The perception of Estonian quantity degrees by Spanish listeners

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Abstract
This paper studies the perception of the Estonian quantity degrees by Spanish L1 listeners. Estonian and Spanish have different prosodic systems. Estonian is a quantity language where duration in combination with tonal components is used to signal quantity while Spanish does not have a phonological length opposition [1]-[5].

Twenty-two Spanish L1 and a control group of ten Estonian L1 listeners participated in the Estonian three-way quantity identification test. The results showed that Spanish L1 listeners find it difficult to perceive the Estonian quantity degrees, in particular to distinguish the long and overlong quantities. The duration of study of Estonian and the time of residence in Estonia did not have an effect on the results. The results of this study support previous findings about the perception of Estonian quantity degrees [6]-[8], and are in line with the Feature Hypothesis [9] according to which the perception of L2 phonological features that are not used in L1 is difficult for L2 learners.

Index Terms: L2, perception, Estonian, Spanish, quantity

1. Introduction
The duration of speech sounds and its function vary cross-linguistically. In quantity languages duration is used to signal quantity contrasts, i.e. the duration of the sounds is contrastive at the lexical level [3]. This paper focuses on the perception of the Estonian quantity degrees by Spanish L1 and Estonian L1 listeners. Estonian is a quantity language whereas in Spanish there is no phonological length opposition and duration acts as the main correlate of stress [4], [5].

Estonian has a rather complex three-way quantity system which combines durational and tonal components. The ternary opposition of short (Q1), long (Q2) and overlong (Q3) quantity degrees functions over a disyllabic foot. The quantity opposition can be carried by the vowel (or the diphthong) of the stressed syllable or by the intervocalic consonant or consonant cluster. The phonological length opposition operates only in the stressed syllable. Because of foot isochrony the vowel in the unstressed syllable is longest in Q1 and shortest in Q3 [1]-[3], [10]-[14]. Traditionally, the Estonian quantity has been described by the duration ratio of the first and second syllable in the foot. The typical S1/S2 ratios between the first and second syllable within a disyllabic foot are 2/3 in a Q1 foot, 3/2 in a Q2 foot, and 2/1 in a Q3 foot [2]. In addition to the durational differences pitch is also an important secondary cue for distinguishing Q3 from Q2 and Q1. In Q3 the fall of F0 takes place earlier than in Q1 and Q2. In case of Q1 and Q2 the F0 falls between the end of the first syllable and the beginning of the second syllable, in Q3 the fall takes place during the first syllable [1],[10], [14].

L2 acquisition theories suppose that the learner’s L1 influences the production and perception of L2. McAllister et al. [9] proposed a Feature Hypothesis which is partly based on the Speech Learning Model’s [15] fifth hypothesis which states that the formation of L2 category can be blocked by the mechanism of equivalence classification. According to the Feature Hypothesis [9] L2 learners have problems perceiving the L2 features that are not used in their L1 to signal phonological contrasts. To check the Feature Hypothesis the perception of Swedish quantity by Spanish L1, English L1 and Estonian L1 speakers was studied. The results suggested that the Estonian L1 subjects were more successful when perceiving the Swedish quantity contrast compared to the English L1 and the Spanish L1 subjects. According to the results, the Spanish L1 subjects found it hardest to perceive the Swedish quantity contrasts. The results confirmed the hypothesis [9].

There are numerous studies about the perception of quantity. A study on the perception of Finnish quantity by Finnish L2 learners and naive Russian listeners [16] showed that the Russian L1 speakers with longer experience of Finnish have access to the phonological quantity categories while Russian L1 speakers with less experience and non-Finnish speaking subjects have not established quantity categories.

A study on the perception of Estonian quantity [6] showed that Estonian L2 listeners are affected by the prosodic system of their mother tongue and depending on their L1 they use different strategies in order to categorize the Estonian quantity degrees. Latvian L1 listeners seem to be using the tonal component to distinguish between Q2 and Q3 while Finnish L1 and Russian L1 listeners rely on the temporal structure of the Estonian quantity degrees [6].

The results of a perception test [7] where Russian L1 listeners had to identify Q1 vs. Q2 revealed that Russian L1 listeners were able to distinguish the Estonian Q1 and Q2 despite the fact that in their mother tongue the duration is non-categorical. A study on the perception of the ternary quantity opposition in Estonian by Russian L1 listeners [8] confirmed the previous results: Russian L1 listeners distinguished Q1 and Q2 patterns. In case of the perception of the Q2 vs. Q3 the results indicated that Russian L1 listeners do not distinguish Q2 and Q3 [8].

The present study was undertaken because Spanish L1 listeners’ perception of Estonian quantity degrees has not been studied so far. As durational aspects play a very different role in the phonological systems of Estonian and Spanish [1]-[5] a L2 acquisition study of Estonian using Spanish subjects was expected to provide further insights into the intricacies of the Estonian three-way quantity system. According to the results
of [9] it is hypothesised that Spanish L1 listeners do not perceive the difference between Estonian Q1, Q2 and Q3. Additionally, it is expected that the Spanish L1 listeners who have studied Estonian and lived in Estonia for a longer time, perform better when distinguishing Estonian quantity degrees than beginner learners, as found in [17]. It is also likely that the quantity of more frequent test words is categorized correctly more often, as implied in [18].

2. Materials and methods

A perception test was conducted to study the perception of Estonian quantity degrees by Spanish L1 and Estonian L1 listeners. The test was carried out using Praat ExperimentMFC [19]. The test took place in a soundproof recording booth at the University of Tartu. During the perception test the stimuli were played to the participants via headphones.

2.1. Stimuli

The stimuli used in the perception test were 16 minimal triplets of voca-10c quantity: in total 48 disyllabic words with the CV(ː)CV structure (see Table 1). In Estonian, Q2 and Q3 of voca-10c quantity are not distinguished in orthography. The stimuli were extracted from carrier sentences where the test word was in the phrase-medial position (e.g. Mehel on sada eurot. ‘The man has a hundred euros’). The stimuli were read by a 26-year-old male native Estonian speaker. He had no reported speech or reading disorders. The sentences were presented to the speaker on the computer screen in a random order and the recordings were made using the BAS SpeechRecorder software, Sound Devices USBPre sound card and Beyerdynamic MC930 microphone. Figure 1 presents the average vowel durations and the pitch contours of the stimuli.

![Figure 1: The pitch of the stimuli by quantity (Q1-grey, Q2-blue, Q3-red). The shaded bars mark the duration of V1 (lighter shades) and V2 (darker shades).](image)

2.2. Participants

Twenty-two Spanish L1 listeners (11 females and 11 males) and a control group of ten Estonian L1 listeners (5 females and 5 males) participated in the experiment. The Estonian L1 listeners were between 23 and 55 years old. The Spanish L1 listeners were between 20 and 46 years old; they had learned Estonian and lived in Estonia from 1 month to 16 years (mean duration of study of Estonian 2.3 years, mean time of residence in Estonia 3.9 years). Spanish L1 listeners were from different Spanish speaking countries: Spain (12), Mexico (4), Colombia (4) and Honduras (2). The participants did not report any hearing problems.

2.3. Test procedure

The stimuli were presented to the listeners in random order. The listeners heard a stimulus and saw three sentences on the screen (e.g. Mehel on sada eurot. ‘The man has a hundred euros’ Palun saada mulle kiri. ‘Please send me a letter’ Tüdruk tahab saada politsseinikus. ‘The girl wants to become a police officer’). The listeners were instructed to match the stimulus with the sentence where they thought that the stimulus word occurred. The listeners could hear each stimulus only once. Along with the response the reaction time was recorded.

<table>
<thead>
<tr>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
</tr>
</thead>
<tbody>
<tr>
<td>pole [pole] ‘to be’ 1 SG</td>
<td>poole [poole] ‘half’</td>
<td>poole [poole] ‘towards’</td>
</tr>
<tr>
<td>tuli [tuli] ‘to come’ 3 SG, PSt</td>
<td>Tuuli [tuuli] proper name</td>
<td>Tuuli [tuuli] ‘wind’ 2P, PART</td>
</tr>
<tr>
<td>Nõri [nɔri] proper name</td>
<td>nõori [nɔri] ‘string’</td>
<td>nõori [nɔri] ‘string’ 2P</td>
</tr>
</tbody>
</table>

Table 1: The test stimuli grouped by the quantity.
Figure 2: The responses of Spanish L1 (on the left) and Estonian L1 (on the right) listeners grouped by the reaction time and the stimulus quantity. The color of the points marks the quantity of the listeners’ responses (grey – Q1, blue – Q2, red – Q3). The mean reaction time is marked with the lines.

2.4. Data analysis

The responses of the test subjects were categorized as “correct” in case the response matched the initial quantity degree of the stimulus, or “incorrect” in case the response was different from the initial quantity degree of the stimulus. A mixed-effects logistic regression model was fitted using the lme4 package [20] in R [21]. In the analysis of the results, the frequency of occurrence of the test words according to the Frequency Dictionary of Estonian within 1 000 most frequent words [22] was taken into account as due to the structure and the quantity degree of the test words, it is possible that some less frequent words are not familiar for beginner learners of Estonian, which would influence the result.

3. Results

Expectedly, the Estonian L1 listeners had no problem differentiating the quantity degrees (see the right panel of Figure 2). The Estonian L1 listeners categorized Q1 words in 100% of the cases correctly. While Q2 and Q3 words were categorized correctly in 95% of the cases, there was some confusion: Q2 words were categorized as Q3 words in 6% of the cases and Q3 words as Q2 words in 5% of the cases.

Spanish L1 listeners categorized 90% of the Q1 words as Q1 words, but confused them with Q2 (7%) and Q3 (5%) words. In case of Q2 and Q3, only 50% and 34% of the words respectively were categorized correctly. 36% of Q2 words were categorized as Q3, and 58% of Q3 words as Q2 words.

In order to evaluate the results a mixed-effects logistic regression model was fitted (see Table 2). The optimal model predicts the probability of correct answers as a function of the listener’s L1, reaction time, and the quantity of the stimulus. Factors such as the listener’s gender, number of foreign languages (s)he had learned, duration of study of Estonian or the time lived in Estonia, and the frequency of the test word (according to [22]) were statistically insignificant, and were therefore excluded from the model.

Table 2: The mixed-effects logistic regression model evaluating the probability of correct responses as a function of the listener’s L1, reaction time, and the quantity of the stimulus.

| Fixed effects           | Estimate | Std. Error | z value | Pr(>|z|) |
|-------------------------|----------|------------|---------|---------|
| Intercept               | 0.218    | 0.218      | 0.999   | 0.318   |
| Mother tongue Estonian  | 6.267    | 0.893      | 7.015   | <0.001  |
| Stimulus quantity Q1    | 2.924    | 0.391      | 7.486   | <0.001  |
| Stimulus quantity Q3    | -1.341   | 0.3        | -4.475  | <0.001  |
| Mother tongue Spanish: reaction time | -0.206 | 0.148 | -1.392 | 0.164 |
| Mother tongue Estonian: reaction time | -2.467 | 0.577 | -4.278 | <0.001 |
| Stimulus quantity Q1: reaction time | -0.765 | 0.281 | -2.717 | 0.007 |
| Stimulus quantity Q3: reaction time | 0.553 | 0.202 | 2.736  | 0.006  |
According to the model the mother tongue of the participants is statistically significant which is seen also in Figure 1. The Estonian L1 listeners are much more likely to give a correct response in the perception test than the Spanish L1 listeners.

The stimulus quantity is also a statistically significant factor for both groups. The participants are more likely to respond correctly to Q1 stimulus while in case of Q3 stimulus the probability of giving a correct response decreases.

There is a statistically significant interaction between the reaction time and mother tongue: the longer the Estonian L1 listeners’ reaction time is, the lower the probability to give a correct answer. There is no such effect in case of Spanish L1 listeners. The model shows another statistically significant interaction between the reaction time and stimulus quantity: in case of Q1 a longer reaction time lowers the probability of giving a correct answer and in case of Q3 a longer reaction time raises the probability of giving a correct answer.

4. Discussion

This paper focuses on the perception of Estonian quantity degrees by Spanish L1 listeners. It was hypothesised that Spanish L1 listeners do not perceive the difference between Estonian quantity degrees, because their L1 does not use duration to signal phonological contrasts [4], [5]. The results showed that the Spanish L1 listeners can distinguish Q1 from Q2 and Q3, but do not perceive the difference between Q2 and Q3. The results of this study are in line with previous results of Estonian quantity perception studies, which have found that Estonian L2 listeners are capable of distinguishing Q1 from Q2 and Q3, but do not perceive the difference between Q2 and Q3 [7], [8]. Similarly, the Spanish L1 speakers have been shown not to distinguish the Swedish quantity contrasts [9].

The distinction of the Estonian quantity degrees is not only problematic for Spanish L1 listeners but also for Russian, Finnish and Latvian L1 listeners [6]–[8]. Estonian L2 listeners are influenced by their L1’s prosodic system and therefore use different cues (tonal components, duration) for distinguishing the Estonian quantity degrees (for more details see [6]–[8]). Which cues Spanish L1 listeners use for categorizing Estonian quantity degrees needs to be studied in further detail.

As noted above, the results of this study show that the Spanish L1 listeners do not distinguish Estonian Q2 and Q3. It is possible that the distinction of Q2 and Q3 may be influenced by the nature of the Estonian declination system where in certain word types the quantity is used systematically to indicate the genitive and partitive cases (e.g. viili (Q2, GEN), viili (Q3, PART)). In addition, in some word types the Q3 is used to indicate the illative and allative cases (e.g. kooli (Q2, GEN), kooli (Q3, ALL); teele (Q3, ALL)). The data collected during this perception test was not sufficient to study the influence of declination to the participants’ perception. A possible interaction between the Estonian cases and Q2-Q3 perception is another aspect that needs addressing in the future.

There are few studies on the production and perception of Estonian by Spanish L1 speakers [17], [23]. A previous study showed that the duration of study of Estonian had a positive effect on the production of Estonian vowels [17]. Therefore, it was expected that there would also be a positive effect in the perception of Estonian quantity degrees. The current results, however, showed that the duration of study of Estonian and the time of residence in Estonia did not have a statistically significant effect on the results. The insignificance of these factors may be due to the relatively small number of stimuli presented to the participants.

It was also proposed that the quantity of words with a higher frequency of occurrence would be categorized correctly more often. Our results showed that the frequency of the test word was not a significant factor, which may be explained by unbalanced distribution of the test words’ frequencies.

5. Conclusions

This paper studied the perception of the Estonian quantity degrees by Spanish L1 listeners. The results of this study are in line with previous results [6]–[9], [16], which show that the perception of quantity can be difficult for the speakers of a non-quantity language as is suggested in the Feature Hypothesis [9]. Estonian L1 listeners were significantly more precise in categorizing Estonian quantity than the Spanish L1 listeners. Spanish L1 listeners did not perceive the difference between the Estonian Q2 and Q3. Unexpectedly, the duration of study of Estonian and the time of residence in Estonia did not have a statistically significant effect on the Spanish L1 listeners’ results. Also, the test word’s frequency of occurrence did not influence the perception of quantity.

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7. References


