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named after K. D. Ushynsky”**

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LABORATORIES OF EXPERIMENTAL PHONETICS

The article is devoted to the specifics of laboratories dealing with experimental phonetics. The author highlights some historiographical aspects regarding the development of experimental phonetics. The popular methods and apparatuses of experimental phonetics have been represented; their functioning peculiarities have been described; their advantages and disadvantages have been analysed.

Introduction

For ages people were dreaming of fixing and preserving sounds, surrounding them in the vast world they lived in. There existed thousands of legends about fixed sounds. But only in the 19th century the dream of humanity was realized.

The American scientist and inventor Alva Mater Edison created the first pneumatic apparatus – phonograph, with the help of which sounds could be recorded and reproduced. The appearance of the phonograph was of great importance for the development of experimental investigations of sounding speech. Pneumatic phonograph was the basis for the first pneumatic apparatuses for speech analysis, which needed further elaboration due to the lack of professional equipment aimed at studying phonetic phenomena.

Results an Discussions

At the end of the 19th century and the beginning of the 20th century the linguists I. P. Rousselot (France), V. A. Bogorodsky, L. V. Shcherba (Russia), A. I. Tomson

(Ukraine) were the first to underline the importance of experimental study of the language and made a valuable contribution to the development of experimental phonetics.

Experimental methods in phonetics began to be systematically applied since the beginning of the 20th century. The first laboratory of experimental phonetics was organized in Paris by I. P. Rousselot. At first the laboratory was equipped with experimental devices of that time – tuning forks, the simplest pneumatic apparatus.

The main object of investigations was speech sounds, especially vowels. The position of the organs of speech in producing speech sounds, the frequency characteristics of vowels and their perception were studied in that laboratory.

Experimental investigations of sounding speech began in Russia at that time too. The first laboratories of experimental phonetics were organized in St. Petersburg and Moscow.

The laboratory of experimental phonetics in the St. Petersburg University, with L. V. Shcherba at its head, began active work in 1908-1909. The laboratory was equipped with phonetic devices of that time – tuning forks, artificial palates, pneumatic kymograph. The scientific interests of the St. Petersburg Laboratory of Experimental phonetics at that time were concentrated on phonetic correlates of functional units in European languages, on their phonetic characteristics.

Another speech investigating laboratory which began its work at the beginning of the 20th century was the laboratory of the experimental phonetics of the 1st Moscow Pedagogical institute of Foreign Languages. The head of the laboratory was V. A. Artemov. The main object of investigations was a comparative analysis of sound systems, stress and intonation of the languages of the former USSR and foreign languages of the learners.

The laboratories of experimental phonetics at St. Petersburg (former Leningrad) State University and Moscow Humanitarian State University (former 1st Moscow Pedagogical Institute of Foreign Languages) became schools for training specialists in experimental phonetics for newly organized laboratories. They organized seminars, tutorials, consultations, helped to master new methods of experimental phonetics. The role of Moscow and St. Petersburg scientists in training young specialists of the newly

organized laboratories in Kiev and Odesa was great. Prof. V. A. Artemov, Prof. S. J. Bernshtein, Prof. J. P. Torsuev, Prof. K. K. Barishnikova, Prof. Zhinkin and others helped selflessly the young researchers in their hard work.

One of the first laboratories of experimental phonetics in Odesa was opened and headed by A. I. Tomson at the so called then Novorosijsk University in 1897. The results of A. I. Tomson's investigations of Russian, Ukrainian, American sound systems were published in 1912, 1922, 1927 and later.

Later numerous laboratories investigating oral speech were opened in different countries of the world and in different cities of the former USSR – in Kiev, Minsk, Odesa, Tbilisi, Yerevan, Novosibirsk and others.

Several laboratories of experimental phonetics in Ukraine began their work.

They are laboratories of experimental phonetics at the Shevchenko Kiev National University, at the National Academy of Sciences of Ukraine, at Odesa National University and others. Odesa laboratory of experimental phonetics stopped its existence in 1935 after professor Tomson's death as he had no followers and the laboratory resumed its work in Odesa nearly thirty years later in 1963.

The first laboratory of experimental phonetics in Ukraine was opened in the 1940s at T. Shevchenko State University. Prof. J. P. Suntsova was the head of the laboratory for a long time till 1964, and from 1964 – Prof. P. I. Totskaya. The object of investigation in the laboratory were the methods of experimental investigations of speech, the way of production and perception of speech sounds and their phonological functions in different languages. Among the instruments and devices, the first electric artificial palate was constructed in the laboratory and used for studying articulation of speech sounds [1, 2, 3, 4].

The laboratory of experimental phonetics of the Academy of Sciences of Ukraine was organized in the 1960s. L. A. Bliznichenko was the head of the laboratory till 1972, and from 1973 – Prof. A. I. Bagmut.

The basic problems elaborated in the laboratory from the very beginning were the problems of the intonation structure of the utterance and its perception. The first electronic apparatus of speech analysis (Martinov A. A.), carrying out automatic

analysis of acoustic characteristics of speech signals and other apparatus, which were in the laboratory, made it possible to undertake rather extensive investigations of intonation structure of different communicative types of sentences in Ukrainian and in foreign languages. Nowadays the linguists of the laboratory, on the basis of new methodology and technology, continue to investigate the characteristic features of Ukrainian pronunciation – stress, intonation and other phonetic phenomena under different conditions of pronunciation, the problems of intonation expressiveness in mass media and many others.

The laboratory of Experimental Phonetics at Odesa National University resumed its work in 1962. The organization work was realized by V. Shatuh. In 1963 T. A. Brovchenko was appointed the head of the Laboratory. At first the members of the Laboratory staff confined themselves to the small number of experimental devices the Laboratory had – artificial palates, tape recorders, oscillographs and later a self-made intonograph designed by V. G. Voloshin – an electronic device which analysed information uttered by a speaker or recorded on a magnetic tape and produced the oscillogram, the outline of the tone and the duration of the utterance.

Beginning from the 1980s new electronic devices appeared in Odesa Laboratory of experimental phonetics, as well as in other laboratories in Ukraine, – a spectrograph and computers – electronic devices which store information on disks and automatically analyse it and produce required information.

Special linguistic phonetic programmes make it possible to receive segmental and supra-segmental characteristics of sounding speech automatically considerably shortening the analysis time.

Over a long period of time the basic problem of Ukrainian Laboratory of experimental phonetics was comparative, contrastive analysis of segmental and supra-segmental characteristics of native and foreign speech – contrastive analysis of sound systems of Ukrainian and English, word stress in English and Ukrainian, the comparative study of intonation of different communicative types of sentences and different types of texts.

Methods and Apparatuses of Experimental Phonetics

Experimental phonetics nowadays is closely connected with other sciences. First and foremost, it is connected with such sciences as psychology, physics, physiology, logic, medicine, radio-technology and others.

Some theoretical principles, methods and instruments of the above-mentioned sciences are adopted by experimental phonetics.

One of the first methods of scientific research used in phonetics is observation. Instrumental methods came later with the development of technique. Though instrumental methods in phonetics are of great value, the method of observation has not lost its significance. It should be borne in mind that even now the method of observation remains one of the most important for a phonetician. It does not exclude, but presupposes instrumental methods. Speech should be investigated by the combined techniques.

Instrumental methods may be divided into methods investigating articulation and methods of physical analysis of speech sounds, the nature of stress and intonation.

Palatography is one of the earliest experimental methods. The aim of the palatogram method is to determine the areas of the palate with which the tongue comes into contact in pronouncing a certain sound, to reveal in a visual manner the actual tongue-palate contacts in the production of a sound.

Palatograms were obtained with the help of artificial palates. An artificial palate was made of vulcanite, cellulose or metal. The most suitable artificial palates were made of cellulose or vulcanite. Those materials made it possible to prepare a very thin palate (0.2-0.3 mm thick) which, made by a dentist for a definite individual, fitted his palate exactly. As a rule, artificial palates were preserved in special forms made of plaster when not in use to avoid their deformation.

The traces of the contact of the tongue with the artificial palate while producing the sound made it possible to obtain the data about the position of the tongue in pronouncing a definite speech sound.

In order to produce a palatogram, the artificial palate was dusted with powder and inserted into the mouth. When a sound was pronounced the places of the artificial palate from which the powder had been removed showed the areas of the palate with which the tongue came into contact in pronouncing the sound.

The artificial palate made it possible to obtain a linguagram, by which one could determine the parts of the tongue which made contact with the palate in pronouncing a sound.

It should be mentioned that the traces of the tongue contact with the artificial palate can be registered only once and then the procedure should be repeated. Besides, static palatography gives no evidence about the changes in the position of the tongue during the pronunciation of the sound.

The first attempt to receive dynamic palatograms was done by R.U. Stetson (1951). He attached several very small balloons connected with capsules to the surface of the artificial palate. When a consonant was pronounced, the tongue was pressed to some balloons at a definite place of the palate and correspondingly the contact was registered. Still, this method was not quite handy for the speaker and the explorer and rather laborious.

A new method of dynamic electric palatography was realized by a group of scientists of the I. P. Pavlov Institute of Physiology in St. Petersburg (Ju. I. Kuzmin, 1963; I. G. Chistovits, V. A. Kozhevnikov and others, 1965).

Electronic sensing elements (data units) were installed into the surface of the artificial palate that made it possible to register the contact of the tongue with the palate during the whole period of pronunciation with the help of an electronic device, connected with the sensing elements.

A similar dynamic artificial palate was made and applied in the T. Shevchenko National University in Kiev.

The scientists of the I. P. Pavlov Institute of Physiology worked out the problem of complex analysis of the articulatory parameters of speech (Kozhevnikov V. A., Shuplyakov V. S., 1962). The experimental installation, including data units and electronic devices, made it possible to receive the articulatory characteristics of speech: the speed of air movement exhaled from the mouth, the movement of the lower jaw and the lips, dynamic palatograms, the vocal cords oscillations, etc.

Photography method is also one of the methods used in experimental phonetics. The aim of the photography method is to determine the position of the speech organs

in pronouncing speech sounds and their combinations. This method includes: photography of the position of the lips and the shape of the mouth opening, filming the position of the lips, photography of the mouth cavity by means of a special camera and X-ray photography.

Lip position photography allows us to photograph the most typical lip position for a certain sound. One of its drawbacks is that it does not show the movement of the lips in articulating sounds.

Cinematography makes it possible to observe the movement of the lips in the articulation of sounds, it allows observation of the changes in the position of the lips for a given sound in different positions in the word, enables us to measure the time of the articulation of the sound and of its separate phases, to observe the changes in the position of the lips in connected speech.

The Feldshtain-Maksutov gastrograph is a specially designed very small camera, (30 mm long, 16 mm wide) which makes it possible to obtain photos of the speech organs position inside the mouth cavity. This camera is of special value as it is possible to investigate not only the position of speech organs but also the shape of the surface of the main articulating organ – the tongue. These facts can hardly be received by means of any other method.

Radiography (X-ray photography) applied in phonetic research, makes it possible to determine the position of the speech organs in the pronunciation of speech sounds, provides the investigator with adequate research tools to study the speaking mechanism.

At the present time, the basic radiographic techniques are applied in experimental phonetics. They are cephalometric röntgenography and cineradiography (“cephalometric” means head measurement). These principles create the possibility of accurate measurements. To obtain a clear picture of the tongue position on the röntgenogram a thin barium line may be drawn along the middle of the tongue. The subject should be placed in a precise position with a careful control of head and neck posture.

Articulation can be studied by either “lateral” or “frontal” radiography, but usually lateral is applied.

If radiography is to be applied as a research technique, investigators must be thoroughly familiar with its limitations. Besides, the judicious application of radiography to phonetic research requires cooperative effort of phoneticians, physiologists, individuals capable of obtaining, reading and measuring radiogram. Without this cooperative approach, more useful information may be overlooked.

Pneumatic kymograph was an apparatus which was used for the investigations of speech physical characteristics in the first laboratories of experimental phonetics.

By means of the pneumatic kymograph air oscillations caused by the sounding speech were transformed into mechanical vibrations of the stylus which left the traces of the recorded speech on the rotating drum of the kymograph, i.e. a kymogram was received. After that the kymogram was fixed, as the drum had been covered with smoke, and analysed. The method of pneumatic speech recording had a lot of shortcomings, but still the pneumatic kymograph was the first device with the help of which acoustic characteristics of speech could be analysed and therefore it was of great importance for the further development of experimental phonetics.

Soon the pneumatic kymograph was replaced by an ***electronic kymograph*** registering speech wave and singling out the main acoustic parameter of speech – fundamental tone (melody). The time marker below the kymogram made it possible to calculate the duration of the speech signal.

Oscillographs as well as other electro-acoustic devices guarantee accurate recording. By means of electro-acoustic apparatus air oscillations are transformed into electric oscillations and recorded in the form of a sound wave.

Intonograph is an electronic device which registers speech signal as a sound wave and signals out the main acoustic characteristics of speech.

With the help of the intonograph the following main physical characteristics of speech may be separated and registered on the intonogram:

1. Fundamental frequency (measured in cycles per second) is marked by a curve at the bottom of the intonogram. The higher the curve of the fundamental frequency rises, the higher is the meaning of the fundamental frequency. The control signs of the fundamental frequency are situated at the upper line of the intonogram.

2. Intensity (measured in mm, conventional units or db) is marked by a curve in the upper part of the intonogram. The lower the curve of intensity falls, the bigger is its meaning.

3. Time marker makes it possible to calculate the duration of the utterance or its parts, measured in msec.

4. The intonograph makes it possible to investigate intonation and stress as well as other phonetic phenomena.

5. The analogous electronic apparatus called “ОФСАРС” was designed in 1971 and used from that time in the Laboratory of experimental phonetics at the National Academy of science of Ukraine.

Spectrography offers the speech investigators remarkable opportunities for serious study of physical characteristics of speech, phenomena of acoustic process on the borders of sounds in speech, etc.

Among the first up-to-date electronic speech analysing apparatuses were *Kay sonographs*.

Modified sonograph is a speech workstation for speech analysis. It is a powerful tool for speech-scientists, or other speech professionals. It produces real time speech analysis on a high-resolution display monitor.

One-screen waveform editing and speech parameter extraction help to analyse speech and select segments for further work. Both narrow and wideband spectrographic analysis can be performed in real time. These analyses can be edited, stored and printed. The very good resolution monitor is capable of displaying 640x480 mm graphics. The design includes the system electronics with built-in speech processing software of high resolution, video-monitor and printer.

Electronic devices are widely used in acoustic investigations of speech and guarantee quick and precise analysis and registration of the experimental data [5, 6].

The computer has simplified its research in experimental phonetics, as it can simultaneously acquire, store in memory, analyse and display speech signals and it also produces the required results from the stored data. Computer speech programmes provide all the possibilities for phonetic professionals. They are a powerful tool for

acoustic analysis of all the phonetic phenomena of speech. Computer speech programmes make it possible to receive the results of two main types of analysis – intonographic and spectrographic.

Computer analysis makes it possible for the researcher to receive the main acoustic characteristics of sounding speech, its spectral and formant structure. With the help of computer programmes all the acoustic characteristics of speech signal may be calculated, registered and singled out.

The computer automatic acoustic analysis of the experimental material makes it possible to receive exact results of the measurements of acoustic characteristics in a considerably shorter time and consequently to enlarge the experimental data under investigation.

Thus, the results of automatic computer analysis may be calculated directly from the computer display or from the printed intonograms and spectrograms with the help of a metric ruler. Nowadays experimental methods in phonetics are widely applied, new apparatuses and new methods continue to appear.

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