross-dialect acoustic description of vowels: Brazilian and European Portuguese', *The Journal of the Acoustical Society of America*, vol. 126, no. 3, pp. 1379–1393, Sep. 2009.
- [24] D. Bates, M. Mächler, B. Bolker, and S. Walker, 'Fitting Linear Mixed-Effects Models Using lme4', *Journal of Statistical Software*, vol. 67, no. 1, pp. 1–48, 2015.
- [25] E. Higby and L. K. Obler, 'Length of residence', *Linguistic Approaches to Bilingualism*, vol. 6, no. 1, pp. 43–63, Jan. 2016.