A PHONOLOGIC-PHONETIC COMPONENT OF A DYNAMIC LINGUISTIC MODEL

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ABSTRACT

As a basic quantitative criterion for a phonologic description choice, an average phonologic code length of a text is suggested. Capabilities of such an approach are demonstrated on the example of a Georgian phonologic system.

A dynamic linguistic model is a system, which fulfils direct and inverse transformation of a "sense-speech (text)". A phonologic-phonetic component of the direct transformation (synthesis) produces to the given phonemes corresponding phonetic characteristics, i.e. descriptions, which must serve as an immediate basis for a choice of articulatory commands. A natural basis of a phonetic description is a set of articulatory features (in the case of synthesis), or their acoustic correlates (for analysis).

These processes are essential components of a complete linguistic model, being the basis of many important practical applications. According to this, conditions of simplicity and description economy acquire not only abstract-theoretical meaning but also practical value, stipulated by natural demands, made by technical realization of such systems. Technical realization of a phoneme in a linguistic model is its code, the choice of which, generally speaking, is arbitrary, not taking into account a trivial condition of noncoincidence of different phonemes codes. According to this, a problem of the code choice naturally arises, providing a chance to create simple and economical coding-decoding procedures, which direct and inverse phonologic-phonetic conversion.

Concretizing this code choice criteria, on the basis of quite general consideration we can suppose, that they may be reduced to the conditions of a code structure simplicity and to minimality of its some quantitative characteristics (of average length) and also to demands of simplicity of its correlation with phonetic characteristics. A binary code, for which a structure of coding-decoding procedure is represented by a dichotomic tree, obviously, possesses the simplest structure. Methods of agreement of such a code with frequency of coded symbols appearance, providing the code construction with minimum average length, are well-known. However, these methods are not intended for taking into consideration an additional condition, which is a requirement for simplicity and directness of relation of a phonological code to a phonetic description.

Evidently, this last demand is satisfied more completely by a code, a coding-decoding tree of which can simultaneously be regarded as the basis for a phonological system description in terms of phonetic features. By the tree of such a type, constructed on the basis of acoustic characteristics, a Russian phonological system is described in /1/. Terminal nodes of such a tree are phonemes; some phonologically meaningful binary features are connected with each nonterminal node, one of the branches, coming from it (in our case -left), is connected with the positive value of the feature, and the other - with the negative one. Now, by attaching a value "1" to each "positive" branch, and "0" to each negative one, for every phoneme can be produced a binary code, which is created in the process of passing the route from the root ("top") of the tree to the terminal node corresponding to this phoneme. A procedure of passing by such tree routes, leading from the root to terminal nodes, can be performed on the basis of the given code sequence, creating the corresponding phonemic features (a process of decoding), as well as on the basis of the given phonetic features succession, providing the construction of the corresponding code (a process of coding).

A set of phonetic features, associated with nodes of his tree, makes up some subset of a meaningful phonetic characteristics set, enough for distinguishing all the phonemes of the given phonologic system. Sets, possessing such a property, can be chosen by many different ways, and thus, some additional condition of minimality is imposed in order to determine some "marked" sets. In the majority of cases, and particularly, in /1/ and /2/ a requirement for minimum of number of different features, forming a set, serves as a restriction.

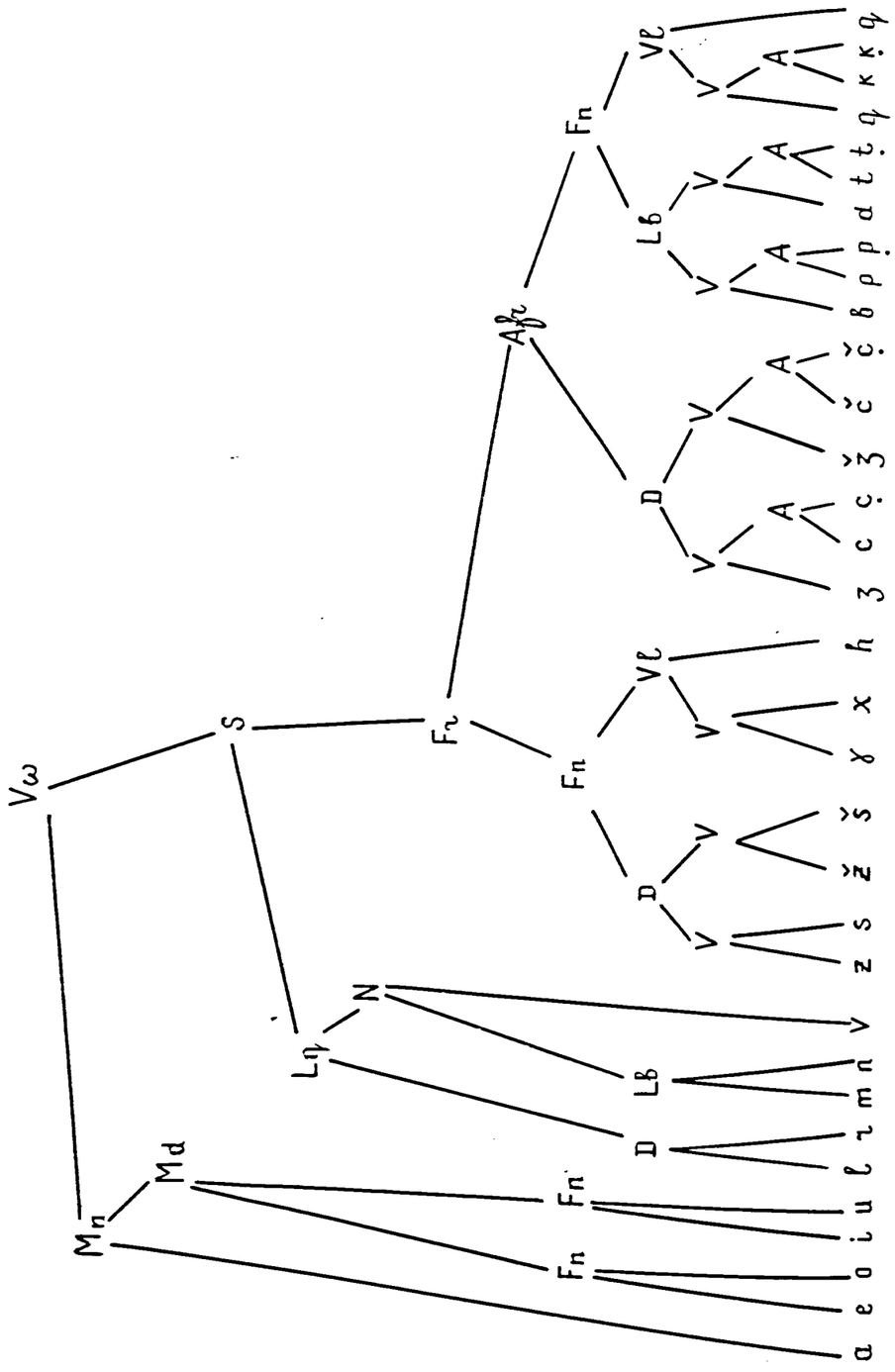

Fig. 1. The coding- decoding tree for Georgian phonemes.

Se 24.5.2

However, taking a standpoint of the dynamic linguistic model, it should be recognized, that a condition of minimality of the phonemes codes average length, is more essential, because exactly this parameter determines the average number of steps of the coding-decoding procedure and, therefore, characterizes time expenses, connected with the phonologic-phonetic component of the model. A degree of this condition fulfilment for this set of features is convenient to determine by a value Q:

$$Q = \frac{L - H}{H} \quad 100\%,$$

where L - is the average length of the phoneme code in the text, and H - is entropy of the phonemes distribution in the text, representing a theoretical lower limit of values L. Thus, Q is the redundant average length of the code in percentage of its theoretical minimum H, and hence, a system with less Q value must be prefered. As the orientator let us note, that for the Russian phonologic system, constructed in /2/ the value Q was 21%.

A tree of dichotomized articulatory features, describing a variant of the Georgian phonologic system, for which Q has the value of 10%, is attained on the basis of the given in /3/ distribution of Georgian phonemes frequencies in the text, to which the meaning of entropy H = 4,31 b.u. corresponds. The phonetic material used in the system construction almost entirely is taken from /4/, though in the choice of the definition for correlation of air passage common features, corresponding to the upper levels of the tree, some consideration were taken from /1/ and /5/.

The top feature of the tree on Fig. 1 is Vw vowelness, positive value of which corresponds to vowel phonemes a,e,o,u. Set of vowels, in their turn, is structurized by usual features of minimum (Mn) and mean (Md) raising of the tongue. Phonemes characterized by the negative value Vw, i.e. consonants, first of all, are divided into two subset by the sonority feature (S). With common representative of sonors (l,r, m,n) a phoneme V is included in this class, that corresponds to the contemporary point of view on the Georgian phoneme, and also to separate remarks from /4/. First of all, from the class of sonors are distinguished liquids (Lq), and then nasals (N), and nonsonors are divided into fricatives (Fr) and nonfricatives, coinciding with the class of stops; the last in their turn - into affricatives (Afr) and nonaffricatives, representing by them a class of pure stops.

Configuration of the upper part of the tree and distribution of the corresponding nodes, almost entirelly reproduces gradations of the opening degree, defined in /5/: Mn corresponds to the sixth gradation, Md - to the fifth, and its negation ($\overline{Md}$) - to the fourth; then liquids (Lq) are characterized by the third degree of the opening, nasals (N) - by the second, fricatives (Fr) - by the first, and stops (Afr and $\overline{Afr}$) - by zero. Exception is the phoneme V, combining characteristics of a sonor and a fricative; on the scheme of Fig. 1 it occupies a sonor position near nasals, being a single representation of the additional to them class, that defines a degree of its opening, as an intermediate between the first and the second, but more close to the last of them. General structuralizing features in this zone are a top feature Vw, dividing a set of gradations of opening degrees into three upper and four lower gradation, and also S feature, dividing these last ones in two.

Below the considered zone there is a two-level zone of features of the formation place: the upper level is represented by a feature Fn with meanings "front" - "non-front", and the next level - by a bilabiality Lb, a dentality D and a velarity Vl. Analogous to the scale of opening degrees regulates common features of air passage, features of the formation place correlates to the following consequent regions of the vocal tract: labial (Lb), dental ($\overline{Lb}$ = D), alveolar ($\overline{D}$), velar (Vl) and transvelar ($\overline{Vl}$), which can be realized as pharyngeal (the phoneme q) or laryngeal (h). Note, that uniting these two last regions into one, we shall be able to say, that not only the positive but also the negative meaning of these features always points to one and the same region of the formation. The same is true for the feature Fn, the positive meaning of which always corresponds to the set of bilabial dental, alveolar and palatal regions, and the negative - set of velar and transvelar. Joining a palatal zone to the positive region of Fn also justifies this feature utilization for the opposition of front and back vowels, that conforms to the corresponding remark in /4/ about the equivalence of this opposition to the opposition: palatal - velar.

Two lower levels create features of voiceness (V) and aspiration (A).

Let us note some alternative possibilities of the tree structure choice, illustrating considerations, which have led us to the variant depicted in Fig. 1. So, for example, the phoneme V is related to fricatives on the concluding scheme of the Georgian phoneme classification in /4/. Equally with the already stated considerations, a choice of a position V was stipulated by the circumstance, that its inclusion in the class of fricatives rather deteriorates the value of Q. accepted by us, as a criterion, particularly, in this case Q = 11%. Further deterioration of the value Q is connected with the accepted in /6/ variant of the tree "top" construction according to the pattern /1/. In /6/ firstly vowels and liquids are opposed to other phonemes by the feature of vocality, and then liquids - to vowels like

Se 24.5.3

onsonants to nonconsonants. In this case Q reaches 16%. On the contrary, concession to the traditional approach, apparently, is a refusal from the variant, opposing firstly fricatives and affricates to simple stops, and then fricatives - to affricates, since this variant provides lower value of the criterion: Q = 8%.

At the same time, economy of description basically defined by the value Q, must not conflict with its completeness, i.e. on the basis of the accepted scheme of the phonologic-phonetic transformation all the characteristics, necessary for the functioning of phonetic, phonologic and morphological rules, must be produced. So if the synthesis of the sound is provided by the modelling of the speech tract configuration in the process of the sound articulation, then it is necessary to enlarge, for example, the sonor characteristics by information about, common to them voiceness and their formation place, and also - to note such specific features as laterality of l and vibrantness of r; voiced consonants deafening in front of voiceless stops needs, differentiating of q by a voiced-unvoiced feature; finally, the formulation of the morphological rules of a stem truncation and contraction will be simplified by the feature, common to a and e, and so on. The most natural is including of all useful characteristics creation into the process of decoding. This can be expressed graphically by adding their symbols to the corresponding branches, for aims of minimizing a number of repetitions; such additions must be made on the maximally high level, for which they are relevant; so the additional feature of voiceness must be created, according to the above adduced examples, when passing the positive (left) branch, coming from S. Let us emphasize, that these additional symbols will be simply ignored when coding.

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