PHONETIC ASPECTS OF STUDYING PHONEMIC SYSTEMS AND SPEECH ACTIVITY

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ABSTRACT

The goals of the phonetic analysis of speech activity are determined by the properties of the language as a means of communication. Production and perception of speech under normal conditions of communication can only be understood if one is aware of both the characteristics of simple acoustic signals, representing a set of allophones and the rules of their processing. Of great importance is also a detailed study of phonetic variance of a particular language as well as information on phonetic structure of meaningful units of the language: morphemes and words. A phonetic fund of the Russian language has been described that combines the information specified above. The fund provides phonetic information for speech analysis and synthesis as well as for linguistic study of Russian sound system.

Phonetics as a science dealing with speech sounds can proceed along two distinct paths: one parallels phonology, whose concern is distinctive function of speech sounds, the other parallels psychophysiology, studying mechanisms of production and perception of sound sequences. Phonology has already devised rather strict methods of analysis enabling linguists to study any sign system. Phonology's traditional refusal to analyze phonetic reality has become now a universal characteristic of phonological studies, where the authors either absolutely deny the importance of physical properties of speech sounds or are satisfied with rather primitive phonetic information.

During the 15 years separating us from the Fifth Congress of Phonetic Sciences when Dr D.B. Fry accused linguists of neglecting scientific knowledge little has been changed. Up to now, experimental phonetic studies of speech activity have been non-essential for phonologists, because it is assumed that by contrast with the systematic character of language, speech is individual and, as a consequence, unsystematic. Many present-day phonological concepts exist absolutely independently of phonetic knowledge, are 'nourished' by their own postulates, and it seems that no new phonetic information obtained in experimental studies can shake the stability of those postulates.

Another approach to speech sounds is represented in studies dealing with speech production and perception. During the last decades a wealth of research work has been done, where the properties of man, allowing him to use speech so effectively in communication, were of utmost importance. Interest in this information is shown first of all by those research workers who, with respect to linguistics, may be called representatives of neighboring sciences — physiologists, psychologists, research workers in speech communication and automatic speech recognition, as well as those studying problems of artificial intelligence. This trend using the most perfect experimental methods and statistical analysis has made an important contribution to our concepts both in the physiology of speech production and in psychophysiology of speech perception, beginning with peripheral processing of speech signals and ending in procedures making decisions by central parts of the hearing system (for a detailed account of a similar approach and extensive bibliography on this subject see, for example, the work by Bernard Delgutte /15/). However, the material used in most of these studies seems to be rather limited, if considered from the point of view of linguistics. For instance, in studying speech perception such simple sound sequences as CV or CVG are often used. Many researchers, on the whole, prefer using synthetic speech-like stimuli which allow them to manipulate the parameters under study, no matter how far their characteristics are from those of real speech signals.

As a result of the development of such diametrically opposed sciences as the phonology and psychophysiology of speech, sciences using their own strict
methods and having specific areas of application, the speech activity of man, who used speech signals for communicati-
on, is beyond the interests of both the
former and the latter trends. Phonolo-
gists, as has been said, are not interes-
ted in the real manifestations of speech.
The psychophysiological concern, on the
other hand, is limited to the phonetic
properties of simple sound sequences.
The former is predominant therefore, to
study speech activity on the basis of
both phonemic concepts and the knowledge
of phonetic mechanisms. It is desirable
that such studies should be more intense-
ly than they are today. From a perceptu-
al point of view, information contained in
the auditory system of any native
speaker may be compared to a curious
puff-pastry, in which without fail
there are the following layers:
(a) Certain universal properties of the
auditory system that are common both to man
and animals.
(b) Some specific properties of the auditory
system that are determined by man's linguis-
tic ability and his use of articulate
speech. These are properties enabling speakers
of various languages to discriminate be-
tween the vowels of the basic triangle, to use on- and off-glides of vowels for
the realization of certain articulatory dif-
ficulties that are common both to man, animals.
(c) Some specific properties of the audi-
tory system that depend on the speaker's
own sound system. These properties are determined not only by the number of phonemes and their allo-
phonies, but also by the sound system.
For example, in experiments on dogs, which allow us to
assumethat phoneme boundaries between
vowels are determined by some fundament-
al properties of man's auditory system, but by his linguistic competence.
characteristics.

No less important, however, is the problem of the problem of manifestation of linguistic and proper specific characteristics of distinctive features in native subjects' speech. These phonemes are represented by a constant set of distinctive features, which have been developed in phonology.

On the other hand, being tolerant to the varying characteristics of speech sounds, native subjects use an extensive set of rules allowing them to proceed from a variable phonetic picture to a sequence of phonemes, thus constituting the expressive means of the phoneme. Thus, in turn, means that native subjects use their own phonemes, which only partly coincides with that of a phonologist.

The Phoneme and the Morpheme.

From the viewpoint of classical phonology one of the main functions of the phoneme is its ability to discriminate morphemes. Morphemic criteria are also used both in determining the independent status of a phoneme and in making decisions as to mono- or bisyllabic interpretation of a sound sequence, as well as in classifying phonemic oppositions.

Indeed, the morpheme is the minimal meaningful linguistic unit and the ability of the phonome to function as the morpheme's exponent is a very important evidence of the linguistic segmentation of the acoustic continuum into minimal segmental units, i.e., phonemes.

It is necessary to point out that experimental phonologists are very rarely based on notions that combine both phoneme and morpheme levels of analysis.

But it is quite clear that a description of human speech activity dealing with natural coherent utterances should not ignore the principal rules that govern the sound (phonetic) structure of morphemes. Russian language studies have evidenced an ever-growing interest in this problem.

Over the past several decades, linguists have accepted the notion of distinctive features but do not concentrate on the intrinsic requirements concerning the correlates of the distinctive features. It is noteworthy that distinctive features have a great number of phonemes and affixes. Any native subjects can use any combination of these correlates for the identification of the distinctive feature in speech.

It follows from what has been said above, that, on the one hand, native subjects behave contrary to the phonological conceptions about phonological operation (which have been developed in phonology).

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In order to gain an understanding of how this segmentation can be rendered more precise, we must first of all formalize the transfer from syllable segmentation to morphemic segmentation. This made it possible to form the morphemic structure of the morpheme. The morphemic structure of the morpheme has phonological and morphological correlation and it can be experimentally investigated as an element of human speech activity.

A close study of phonetic properties of morphemes revealed certain facts which are important in the evaluation of morphological criteria used in phonology. First of all, not every morpheme is a meaningful unit; secondly, many morphemes differing in their sound pattern have the same grammatical meaning (we are not considering root morphemes here, of course). These facts challenge the exclusiveness of morphological criteria in phonology.

Nevertheless, rules governing the combination of phonemes (sounds) into morpheces and their arrangement into word-forms are language specific; they form one of the building blocks of what is generically called "information about higher levels" in constructing speech recognition systems.

Systematic studies of the Russian Language Dictionary where each word is represented as a sequence of phonemes/elements have considered "information about higher levels" in constructing speech recognition systems. The study of speech perception, exhaustive as it might be, will give us information about the potential capabilities of human speech activity, whereas information about the predictability of occurrence of phonetic patterns of meaningful units makes it possible to put forward a reasonable hypothesis about the mechanisms which enable the listener to predict one element of speech by the other and the abilities of the listener on which the speaker can rely when he allows himself certain deviations from the "ideal" phonetic pattern of the utterance he produces.

In fact, the problem of defining the acoustic cues for the transformation of the acoustic continuum into a succession of discrete elementary speech perception or automatic recognition by a computer cannot be solved without reference to all possible modifications of the whole word. These modifications are governed by certain rules. This means that in order to give a thorough and comprehensive phonetic description of the sound system of a particular language, it is necessary to take into consideration both allophonic modifications and modifications due to tempo variation, the intonation pattern and the placement of the word in the phrase (which cause or deviations from standard pronunciation is the subject of a special study).

The computer based dictionary has made it possible to determine the frequency of occurrence of syllables. The reduction of vowels in a prefix is an exception rather than the rule, which any Russian speaker can use to find the phonetic identification of a word in a prefix (the prefix de = b'is for example), whereas in the phonetic dictionary 4/5 times, whereas the prefix de = b'is only 4 times; the prefix de occurs 4/5 times, whereas de is found only 4 times).

The absolute number of roots containing this vowel

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<tr>
<th>i</th>
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<th>o</th>
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The table shows that there is a consistent reduction in the number of syllables in the root and the frequency of syllables: the longer the roots, the fewer their number. The frequency occurrence in stressed syllables are /a/, /e/ and /o/.

3. The probability of occurrence of unstressed vowels in the root is the same: the more frequent are /a/ and /e/, less frequent are /u/ and /o/.

4. The description of root morphemes in terms of generalized phonetic structure (G and V) revealed 40 different combinations, the more frequent of them being GCV, GCV, GCV and CGCV.

5. Historical alternation of vowels, changes in the phonemes of the root morphemes which cannot be explained by phonetic rules of modern pronunciation occurs in approximately 3% of all root combinations of components. In nearly 60% of cases, as our investigation revealed, contain an unstressed vowel. This indicates that the stressed vowel in a prefix is an exception rather than the rule, which any Russian speaker can use to find the phonetic identification of a word in a prefix (the prefix de = b'is for example), whereas in the phonetic dictionary 4/5 times, whereas the prefix de = b'is only 4 times; the prefix de occurs 4/5 times, whereas de is found only 4 times.

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Fig. 3(a,b,c) shows the relative frequencies of syllables in Russian:

(a) containing various vowels (b) containing either stressed or unstressed vowels (filled and unfilled circles). Data on syllables are given in (b), and on CGV and CCV syllables in (c).
The occurrence of consonants and their clusters in these syllables is in accord with the phonetic properties of the Russian language. The creation of a phonetic dictionary is a necessary task and is not only for experimental studies of speech activity but rather should serve as a basis for the phonetic realization of phonetic data obtained for any language in the construction and storage of phonetic information. The phonetic realization of a speech signal in the first block, such a transcriber should provide for the description of each text. The transcription of the bank of phonetic data is described here is a very difficult and responsible task. Only a few from the four blocks have been realized up to now. But our confidence in the necessity of this work is justified by the interest aroused by this idea in linguistics and representatives of applied sciences. In some respect, to create a bank of phonetic data seems to construct a model of human speech activity.

Fig. 6 shows the structure of the bank of phonetic data and the relations that seem important both from the linguistic point of view and from that of the investigation of human speech activity.

The block of acoustic properties of a text which in fact is the algorithm for an automatic transcription which converts the phonetic description into a sequence of phonetic symbols. Since each phonetic symbol is assigned an allophone transcription for the description of the corresponding allophone. Phonetic transcription provides information about phonetic properties of each phoneme. It is important that these segments can also be used for the analysis of phonetic and phonological units. This makes it clear that information cannot be obtained by use of computer techniques which are employed not just because of fashion but as vital research necessity.

From the linguistic point of view, information about the phonetic properties of a word-form as a combination of morphemes is also of some interest, since it enables us to obtain quantitative data that characterize processes of forming a phonetic pattern of lexical item. The occurrence of definite classes of phoneme in definite positions within a word-form is a universal phenomenon, but only by comparing inherent phonological properties of sound units with their function within the word-form we can obtain new data in this respect. These phenomena which occur within the word-form may even give specialists in the field of diachronic phonetics something to think about.

Finally, an automatic transcriber should be considered as any text in terms of the first three blocks, and thus not only verifies the various properties of the word-form, but also gives the content of these blocks with the data of the text.

In conclusion, I would like once again to draw your attention to the necessity of the investigation of those specific aspects which are pertinent to human speech activity. The development of new and reliable methods is only beginning. By the time of the investigation of the perception of foreign language sounds by a foreign speaker (i.e., to the listener), the comparison of results of the identification of the same speech stimuli (for example) by speakers of different languages, the analysis of personal abilities of speakers of those languages which differ in the combination of phonemes into meaningful units (Russian compared to Turkish, with its broad diotactic pattern of phonemes) the differences among the Russian sound units produced by the speakers of different languages is a good model of the influence of one's native language on one's speech activity in a foreign language.

How to investigate these fine mechanisms of the interplay of different linguistic systems on human speech activity is the problem which requires closer attention of all specialists interested in obtaining new data about properties of speech production and perception.

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