

Software for experimental methods in phonetic research

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Abstract — The article examines the methods and computer programs for experimental phonetics. Studies of experimental phonetics give more accurate results and for this reason it is interesting for many researchers in various scientific fields. This article is up-to-date because the materials and methods of experimental phonetics presented here are considered from the point of view of digital technology, which is the most relevant area of the present. The purpose of our study is to analyze computer programs for phonetic studies using the example of studies already made by various researchers. During the research when analyzing scientific work with the software such as PRAAT and Speech analyzer, we focus on descriptive and comparative descriptive methods. Summing up the results, the article notes that at the moment experimental phonetics reached a new level thanks to computer technologies. The materials of this study may be interesting for young phoneticists and linguists, as the newest source of information in this area.

Keywords — *experimental phonetics, computer technologies, PRAAT, Speech analyzer, digital technologies, software, phonetic studies.*

I. INTRODUCTION

Despite the fact that a lot of time passed since the formation of experimental phonetics, this field of science still attracts the attention of many researchers of linguistics. The reason for this is that the application of experimental methods during phonetic studies provide accurate resulting materials. "The experiment allows to capture such delicate moments that the researcher, even with normal hearing, cannot determine. For example, in Azerbaijani language it is not always possible to determine the features of sound [r] at the end of a word, but with the help of recording devices we can get a complete acoustic presentation of this event" [26, 21-33]. The correctly chosen software of phonetic studies plays the main role here. According to the dynamic development of information technologies in the modern world, these programs are still being improved by programmers and technicians. Even many linguists-phoneticists do not always know about innovations in this field, that is why our research is urgent. The main purpose of this article is to consider the essence of experimental methods in phonetics, comprehensively analyze the results of

research conducted using computer programs in the field of phonetics, which is the scientific novelty of this work.

The advantage of experimental phonetics is that you can learn not only individual sounds, but also their interaction with other sounds. Even F. de Saussure in his research, indicated that the study of separate sounds is not acceptable. "If phonology prefers isolated sounds in search of its basic principles, this is contrary to the sound idea. When faced with a bilateral association, phonology is considered unsuccessful. To understand what happens in sound combinations, it is necessary to create a phonology with which these sound associations can be viewed as algebraic equations" [17, 87]. "In general, it should be noted that it is difficult to say something specific about the phonetic properties of the language without an experimental study of the speech chain" [25, 6].

II. RESEARCH METHOD

The research method is descriptive and comparative-descriptive method. With the help of these scientific methods, we are going to consider the studies that were conducted on the material of multi-system languages by researchers of different eras. Thus, we will be able to observe the history of the use of technological and instrumental means in phonetic studies.

III. RESULTS OF THE RESEARCH

Phonetics and phonology

Compared to other areas of linguistics, phonetics is of particular importance and studies the sound system from different angles. "It is worth noticing that in all languages sound substances are almost identical, but in some languages their role is very specific for each language. For example, the sign of rigidity and subtlety is common for both Russian, and Azerbaijani languages. But these signs are relevant for the Russian language, and irrelevant for the Azerbaijani language. In Russian, it does not depend on the position of the consonant. But in the Azerbaijani language, the position of the consonant is of key importance. For example, in the Azerbaijani language, in the words "ləl" and "lal" in the first version, the phoneme [l] sounds in a subtle version, and in the second version the hard version is used: [l̥], [l] of that phoneme. In

contrast to this, it should be noted that in Russian different versions of this phoneme are considered different sounds" [8, 6]. This phenomenon was the main reason for I.A. Boduen de Courtenay, N.S. Trubetskoy and other researchers to identify such scientific fields as phonetics and phonology. According to the researchers, the first thing has nothing to do with the language, and this is explained by the fact that language is a sign system, and a sign is arbitrary in nature, therefore, its material part has nothing to do with the language [8, 6]. Despite all this, the importance of the phonetic system of language is indisputable. Traditional phonetics is not limited to the study of only speech sounds, it also studies stress, syllable and intonation. In addition, it should be noted that spelling and orthography are closely related to sound, syllable and stress. In particular, the theoretical basis of spelling was originally related to how the word was voiced.

As a specialized area, phonetics is of great importance for linguistics, because speech used between people, as an important communicative tool, is expressed through the language sound system. In this sense, it is not so difficult to understand how important the science of studying the sound system of a language is.

The sound system of a language ensures its survival and determines its transmission from generation to generation. The sound of the language also ensures that the language is learned and mastered by children. The fact that dead and artificial languages do not function is due to the fact that the sound system of these languages is not alive.

The sound system of a language ensures its survival and determines its transmission from generation to generation. The sound system of a language also guarantees learning of a given language, and children master the language with its help. The fact that dead and artificial languages are not used is due to the fact that the sound system of these languages is dead. Of course, as we have already noted, in spite of the fact that some linguists consider phonetics as an "imperfect" branch, linguistically this does not affect its scientific significance. Agreeing with American linguist Whitney and F. de Saussure, they also claim that if the sign system of the language is conditional, then the phonetics is also conditional, unstable. But their opinion is erroneous. It is indisputable that these thoughts and positions of researchers served as an impetus for the formation of phonetics and phonology as separate matters, and at the moment phonetics and phonology are different areas in the scientific world that have completely different objects of study. F. de Saussure and his supporters sometimes give too much importance to the sign nature of the language, and identify it with other sign systems. According to them, language is also a part of semiotics, and if sounds did not exist in it, they could be replaced with other signs. As an example, they mention the possibility of replacing sounds with colors. Nevertheless, many linguists, in their works, noted that it is impossible to replace the voice with other means for one simple reason that understanding occurs in the brain by analyzing what was heard through hearing and seen through sight [11, 5; 8, 7-8]. Sign language is also imperfect. For people who use this language, visibility is an important element. Because they will not be able to communicate in the dark or on the phone at all [11, 5]. Such thoughts alienate linguists from the subject matter. In this sense, we agree with the idea of F. Weisalli who states that phonetics and phonology are in fact two different aspects of the science of the sound composition of a language [8, 8]. The sound composition of the language consists of segment (phonemes and its types) and

super-segment units (stress, prosody and intonation). All these elements are subject of study in phonetics and phonology.

Phonetic studies differ from other areas of linguistics by their peculiarities. Since phonetics also studies the physical characteristics of sounds, not only linguists, but also physicists and physiologists are engaged in their research. Linguists should also study the physical and physiological properties of sounds. But this position is not the basis for talking about phonetics, as about a completely different direction of linguistics.

As mentioned above, given the nature of phonetic research, phonetics and phonology are two different areas of phonetics in general. Phonetics studies the sounds of the physiological-acoustic aspect, and analyzes its sociological properties. Baudouin de Courtenay mentioned in his studies the definition of these two branches. He proposed to call these directions anthropophonic and psychophonic [6, 100]. But modern phonetic scholars do not accept this classification. B. Malmberg wrote that the formation of two teachings on speech sounds is already a historical fact [23, 14]. In fact, before the advent of phonology, the concept of phoneme already existed in the scientific world. Because the main feature of the sound is that it is a distinctive unit of semantics. When we talk about the characteristics of any sound, we take into account its articulatory-acoustic features that are distinctive from other phonemes, on the one hand, and on the other hand, they can give different meanings to the word. In other words, phonetic and phonological aspects are taken into account when describing and analyzing any sound. Given this fact, some modern researchers of phonetics call it physiological phonetics [20, 52]

Experimental phonetics

The study of phonetic speech sounds by experimental methods began at the end of the 19th century, and at the beginning of the 20th century, experimental phonetic laboratories were established in a number of countries that used several devices to study the acoustic and articulation properties of speech signals. But, before that, primitive devices were used to study speech sounds that met the requirements of their era. According to some linguists, the scientific work of A. von Galvag is considered the first step in creating experimental phonetics. In this scientific study, the author invented the triangle of German vowels. This triangle is still a significant scheme for studying the phonetics of German language [25, 71; 22].

Experimental phonetics explores the acoustic and physiological characteristics of the speech sounds of both individual languages and language families using devices. After appearing of experimental phonetics, phonetics has become the most accurate science of language. These methods helped to get a clear picture of speech sounds and signals and to investigate the intonation of the speaker in different emotional situations. At later stages, these methods created the basis for psycholinguistics, speech recognition, forensic examination and other fields. Experimental phonetics is "a set of instrumental methods for studying the sound composition of speech" [2, 497].

To study the speech sounds in the acoustic plan, special resonators (more precisely, the Helmhols resonator) and tuning forks are used. With their help, we study general and specific tone of the sound. Instruments also record vibrations, or rather sound waves.

Experimental phonetics studies speech phonetic sounds in atypical speech conditions. Often, depending on the purpose of the study, it is necessary to record each sound separately. But lately, especially thanks to the capabilities of computer programs, it became possible to study the sound in separate speech passages. This method allows you to explore each sound separately and in combination with other sounds.

Experimental phonetic studies on the materials of the Azerbaijani language

Corresponding research in this field has also been conducted in Azerbaijani linguistics. Especially, we want to mention the research of A. Akhundov. In his scientific works, he widely used experimental methods and we can see the clear results of such approach. He used the most leading technologies of that time and managed to use this innovation to explore the entire phonetic system of the Azerbaijani literary language. A. Akhundov at the same time studied the sound system of the Azerbaijani language using statistical methods. Also he studied the intonation of the Azerbaijani language and obtained some new results in the field of syntactic phonetics [21]. In particular, in studies conducted by A. Akhundov in this area, statistical method was used for an attempt of identifying the frequency and pattern of occurrence of phonemes of the Azerbaijani language [21].

During last years F. Weisally did a lot in the area of experimental studying of Azerbaijani phonetics. Specifically, his role in the study of super-segment units of the Azerbaijani language is indisputable [26]. Exploring the phonetics of Azerbaijani language using experimental methods, F. Weisally writes: "Units that are semantically significant and have the ability of free use, are primarily a straightforward combination of two or more phonemes (in the Azerbaijani language, the phoneme "o" is an exception. Apart from that, one-phoneme morphemes with grammatical meaning can also be encountered. An example of this is the accusative and genitive suffixes in the Azerbaijani language)" [25, 6].

Also, it should be noted that as early as in 1980, Azerbaijani phonetic researchers had written a book called "Experimental phonetics". The authors of this book, Z. Verdiyeva, F. Veisalov, F. Agaev, with the material of the Azerbaijani language, comment on the subject, object and methods of research of experimental phonetics.

In modern Azerbaijani linguistics a diligent research in this area is conducted by young scientists. A phonetic laboratory is created at the I. Nasimi Institute of Linguistics of the National Academy of Sciences of the Republic of Azerbaijan.

Experimental phonetics methods

As known, the first who began to use some physiological devices in the analysis of speech articulations, was V. Bogoroditskiy [4]. And the valuable works in the field of experimental phonetics were created by the talented pupil of Professor V. Bogoroditskiy S. Galimdzhan ("Palatograms of the sounds of the Tatar language in comparison with the Russian language" (1927); "Sonorous duration of Tatar vowels" (1928)). He also published a number of articles on syllabification, lip assimilation and the phonetic nature of individual sounds.

After him, but independently from him, P. Russlo created a special laboratory at the Sorbonne, which later became widely known and became a school for many phoneticists not only from France, but also from a number of other countries,

including Russia. The works of P. Russlo, although they had linguistic orientation, sometimes suffered from disregard for the aspect of research.

In 1912 L. V. Scherba indicated the method of segmentation of speech into linguistic units by the division of phonemes based on linguistic criteria in the book "Qualitative and quantitative relations of Russian vowels". Later he wrote: "Nothing separates one sound from another neighbouring with it in the speech: each sound goes directly into the other without any sudden jumps. However, since individual sounds of speech serve to distinguish the meaning of words and since individual sounds can have independent significance, it is fair to say that every speech splits into separate sounds or consists of separate sounds" [18, 20]. There must not be a phonetic study that does not take into account the phonological aspect, which would not have the ultimate goal of finding out certain linguistic relations. This means, however, that the method with which the phonetic research should begin must coincide with the method of analysis of any linguistic phenomena.

Experimental phonetic methods help the researcher identify phonetic differences and features of sounds. With their help, you can clarify the exact articular properties of a sound. With their help, you can hear a specific sound or spectral analysis or clearly identify differences in dialects or individual differences in speech.

To obtain an answer to various questions in the field of phonetics, various experimental phonetic methods are needed, that represent a variety of techniques and methods for working with the objects under study. Methods of experimental phonetics appeared in the depths of linguistics. Experimental phonetic methods are extremely diverse: from spectrographic and cinematoradiographic to auditory. If we compare these methods during the work, it is definitely clear that X-rays and palatograms show the place of articulation; previously used kimograms account the method of articulation, allowing you to find out the duration and some acoustic characteristics of sounds, and the spectrograph gives information about which overtones are amplified in resonating cavities when a particular vowel is pronounced, it transmits the acoustic spectrum of the sounds of the language. The palatogram method is less perfect than the x-ray method. It gives only an imprint of the greatest rise of the tongue, and, with the exception of monosyllabic words with labial consonants, it is applicable only to the study of isolated, established by sound, few phoneme variants, since this method leaves aside all the diversity of sounds of human speech. Radiography is the most versatile method that allows you to see in the process of articulation something that is not available to the palatographic method. It shows the position and activity of all organs of speech articulation, starting from the vocal cords and ending with the lips [3; 7, 246-293; 16]. Experimental phonetic methods, of course, cannot be replaced one with another, and all of them are necessary for studying sounds from different sides. These methods include the method of auditory analysis, the need for which was mentioned by V. Bogoroditskiy [5, 63].

A researcher who uses experimental phonetic methods should be aware that all recording devices inevitably introduce larger or smaller distortions into the recording, and all analyzing instruments give larger or smaller measurement errors. If both are within the available limits, which the experimenter will know, and depends on the accuracy needed to solve the problem, then one needs to be able to evaluate all sorts of errors and take them into account when processing the

received data. Evaluation of the reliability of the results is one of the most important moments in the experimental phonetic research. One of the most important questions of principle related to the conduct of experimental phonetic research is the question of analyzing the perception of the phenomena studied. This problem is essentially closely connected with the general methodological principles of linguistics [11, 7].

In phonetic and phonological studies, experimental methods are of great importance. "The experiment, as we know, differs from observation in the fact that the researcher does not just passively observe the object, but puts the object in a position to determine the relationship between these situations and relations the researcher is interested in" [11, 19]. The application of the experimental method in phonetic studies is not limited to the use of certain devices. Which means that it is wrong to think that the essence of phonetic research changes when certain devices are used. In fact, in traditional linguistics some studies also use experiments. If we take the situation from this point of view, as L. Zinder said, we would deal with "instrumental phonetics", not with "experimental phonetics" [11, 19]. The essence of experimental phonetics is that it gives only "negative" materials [19], i.e. clarifies what is impossible in the studied language. "From the point of view of a correctly set experiment, one can say that it is carried out by two means: hearing aids and special devices. The first is often subjective, and the second is objective" [11, 20]. The use of objective methods is based on the fact that the person's hearing aid, in particular, hears not what is voiced, but what the person is used to hear. On that matter, L. Scherba writes: "Even a person with the most absolute pitch hears what they are used to with their own association of thinking" [21, 200]. "Objective or experimental phonetic methods (in the narrow concept) allow controlling the subtlety of a sound that cannot be heard, and it is especially important to note that these methods make it possible to separate articulation and acoustic sound map to elements exactly when it sounds as a single whole. Even if that division is possible with auditory perception, the results of such an analysis mostly depend on the researcher himself" [11, 20].

When using objective methods, the role of an experienced specialist is of great importance. Despite the fact that modern computer programs allow a thorough analysis of speech, it also requires an experienced researcher who is able to correctly identify and evaluate the results of this study. Devices used in modern phonetic studies allow more accurate research.

Experimental methods and phonology in linguistics have created the basis for the formation of each other. Ferdinand de Saussure, who criticized the study of individual sounds in isolation, wrote: "The method of modern phonology cannot be considered satisfactory in the following sense: they do not take into account the fact that there is also a speech flow in the language in addition to sounds. In fact, attention is focused only on isolated sounds. But we must take into account that what we perceive is not an isolated sound" [25, 6].

During phonetic studies, a number of research methods are applied, that are grouped as follows:

- 1) Method of observation;
- 2) Somatic method;
- 3) Pneumatic method;
- 4) Oscillographic method;
- 5) Spectral method;
- 6) Combinatory method;
- 7) Historical-comparative method [25, 3].

Acoustic research of speech provides a scientific method for conducting an objective analysis of speech sounds by measuring the physical properties of sounds and their acoustic realizations [20, 52]. In this concept, experimental methods are also widely used in the study of supersegment units. Specifically, lately the creation of various computer programs has facilitated this process. With the help of such types of programs, the researcher can study a phoneme from different sides: as an isolated unit, and as part of any language formant.

Software for experimental phonetics

For several years, computer programs are widely used in phonetic studies. But these programs are sometimes not so effective. G. Gubaidullina writes that "with the advent of computers, phoneticists began to face new problems. Firstly, this is due to the fact that many researchers of phonetics are experimenters and they do not know computer programs, and working together with a professional programmer is not always effective. Because the programmer sees the tasks set by the researcher from their professional point of view and can apply the corresponding unnecessary changes that may affect the research results. The only way out of this situation is phonetician learning programming [10, 22-25].

The advantage of modern computer software and devices is that the researcher can use them to study phonemes both in isolation and in any language module. For example, A. K. Alimuradov and Yu. S. Kvitka consider in their study a speech signal as a segment of sound according to a consonant of the phoneme "a" with a duration of 30 m/s using a suitable computer program. The duration of one phoneme varies from 10 to 25 m/s, therefore, the processing of speech signals is carried out sequentially in segments of an average of 10 - 30 m/s. [1, 72]. Speech signals of such duration are considered to preserve the integrity of the phoneme's auditory information.

This method gives very good results in the study of segmental and supersegmental units. In general, we should note that the study of patterns of phonemic connections was always the focus of linguists and was of great importance for typological and theoretical linguistics. True clarifications on this issue also provide important material for comparing one language with another. In particular, it is important to study the sequence of phonemes in terms of differences between national and acquired words. Studying the sequence in phoneme compounds is also very important when learning a new language.

Currently, for the production of phonoscopic studies (especially in forensic examinations) software packages of various complexity are used, ranging from standard software to specially developed identification systems (for example, the OTEExpert 5.0 system. As well as the SIS II program, it is the most common in the practice of Russian, as well as Azerbaijani phonoscopist experts.

The Dialect software and hardware complex provides automatic analysis of phonograms recorded through high-quality transmission channels (a telephone channel, for example, is not sufficiently high-quality for this complex), giving an oscillographic image of a speech wave, allows to determine the frequency characteristics of a speech signal, the frequency range of noise, signal-to-noise ratio, calculate the frequency of the main tone and formant.

SIS II system provides a wide range of professional tools for various types of speech signal research, such as segmentation and text interpretation, a clear visual

representation of the signal, automated and manual comparison of speech phonograms, automatic calculation and comparison of pitch statistics. The OTEExpert 5.0 system is considered to be sufficiently developed. This system allows you to represent the audio signal in the types of waveforms, spectrograms, intonograms; calculate the basic tone, formants, make comparative studies of phonograms and their sections, calculate the signal-to-noise ratio; use the built-in text editor to set the corresponding sound text. The use of new technological research methods allows us to expand the field of types of analysis and to ensure the reliability of the results obtained.

The most famous program used in phonetic research is the PRAAT program. This product was created by the research officers of faculty of phonetics of the University of Amsterdam Paul Boersma and David Weenink and is intended for linguists who study speech. This program allows to exercise multi-level markup of sounding speech, including the construction of oscillograms, spectrograms and intonograms.

Applying this program in the study of maternal speech, A. Kolmogorova and O. Varlamova come to the conclusion that "as a result of perceptual-acoustic and electronic-acoustic analysis, prosodic changes in the maternal speech in a child's wake-up situation were identified, a high emotional coloring, expressed through tonal features, was also highlighted." In the present study, PRAAT software was used to describe the prosodic characteristics of maternal speech. For the maternal speech in the Russian language in this situation, as noted by the authors of the study, the phenomenon of lengthening of vowels in significant words at the end of a rhythmic group is distinguishing [13, 131].

Using the technology of computer-aided speech analysis, it is possible to identify distinctive deviations in prosodic speech formalization. The computer program "Speech Analyzer" allows, after the auditory complex analysis, to clarify the specifics of the syntagmatic division of the text, the duration of the pauses, curves of intensity and tone. This software was used in his research R.E. Kulsharipova and Ch. Weiwei. This program allowed us to analyze syntagmatic articulation, determine the duration of each syntagma, pauses between them, as well as to analyze intensity curves, calculate the intensity range [14, 221-228].

To identify the causes of speech errors D.I. Kaparushkina, using the PRAAT 5.3.04 program for fixing observation materials, conducted an experiment comparing the acoustic characteristics of explosive Korean consonants with the characteristics of Russian explosive consonants in the pronunciation of native speakers. According to the results of this study, the acoustic characteristics of Russian explosive consonants in the pronunciation of Korean students were analyzed [12, 48-54].

The PRAAT program allows you to select arbitrary parts of the sound and listen to them. It should be noted that when a segment of sound corresponding to the bow and explosion of a consonant is selected and listened to, no consonant sounds are heard, they sound only when accompanied by a vowel, merging with it. The same fact explains the validity of recording not isolated consonant sounds, but sounds accompanied by vowels. Using this function of the program PRAAT, D.I. Kaparushkina independently divided the analyzed sound into the following areas: vowel, bow and explosion (the explosion in the spectrogram is colored in pink). The computer program PRAAT simultaneously displays on the monitor screen the spectrogram of the recorded sound signal and the corresponding oscillogram. This program also allows

you to fragment the sound signal to determine which sounds belong to certain acoustic properties. In this program, oscillograms and spectrograms complement each other, specifying certain characteristics of the speech signal.

Using instrumental phonetic analysis in her research, N.N. Grotskaya performed it with the help of the PRAAT and Speech Analyzer programs. [9, 255-258]. In the course of the present study, the frequency of the main tone, duration and intensity when pronouncing interjections were analyzed in comparison with onomatopoeic words, children's vocabulary in exclamatory sentences and ordinary words (nouns, adjectives, verbs) as primary questions and denominative sentences. As a result of this study, the author has revealed new types of references.

Another program for phonetic research is a program called Sound Colour. The authors of this program are L. P. Prokofieva, I. L. Plastun and programmer T. V. Mironova. It's a tool for analyzing the sound-color component of the text. The Sound Colour program consists of several modules, the work of the first one is based on information about the average frequency of Russian sound letters and the data on the correspondence of each letter of a certain color or several colors. As a result of the analysis, the user is provided with a table of information on the calculated frequency of the sound letters and data on the presence/absence of reception of semantization, as well as diagrams and graphs of chromaticity and color dynamics in the text fragment [15, 152-155].

All of these programs are used by researchers as needed in connection with the purpose of the study. Along with the technology development, these programs are also being improved and new versions are created. Such intense influence of the technological development of the modern world requires modern linguists to always update their information resources and knowledge.

IV. DISCUSSION OF RESULTS

When analyzing any sound, phonetic and phonological aspects should be considered as a whole.

With the advent of information technology a new era began in experimental phonetics that bases on computer programs.

Despite the fact that the methods of experimental phonetics appeared, the depths of linguistics, in modern studies it is closely connected with computer technology.

When investigating software for phonetic experiments, we can conclude that among these programs the most well-known and widely used program is PRAAT and Speech analyzer. And programs like OTEExpert 5.0 and SIS II are relevant for linguistic and criminological research.

V. CONCLUSIONS

Conclusions and presented research materials may be interesting for young researchers of experimental phonetics. Considering the fact that this area of linguistics is narrower area, our research can be a useful source of information for new research.

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