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 liguistic 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 16 years separating us from the XIIth 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 neighbouring 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 /13/). 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 CVC 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 communication, is beyond the interests of both the former and the latter trends. Phonologists, as has been said, are not interested in the real manifestations of speech. The psychophysiologists' concern, on the other hand, is limited to the phonetic properties of simple sound sequences.

It becomes expedient, 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 intensive than they are today. From a perceptual 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 auditory system that are common both to man and animals.

For example, the ability to classify synthetic speech-like vowels according to the values of F1 and F11 and ascertain "phoneme boundaries"/16/ was found in experiments on dogs, which allows us to assume that "phoneme boundaries between vowels are determined by some fundamental properties of man's auditory system, not by his linguistic competence" /1/.

(b) Some properties of the auditory system that are determined by man's linguistic ability and his use of articulate speech.

These are properties enabling speakers of various languages to discriminate between the vowels of the basic triangle, to use on- and off-glides of vowels for the identification of adjacent consonants to define the accentual structure of a sound sequence, etc. To these abilities, common to all people, one might add sound symbolism, i.e. the presence of certain psychological and sound associations /22, 24/.

(c) Some specific properties of the auditory system that depend on the speaker's own sound system.

These properties are determined not only by the number of phonemes and their allophonic variation but also by the whole sound system. For example, in experiments on Russian subjects estimating the distance between pairs of sounds it was found that 2 vowels were similarly rated on the basis of the reguler alternation they take part in (/l'es/- /lisá/;/dom / - /damá/), rather than on closeness of their F1 and F11 values.

No doubt it is very difficult, or even impossible, to find the exact boudaries of the layers. As has been said above, the ability to identify adjacent consonants by on- and off-glides of vowels is a common feature of man (we may assume that animals can acquire this ability as well). However, Russian subjects easily identify hard and soft consonants on the basis of on-glides, because in Russian hard and soft consonants are in phonological opposition, but they show poor discrimination of the place of hard consonants /p, t, k/ and /b, d, g/. French and American subjects, on the other hand, as is well known from the classical studies of the early '50s/12/ do this very well, but the /i/-glides of Russian vowels are not used by them as reliable cues for correct identification of preceding consonants/7/ because softness in these languages is something unknown and phonologically irrelevant.

In any case, investigation of speech activity should be based on the results of experimental psychophysiological studies, but the main function of speech, i.e.conveying meaning, should also be properly considered. This very function allows or even provokes variation of speech signals and hinders successful modelling of man's perceptual properties in automatic speech recognition.

To demonstrate the degree of divergence between physiological and psychophysiological data, on the one hand, and the results of speech activity, on the other hand, two figures are given. In Fig.1(a and b) Russian consonants are shown in two different feature spaces. Fig.1a demonstrates a geometrical arrangement of the consonants in a space of articulation features/18/, which seemed to be a convenient way to show the relations between Russian consonants and their features. Fig.1b demonstrates an arrangement of Russian consonants in a space of psychological features comparable with such oppositions as hard-soft and continuous-discontinuant/24/. What a great difference between the geometrical linguistic pattern and the real arrangement of the consonants in the perceptual space!

Fig.2 (a and b) shows schematic representation of the vowels used as stimuli in experimental phonetic studies: Fig.2a demonstrates synthetic four-formant stimuli used in numerous works aimed at ascertaining "phoneme boundaries"/16/, Fig.2b shows Russian stressed and unstressed vowels. As can be seen from the comparison of steady-state synthetic vowels (400 msec long) and transitory natural vowels(varying in duration from 200 to 50 msec), the differences between them are so great that one cannot assume that in processing and identification of these two groups of stimuli the same mechanisms are used.

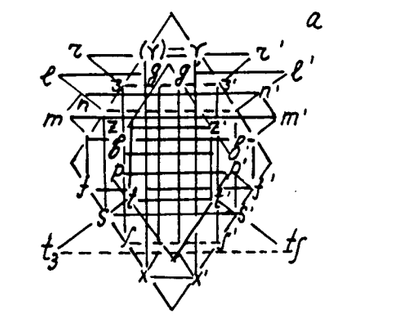

Fig.I. Russian consonants in a space of features.
(a) Russian consonants in a space of articulatory features, demonstrating the arrangement of the consonants within phonemic system/18/;
(b) Russian consonants in a space of perceptual features related to the features "hard-soft" and "continuous-discontinuant"/24/.

Thus, in investigating speech activity, when natural languages are studied, one should consider the following: (1) psychophysiological properties of man, (2) how these properties are realized in a particular phonetic system, (3) in what way the phonemic system as one of the upper levels of the linguistic structure effects speech activity.

Such an approach to the study of speech activity will undoubtedly cause the disapproval of both phonologists and representatives of the natural sciences. Let us take courage and borrow what we need from these opposite provinces!

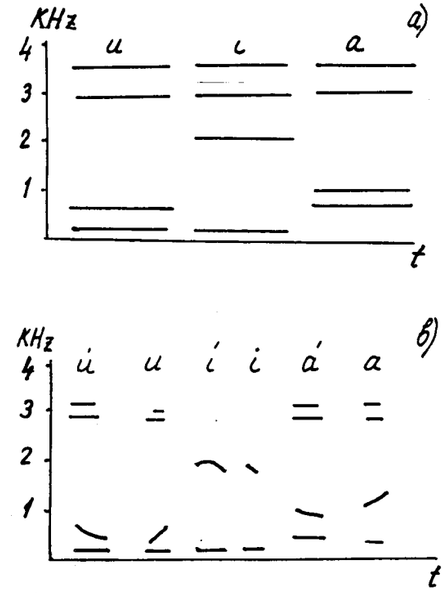

Fig.2 The scheme of formant characteristics of the experimental vowels.
(a) synthetic vowels
(b) natural Russian vowels, both stressed and unstressed, occurring in different phonetic contexts.

Phonemic terminology, due to thorough elaboration of the main concepts of the field, is more precise than psychophysiological one. Let us consider some of the terms.

I. The Phoneme is the minimal unit of the expression system which is able to constitute and distinguish meaningful units, i.e.words and morphemes /25/.The term "psychophysiological phoneme", as used by psychophysiologists, is less precise: psychological phonemes are defined as units corresponding to non-overlapping areas in the space of acoustic parameters of the speech signal. The number of these phonemes exceeds that of linguistic phonemes in any language.However, it is not known exactly how great this excess is /16, p.82/. Fig.3 presents the phoneme boundaries of psychological vowel phonemes in relation to the arrangement of Russian vowels in F1-F11 plane(Fig.3a), as well as data on possible changes in F1 and F11 of the vowels as a result of coarticulation with adjacent consonants(Fig.3b). Comparison of these figures shows that psychological phonemes, as revealed in experiments on synthetic vowels, do not correspond to the arrangement of natural vowels based on their acoustic and perceptual

characteristics.

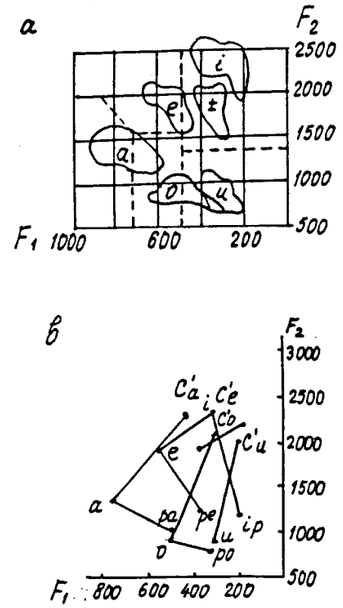

Fig.3 Areas of F-values of natural Russian vowels and "phoneme boundaries"
a) arrangement of Russian vowels in F1-F11 plane and as related to "phoneme boundaries" obtained in experiment with synthetic vowels;
b) possible F1 and F11 values of glides with respect to stationary segments of the vowels:/a, o, e, ɨ ,u, i/ - stationary segments; /c'a/ etc. - i-glides of the vowels preceded by soft consonants; /pa/,etc.- glides of the vowels preceded by labials.

What are the correlates of phonemes in speech activity? From the viewpoint of speech production, the minimal unit of pronunciation is an open syllable(CV,CCV), in which the information about the consonant(s) and the vowel is contained nearly in the whole of the syllable /4, 6/; neither is it the minimal unit from the viewpoint of speech perception, because some phonemes and classes of phonemes cannot be identified without minimal phonetic context /10/. Finally, if we consider the main function of phonemes, which is to constitute and distinguish meaningful linguistic units, the phoneme does not appear to be their obligatory element: it is a well-known fact that it only seems to a subject that the two words differ in some sound segment /ɔ/; it is also known that man can "hear" the sound in a sound sequence(more often in meaningful units) even if it is not present at all.

We may speculate that the phoneme as the minimal unit of the expression system is only necessary to put in good order conceptions about the structure (arrangement, set-up) of meaningful units, and such a conclusion gives grounds for the very bold but false claims that the phoneme as an operational unit of linguistic analysis bears no relation to speech activity of native subjects. Researchers studying speech activity have already gone through the period when the concept of the phoneme seemed to be a logical device which did not have any correspondence with speech material/20/. Now one can safely say that the phoneme is as real as other units of linguistic structure, such as the morpheme, the word, etc. Evidence of its reality for native subjects is quite plentiful and is discussed on a large scale in experimental phonetic studies. Let us consider some of the facts in the sequence that seem to be the most natural[x].

A phonemic system is represented in the brain of native subjects as an organized structure /4, 17/. Phonemic classification is used by native subjects for systematization of sound units (in speech perception), which greatly vary in their parameters, and for coding programs of essential articulations (in speech production). Phonetic realization of a phonemic sequence, as a specific phenomenon of any language, is regulated by a whole set of rules (the articulatory basis)and leads to certain peculiarities of perceptual processing of acoustic signals(the perceptual basis)/8/.

2. The phoneme and its distinctive features. Since the middle of the 20th century, this problem, due to the scholarly work of Jakobson, Fant, Halle,etc, has become central in phonological discussions and experimental phonetic studies. Linguists concern themselves first of all with the idea of regarding a distinctive feature as an independent unit of the expression system/3, 14/. Of utmost importance for phoneticians is the study of articulatory and acoustic correlates of distinctive features, as well as procedures for obtaining information about distinctive features in speech perception /6, 19/.

x Taking this opportunity to acquaint wide circles of phoneticians with studies little known outside this country, I will mainly mention here the results of studies of Soviet phoneticians.

No less important, however, is the problem of the degree of manifestation of linguistic and proper phonetic characteristics of distinctive features in native subjects' speech activity. Is the phoneme represented by a constant set of distinctive features or does it vary from one context to another? As a matter of fact, the answer to this question is closely connected with a different problem: is the set of distinctive features of a phoneme based only on the phonemic oppositions existing in a given language or does the phonemic system itself effect the procedure of attributing distinctive features to phonemes? For example, are the phonemes / k', g', x'/ in the words /rúk'i/ "hands", /g'imn/ "anthem" and /x'ítrɯj/ "cunning" soft or is their softness an allophonic variation determined by the character of the following vowel? Are the affricates /c/ and /č/ voiceless or are they lacking characteristics of the feature "voiceless/voiced"? Experiments on speech activity of Russian subjects demonstrate that the set of distinctive features of each phoneme is ascertained on the basis of knowledge of the phonemic system as a whole, and if the feature in question is distinctive for most phonemes, it is also attributed to the phoneme which is not opposed to others by this feature. Thus, /n/ is a forelingual nasal phoneme, though in Russian there is no opposition of forelingual and backlingual nasal consonants; backlingual /k', g', x'/ in the words given above are soft phonemes but not the allophones of hard /k, g, x/. This conclusion is supported not only by numerous experiments where subjects make phoneme discriminations of such sounds, but also by the indisputable ability of the subjects to mark the "unnaturalness", "anomaly" of those stimuli which satisfy our phonological concepts about distinctive features but do not meet the phonetic requirements concerning the correlates of the distinctive features. It is noteworthy that distinctive features are abstractions: each distinctive feature has a great number of phonetic correlates, and native subjects can use any combination of these correlates for the identification of the distinctive feature in question. The abstract nature of distinctive features is also supported by the fact that the character of phonemic oppositions is determined not by the degree of phonetic manifestation of distinctive features but by phonemic relations proper. For example, Russian nasal and soft consonants having distinct phonetic characteristics are in phonemic oppositions to each other as unmarked and marked members, the fact having been definitely confirmed in perceptual experiments on Russian subjects/5/.

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). On the other hand, being tolerant to the varying charateristics of speech sounds, native subjects use an effective set of rules allowing them to proceed from a variable phonetic picture to a sequence of phonemes, thus constituting the expression of meaningful units. This, in turn, means that native subjects use their own phonemics, which only partly coincides with that of a phonologist.

3. 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 biphonemic 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 phoneme 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 phonetic studies are very rarely based on conceptions that combine both phonemic and morphemic 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 excited an ever-growing interest in this problem. Every chain of sounds can be represented phonetically, for Russian at least, as a sequence of open syllables, and from a morphological viewpoint, as a sequence of morphemes: affixes, roots and inflections (Fig.4). Segmentation of the utterance into open syllables is used in applied studies and is confirmed by experimental data/2/.

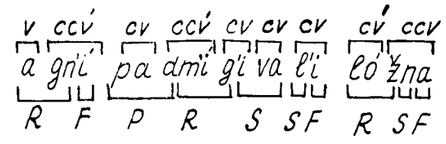

Fig.4 A sound sequence segmented into open syllables (at the top) and morphs (at the bottom).
R-root, P-prefix, S-suffix, F-flexion

In order to gain an understanding of how this segmentation can be rendered morphologically, that is, how to transform a sequence of syllables into a sequence of morphemes, a special study was carried out.

Each syllable was considered from the point of view of its morphological segmentation, producing the morphemic syllable structure. This made it possible to formalize the transfer from syllable segmentation to morphemic segmentation/21/.

We have every reason to believe that the relation between the "morphemic structure of the syllable" and the "syllabic structure of the morpheme" has psycholinguistic 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 morphemes and their arrangement into word-forms are language specific; they form one of the building blocks of what is meant by "language comprehension" or "information about higher levels" in constructing speech recognition models.

Systematic studies of the Russian Language Dictionary [x] where each word is represented as a sequence of morphemes/23/, have made it possible to obtain quantitative data for linguistic interpretation of the predictability of phonemes both in a dictionary and in speech flow.

110 thousand words were organized into 10 thousand word-families having the same basic root.

The phonetic analysis[x] of these roots revealed the following:

1. Approximately half of the roots contain a stressed vowel.
2. The probability of the occurrence of a stressed vowel in the root depends on its quality:

stressed vowel	Number of syllables in the root					
	1	2	3	4	5	6
1	2	3	4	5	6	7
a	10250[xx]	3868	1032	126	22	2
e	6299	2401	572	67	7	
o	8845	3371	597	56	3	

[x] The data presented below were obtained by computer analysis of the dictionary.

1	2	3	4	5	6	7
i	3866	1461	641	75	1	
ɨ	1429	360	22	1		
u	4105	1049	279	26		

[xx] The absolute number of roots containing this vowel

The table shows that there is a consistent relationship between the number of syllables in the root and the frequency of roots: the longer the roots, the fewer their number. Of frequent occurrence in stressed syllables are /a/,/e/ and /o/.

3. The probability of occurrence of unstressed vowels in the root morpheme varies: the more frequent are /a/ and /i/, less frequent are /u/ and /ɨ/.
4. The description of root morphemes in terms of generalized phonetic structure(C and V) revealed 29 different combinations, the more frequent of them being CVC, CCVC, CVCC and CVCVC.
5. Historical alternations of vowels(i.e. changes in the phonemes of the root morphemes which cannot be explained by phonetic rules of modern pronunciation) occur in approximately 3% of all roots,alternations of consonants - in nearly 6%.

Most prefixes, as our investigation revealed, contain an unstressed vowel. This indicates that a stressed vowel in a prefix is an exception rather than the rule,which any Russian speaker can use in phonemic identification of a vowel in a prefix (the prefix *без* = b'is for example, occurs in the dictionary 409 times, whereas the prefix *бес* =/b'es/ only 3 times; the prefix *от* =/at/occurs 2045 times, whereas *от* =/ot/ is found only 32 times).

The computer based dictionary has made it possible to determine the frequency of cases in which considerable vowel reduction occurs and, as a consequence, the simplification of the phonemic sequence. In Russian vowel reduction is often found in post-tonic parts of the word. A special computer programme enabled us to extract all unstressed fragments given in the dictionary; 67% of word-forms contain such fragments in their structure; every 311 fragments out of the 1200 which are possible occur in 90% of all word-forms having post-tonic parts. Research is under way to establish the relationship between the phonetic and morphological properties of these fragments.

These studies may seem to have no direct reference to the investigation of human speech activity, but this is not so.The "language competence" of a speaker implies not only his ability to make use of phonemic and phonetic distinctions of his language, but also to understand the meaning of the phonetic complexes. The system of basic knowledge which forms the mechanisms of recoding sounds into meaningful units includes also the comprehension of rules of word-formation which enable the speaker to make lexical and grammatical interpretation of a phonetically vague series of sounds.

The study of regularities governing the formation of the phonetic structure of an utterance in a particular language is one of the necessary constituents in the investigation of human speech activity. The study of speech perception, exhaustive as it might be,will give us information only 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 elements in 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 caused by the phonetic environment and modifications due to tempo variation, the intonation pattern and the placement of the word in the phrase (variability caused by deviations from standard pronunciation is the subject of a special study).

So the problem is to create a phonetically representative speech material that will enable us to obtain necessary information.

We will use the Russian language to illustrate how it can be done.

As mentioned above, there are statistical data on the open syllable in Russian: 200 most frequently occurring syllables acconnt for about 80% of any Russian text /15/. These are sequences of CV, CCV and CCCV, both stressed and unstressed.

Fig.5(a,b,c) shows the relative frequencies of syllables with various vowels (in per cent) and the relative frequencies of stressed and unstressed vowels in CV, CCV and CCCV sequences.

It is evident that syllables with the vowels /a/,/i/ and /u/ prevail in the group of most frequently occurring syllables; the number of syllables containing stressed /o/ and /e/ is considerably greater than that of syllables with unstressed vowels; other vowels were more frequently found in unstressed syllables.

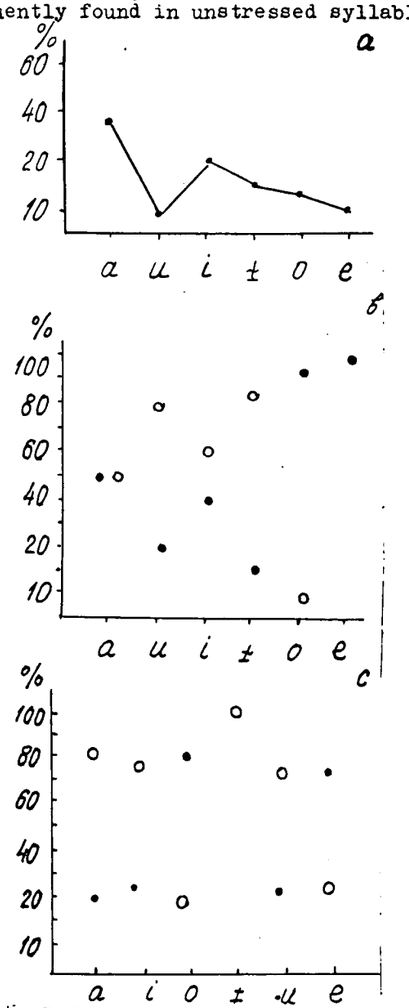

Fig.5 Relative frequencies of syllables in Russian:
(a)containing various vowels
(b)and (c)containing either stressed or unstressed vowels (filled and unfilled circles). Data on CVsyllables are given in (b), and on CCv and CCCV syllables in (c).

The occurrence of consonants and their clusters in these syllables is in accord with the known statistical data for the Russian language /II/. The creation of a phonetically representative text is necessary not only for experimental studies of speech activity but rather it should serve as a component of the bank of phonetic data obtained for any language in various computer techniques for processing and storage of phonetic information. This text, together with simple phonetic sequences like CV and CCV, will provide necessary information both for theoretical research and applied studies of speech signals. In its "ideal" form this bank of phonetic data must contain the following four blocks(Fig.6):

I. Block of physical(acoustic) information proper, which characterized distribution of acoustic parameters at the allophonic level as well as their combination within a word-form,

II. Block of phonetic properties of final constituents of the word-form(i.e. morphemes).

III.Block of phonetic properties of the word-form as a combination of morphemes: it allows sequences of sounds which are impossible within a morpheme.

IV. Block of phonetic properties of a text of any length.

The first of these blocks seems to be the simplest since it transforms the recorded text into digital representation and performs segmentation of the computer version into "fragments" in accordance with the prescribed transcription. One of the disputable questions here is the number of informants necessary for obtaining a statistically adequate and reliable corpus. They may be few ,but a preliminary selection with the help of an experienced phonetician is necessary, since he is able to assess both the standard of pronunciation and the degree of its individual variability. The computer version of phonetic material makes it possible to obtain any information which may be interesting for a phonetician and also makes possible accurate comparison of data obtained by other linguists.

The second block in which the information about phonetic properties of morphemes is stored, also requires the use of the computer based dictionary segmented into morphemes and computer programmes which make it possible to obtain the necessary information.

The realization of the third block is also impossible without the computer based dictionary. One of the best examples of such dictionary is the above mentioned Russian Derivational Dictionary by Dean S. Worth (et al.) which gives information about predictable combinations of derivational morphemes in Russian.

And, finally, the block of phonetic properties of a text which in fact is the algorithm for an automatic transcription which converts any orthographic recording into a sequence of phonetic symbols. Since every phonetic symbol is assigned its possible acoustic realizations in the first block, such a transcriber should provide an optimal synthesis of the text.

The realization of the bank of phonetic data as it is described here is a very difficult and responsible task.Only a few fragments of each of 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 linguists and representatives of applied sciences. In some respect, to create a bank of phonetic data means to construct a model of human speech activity.

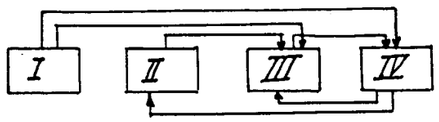

Fig.6 A scheme of phonetic base data with linguistic information considered I,II,III, and IV - blocks of phonetic properties.Upper lines with arrows indicate the most closely tied blocks providing for analysis and synthesis of speech. Lower lines with arrows indicate the direction of information transmission in linguistic processing of speech.

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 data which contains information about the realization of sound units may provide data for a reliable and thorough description of the acoustic cues of the distinctive features and for the description of standard pronunciation. Segments from this block may serve handsomely as transcription symbols, since each of them is assigned information about the position of the corresponding allophone. Phonetic transcription provides information about potential phonetic variability of each phoneme. It is important that these segments can also be used for comparison as "ideal" models.

Classification of final constituents of word-forms - morphemes - in terms of phonetic and phonological units is extremely important for linguistic analysis proper, since we know very little as yet about the quantitative aspect of the relationship of the two types of linguistic units, the phoneme and the morpheme. How often does a phoneme perform its distinctive function, i.e. how many morphemes are distinguished by the phoneme alone? Which phonemes are the more active in this respect and which are less so? How often do the morphemes which differ in various respects have the same phonemic make-up? How many morphemes with the same grammatical meaning differ in their phonemic make-up? Even the listing of these problems makes it clear that information cannot be obtained without the 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 items. The occurrence of definite classes of phonemes in definite positions within a word-form is a universal phenomenon, but only by comparing inherent phonological properties of sound units with their functions within the word-form and the morpheme can we 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 performs the analysis of any text in terms of the first three blocks, and thus not only verifies the various properties of sound signals but also enriches 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 sppech activity. The development of new and reliable methods is only beginning. To these we may refer the investigation of the perception of foreign language sounds (familiar and unfamiliar to the listener), the comparison of results of the identification of the same speech stimuli(synthetic sounds, for example) by speakers of different languages, the analysis of perceptual abilities of speakers of those languages which have different rules governing the combination of phonemes into meaningful units (Russian compared to Turkish, with its law of vowel harmony). The modifications of 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 influence of the linguistic system on human speech activity is the problem which requires close attention of all specialists interested in obtaining new data about properties of speech production and perception.

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