

THE TONAL COMPONENT IN PERCEPTION OF THE ESTONIAN QUANTITY

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ABSTRACT

This paper studies the role of the pitch cue for perceiving the Estonian quantities. In addition to the importance of the tonal component we investigate the differences in native vs. learned discrimination of the quantities. Perception tests were carried out with manipulated natural speech stimuli on a group of Estonian native speakers and a group of non-native Estonian speakers. The test results show that for Estonian listeners the pitch is a vital cue to the perception of overlong quantity. This indicates that rather than ternary on one level, the Estonian quantity system is a binary distinction on two levels, where the distinction between short and long is perceived on the basis of durational ratios, but for the distinction of long and overlong, the pitch cue is needed. The results of the non-native Estonian group show that the non-native speakers have learned how to focus on the duration of the stressed syllable whereas the tonal pattern does not affect their perception of quantities.

Keywords: Estonian quantity, Estonian tone, word prosody.

1. INTRODUCTION

The existence of a tonal component in Estonian was already introduced by Polivanov [13], who regarded tone in Estonian as a secondary feature in combination with quantity. It was Trubetzkoy [14] and Jakobson [6] who first showed that Estonian had characteristics of a tone language. Later Helimsky [5] and others also regarded Estonian as a tone language.

Later experimental evidence has shown that pitch plays an important role in the three-way quantity distinction of Estonian. Lehiste [7] demonstrated that in disyllabic metric feet of the first (Q1) and second quantity (Q2) there is a step-down in F0 contour between the end of the first syllable nucleus and the beginning of the second syllable while the third quantity (Q3) is associated

with a fall early during the first syllable. This result was independently confirmed by Liiv [11].

Previous perception studies (Lehiste [8], Eek [2]) have shown that the pitch cue is crucial for distinguishing Q2 and Q3. The claim that the prosodic foot functions as the main domain of the quantity degrees was introduced by Lehiste in her work in the 1960s. The most important factor for her was the durational ratio of the stressed syllable and the following unstressed syllable. Lehiste and Danforth [10] present a hierarchy of phonetic cues for the perception of Estonian quantities according to which the pitch cue is the second most important after the duration of V1. Within the whole foot the tonal peak is at the end of the nucleus of the stressed syllable in Q1 and Q2 but falls noticeably in the unstressed syllable; in Q3 the fall starts already in the first half of the stressed syllable and continues in the unstressed syllable. On the basis of all the perception tests Lehiste concludes that the quantity opposition is binary: the syllable ratios discriminate short from long, but for the discrimination of long and overlong the pitch cue is vital [9]. More recent perception studies on Estonian quantities have, however, neglected the pitch cue concentrating mainly on durational aspects (e.g. Eek and Meister [3], [4]).

In this paper we test the perception of Estonian quantities on native Estonian speakers and second language speakers of Estonian. In addition to the importance of the tonal component we investigate the differences in native vs. learned discrimination of the Estonian quantities. The perception of the Estonian quantity degrees by second language speakers of Estonian have been studied most in connection with a foreign accent in Estonian. Pajusalu [12] has studied how the Finns perceive the quantity degrees in Estonian. His results show that native Finnish speakers attributed more phonological weight to the length of the unstressed syllable, similarly to Finnish where there is a phonological opposition of long and short duration

in unstressed syllables, and they perceived the Estonian words with Q2 similarly to Finnish words with the long first and second syllables.

2. METHOD

The perception test involved assigning quantity degrees to the stimuli synthesised from natural words with Q1, Q2 and Q3. For the test stimuli two quantity triplets were used: one for the vowel quantity where the quantity distinction is carried by V1 (sada [sata] 'hundred', saada [saata] 'send!', saada [sa:ta] 'to get') and the other for the consonant quantity where the quantity distinction is carried by the intervocalic consonant (kada [kata] 'slingshot', kata [katta] 'cover!', katta [kat:ta] 'to cover'). The words were read in a carrier sentence by a male speaker. From each word a set of nine stimuli was created by manipulating the duration of either the first vowel or the intervocalic consonant. According to Lehiste, the syllable duration ratios for Q1, Q2 and Q3 are 2:3, 3:2 and 2:1 (see [9] for details). The stimuli were synthesised so that for the first stimuli the syllable duration ratio would be $<2:3$ and for the last $>2:1$. Only the duration of one sound in the word was changed, starting from 50 ms in nine steps of 30 ms to 290 ms. In addition to the sound the pitch contour was also stretched or shrunk, but the location of the peak remained proportionally unchanged. The stimuli were presented to the listeners in six blocks of 9 with 10 repetitions in random order. The pitch curves of the original words are presented in Figures 1 and 2.

Figure 1: The pitch curves in the test words [sata] (Q1) dashed line, [saata] (Q2) dotted line, [sa:ta] (Q3) solid line.

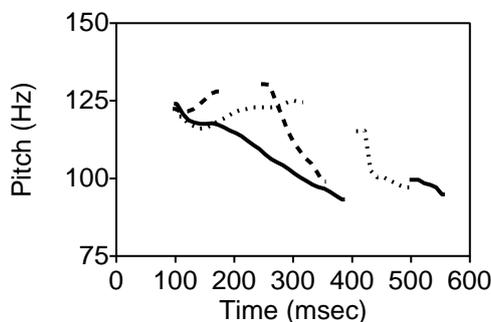
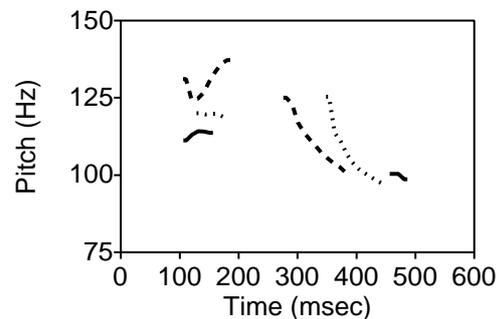


Figure 2: The pitch curves in the test words [kata] (Q1) dashed line, [katta] (Q2) dotted line, [kat:ta] (Q3) solid line.



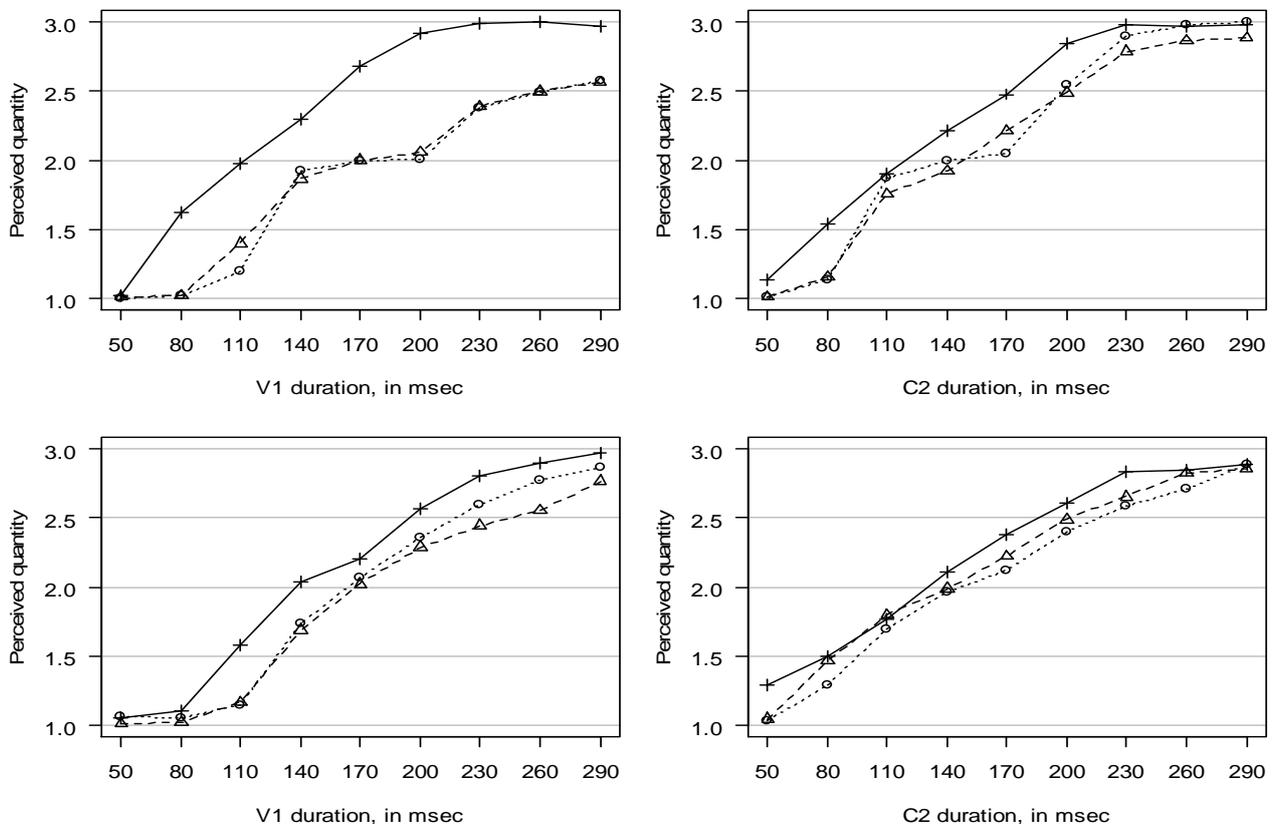
For creating the stimuli and for carrying out the perception test the Praat program [1] was used.

The test subjects formed two groups: 9 native Estonians, 9 near-native Estonian speakers. The subjects in the non-native Estonian group have learned Estonian as adults; they speak it fluently but have a slight accent. They use Estonian frequently, several even as their home language. The first languages of the non-native Estonian subjects were Bulgarian, English, Finnish, German, Latvian, Livonian, Norwegian, Russian and Yiddish. None of these languages have a similar quantity system to Estonian.

3. RESULTS

The results of the perception tests were tested with paired t-test for each judgement point. The results of the native Estonian speakers show that in the case of the first set (vowel quantity; Fig. 3 top left) the difference between the F0 in Q1 and Q2 is not perceived (t-test showed no significant difference, $p=0.478$): the response curves are practically overlapping. The fact that the response curves of the Q1 and Q2 F0 never reach the ceiling implies that the listeners fail to perceive Q3 if the characteristic pitch cue is not available. If, however, the pitch movement of the stimuli is that of Q3 the listeners perceive Q3 easily as soon as the duration of V1 is longer than about 170 ms. Q1 is perceived only if V1 has the shortest possible duration. The Q3 F0 results are significantly different from the Q1 and Q2 F0 results ($p=0.000$).

Figure 3: The judgments of the Estonian speakers (top row) and non-native Estonian speakers (bottom row), quantity assignment as a function of V1 duration (left) and as a function of C2 duration (right). The dashed line represents the results of the stimuli with the Q1 F0, the dotted line the stimuli with the Q2 F0 and the solid line the stimuli with the Q3 F0. The judgments were coded 1, 2 and 3 for the reported Q1, Q2 and Q3 respectively.



In the case of the second set (consonant quantity; Fig. 3 top right) all three quantities were perceived regardless of the original pitch cue of the stimuli. However, perceptual boundaries between the quantities varied depending on the original pitch cue. Still the t-test showed a significant difference between the Q1 and Q2 F0 vs. the Q3 F0 ($p=0.000$). No significant difference was found between Q1 F0 and Q2 F0 ($p=0.845$).

The results of the non-native Estonian speakers in case of the first set (vowel quantity; Fig. 3 bottom left) show that the difference between the Q1 F0 vs. Q2 F0 was not significant ($p=0.174$). However, the result was significant between the Q1 and Q2 F0 vs. the Q3 F0 ($p=0.005$). In the second set (consonant quantity; Fig. 3 bottom right) the difference was significant for all the F0 patterns ($p<0.050$). Hence the differences in both sets are in the crossover points in time. All the quantity levels were perceived with all the sets of stimuli.

The differences between Estonians and non-native Estonian speakers were significant for all the stimuli sets ($p<0.001$).

4. DISCUSSION

We can see that the results differ greatly. The perception of words with the Q1 F0 and Q2 F0 is rather similar but the responses to words with the Q3 F0 are different. Within the groups and the sets the perception of the stimuli with the Q1 F0 and Q2 F0 is rather similar but the responses to the stimuli with the Q3 F0 are different. In some cases the differences between the stimuli with the Q1 F0 and Q2 F0 are even greater for non-native Estonian speakers.

The overall rule seems to be that the stimuli with the Q3 F0 are judged to be longer than the stimuli with the Q1 F0 and Q2 F0 but the difference between the Q3 F0 and the Q1 and Q2 F0 is greater when the quantity distinction is carried by V1. In case of the vowel quantity it is the F0 contour that determines whether the hearer

perceives Q2 or Q3. Yet, Q3 responses can hardly be obtained with the F0 of Q2, even where the vowel in the first syllable is lengthened to 290 ms.

In the case of words with a consonantal pattern the respective consonant was changed at the boundary of the first and second syllable, so that the F0 contours of the vowel in the first syllable with different quantities did not change. But the consonant that carried the quantity assignment was a voiceless consonant, so the success of perceiving Q3 with the Q1 and Q2 F0 is most possibly due to missing the pitch cue.

The results of the perception test show a considerably smaller effect of fundamental frequency in case of non-native Estonian speakers. There is no problem perceiving Q3 of the stimuli with the step-down pitch pattern in the first set (vowel quantity). The results are almost the same for both sets but the perception of the stimuli with a Q3 F0 contour differs slightly from the perception of words with F0 of Q1 and Q2. Words with a consonantal pattern show a minimal difference. All over difference is the bigger dispersion of the judgments; the crossover points are more accurate for Estonians.

An important difference between Estonians and non-native Estonian speakers was that the crossover points for different quantities were at different places. For Estonians when the quantity distinction is carried by V1 and the stimuli are with the Q3 F0 the border of Q1 and Q2 is perceived at the V1 duration of 70 ms and the border of Q2 and Q3 at 177 ms. For non-native Estonian speakers the borders were at 105 and 190 ms. This shift between the perception of Estonians and non-native Estonian speakers was also to a certain extent present when the quantity distinction was carried by Q2.

5. CONCLUSIONS

The experiment confirms the vital importance of the pitch cue in the perception of Estonian quantity degrees, and raises the issue of the typological classification of Estonian as a quantity or tone language. The results of this study confirm Lehiste's conclusion that the quantity opposition is binary in Estonian: the syllable ratios discriminate short from long but for the discrimination of long and overlong the pitch is the vital cue.

The experiment also shows that non-native Estonian speakers have successfully learned to discriminate the quantities by the duration of the

stressed syllable. This is because the quantity distinction in Estonian is taught as a segmental feature but also because it is affected by the prosodic system of the subject's first language.

6. ACKNOWLEDGEMENTS

We would like to thank all our test subjects. We are also very grateful to Eva Liina Asu-Garcia and Pire Teras for their constructive comments. The present research was partly supported by the Estonian Science Foundation grant No. 5812.

7. REFERENCES

- [1] Boersma, P., Weenik, D. 2007. Praat: doing phonetics by computer. <http://www.praat.org> visited 25-May-07
- [2] Eek, A. 1980. Further information on the perception of Estonian quantity. *Estonian Papers in Phonetics 1979*, 31-57.
- [3] Eek, A., Meister, E. 2003. Foneetilisi katseid ja arutlusi kvantiteedi alalt (I). Häälikukestusi muutvad kontekstid ja välde. *Keel ja Kirjandus* 11-12. 815-837, 904-918.
- [4] Eek, A., Meister, E. 2004. Foneetilisi katseid ja arutlusi kvantiteedi alalt (II). Takt, silp ja välde. *Keel ja Kirjandus* 4-5. 251-271, 336-357.
- [5] Helimski, E. 1977. Some preliminary data on lexical tonal oppositions in Estonian. *Estonian Papers in Phonetics 1977*, 35-38.
- [6] Jakobson, R. 1962. Über die Phonologischen Sprachbünde. *Selected Writings of Roman Jakobson I, Phonological Studies*. The Hague: Mouton & Co. 137-143.
- [7] Lehiste, I. 1960. Segmental and syllabic quantity in Estonian. *American Studies in Uralic Linguistics* 1. Bloomington, 21-82.
- [8] Lehiste, I. 1970-1975. Experiments with synthetic speech concerning quantity in Estonian. Hallap, V. (ed.) *Congressus Tertius Internationalis Fenno-Ugristarum, Tallinae habitus, 17-23. VIII 1970. Pars I: Acta Linguistica*. Tallinn: Valgus, 254-69.
- [9] Lehiste, I. 1997. Search for phonetic correlates in Estonian Prosody. In: Lehiste, I., Ross, J. (eds), *Estonian Prosody: Papers from a Symposium*. Tallinn: Institute of Estonian Language, 11-35.
- [10] Lehiste, I., Danforth, D. 1977. Foneettisten vihjeiden hierarkia viron kvantiteetin havaitsemisessa. *Virittäjä* 4, 404-411.
- [11] Liiv, G. 1961. Eesti keele kolme vältusastme vokaalide kestus ja meloodiatüübid. *Keel ja Kirjandus* 7, 8. 412-424, 480-490.
- [12] Pajusalu, K. 1994. Kuidas soomlased õpivad kuulma eesti välteid. Pajusalu, K., Yli-Vakkuri, V. (eds.) *Lähivertailuja 7*. Publications of the department of Finnish and general linguistics of the University of Turku, 44, Turku, 75-88.
- [13] Поливанов Е. Д. 1928. *Введение в языкознание для востоковедных вузов*. Ленинград: Восточный институт им. А. А. Энукидзе.
- [14] Trubetzkoy, N.S. 1939. *Grundzüge der Phonologie*. Prague.