FROM STOMATOSCOPY TO BEA: THE HISTORY OF HUNGARIAN EXPERIMENTAL PHONETICS

Mária Gósy

Research Institute for Linguistics, Hungarian Academy of Sciences, Budapest, Hungary
gosy@nytud.hu

ABSTRACT

Hungarian phoneticians were often among the first to do high quality research of certain types or to adopt the most advanced methods of their time. The first objective method in the investigation of the articulation of speech sounds, called 'stomatoscopy', was used about ten years earlier than Rousselot's famous work was first published. More than a hundred years ago various tools were developed for the measurement of the air flow, voicing, articulation, lip movements, and the amount of energy necessary for articulation. At the beginning of the 20th century, research on the artificial recognition of vowels started. These early methods and their results are discussed here.

Keywords: old devices for studying speech, early achievements, first steps in speech technology

1. INTRODUCTION

New generations should learn from the experiences of earlier ones. We must acknowledge the expertise, thoughts, attempts, successes or failures of people who had lived in the old times. It is advisable to review our predecessors' work from time to time in order to see our own scientific developments in the right perspective. In addition, there are cases when the roots of our present success can be found in the past (although sometimes they are secretly buried somewhere). Present-day research should not ignore the past as it might help in our further investigations. Looking back in the history of Hungarian phonetics one can realize that prominent figures of the field in this country were either the very first of the world to do high quality research or followed quickly the new trends of the time. The pioneers of Hungarian speech science who carried out the first experiments on speech started working in the last third of the 19th century.

2. EARLY RESEARCH AND RESULTS

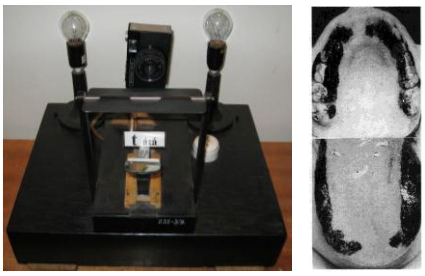
The first remarkable technological development was a mechanical speaking machine created by Wolfgang von Kempelen in the 18th century. He spent a long time doing research on the articulation physiology and acoustics of speech sounds. He was the first to describe the transition phases between speech sounds, claiming that if these minor parts were too long, one perceived them as pauses, if they were too short, the sounds merged. His manually operated mechanical machine spoke like a child, a fact that was confirmed by the replica of the original machine built successfully by two Hungarian phoneticians in 2001 and by German phoneticians in 2007 [9].

2.1. Early experiments in the physiology of speech sounds

The laryngeal mirror was invented originally by a singer and music educator named Garcia Manuel in 1854. This device was further developed by Johann Czermák, professor of laryngology at Budapest University and by Ludwig Türk, a Viennese professor, almost at the same time in the 19th century. Czermák stated (4), for example, that the movement of the uvula did not seem to be independent of vowel quality. It was highest in the articulation of high front vowels and its height gradually decreased from [iː] to [aː].

In the second half of the nineteenth century new techniques were involved in speech research, and experimental phonetics came into being. Rousselot's famous book [7] contains four palatograms representing the articulation of Hungarian sounds. What is interesting here is that two of them show the velar stop in various contexts supporting the Abbot's view on context-dependent articulation. Hungarian phoneticians reacted very quickly to this new trend of the field claiming that Rousselot's work defines a new direction: instead of observations by ear, objective analysis is preferred. Subjective observations of the movements of speech organs where judged unreliable and uncontrolled already in 1900 in contrast to the results obtained by objective analysis [4]. The phonetician József Balassa conducted the first objective investigations concerning the articulation of speech sounds about a decade earlier than Rousselot's book. He used an artificial palate and called this method 'stomatoscopy'. Twenty years later he admitted that the thickness of the artificial palate used was more than 1 mm, a fact that must have influenced articulation. For making articulation "transparent", there was a technique, more advanced than the artificial palate, that yielded the same (or better) results. In this 'natural mode' of examination, the speaker's tongue was painted by some mixture that left its mark on the palate after articulation. These marks can be observed either using a laryngeal mirror or by simple self-observation in a mirror. This mixture contained Indian ink, baked starch, and acacia gum. (About 70 years later the ingredients of a similar mixture were medical carbon and cocoa powder.) 21 years later very thin (1/4–1/2 mm) and light artificial palate was used in order to measure the articulation marks more easily and another four decades later the natural mode was used with the combination of photography [4]. Taking pictures either of the palate or of the tongue, the markings due to the mixture of medical carbon and cocoa powder made it possible to measure the consequences of articulation properly (Fig. 1).

Figure 1: Old palatograph (left side) and palatogram and linguogram prints (right side).



The use of the X-ray technique in Hungarian phonetics goes back to 1904 when Balassa used Techmer's drawings for his own purposes. In 1912, an X-ray picture of the nasal cavity was published. The X-ray technique was first used in the investigation of Hungarian speech sounds in 1928 [4]. Gusztáv Bárczi's pictures contained special lines and numbers that were subsequently drawn on the pictures for better understanding. It is likely that the X-ray pictures gave the idea a few years later to demonstrate the articulation mechanism for deaf children by constructing the 'Phantophon' (Fig. 2). This device is made of wood and metal and is based on experimental-phonetic knowledge. All parts of the device could be moved demonstrating visually the movements of articulation organs.

Figure 2: Phantophon.

The Phantophon can be considered as an ancient version of modern computer-based multimedia programs used in teaching hearing-impaired children's articulation. Bárczi created a "phonetic transcription" to illustrate the main articulation gestures of the Hungarian speech sounds (Fig. 3). These symbols followed Brücke's ideas to visualize articulation gestures in transcription.

Figure 3: Hungarian phonetic transcriptions of the words *cipő* 'shoe' and *fészek* 'nest'.

[ts i p øː] [f eː s ɛ k]

Early results of experimental phonetics on articulation were sometimes obtained by funny devices. There were tools for measurements of the air flow and lip movements during articulation (Fig. 4) that were able to make the results visible. Another tool was created to measure articulation energy (Fig. 5).

Figure 4: Device for measurements of air flow and lip movements.

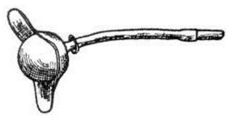
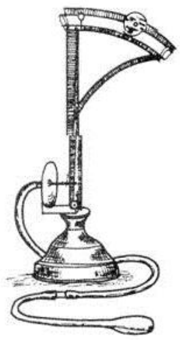


Figure 5: Device for measuring articulation energy.



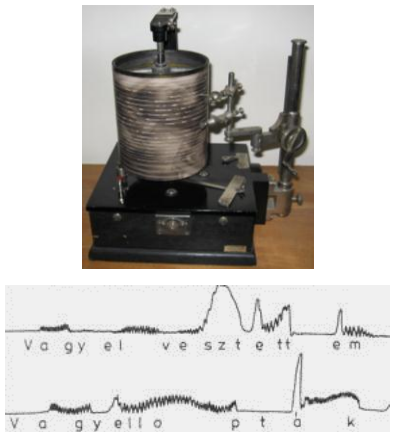
A small bell was used to mark the energy required for articulation. During articulation with an acceptable energy level, the bell was continuously ringing. If the level of energy was insufficient, the bell remained silent. If the energy was too much, the small ball of the bell was forced to the bell wall and the sound of the bell was muffled. This device was planned to use also in speech therapy. Another tool called voicing indicator was able to measure the differences between voiced and voiceless consonants (Fig. 6). The idea was an attempt to measure differences of voice onset time in stop consonants. According to the description of this tool, it seems that it was meant to measure the intensity of vocal cord vibration rather than the movements of vocal cords during articulation. However, the results were convincing data about the differences of voiced Hungarian and German stops.

Figure 6: Device: voicing indicator.

2.2. Early investigations in speech acoustics

The acoustic components of speech sounds were first mentioned in the Hungarian literature in 1904, reviewing claims and results of the international literature: Fundamental frequency, harmonics and their interrelations as well as the interaction of frequency, intensity and the quality of the vowels were discussed. The first experimental approach toward the acoustic aspects of the speech sounds came from physicists. The first definition of the term *formant* was given in 1898 without using the word itself: "… one or two frequency components of the vocal cord vibration become stronger as a result of the air flow of the nasal and oral cavities. The form of the oral cavity is different and definite in the case of each vowel, so the overtone formed in the cavity is characteristic of the vowel itself" [6]. The first acoustic investigation concerning Hungarian vowels was conducted by Gyula Kohn in 1874. The vowels were analyzed by means of what were called König-flames. The sound pressure differences of sung vowels were analyzed using mirrors in 1894, aiming at defining the harmonics of each vowel within three octaves [4]. A couple of years later vowels were analyzed by Béla Gáti using oscillograms. Hungary was the place where the oscillograph started from (at the end of the eighteenth century) due to Wittmann's experiments. Gáti complained in his paper that the number and intensity of the upper harmonics of human speech were so high that it was impossible to define the fundamental frequency using a harmonic analyzer. It is not clear, however, what he understood by 'fundamental frequency' since he analyzed voiceless consonants, too. Perhaps what he meant was the characteristic frequency range of a given segment. He defined the fundamental frequency of the consonants [s, ʃ, ʒ, tʃ, h] as being higher than 1,000 Hz. In another paper he showed the oscillograms of the vowels [i] and [y] using 250 Hz and 600 Hz sinus tones as reference tones. In 1908, the oscillograms of all Hungarian vowels were published (first in a German journal, [3]); later, in the Hungarian version, a Siemens–Halske oscillograph was used for the experiments. The reason for this change was that the Siemens–Halske oscillograph was able to use reference tones up to 6,000 Hz with a very small distortion of speech. The kymograph-type device was used in the 1920's where investigations focused on the intonation patterns of Hungarian [5]. This kind of analysis was the first objective method in the research on Hungarian intonation (Fig. 7).

Figure 7: Kymograph used for intonation research and below a sample made by the device.



Scientific curiosity resulted in interesting data on Hungarian vowels in a singing-master's book from 1906. Tódor Szőnyi made thorough investigations concerning speech sounds because he thought that articulation was very important during singing. He used the expression 'self-tone' (as phoneticians did later), presumably a loan translation of the corresponding German term (cf. *Eigenton*). Szőnyi claimed that these self-tones changed according to vowel quality. He thought that the back vowels had a single self-tone each while the front vowels had two self-tones. His values given in musical tones for all Hungarian vowels clearly corresponded to first and second formants [8]. The vowels were synthesized 80 years later (by means of a formant synthesizer) based on Szőnyi's data and all of them were acceptable qualities for Hungarian ears [4]. The acoustic analysis (harmonics and durations) of all the vowels started again in the 1930's.

The first sound spectrograph of the fifties provided an opportunity for investigating Hungarian speech sounds and short utterances (Fig. 8.).

Figure 8: The first sound spectrograph used in Hungarian experimental phonetics.

A second revolutionary step in experimental phonetic research was to obtain the PDP 11/34 computer in the seventies: it was an advanced machine of the time internationally, too.

2.3. Early steps toward speech technology

The ideas of today's speech technology can be found in the Hungarian literature of many decades ago. In 1909, Gáti wrote about the frequency band of the telephone channel which he supposed to be best between 1,000 Hz and 10,000 Hz. Lip movement examinations were first carried out, by means of Demény's device called phonoscope, by the inventor himself. This device had no close relation with phonetic science but it was demonstrated as a new technique in Paris at the International Photo Exhibition in 1892. Demény projected a speaking person's face and lip movements. He pointed out that his device could be connected to a phonograph and so the pictures could be made to talk. Gáti in 1910 tried to create a system that was meant to recognize speech sounds. The result of his experiments was that his system unmistakably recognized the vowel [aː] in his pronunciation: his typewriter typed the letter *á* for the vowel [aː] and did not react at all for any other vowel. Three decades later automatic speech recognition was tried again by Tamás Tarnóczy whose device was successful in recognizing all Hungarian vowels in isolation [4].

Scholars of the turn of the 19th and 20th centuries connected objective investigations with practical applications. The "funny" devices were thought to be useful in speech therapy (correction of speech errors) and foreign language teaching (to diminish accent in the articulation of a second language). However, the applicability of the phonetic results was sometimes overestimated.

3. CONCLUSIONS

The history of Hungarian phonetics shows the international trends and particularly the three milestones in the development of speech science: the demand for objective speech analysis more than 100 years ago, the use of computers from the seventies and presently developing a large spontaneous speech data base called BEA (which contains at the moment 180 hours' material with 260 speakers). All of them recorded in the same sound attenuated chamber, using the same recording facilities, and following the same protocol. Several studies have already been conducted based on this BEA data base [1]. The roots of the revolutionary changes of techniques, knowledge and achievements in speech science can be found in the past century or even earlier.

4. ACKNOWLEDGEMENTS

This research was supported by OTKA project; No. 78315.

5. REFERENCES

[1] *Acta Linguistica Hungarica* 2010. 57, 2-3.
[2] Balassa, J. 1887. A magyar hangok képzése. Stomatoskopikus vizsgálódások alapján. *Nyelvtudományi Közlemények* 21, 130-142.
[3] Gáti, B. 1908. Ueber Selbslaut-Mikrophon-Oscillogramme. *Sonderabdruck aus der Zeitschrift für Schwachstromtechnik*. Heft 4, 2.
[4] Gósy, M., Olaszy, G. 1985. A magyar kísérleti fonetika első évtizedei. *Nyelvtudományi Közlemények* 87, 109-121.
[5] Hegedűs, L. 1930. Magyar hanglejtésminták grafikus ábrázolása. Kísérletfonetikai tanulmány. *Collegium Hungaricum Füzetek* V.
[6] Klug, N. 1898. Az ember hangja és a beszéd. *Budapesti Szemle* 96, 215-232.
[7] Rousselot, P.J. 1897-1908. *Principes de Phonétique Expérimentale*. Paris.
[8] Szőnyi, T. 1906. *Az Emberi Hang és Annak Kiképzése*. Budapest.
[9] Trouvain, J., Brackhane F. 2011. Wolfgang von Kempelen's speaking machine as an instrument for demonstration and research. *Proc. 17th ICPhS* Hong Kong. (To appear)