ON THE QUANTITY AND QUALITY OF ESTONIAN VOWELS OF THREE PHONOLOGICAL DEGREES OF LENGTH

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1. The quantitative system of Estonian is unique in that it has three phonologically relevant degrees of length for vowels as well as consonants (the number of phonetic degrees of length is considerably greater). The views of specialists on quantity in Estonian differ widely. Studies of the nature of quantity in the light of experimental data have been quite haphazard, scanty and insufficient.[1]

In this report the author presents some results of his experimental work on the duration and pitch patterns accompanying the three phonological degrees of length of Estonian vowels. The articulatory as well as acoustic features of vowels in different degrees of length have also been analyzed. Our conclusions are based on kymographic recordings of 994 sentences (5 informants), oscillographic recordings of 95 sentences (5 informants), over 200 X-ray photographs (6 informants), 1205 palatograms (4 informants), films of the external organs of speech in pronouncing 81 sentences (3 informants), over 600 spectra of different types (5 informants), the auditory analysis by means of a gating circuit of language material obtained from 5 informants.

2. The vowel system of Standard Estonian consists of 9 phonemes: /i/, /ü/ (= IPA /y/), /e/, /ö/ (= IPA /ø/), /ä/ (= IPA /æ/), /u/, /o/, /a/, /õ/ (= IPA /ɔ/ = [ɤ̞] or [ɘ̞–]), and numerous diphthongs. The Estonian monophthongs of three phonological degrees of length have been investigated in stressed syllables of disyllabic words with both syllables open. The words studied were pronounced by the informants not separately, but as identical portions of a sentence: as the first words of declarative affirmative sentences in the indicative mood that do not carry the logical sentence stress. The duration of vowels in the unstressed syllables of the same words was also investigated. The vowels contrasted as to quantity occurred in completely identical consonantal environments in all three, i.e. the short, long and over-long degrees of length. In all sentences the second word began with a stop consonant.[2]

[1] A survey of the divergent views on the quantitative system of Estonian is given in G. Liiv, "On Qualitative Features of Estonian Stressed Monophthongs of Three Phonological Degrees of Length", *Eesti NSV Teaduste Akadeemia Toimetised, Ühiskonnateaduste Seeria* [*Transactions of the Academy of Sciences of the Estonian S.S.R., Series of Social Sciences*], (Tallinn, 1961), Nos. 1, 2, pp. 41–66, 113–131, Survey pp. 42–46.

[2] For a description of the methods and materials used in different series of experiments, see G. Liiv, "Eesti keele kolme vältusastme vokaalide kestus ja meloodiatüübid" ["The Duration and Pitch Patterns of Estonian Vowels in Three Degrees of Length"], *Keel ja Kirjandus* [*Language and Literature* (Tallinn, 1961), Nos. 7, 8, pp. 412–424, 480–490; an account of materials and methods is given on pp. 415–417! G. Liiv, "On Qualitative Features of Estonian Stressed Monophthongs of Three Phonological Degrees of Length", pp. 46–50; G. Liiv, "Acoustical Features of Estonian Vowels Pronounced in Isolation and in Three Phonological Degrees of Length", *Eesti NSV Teaduste Akadeemia Toimetised, Ühiskonnateaduste Seeria* [*Transactions of the Academy of Sciences of the Estonian S.S.R., Series of Social Sciences*] (Tallinn, 1962), No. 1, pp. 63–97; an account of materials and methods may be found on pp. 63–69.

3.11 The results of measurements of Estonian vowels are summarized in Table 1. The *average* figures for the *absolute duration* of Estonian vowels *in stressed syllables* are as follows: first degree of length – 118.8 msecs, second degree of length – 204.4 msecs, and the third degree of length – 240.4 msecs (each of these figures is the average of about 300 measurements).

It can be seen from Table 1 that the durations of vowels depend on their quality (cf. the figures in the vertical rows) and the manner of production of the following consonants (cf. the figures in horizontal rows)[3].

3.12 The *ratios* of the absolute average durations *of the degrees of length* in vowels of stressed syllables are: 1.00 : 1.72 : 2.02 in the case of the first, second and third degrees of length; 1.00 : 1.18 in the case of the second and third degrees. The ratios given in earlier investigations based on measurements of words pronounced in isolation are evidently much exaggerated.

The ratios of the average durations of vowels in three degrees of length depend to a certain extent on the phonetic positions of the vowels (i.e. on the character of the following consonants) and also on the specific duration of each vowel.[4]

3.2 Measurements show that the *duration* of a vowel *in an unstressed syllable* is in inverse proportion to the duration of a vowel in a stressed syllable (see Table 1). The *average absolute duration* of the vowel in a second syllable is 162.9 msecs in words of Quantity 1, 127.1 msecs in words of Quantity 2 and 93.1 msecs in words of Quantity 3 (each figure is the average of about 300 measurements). One may thus speak of three phonetical lengths of second-syllable vowels. The ratio of the absolute average durations of vowels in unstressed syllables of words of Quantities 3, 2 and 1 is 1.00 : 1.37 : 1.75; the ratio of the average durations of vowels in unstressed syllables of words of Quantity 3 and Quantity 2 is 1.00 : 1.28.

3.3 From the point of view of the perception of the quantity of a word the *ratio of the duration* of the vowel *in the stressed syllable to that* of the vowel *in the unstressed syllable* appears to be more significant than the contrasting of absolute figures for the degrees of durations of vowels in stressed syllables, or, for that matter, in unstressed syllables (at least in the type of words analyzed in the present work).

This postulate is given numerical expression in Table 1 where the ratios of the durations of vowels in first and second syllables have also been given in all cases.

[3] For the discussion and details see G. Liiv, "Eesti keele kolme vältusastme vokaalide kestus ja meloodiatüübid", pp. 417–421, Tables 2–3, Fig. 2.

[4] *Ibid.*, for these phenomena see p. 423, Tables 4–5.

The average ratio of the durations of vowels in stressed and unstressed syllables is 0.73 : 1.00 in the first degree of quantity; 1.60 : 1.00 in the second degree and 2.58 : 1.00 in the third degree.[5] It must be noted that there is hardly ever any overlapping between the fluctuation ranges of the relative figures characteristic of the different degrees of quantity. Thus, the maximum variation of the ratio of the duration of a vowel in a stressed syllable to that of a vowel in an unstressed syllable is generally 0.50 to 1.00 in the case of words of Quantity 1, 1.00 to 2.00 for words of Quantity 2 and 2.00 to 3.00 in the case of words of Quantity 3 (in the last case the ratio may also be bigger).

The relation of ratios for the average absolute durations of vowels of stressed and unstressed syllables in words of Quantities 1, 2 and 3 is 1.00 : 2.19 : 3.53; in the case of words of Quantities 2 and 3 it is 1.00 : 1.61. It is obvious that the ratios for the durations of vowels in stressed and unstressed syllables of different degrees of quantity contrast much more markedly than do the durations of vowels in stressed syllables alone. This seems to suggest the greater importance of such contrasts in the process of the perception of different degrees of quantity.

The opinion expressed above is corroborated by *auditory tests*. The object of these tests was to observe possible changes in the perception of degrees of quantity under different conditions when certain segments of vowels in stressed or unstressed syllables were removed from a magnetic tape by gating out, thus reducing the vowel durations.

From the point of view of language structure it is interesting to note in this connection that there are no quantitative oppositions of Estonian monosyllabics.

3.4 In the course of the computation of observations empirical frequency distribution has been plotted for the variation of absolute durations of vowels in stressed as well as unstressed syllables of words in three degrees of quantity. The relevant theoretical (normal) distribution has also been computed on the basis of these empirical data.[6] *Statistical data* show that all the mean values given are wholly reliable as regards the different durations of vowels in stressed as well as in unstressed syllables.

4. The *pitch patterns* accompanying different degrees of length in Estonian can be characterized in general terms as follows (the conclusions are based on the analysis of 159 pitch movement curves).

4.1 Pitch movement within the limits of a vowel of the first degree of length has a rising tendency. The terminal point of the pitch curve is, on the average, one minor

[5] Cf. the ratios listed in this work with the relative figures of durations of *syllables* given in I. Lehiste, "Segmental and Syllabic Quantity in Estonian", *American Studies in Uralic Linguistics* (= *Uralic and Altaic Series*, I) (1960), p. 62.

[6] All the curves referred to may be found in G. Liiv, *op. cit.*, p. 484, Fig. 8; parameters of the distribution of vowel durations are given on p. 485, Table 7.

tierce (three musical semi-tones) higher than the initial point.[7] The form of pitch movement is characterized mainly by a comparatively sudden rise on the initial portion of the vowel and by a subsequent level pitch (graphically *). In some cases level pitch pattern has been registered.

4.2 Pitch movement on vowels of the second degree of length has a generally rising tendency. The terminal point of the pitch curve is on an average one major tierce (four semi-tones) higher than the initial point. It is possible to distinguish two principal forms of pitch movement. The first is more common and is characterized by level pitch on the initial portion of the vowel, by a steep rise on the middle part and by level pitch in the culmination at the end (graphically ⌋⌉). Another form of pitch contour is characterized by a marked rise in pitch on the initial and middle portions of the vowel and a certain fall on the terminal portion (graphically /). The culmination of the pitch movement is on the average an augmented quarto (six semi-tones) higher than is the initial point; subsequently the pitch falls by about a major second (two semi-tones). Thus the terminal point of the curve is, on the average, a major tierce higher than the initial point (as in the first pitch contour form). The rising pitch on the second degree of length of the vowels differs from the corresponding contour in the first degree of length in form and range.

4.3 Pitch movement within the limits of a vowel in the third degree of length reveals a generally falling tendency. Two principal forms of pitch movement may by met with here. The first and more common of these is characterized by level pitch on the initial portion of the vowel and by a fall on the middle and terminal portions (graphically ¬\). Another form of pitch contour is characterized by a certain rise in pitch on the initial portion of the vowel and a marked fall on the middle and terminal portions (graphically ^\). The culmination of the pitch curve is on the average a major second higher than the initial point, the terminal point is, on the average, an augmented quarto lower than the culmination. In the case of both principal forms of pitch movement the major tierce serves to distinguish the terminal and initial points – a surprisingly simple and logical regularity! (see Fig. 1).

4.4 From the point of view of the phonological system a different pitch pattern in different degrees of duration appears to be merely a concomitant phonetic phenomenon that does not play a decisive role in the perception of the corresponding degrees of quantity. This is confirmed above all by auditory tests where a definite pitch pattern when changing durational relations is not an insurmountable obstacle in identifying a word with a shortened vowel as being of a different degree of quantity than the original word. A further corroboration of the same is the relatively greater variation of pitch patterns.

5. The investigation of the *articulatory features* of vowels in stressed syllables of three phonological degrees of length has revealed considerable differences in the

[7] The average pitch of the initial portion (duration 30 msecs) of the vowel has been taken for the initial point of all pitch curves.

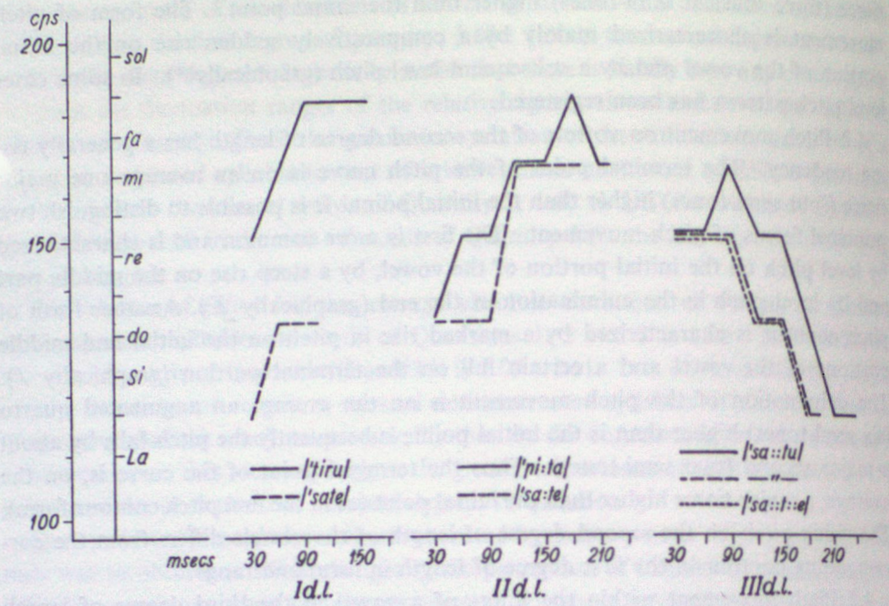

Fig. 1. Changes in fundamental pitch on stressed vowels of three degrees of length (d.l.) in words /'tiru/ "gland", dial., *Genitive Sg.*, /'sate/ "sediment", *Nominative Sg.*, /'pi:ta/ "jamb (of a door, etc.)", *Genitive Sg.*, /'sa:te/ "transmission", *Nominative Sg.*, /'sa: :tu/ "hayrick", *Illative Sg.*, /'sa: :t: :e/ "transmisson", *Genitive Sg.*

production of such vowels as regards the movement of the articulators and in the configuration of the vocal tract as a whole.[8]

6. The *auditory*, *oscillographic* and *spectral analysis* of the language material likewise proves that there are regular qualitative differences between vowels of three degrees of length.[9]

7. The absolute durations as well as the relative durations of the so-called *characteristic* and *transitional segments* of vowels in three degrees of length are also different.[10]

8. Our material proves convincingly that the complicated quantitative system of

[8] An articulatory analysis is given in G. Liiv, "On Qualitative Features of Estonian Stressed Monophthongs of Three Phonological Degrees of Length".

[9] For the acoustical correlates of Estonian vowels in different degrees of length, see G. Liiv, "Acoustical Features of Estonian Vowels Pronounced in Isolation and in Three Phonological Degrees of Length".

[10] For details see G. Liiv, "On the Acoustic Composition of Estonian Vowels of Three Degrees of Length" (to be published in *Transactions of the Academy of Sciences of the Estonian S.R.R., Series of Social Sciences*, Tallinn, 1962, No. 3).

Estonian is based on three phonological degrees of length. It is quite natural that a number of qualitative differences are associated with quantitative differences. In the light of the information theory it is obvious that a great redundancy of information pervades the whole structure of language and ensures the stability of the communicative function of language.

On the whole, it seems that as regards duration the first and second degrees of quantity are more markedly contrasted than are the second and third degrees, whereas the differences in many qualitative features associated with quantity appear to be comparatively greater between the second and third degrees of quantity. One may also assume that the differing contact between vowel and following consonant [tight (close)/loose (open) contact] plays a more important role in distinguishing the second and third degrees of quantity.

From the point of view of the perception of the quantity of a word the ratio of the duration of the vowel in the stressed syllable to that of the vowel in the unstressed syllable appears to be the most significant feature in comparison with the others. There seem to be sufficient grounds for believing that the ratios between the durations of vowels in stressed and unstressed syllables may be phonologically interpreted as three supra-segmental quantity structures of Estonian words.

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