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ARTICULATION OF THE ESTONIAN SONORANT CONSONANTS. II. [r]

1. Methods and material *

1.1. The experimental material for the description of the articulation dynamics of [r] was obtained by the complex techniques of lateral cinefluorography and the filming of lip articulations, both synchronized with sound spectrography (and oscillography). One and the same language material was used in both filming procedures, comprising these three sentences:

Sa|r|a katus laseb läbi 'The roof of the s h e d leaks'.
Sa|rı|a pulgad pehastusid 'The sticks of the drying h u r d l e decayed'.
Sa|rr|a toodi veel üks koorem heinu 'One more load of hay was brought into the s h e d.'

The trills under study, in the three phonemic degrees of quantity, all occur in the initial word of a sentence and are surrounded by the vowels [a]. As a rule, one sample of each unit to be analyzed was obtained from every informant. The total experimental material under analysis amounts to 153 cinefluorograms and 100 cineframes of lip movements embracing the trills with the preceding and following vowels (plus a few remoter frames).

1.2. The same language material was further utilized to prepare X-ray shots visualizing the so-called culmination phases of [r] by the technique of static roentgenography synchronized with oscillography (we have analyzed only those shots, 11 in all, which were made in the medial temporal phase of the sonorant with permitted variation of ±20 msec). In addition, 9 X-ray shots were made of [r] pronounced in isolation.

1.3. In order to measure the contact between the tongue and the hard palate, the traditional palatographic procedure was used employing artificial palates which include the inner surfaces of teeth; this was supplemented by the method of direct palatography (Прокопова, Скворцов, Тоцька, 1963). The language material here consisted of single words containing [r] in the three degrees of quantity embedded in the vowel [a] and the same sonorant in a word-final position:

ɒa|r|a 'shy' (Genitive Sg.),
pɒa|rr|a 'beard' (Genitive Sg.),
A|rr|a (imaginary place name, Illative),
Ma|rr (proper name).

Each of the informants used for traditional palatography pronounced every word 8 times (128 palatograms in all); one informant used for direct palatography pronounced every word 4 times (16 palatograms in all).

1.4. Two informants were used for cinefluorography: Ö. P. (female), R. T. (male). Static X-ray shots were made of six informants: R. T., A. S., A. E. (male), K. K., H. P.,

* A detailed description of the methods used, along with technical particulars, has been presented in earlier papers (Лийв, Ээк, 1968; Eek, 1969; 1970a).

T. K. (female). One informant was used for the filming of lip articulation: Õ. P. Four informants were used for traditional palatography (R. T., A. S., A. E., K. K.) and one for direct palatography (A. E.). All the informants speak perfect Standard Estonian with a Tallinn pronunciation (except A. E. whose speech may contain certain traces of the Western dialect).

2. Results

2.1. *Linguopalatal contact*

2.1.1. The preceding literature on Estonian phonetics has, on the basis of palatograms, qualified [r] as a medio- or postalveolar trill (Kettunen, 1913, 7) and more recently as a (post)alveolar or a prepalatal trill (Ariste, 1939, 225; 1943, 32; 1953, 47; 1968, 80). Two possible manners of articulation for [r] have been stated: "The tongue tip may be strongly pressed against the opposite organ so as to produce a real closure for a moment; but more often the front part of the tongue is pressed against the opposite organ in such a way that the tongue tip itself does not come into contact, while the contact is made by the edges of the tongue on both sides of the tip" (Ariste, 1943, 32), i. e. in one case a short and lax closure alternates with a constriction, in the other case a narrower constriction alternates with a wider constriction.[1] All this is again corroborated by the palatograms produced for the present study. Only this much should be added: when [r] appears in a higher degree of quantity the number of cases where during the vibration of the front part of the tongue a complete alveolar closure is formed also increases (for all the informants this number totals 7, 18 and 24 times, out of 36 possible, in the Ist, 2nd and 3rd degrees of quantity[2] respectively); more than that, Informants K. K. and A. S. have pronounced [r] in Q3 with complete alveolar closure in every single case. There is only one informant who deviates from the tendency expressed by the numbers above. On the whole, however, cases of the [r] with incomplete alveolar contact make up more than a half of the total number of the palatograms of [r] in three degrees of quantity (59 out of 108).

P. Ariste (1943, 32) likewise points out that the higher the degree of quantity, the wider the area of the palate touched by the tongue. However, we find no data concerning the direction of the increase of the linguopalatal contact area with the growth of the degree of quantity.

2.1.2. We shall present here some data on the location and extent of linguopalatal contact as derived from the palatograms produced for the present study. The distances of the anterior and the posterior edge of the a l v e o l a r c o n t a c t from the upper edge of the incisors, represented in Fig. 1 by the segments *AB* and *AC* respectively, were measured along the median line of the palate, *a—a* (in cases where a complete alveolar contact takes place). The same distances were measured from the upper edge of both the left and the right second incisor along the straight lines *a′—a′* and *a″—a″* respectively; these are the only measures describing the alveolar contact in cases when it is incomplete. An integrated description of the right-hand and the left-hand l a t e r a l c o n t a c t is given by the segment *DE* on the straight line *b—b* passing between the

[1] [r] which is pronounced with a complete alveolar closure alternating with a constriction will be called a t r i l l w i t h c o m p l e t e a l v e o l a r c o n t a c t; [r] which is pronounced with a contact formed only by the sides of the front part of the tongue, having an open air passage in the middle of the tongue dorsum (a narrower constriction alternating with a wider one) will be called a t r i l l w i t h i n c o m p l e t e a l v e o l a r c o n t a c t. Judging by the cinefluorographic film the whole anterior part of the tongue vibrates (including the central part of the tongue tip which, however, does not always touch the alveoli). We lack sufficient reason in this work to consider the [r] with an incomplete alveolar closure to be a fricative. Although some friction is audible when [r] is pronounced, it is weaker than that of fricatives. For the present a detailed acoustic analysis is lacking.

[2] Abbreviated as Q1, Q2 and Q3 in the following text.

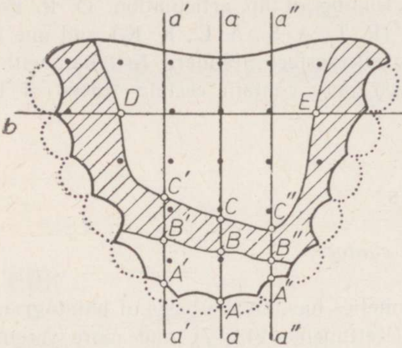

Fig. 1. Coordinate system for measuring palatograms.

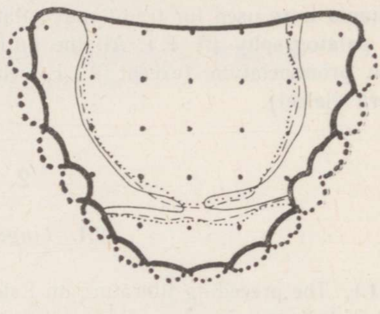

Fig. 2. Superimposed palatograms of Estonian [r] of three degrees of quantity. Informant K. K. Q1 ————; Q2 — — —; Q3 . . . .

first and the second molar on either side (the smaller the lateral contact the longer the segment *DE*, and *vice versa*).

2.1.3. The area of linguopalatal contact can be estimated indirectly from the length of alveolar contact (measures *BC*, *B′C′*, *B″C″*) and the width of lateral contact (measure *DE*). P. Ariste's calculations of contact areas of trills in different degrees of quantity are confirmed by the data of the present paper, e. g. Inf. K. K: the average $BC=2.0$, 2.7, 2.6; $B'C'=4.3$, 6.1, 6.8; $B''C''=3.6$, 3.8, 4.3; $DE=44.8$, 43.7, 42.4 mm for Q1, Q2, Q3 respectively[3] (cf. Table 1; Fig. 2). The increase of the average linguopalatal contact area in Q2 and Q3 is in part unmistakably due to the circumstance that higher degrees of quantity furnish more cases with complete alveolar contact.

In case of complete alveolar contact a rise in the degree of quantity is accompanied by an advance of the center of both the anterior and the posterior edge of the contact, as with Inf. A. S.: the average $AB=9.8$ in Q1, 8.5 in Q2, 6.9 in Q3; $AC=14.4$ in Q1, 14.5 in Q2, 14.3 in Q3; Inf. A. E.: the average $AB=8.5$, 7.3, 6.0; $AC=9.8$, 9.8, 9.3 mm in Q1, Q2 and Q3 respectively. A certain lengthening of the contact occurs chiefly on account of an advancement of its anterior edge. The length of the side parts of the alveolar contact (in cases of both complete and incomplete contact) increases on account of a forward shift of the anterior edge and a backward shift of the posterior edge, thus data in mm in Q1, Q2 and Q3 from A. S.: the average $A'B'=8.6$, 7.2, 7.0; $A'C'=14.4$, 15.4, 15.7; $A''B''=9.3$, 8.1, 6.9; $A''C''=14.0$, 14.1, 12.3; A. E.: the average $A'B'=12.3$, 11.8, 9.6; $A'C'=14.6$, 14.8, 11.1; $A''B''=10.0$, 9.9, 9.8; $A''C''=11.5$, 12.6, 12.9 (cf. palatograms in earlier literature: Ariste, 1943, 33). As is revealed by these data, Q3 may be pronounced by a forward shift of both the anterior and the posterior edge of the contact so that even the length of the contact decreases. But as a rule this happens only on one side of the mouth, the side depending on the informant, which gives indication of a certain asymmetry of articulation.

2.1.4. Word-final [r] is pronounced with a still more advanced alveolar contact than in Q3 (except Inf. R. T. who consistently tends to a more backward articulation), although the length of the contact may be even decreasing. Contrarily the lateral contact area is regularly the largest for [r] in a word-final position.

2.1.5. From the viewpoint of the place of articulation [r] is principally an alveolar sound in all degrees of quantity. The dispersion of measurement data (see standard deviations in Table 1) is not so high as with [n] or [l]; thus the articulation of [r] involves a relatively narrow region.

All informants display a more forward position of the anterior edge of alveolar contact (measure *AB*) for [r] than that of [l] of the corresponding quantity degree. While the anterior edge of alveolar contact of [r] in Q1 falls within nearly the same

[3] The author is very much indebted to M. Remmel for statistical computations.

Table 1

Selection of data from the measurement of palatograms, mm

(Informant K. K.)

Word		Alveolar contact: Distance of the anterior edge *AB*	*A′B′*	*A″B″*	Distance of the posterior edge *AC*	*A′C′*	*A″C″*	The length of the alveolar contact *BC*	*B′C′*	*B″C″*	Lateral contact: *DE*
ara	Average	11.0	6.9	8.1	13.0	11.1	11.7	2.0	4.3	3.6	44.8
	Confidence borders of the average at p=0.95	—	6.7—7.0	8.1—8.2	—	10.5—11.7	11.0—12.4	—	3.6—4.9	3.1—4.1	43.7—45.8
	Limits of individual cases	—	6.0—7.5	8.0—9.0	—	9.5—13.0	10.0—13.0	—	3.0—6.0	2.0—4.5	43.0—47.5
	Standard deviation	—	0.2	0.1	—	0,9	1.0	—	0.9	0.7	1.6
par:a	Average	10.2	6.4	7.3	12.8	12.6	11.2	2.7	6.1	3.8	43.7
	Confidence borders of the average at p=0.95	10.0—10.4	6.4—6.5	7.1—7.5	12.8—12.9	12.1—13.0	10.7—11.7	2.4—3.0	5.6—6.6	3.0—4.7	43.2—44.2
	Limits of individual cases	9.0—10.5	6.0—7.0	6.5—8.0	12.5—13.0	11.0—13.5	10.5—13.0	2.0—4.0	5.0—7.5	2.5—6.0	42.5—45.0
	Standard deviation	0.3	0.1	0.3	0.1	0.7	0.7	0.5	0.7	1.2	0.7
ar::a	Average	10.1	6.2	6.3	12.7	13.0	10.6	2.6	6.8	4.3	42.4
	Confidence borders of the average at p=0.95	10.0—10.2	6.0—6.4	6.2—6.3	12.6—12.8	12.8—13.2	10.3—10.8	2.4—2.7	6.6—7.1	4.1—4.5	42.1—42.8
	Limits of individual cases	9.5—10.5	5.5—7.0	5.5—6.5	12.0—13.5	12.5—14.0	10.0—11.5	2.0—3.0	5.5—7.5	3.5—5.0	41.5—43.5
	Standard deviation	0.2	0.2	0.1	0.2	0.3	0.4	0.2	0.4	0.2	0.5
mar::	Average	9.8	5.9	6.8	12.4	13.9	10.4	2.7	7.9	3.6	40.8
	Confidence borders of the average at p=0.95	9.6—9.9	5.9—6.0	6.3—7.3	12.2—12.6	13.4—14.4	10.1—10.7	2.6—2.7	7.3—8.5	3.1—4.0	40.5—41.1
	Limits of individual cases	9.0—10.0	5.5—6.0	5.0—8.0	11.5—13.0	12.0—15.0	9.5—11.5	2.5—3.0	6.0—9.0	2.5—5.0	40.0—42.0
	Standard deviation	0.1	0.0	0.7	0.3	0.7	0.4	0.1	0.8	0.7	0.4

region as, or is slightly more advanced than, that of [n] in Q1, in case of [r] in Q2 and Q3 it is found to be backward of [n] in a corresponding quantity degree (with the exception of Inf. A. S. whose [n] of Q3 is characterized by a more backward articulation, the anterior edge of the alveolar contact of [r] of Q3 being thus shifted more in front). All informants exhibit a more forward position of the posterior edge of the alveolar contact (measure *AC*) for [r] than that of [n] and still more forward than that of [l] of a corresponding degree of quantity. These comparative data once more corroborate the statement that [r] has a relatively narrow region of articulation on the alveoli.

The alveolar contact area (as expressed in terms of measure *BC*) is regularly smaller for [r] than for [n] and [l] of a corresponding degree of quantity. On the other hand, the lateral contact area (as expressed in terms of measure *DE*) for [r] is in every degree of quantity larger than it is for [n] and [l] of a corresponding quantity degree.

2.2. *The configuration of the vocal tract in the culmination phase of* [r]

2.2.1. When the articulation of [n] and [l] was described, certain difficulties were pointed out in defining articulatory steady-stateness from a cinefluorographic film (Eek, 1970a, 2.1.6). The vibration of the front part of the tongue for the pronunciation of [r] obviously requires the fixation of the rest of the tongue in a relatively stiff position; this renders the back part of the tongue less movable and hence articulatory steady-stateness more noticeable. A delay of culmination in the sonorant-bound movement of the postdorsum and the tongue root, such as appeared during the articulation of [n] and [l], is not observed here. Thus the comparison of the positions of articulators in the three quantity degrees of [r] is effected through the (quasi-)culmination phases, such a phase being defined here as the first frame of a cinefluorographic film where both the vibrating front part and the back part of the tongue have attained their maximum in the motion toward [r]. The temporal location of the segments under comparison is more or less in the middle of the trills.

2.2.2. For the measurement of roentgenograms a coordinate system was utilized which has been described elsewhere (Eek, Remmel, 1969). Here is a brief list of coordinates applied in this study (see Fig. 3; more comprehensive definitions are to be found in: Eek, 1970a, 2.1.7): L_h — the height of the lip aperture; I_d — the distance between the tips of the anterior upper and lower incisors; *2′*, *3′* — the distance of the predorsum from the alveoli or the prepalate; *4*, *4′*, *5*, *6* — the distance of the mediodorsum from the medio- and postpalate; $6'_o$, 7_o, 8_o — the distance of the postdorsum from the origin of the coordinate system (describes the movement of the tongue dorsum in the velar and uvular region); *10a*, *10*, *10b* — the distance of the root of the tongue from the rear wall of the pharynx; *12*, *13*, *13′* — the distance of the epiglottis from the rear wall of the pharynx; U_h — the height of the uvula; H_u, Lar_u — describe the up-and-down movement of the hyoid bone and the larynx respectively; H_f, Lar_f — describe the forward-and-back movement of the hyoid bone and the larynx respectively.

2.2.3. The following is a comparison of vocal tract configurations in the culmination phases of [r] in Q1, Q2 and Q3 (Fig. 4). The corresponding measured data are presented in Table 2.

Growth of quantity degree is accompanied by a regular narrowing of the lip aperture and the front part of the oral cavity (R. T.: L_h = 10.5, 9.5, 8.5; I_d = 8.0, 9.0, 7.5; *3′* = 8.5, 8.5, 7.5; *4* = 16.0, 14.5, 14.0; *4′* = 16.0, 15.0, 14.5; *5* = 12.5, 11.5, 11.0 mm in Q1, Q2 and Q3 respectively). This regularity is not observed in the opening between the jaws (measure I_d). Although in most cases I_d does show consistent shortening, there are individual cases where I_d in Q2 or Q3 is longer than in Q1.

P. Ariste (1953, 48; 1968, 81) writes: "Behind the tongue tip which produces vibrations the tongue is concave. The deeper the concavity the stronger is [r], for a deeper concavity gives the tongue tip more freedom for oscillation." Roentgenograms reveal that the spot where the dorsum of the tongue is at the farthest from the palate (i. e. the

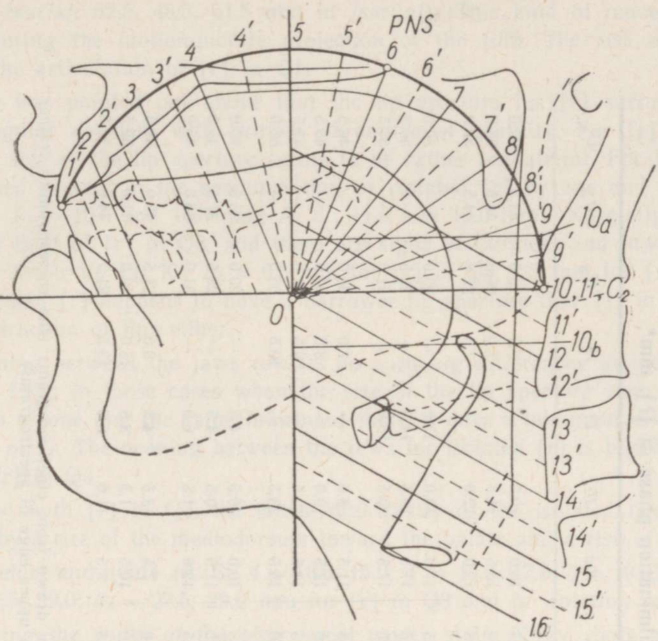

Fig. 3. X-ray tracing with landmarks and reference coordinate system.

concavity of the tongue contour) is located on the mediodorsum for [r] as well as [l] (marked here by coordinates *4, 4'*). With growth of quantity the entire dorsum of the tongue rises toward the palate (on palatograms the lateral contact area grows), so the concavity on the mediodorsum may even decrease when a tenser [r] is pronounced. Such palatality of [r] increasing gradually with degree of quantity hampers the tongue tip in vibrating (particularly so in case of the palatalized [ŕ] known in Estonian dialects: cf. Ariste, 1943, 33—34). The vibration is somewhat facilitated by the forward movement of the tongue tip in Q2 and Q3 (see Sec. 2.1.3; cf. Скалозуб, 1963, 48).

The back part of the oral cavity narrows through the shift of the convex postdorsum toward the velum and uvula (R. T.: $6'_o$ = 35.5, 38.0, 39.5 mm; $7'_o$ = 34.0, 36.5, 38.0 mm in Q1, Q2 and Q3 respectively).

The pharyngeal cavity widens through the removal of the tongue root and the epiglottis from the rear wall of the pharynx (R. T.: *10* = 18.0, 19.5, 20.5 mm; *12* = 13.0, 14.5, 15.0 mm in Q1, Q2 and Q3 respectively).

The movement of the hyoid bone is difficult to interpret on account of the great variety of muscles of very different functions joined to it from above and from below. Still, the higher the quantity degree of [r], the higher up the hyoid bone is pulled (R. T.: H_u = 23.0 in Q1, 22.5 in Q2, 21.0 in Q3). Even if in the culmination phase of [r] of Q2 or Q3 the hyoid bone remains lower than in Q1, the distance passed by the hyoid bone from the culmination phase of the vowel to that of the trill is still longer for [r] in Q2 or Q3 than in Q1 (thus Inf. Õ. P.: the difference of H_u for [r] and H_u for the preceding [a] is 2.5 mm in Q1, 3.0 in Q2, 3.5 in Q3; the same readings of Inf. R. T. are 4.5, 5.0, 8.0 mm).

The velopharyngeal passage is closed. Presumably as a result of a difference in the supraglottal air pressure during the pronouncing of [r] and [a], there is an abrupt shift of the velum 0.5—3 mm upwards from its location for the preceding [a]. It is still higher up along the rear wall of the pharynx that the velum moves during word-initial [s] (R. T.: U_h for [s], [a] and [r] is 52.5, 48.5, 50.0 mm respectively in /sara/; 52.5, 48.5,

Table 2

Selection of data from the measurement of the culmination phase of [r], mm*

		L_h	I_d	4	4′	5	6	6′o	7o	8o	10a	10	12	13	H_u	Lar_u	U_h
Õ. P.	sara	13.0	5.0	12.5	13.0	12.0	11.0	26.5	26.5	26.5	13.0	10.5	—	6.5	26.0	43.5	37.0
	sar:a	11.5	5.0	10.5	11.0	11.0	10.5	27.0	27.0	26.0	13.5	11.5	—	7.0	26.5	44.5	38.0
	sar::a	11.5	5.5	9.0	11.0	10.5	9.5	27.5	28.0	27.5	13.0	12.0	—	7.0	27.0	44.5	38.0
R. T.	sara	10.5	8.0	16.0	16.0	12.5	10.0	35.5	34.0	32.5	17.0	18.0	13.0	—	23.0	—	50.0
	sar:a	9.5	9.0	14.5	15.0	11.5	8.0	38.0	36.5	33.5	17.5	19.5	14.5	—	22.5	—	50.5
	sar::a	8.5	7.5	14.0	14.5	11.0	6.0	39.5	38.0	34.5	17.5	20.5	15.0	—	21.0	—	51.5
A. S.	sara	13.5	7.5	20.0	22.5	22.5	19.0	24.5	26.5	29.5	11.5	8.0	—	7.0	36.0	—	46.5
	sar:a	11.5	4.5	17.0	19.5	19.5	16.5	26.5	27.5	28.0	12.5	10.0	—	8.0	36.0	—	46.5
	sar::a	10.5	4.0	16.5	19.0	19.5	16.5	26.5	27.5	27.5	14.5	12.5	—	9.5	36.0	—	47.5
	isol. [r]	10.5	4.5	15.0	17.5	17.5	13.5	29.0	29.0	29.0	15.5	13.5	—	10.5	35.5	—	50.0
K. K.	sara	11.5	7.0	16.0	15.5	14.0	12.0	31.5	32.0	32.5	10.0	10.5	4.5	—	29.0	35.5	45.0
	sar::a	7.5	3.0	13.0	13.0	12.0	11.0	31.5	31.0	31.5	11.5	10.5	4.5	—	28.5	37.5	45.5
	isol. [r]	10.0	4.5	12.5	12.0	11.0	10.5	32.5	32.0	31.5	12.0	11.5	6.0	—	31.0	36.0	45.0
A. E.	sara	10.5	6.0	14.0	16.5	16.0	11.5	36.5	35.5	36.0	7.5	8.5	4.5	9.0	21.5	43.0	51.5
	sar::a	9.5	5.0	13.5	14.5	14.0	8.0	39.5	38.5	38.0	10.5	11.5	8.5	15.0	19.0	41.0	52.5
	isol. [r]	11.0	5.0	10.5	13.0	13.0	7.5	41.0	41.5	39.5	8.5	11.0	6.5	13.5	21.5	44.0	53.5

* Data on the culmination phases of Informants Õ. P. and R. T. have been drawn from cinefluorograms (the corresponding frames of Informant R. T. are indicated in Fig. 6 by encircled numbers on the upper edge of spectrograms).

50.5 mm in /sar:a/; 52.5, 48.5, 51.5 mm in /sar::a/). This kind of movement is clearly observable during the motion-picture projection of the film. The rise of the velum is minimal in the articulation of [r] in Q1.

2.2.4. It was pointed out above that the lip aperture for [r] surrounded by [a]'s showed a regular decrease with growth of degree of quantity. For [r] pronounced in isolation the size of the lip aperture seems to be rather immaterial. For instance, the lip aperture varied greatly in the pronunciation of isolated [r] by one and the same informant (A. S.: L_h = 10.5 and 16.5 mm; A. E.: 11.0 and 15.0 mm). Normally L_h of isolated [r] is bigger than of [r] in Q3, and there are signs of tautness and inward draw, especially on the lower lip (T. K.: L_h = 6.5 mm for [r] in Q3, 7.5 mm for [r] in isolation). When an isolated [r] happens to have a narrower lip aperture than [r] in Q3, there is no noticeable retraction of lips either.

The opening between the jaws reveals no such big differences in the articulation of isolated [r]. Even in those cases when the size of the lip aperture varies greatly in the pronunciation of one and the same informant there is only a minimum difference between the readings of I_d. The opening between the jaws for isolated [r] is bigger than or equal to that for [r] in Q3.

Compared with [r] in Q3, the entire oral cavity of the isolated trill has narrowed still further by a rise of the mediodorsum toward the palate and a rise of the postdorsum toward the velum and uvula (A. S.: *4* = 16.5, 15.0; *4'* = 19.0, 17.5; *5* = 19.5, 17.5; $6_o'$ = 26.5, 29.0; 7_o = 27.5, 29.0; 8_o = 27.5, 29.0 mm for [r] in Q3 and in isolation respectively).

Considering the width of the pharyngeal cavity static X-ray shots allow us to distinguish two pronunciation usages of isolated [r], viz. one with a relatively narrow pharyngeal cavity and the other with a relatively wide one. With a relatively wide pharyngeal cavity for isolated [r] (Infs T. K., K. K., A. S.), the pharyngeal cavity does show continual widening with increase of quantity of [r] in the context of [a] but it never grows as wide as with isolated [r] (T. K.: *10* = 18.0, 22.0; *12* = 8.5, 14.0 mm for [r] in Q3 and in isolation respectively). With a relatively narrow pharyngeal cavity for isolated [r] (Infs H. P., A. E.), the pharyngeal cavity for [r] in the context of [a] (especially in Q3) is wider (A. E.: *10*=11.5, 11.0; *12*=8,5, 6.5 mm for [r] in Q3 and in isolation respectively).

On the basis of the cinefluorographic material it may be said to sum up that the higher the degree of quantity of [r], the more the tongue has moved away from the position of articulation of the surrounding [a]. On the basis of the material concerning [r] pronounced in isolation, and when defining the vocal tract configuration for the isolated trill as the so-called target value of the sound type, it can be added: the undershoot of the vocal tract configuration for intervocalic [r] from its target value increases with the diminishing of degree of quantity. Besides the width of the pharyngeal cavity demonstrates some overshoot of the target value in cases when isolated [r] is pronounced with a relatively narrow pharyngeal cavity. The overshoot increases with the quantity degree of intervocalic [r]. On the basis of palatographic material it can be seen that with the growth of degree of quantity the area of alveolar and lateral contact for [r] increases. These facts seem to attest that of intervocalic trills it is [r] in Q3 which is produced with the greatest articulatory tension.

2.2.5. In a previous paper we presented articulatory features distinguishing between [l] and [n] (Eek, 1970a, 2.2.6 and Tables 1, 2). Below we shall first deal with what distinguishes [r] from [l] and [n] by comparing vocal tract configurations for the sounds pronounced in isolation. And if certain distinctive features will be found, we shall check whether they are preserved when [r] is pronounced in the three degrees of quantity in the context of [a].

The tongue contours of [n] and [l] are clearly defined by the front part of the tongue rising onto the alveoli and the mediodorsum rising toward the palate so that a concavity forms on the contour between the predorsum and the mediodorsum (Fig. 5). The postdorsum for [l] is convex and directed toward the velum and uvula, disclosing thereby a certain velarization of [l].[4] [n] is characterized by the concavity of the postdorsum. In contrast, for [r] the tongue is the most straightened (from front to back) so that the postdorsum may even be closer to the velum and uvula than for [l] and the rise of the front part of the tongue to produce vibrations against the alveoli is not so steep. Therefore the concavity on the tongue contour between the predorsum and the mediodorsum is reduced and shifted slightly backwards (see Fig. 5).

Differences in tongue contours bring about differences in the dimensions of the cavities of the vocal tract. According to the width of the pharyngeal cavity the sonorants range in the following way: (from narrowest to widest) [r], [l], [n] (K. K.: *10a* =12.0, 22.0, 25.5; *10* = 11.5, 22.5, 23.5 mm respectively). Beginning with the shortest, the lengthening of the pharyngeal cavity as a result of the downward movement of the larynx yields the following order: [r], [n], [l] (K. K.: Lar_u = 36.0, 39.5, 41.5 mm respectively)[5]. Only one informant (T. K.) has pronounced [l] with a slightly higher position of the larynx than [n], but for [r] the pharyngeal cavity is the shortest all the same. The order remains the same when the sonorants are arranged by the position of the hyoid bone (from highest to lowest) (K. K.: H_u = 31.0, 35.0, 38.0 mm for isolated [r], [n], [l] respectively). The smallest lip aperture was measured for [n] and the biggest for [l]. Here [r] and [l] tend to make up a separate group, their difference from each other (if any) being considerably less than from [n] (K. K.: L_h = 8.0, 10.0, 11.0 mm; H. P.: 4.5, 8.0, 8.0 mm for isolated [n], [r], [l] respectively). Comparing the distance between the jaws we obtain this sequence once more. According to measurements from lateral roentgenograms the sonorant produced with the widest oral cavity is [n]. The oral cavity for [r] and [l] is narrower, but no such tendency reveals itself which would lead to the separation of the two in the pronunciation of the whole cast of informants. Though it is evident that the convexity of the tongue dorsum and the suppression of the tongue sides for [l], as well as the raised attitude of the sides of the front part of the tongue if nothing else for [r], do result in changes of the size of the oral cavity, making any more detailed decisions on it on the basis of lateral roentgenograms would involve too large an element of speculation. We can only refer to palatograms which show that [r] is produced with the largest area of lateral contact.

Let us now see whether and how much the enumerated differences in the vocal tract between the sonorant types pronounced in isolation hold for the sounds pronounced in the context of [a] in different degrees of quantity. This is done by comparing (quasi-) culmination phases of one and the same quantity degree. It turns out that in the context of [a] the stated distinctions of the vocal tract do not reveal themselves so markedly. The most persistent feature (particularly in Q3) is the narrowing of the pharynx from [n] over [l] to [r]. In any case [r] takes the highest position of the hyoid bone and mostly also the shortest pharyngeal cavity. The distance between the lips and between the jaws is in all cases longest for [l]. While the pronunciation of Q1 and Q2 manifests a tendency towards an increase in the distance between the lips and between the jaws in the order [n]→[r]→[l], in Q3 [n] and [r] may change their places in the sequence. While on the basis of the comparison of isolated sonorant types we could at least say that [n] was pronounced with the widest oral cavity, the comparison of context-embedded sonorants of equal quantity degree reveals in this respect no regularity at all that would involve all the informants.

Consequently part of the above-mentioned distinctions of the vocal tract are not valid in the context of [a] and hence do not function as parameters distinguishing the sonor-

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[4] Although the Estonian [l] is occasionally as much velarized as the Russian [ł] it lacks the [u]-like sound quality of the latter. Apparently the so-called clear timbre of the Estonian [l] originates from these two differences in the shape of the vocal tract: the pre- and mediodorsum is higher and closer to the palate, and the pharyngeal cavity is wider than for the Russian [ł] (cf. Скалозуб, 1963, 44).

[5] Cf. these data with the data on other languages (Holbrook, Carmody, 1937; Carmody, 1941).

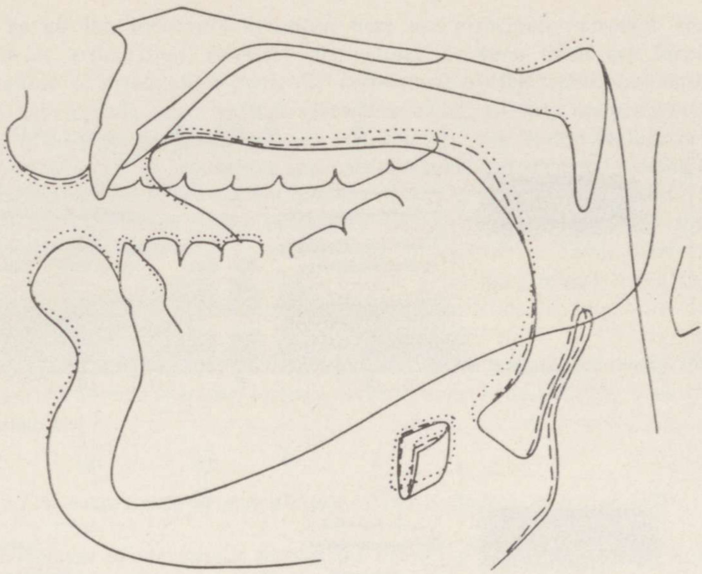

Fig. 4. Superimposed X-ray tracings of Estonian [r] in the culmination phase. Informant R. T.
Q1 (in the word *sara*) ———; Q2 (*sarra*, Genitive) – – –;
Q3 (*sarra*, Illative) . . . .
The median line of the dorsum has been drawn; projections of the side edges of the tongue have been omitted for the sake of clarity. The exposures of the frames traced for this Figure are indicated on the spectrograms *a*, *b*, *c* in Fig. 6 by a circle.

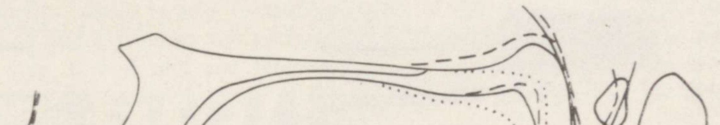

Fig. 5. Static roentgenograms of [l], [n] and [r] pronounced in isolation. Informant K. K.
[r] ———; [l] – – –; [n] . . . .
The median line of the dorsum has been drawn; projections of the side edges of the tongue have been omitted for the sake of clarity.

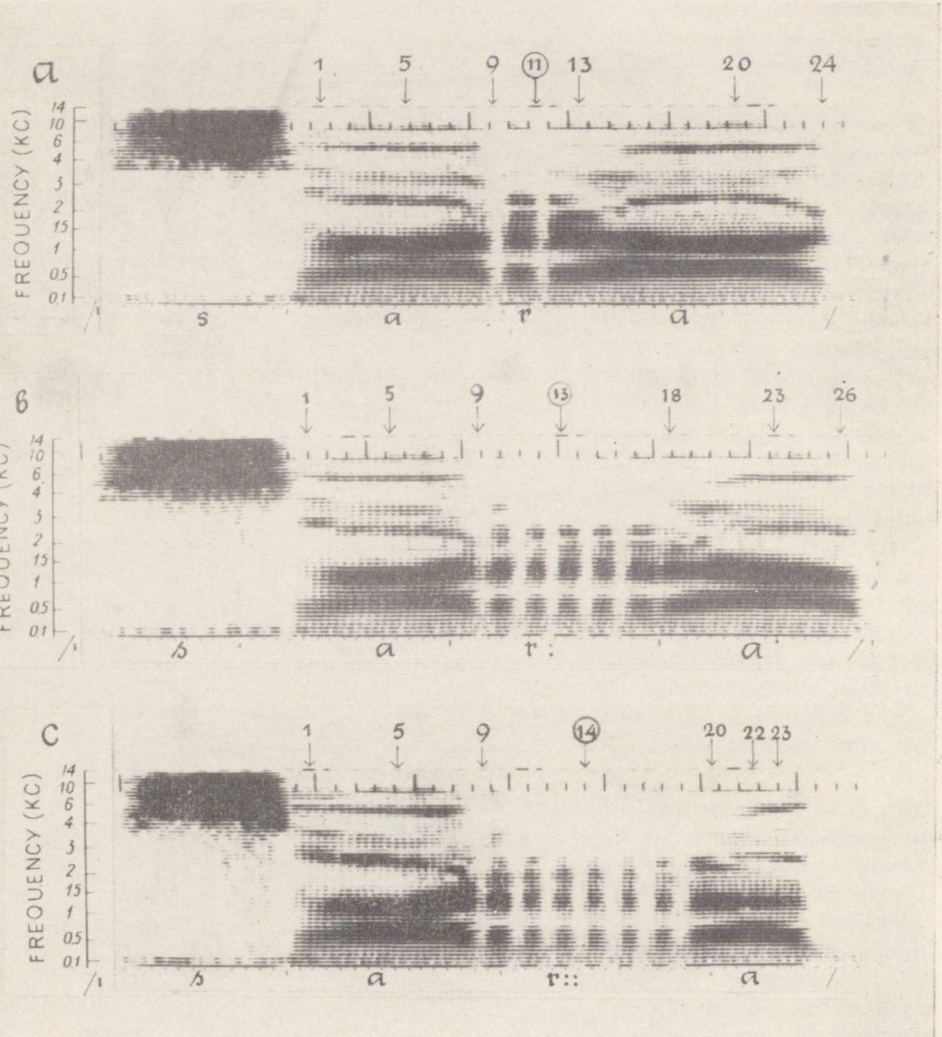

Fig. 6. Dynamic spectrograms, synchronized with cinefluorograms, of the Estonian words *sara* (*a*); *sarra*, Genitive (*b*); *sarra*, Illative (*c*). Informant R. T.

Vertical lines in the upper part of the spectrograms indicate time intervals, the distance between two shorter lines represents an interval of 20 msec and the distance between two longer lines an interval of 100 msec. X-ray frame exposures (10 msec) have been registered on the upper edge of the spectrograms in the form of horizontal lines; as a facility for frame counting every tenth and every first frame have been marked with darker lines. The first vertical arrow in the uppermost edge of the spectrogram indicates the first frame of [a], the second arrow designates $[a_1]$, the quasi-culmination phase of the stressed vowel; the third arrow marks the first closure frame of [r], the fourth arrow (encircled) — the culmination phase of [r], the fifth is for the last frame of [r], the sixth indicates $[a_2]$, the quasi-culmination phase of the unstressed vowel; the seventh — the last frame of [a].

ants. Inasmuch as all the sonorants described here are principally alveolar consonants as to their place of articulation, relevant distinctions between them are furnished by differences in manner of articulation generally understood by the traditional terms nasal, lateral, trill. As has already been written elsewhere (Eek, 1970a), mainly two features are essential in the distinguishing of Estonian [n] and [l]. One is the feature of nasality connected with the behavior of the velum and uvula (the velopharyngeal passage is open vs closed), i. e. a material role for the production of [n] is played by the nasal pharynx and the nasal cavity. The other is the feature of laterality[6] connected with the tongue articulation in its median part (the tongue dorsum in a cross-sectional view is convex vs concave), i. e. when [l] is pronounced the tongue sides are pressed down to make a free egress for the air flow, while during [n] the air flow from the mouth is completely obstructed both in the median part of the tongue and at the sides. [r] is an oral sound. [r] is similar to [n] in that the sides of the front part of the tongue are raised to produce a closure. The basic difference is in the periodic interruption of the air flow from the mouth when [r] is pronounced.[7]

2.3. *The movements of articulators in the occlusion phase of* [r]*

2.3.1. The movement of the tongue during the occlusion phase of [r] is a little different from the movement during [n] and [l]. The amount of movement of various parts of the tongue, viz. the pre-, medio- and postdorsum, from the implosion to the quasi-culmination phase is more or less equal for all the three sound types; but a difference comes in thereafter. While after a relatively short steady-state segment of [n] and [l] — obviously as a result of the relaxation of alveolar contact — the pre- and mediodorsum move downward for 3—6 mm before the release takes place, the corresponding movement during [r] is but 1—2.5 mm covering just 1—2 frames immediately before the release (in [n] and [l] the movement toward the following vowel begins by far earlier). The postdorsum moves very little in the final phase of occlusion of all the three sonorants. There is another difference which is seen in the movement of the tongue root. While the occlusion phase of [n] and [l] allows the tongue root to move away from the rear wall of the pharynx by a step of 4—5 mm and then to approach it by as long a step in the final phase of occlusion, the occlusion phase of [r] involves less movement of the tongue root.

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6 Presumably as a consequence of laterality (suppression of the tongue sides) [l] is a sonorant having the largest mouth orifice and the smallest area of lateral contact on palatograms (although the contour of the tongue dorsum on roentgenograms comes in most cases closer to the palate than that of [n]).

7 The necessity of raising the tongue sides for [r] seems to be demonstrated by palatograms where [r] appears in all degrees of quantity as a sonorant with the largest area of lateral contact (although in roentgenograms of [r] and [l] no essential differences can be observed in the distance between the tongue dorsum and the palate).

Presumably for the sake of facilitating vibration the tongue has straightened from front to back for [r]. As a result of such so-called pseudovelarization the postdorsum has approached even closer to the velum and uvula than for [l] which has a certain degree of velarization. Thus [r] and [l] exhibit the narrowest oral pharynx in all degrees of quantity, while [n] is a sonorant with the widest oral pharynx. One should add here that when speaking of measurements of a cavity, it is always the distance of the barium-marked median line of the tongue from the outer boundary of the vocal tract that is meant. Conspicuously broad shadows of the tongue sides in the region of the postdorsum which appear with [n] (but are absent altogether or just negligible in the case of [r] and especially [l]) are indicative of a certain concavity of the median part of the tongue. However, lateral roentgenograms are insufficient to give a precise idea of the volume of cavities, even when one is provided with additional data on the third dimension from palatograms.

* The onset of the occlusion phase of [r] is defined by the first closure frame of the cinefluorographic film and the end by that frame (usually displaying constriction already) which is followed by a frame where an abrupt downward shift of the tongue tip for [a] has been recorded (see Fig. 6).

This explains why the whole tongue attains to culmination more or less simultaneously. Presumably the vibration of the front part of the tongue requires a very rigid position of the rest of the tongue; hence the steady-state segment in the occlusion phase of [r], compared to that of [n] and [l], is the longest. As mentioned above, transition toward the following vowel can be noticed only in a couple of frames right before the release, and even then to a very small extent. In these last frames of [r] the apex makes no longer a closure on the alveoli, and the distance between the apex and the alveoli is greater than in the preceding constriction phases. The formant structure identifiable from spectrograms of the same period is that of [a] (see Fig. 6). Yet the tongue tip begins to move rapidly downwards only just after the occlusion phase.

2.3.2. Now we shall present the average durations of the occlusion phases of [r] in the three degrees of quantity as measured from spectrograms and oscillograms made of the speech of 5 informants recorded during the X-ray procedures; these averages are: 65 msec in Q1, 174 msec in Q2, 228 msec in Q3 (Q1:Q2:Q3 = 1:2.6:3.5; Q2:Q3 = 1:1.3). There are cases where Q3 has a duration merely 20—35 msec longer than Q2. Thus the durational opposition of Q1 and Q2 is considerably stronger than that of Q2 and Q3.

The number of vibrations of [r], counted from spectrograms as the number of closure phases (absence of formant structure) and constriction phases (presence of formant structure), reads as 2 in Q1, 4—5 in Q2, and 5—7 in Q3. Hence the Estonian [r] is a relatively weak trill.

2.4. *Vowel transitions*

The subsequent is an attempt to evaluate the extent to which the stressed vowel [a] preceding [r] and the unstressed [a] following [r] are related to the trill's quantity structure. The symbol [a_1] will be used to designate the quasi-culmination phase[8] of the preceding vowel and the symbol [a_2] for that of the vowel following the sonorant.

2.4.1. The vowel of the stressed first syllable. The duration of the vowel of the stressed syllable in the words /sara/, /sar : a/, /sar : : a/ is almost equal, irrespective of the quantity degree of the following [r]: the absolute durations of [a] before [r] in Q1, Q2 and Q3 as averaged over 5 informants are 165, 165 and 164 msec respectively. Nevertheless, the quasi-culmination phases of the vowel are different. The [a_1] preceding [r] in Q3 is pronounced with the widest lip aperture and oral cavity, the narrowest pharyngeal cavity, and the lowest position of the hyoid bone, i. e. the articulators move to the closest of the target position of [a] (cf. measurements from Inf. Õ. P. for [a_1] before [r] of Q1 and Q3 : L_h=16.0, 16.5; I_d=7.0, 9.0; $2'$=13.5, 15.0; 4=20.0, 21.5; $4'$=19.0, 20.5; 5=17.5, 19.0; $6'_0$=22.0, 21.5; $10a$=11.5, 10.5; 10=7.5, 6.5; H_u=28.5, 30.0 mm respectively). But before [r] of Q2 may be produced with the oral cavity even narrower and the pharyngeal cavity wider than [a_1] before [r] of Q1 (Inf. Õ. P.). Incidentally, the same tendency becomes manifest when measurement data of the word-initial [s] are compared. Measurements drawn from the third frame of [s] as counted back from the onset of the following vowel (see Fig. 6) rank the [s] of /sar : : a/ as a sound pronounced with the widest oral cavity, while that of /sara/ or (Inf. Õ. P.) /sar : a/ is one with the narrowest oral cavity.

2.4.2. In the discussion of [n] and [l] we maintained that two contrastive durations should be referred to when speaking of Estonian intervocalic sonorants: short with regard to Q1 and long with regard to Q2 and Q3. In doing so we relied on the fact that a sonorant of Q3 differed from that of Q2 not so much in duration (which difference could be quite negligible) as in its tenser articulation, longer duration being only an eventual concomitant of greater tension. The same can be said of intervocalic [r] (see data in Secs 2.1.3, 2.2.3, 2.2.4, 2.3.2). As has been evidenced by the comparison of data

[8] The quasi-culmination phase of a vowel is described by the data from the last frame of its culmination phase, the next frame displaying already a measurable transition toward the articulation place of the following consonant.

about [s] and $[a_1]$ in Sec. 2.4.1, the feature of tenseness culminating in the occlusion phase of [r] of Q3 coordinates the movements of articulators throughout the whole syllable. The finding that $[a_1]$ in a word of Q2 may be articulated with the oral cavity even narrower than in a word of Q1 (not to speak of a word of Q3) would appear to betoken that the feature of tenseness has no decisive role in the articulation of [r] of Q2. As for the perception of quantity degree, the difference in duration is probably sufficient to distinguish Q1 and Q2; but the separation of Q3 from Q2 depends largely on the nature of the transition from the preceding vowel to the sonorant.[9] The fact of the matter is that in a word of Q3 the mean speeds of articulators moving from the quasi-culmination phase of [a] to the trill's implosion frame inclusive are regularly highest, while in a word of Q1 the speeds are lowest or equal with those in a word of Q2 (thus R. T., mean speeds in millimeters per 20 msec for [r] in Q1, Q2, Q3 respectively: L_h=0.4, 0.6, 0.9; l_d=0.3, 0.3, 0.7; *2'*=3.6, 3.8, 3.9; *4*=1.1, 1.2, 1.7; *4'*=0.9, 0.9, 1.1; *5*=0.8, 0.9, 1.1; $6'_o$=0.6, 0.9, 1.4; *10*=0.8, 0.8, 1.0). Besides, when the data from Inf. Õ. P. are also taken into account, it appears that movement speeds of articulators are closely related to starting positions, i. e. the positions of articulators in the quasi-culmination phase of the vowel.

In view of the above data concerning the articulation of [r], the three phonological quantity degrees of trills can be re-interpreted as simple /r/ (Q1); /rr/, a geminate with a lax beginning before the putative syllable division (Q2); and /ṙr/, a geminate with a tense beginning before the syllable division (Q3).

2.4.3. The vowel of the unstressed second syllable. An increase in the quantity degree of intervocalic [r] brings about the shortening of the vowel of the unstressed second syllable. The average absolute durations of the unstressed vowel [a] of 5 informants after [r] in Q1, Q2, Q3 are 239, 174, 111 msec respectively. As it is commonly known, in words of Q1 the unstressed vowel always has a longer duration than the stressed vowel. In the words of Q2 we could observe only a minimum difference between the length of the two vowels. In the words of Q3 it is quite usual that the unstressed vowel is shorter than the stressed one, yet even our scanty material provides cases (Infs K. K., T. K.) where the unstressed vowel is by no more than 10 msec shorter or even longer than the stressed vowel.

A comparison of the vocal tract configurations of the unstressed vowel is more difficult since the initial stops of the following words are different. Thus when after the medial temporal phase of the unstressed vowel [a] in the sequence /sara+ka-/ the postdorsum begins its rise toward the velum for the articulation place of [k], the anterior part of the oral cavity may go on widening for two or three frames by the continuing downward movement of the predorsum. In the sequence /sar : a+pu-/ the lips may start the closing movement for the following [p] as early as before the medial temporal phase of [a], while at the same time the anterior part of the oral cavity goes on widening by the downward movement of the predorsum. The downward movement of the front part of the tongue before velar sounds (followed by a slight rise) is rather consistent. After the medial temporal phase of [a], the postdorsum begins to rise slowly toward

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[9] It is highly possible that the situation is similar regarding the perception of quantity degrees (in particular of Q3) of vowels in the syllables under primary stress. Under this assumption V. Hallap (1962, 249) must be credited with a valid interpretation of the results of G. Liiv's (1961, 487—488) listening tests as he emphasized the role of the initial transition as a carrier of a probable feature of tenseness of a vowel in Q3. That is to say, overlooking all other factors determining the perception of quantity we suppose this: in the first series of G. Liiv's tests the curtailed vowel of Q3 was heard as a vowel of Q2 because the initial transition of the Q3 vowel was cut off; in the second series the percentage of cases where the curtailed Q3 vowel was perceived as a Q2 vowel decreased considerably because the initial transition of the Q3 vowel was preserved; in the third series (where on the basis of the durational relation of the stressed and unstressed vowel Q3 was expected to be heard) the percentage of desired responses was low because the initial transition of the Q2 vowel was preserved (i. e. the transition peculiar to Q3 was lacking).

the [k] or [u] of the next syllable. In the sequence /sar : : **a**+to-/ the postdorsum moves continuously away from the velum and uvula throughout the unstressed vowel.

Aware of these circumstances, let us now compare the unstressed vowels [a] in their quasi-culmination phases (as defined in footnote 8); the figures from the measurement of the vocal tract which characterize this particular phase will be supplemented in brackets by maximum measurements in the region of the anterior part of the oral cavity which have been fixed for a given coordinate in some later frame of [a]. The narrowest lip aperture and anterior part of the oral cavity is used to produce [a_2] after [r] of Q3; the same measures are widest after [r] of Q1 (in view of the data in brackets the differences between [a_2] following in Q1 and that following [r] in Q2 are not at all big). Here are the values of some measures for [a_2] in the words /sara/, /sar : a/, /sar : : a/, Inf. Õ. P.: L_h=15.0, 13.5, 13.0; l_d=8.5, 8.0, 8.0; *2'*=17.0, 12.5 [13.5], 11.0; *3'*=20.0 [20.5], 16.5 [19.0], 15.5; *4*=20.5, 17.5 [19.5], 16.5; *4'*=18.5, 16.5 [18.5], 15.5; *5*=16.0, 15.0 [16.5], 14.0 [14.5] mm. Comparing these figures with those presented in the preceding subsection we find that the difference between the stressed and the unstressed syllable is biggest in a word of Q3.

Of course we might say that the strongest reduction of [a_2] in a word of Q3 is an inertial effect of the tense articulation of the Q3 [r] (and the latter obviously should be taken into account at least as far as the fairly large decrease of duration is concerned). But considering the knowledge gained in the study of coarticulation effects (Eek, 1970b), the influence of the following syllable must also be taken into account for the interpretation of differences in the vocal tract for [a_2]. The fact is that although the duration of the unstressed [a] in the sequences /an : : **a**+ta/, /sar : : **a**+to-/ and /tal : : **a**+ka-/ is more or less equal, the anterior part of the oral cavity for [a_2] before the syllables beginning with [t] is narrower than before the syllable beginning with [k].

The influence of the following syllable can to some extent be regarded as a cause of differences in the postdorsal articulation of [a_2] as well. Despite the fact that the unstressed vowel in the sequences /sar**a**+ka-/ and /sar : **a**+pu-/ is longer than it is in the sequence /sar : : **a**+to-/, the postdorsum remains closer to the velum and uvula during [a_2] in the two first-mentioned sequences than it does in the sequence containing a word of Q3. Or, from another point of view, even though the postdorsum comes the closest to the velum and uvula in the occlusion phase of [r] of Q3, it (i. e. the postdorsum) succeeds in covering the longest way while moving from the velum and uvula toward the position for [a] although it has much less time to do so (4 frames as against 6—7 in the words of Q1 and Q2). Hence we may surmise the effect of regressive coarticulation from the velar sounds [k], [u] on [a_2] of the Q1 and Q2 words and the influence of [t] characterized by develarization on the [a_2] of the Q3 word.

3. Summary

[r] is an alveolar trill during the pronunciation of which a short lax alveolar closure alternates with a constriction, or a narrower constriction alternates with a wider constriction. A higher quantity degree of [r] is characterized by increase in the area of the linguopalatal contact, narrowing of the lip aperture and the oral cavity and widening of the pharyngeal cavity.

It is supposed that in the articulation of the trill as well as of the whole primary-stress syllable when pronounced in words of the **1st** and the **2nd** degree of quantity, provided that otherwise the context is identical, differences originate from the very opposition of short vs long duration of intervocalic [r]. For words of the **2nd** and the **3rd** degree of quantity (of otherwise identical context) the differences in the vocal tract probably depend on the feature of tenseness which culminates in the occlusion phase of the 3rd degree of quantity and has a power of coordinating the movements of articulators. In view of these circumstances the quantity degrees of the trill may be treated in the following manner: the sound in the 1st degree of quantity is a simple /r/;

in the 2nd degree of quantity a geminate /rr/ beginning with a lax syllable-final component; and in the 3rd degree of quantity a geminate /r̀r/ beginning with a tense syllable-final component.

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EESTI KEELE SONOORSETE KONSONANTIDE ARTIKULEERIMINE. II.

[r]

Resümee

[r] on alveolaarne tremulant, mille häältamisel lühike ning lõtv alveolaarne sulg vaheldub ahtusega või kitsam ahtus avaramaga. Kvantiteediastme kasvamisel keele-suulae kontaktipindala suureneb, huultevaheline ava ning suuõõs ahenevad, neeluõõs laieneb.

I ja II kvantiteediastme sõnades määrab identse konteksti korral tremulandi ja rõhulise silbi artikulatoorsed erinevused oletatavasti intervokaalse [r] lühikese ja pika kestuse vastandatus. Identse konteksti korral sõltuvad II ja III kvantiteediastme sõnade kõnetrakti erinevused tõenäoliselt III kvantiteediastme [r] oklusioonifaasis kulmineeruva pingsustunnuse artikulaatorite liikumisi koordineerivast mõjust. Neid asjaolusid arvestades võime tremulandi kvantiteediastmeid käsitleda järgmiselt: I kvantiteediaste kui /r/, II kvantiteediaste kui geminaat /rr/ silpi lõpetava *lax*-komponendiga ja III kvantiteediaste kui geminaat /r̀r/ silpi lõpetava *tense*-komponendiga.

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2. III 1970

А. ЭЭК

АРТИКУЛЯЦИЯ ЭСТОНСКИХ СОНОРНЫХ СОГЛАСНЫХ. II.

[r]

Резюме

[r] — альвеолярный дрожащий, при произношении которого короткая и слабая смычка чередуется с сужением или более закрытое сужение с более открытым. С увеличением степени долготы возрастает площадь соприкосновения языка с нёбом, губное отверстие и полость рта сужаются, полость глотки расширяется.

При одинаковом контексте различия в артикуляции дрожащего согласного и ударного слога в словах первой и второй степени долготы определяются, очевидно, противопоставлением короткой и долгой длительностей интервокального [r]. В случае идентичных контекстов различия речевого тракта слов второй и третьей степени долготы зависят, очевидно, от координирующего движение артикуляторов влияния признака напряженности, кульминирующего в оклузионной фазе [r] третьей степени долготы.

Учитывая эти обстоятельства, степени долготы дрожащего можно рассматривать следующим образом: первую степень как /r/, вторую степень как геминату /rr/ с заканчивающим слог ненапряженным компонентом и третью степень как геминату /rr/ с заканчивающим слог напряженным компонентом.

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