How Did it Work? Historic Phonetic Devices Explained by Coeval Photographs

Rüdiger Hoffmann, Dieter Mehnert, Rolf Dietzel

Chair for System Theory and Speech Technology, TU Dresden, Dresden, Germany
ruediger.hoffmann@tu-dresden.de

Abstract

The early history in experimental phonetics and speech technology is featured by numerous sophisticated devices which we can study today in a number of historic collections which are located mainly at universities. In many cases, however, it is not easy to understand how these devices have been applied in an optimal way. Illustrations and historic photographs are especially helpful. The historic collection of the TU Dresden, which also includes the former devices of the Hamburg phonetician Giulio Panconcelli-Calzia, benefits from the fact that he prepared a lot of photographs which are still available in the collection. They show selected phonetic experimental equipment in function. This paper informs about the photographic part of the Dresden collection and presents some examples.

Index Terms: history of phonetics, historic photographs, early experimental phonetics

1. The HAPS collection

Research and teaching in speech technology in Dresden started in the early 1950th when the development of a vocoder enabled detailed research in speech analysis and synthesis, resp. Walter Tscheschner (1927–2004) was appointed as a professor of speech communication as early as 1970. Due to this long lasting tradition, the TU Dresden is able to illustrate the development of speech technology by historic exhibits, forming the root of our historic collection. The most interesting devices are speech synthesizers of various technologies.

Speech technology needs close cooperation with experimental phonetics. In the case of TU Dresden, the Humboldt University at Berlin served as the main partner institution in phonetics [1]. Due to these close contacts, it was possible to expand the collection by objects illustrating the development of experimental phonetics from 1900 until the introduction of the computer. The items of this part were collected from different phonetic laboratories and rehabilitation units throughout Germany. The collections in experimental phonetics and in speech technology were physically united in 1999. Therefore we consider this as the year of founding the “historic acoustic-phonetic collection” (HAPS) of the TU Dresden.

In 2005, the HAPS collection was considerably expanded because the famous Institute of Phonetics of the Humburg University was closed after 97 years of existence. This institute owned an important collection of phonetic devices which were collected, partially developed, and applied by Giulio Panconcelli-Calzia (1878-1966). It was transferred completely to the TU Dresden in accordance with a contract between the two departments. After this fusion, HAPS is now a collection with a high degree of completeness. We reported about this at different opportunities (e. g., [2]). A first part of a printed catalogue was published recently [3].

2. Giulio Panconcelli-Calzia

Giulio Panconcelli-Calzia [4] was born in Rome in 1878 as a son of a forest officer who sent him at first to the forest academy. His remarkable talent for foreign languages, however, directed him to philological studies at Rome, Kassel, and Marburg. There he was influenced by the phoneticians E. Koschwitz and W. Vätor. After some further movement, he finally turned to Paris where the father of experimental phonetics, Pierre Jean Rousselot, was teaching. There Panconcelli–Calzia finished his PhD thesis under his supervision, was graduated from the Sorbonne in 1904, and started academic work as an assistant. Serious financial problems, however, forced him to leave Paris and spend some difficult years looking for an academic position.

In 1908, the Colonial Institute in Hamburg was opened, which is one of the roots of the today's Hamburg University. It included a Seminar for Colonial Languages which was equipped with a phonetic laboratory in 1910 [5]. Panconcelli–Calzia received the chance to direct this laboratory at first as an assistant for experimental phonetics, which he did very successfully. He organized the first international congress on experimental phonetics in Hamburg in 1914. After the phonetic laboratory was converted to an independent unit of the Hamburg University, he was appointed as extraordinary professor for phonetics. He was extremely productive in experimental phonetics and speech therapy. Together with Hermann Gutzmann (1865–1922), he converted a traditional journal into the “Internationales Zentralblatt für Experimentelle Phonetic – VOX”, which formed the leading platform for experimental phonetics from 1913 to 1936. He retired in 1947 and handed over the direction of the laboratory to his successor Otto von Essen in 1949.

It must be mentioned that Panconcelli-Ca Calculia was deeply interested in the historic development of phonetics. He wrote numerous historic papers and books (we only mention [6], [7], reprinted as [8]) which were subdivided by Köster [9] into three thematic groups:

- Development of phonetics over 3000 years,
- important persons who contributed to phonetics,
- development of phonetic research methods and devices.

After his death in 1966, the written heritage of Panconcelli-Calzia including his scientific library remained testamentarily at the university, where the Phonetic Laboratory had been transformed to an Phonetic Institute in 1962. This collection of books, reprints and personal files, which forms 44 linear meters, was kept in Hamburg until 2012. It proved, however, that the investigation of the historic phonetic devices requires continuous access to the written documents, which were finally transferred to the HAPS of the TU Dresden. In this way, the material and the written heritage of one of the most important phoneticians of the 20th century is now reunited and available to the scientific community as an entirety.
3. The photographic fundus

The photographs from the former Phonetic Institute aimed mainly for teaching. Therefore it is not surprising that the core of the photographic stocks is formed by more than 1,000 glass transparencies in the format of $8.5 \times 10$ cm$^2$ which was very widespread for teaching material in that times. The format is one of the standardized sizes of DIN 108.

The collection of transparencies includes all kind of teaching material for lectures in phonetics and phoniatrics like copies from books and journals, anatomic and medical stuff, pictures showing experimental setup, and many results of experiments like diagrams and waveforms. Part of this material was also used for the practical training in experimental phonetics. There was a ‘big’ and a ‘small’ course at the Phonetic Laboratory [10].

The glass negatives (photographic plates) of this material are also preserved in our collection. They show the same dimensions like the diapositives because enlargements have been rarely performed in the photography of that times. Additionally, there is a collection of glass negatives of bigger sizes ($9 \times 12$ and $13 \times 18$ cm$^2$, resp.). Some of them show scenes from the phonetic laboratory, which is very interesting for the following reason.

If a collection like the HAPS is widely published by means of a catalogue like [3], the result should not only be an inventory, but also include a reasonable description how the devices were used. This is sometimes not easily to achieve. Therefore, we made a number of device-specific investigations during the last decade, which we have summarized in [11] and in [12]. In many cases, it was very helpful to have a visual impression of the real interplay between the experimenter and the devices. We will demonstrate this material in the following by three examples.

4. Examples

4.1. Explaining kymographic measurements

Experimental phonetics requires recording many different waveforms. In the case of sound signals, recording by means of the Edison phonograph using wax cylinders was possible. However, the recordings on the wax cylinders were hard to measure (Boeke invented a special microscope for this purpose [13]), and the method was not suited for other (physiologically) waveforms like the breathing movement of the chest. Therefore writing curves on paper which was blackened by soot formed the preferred method.

The “kymographion” formed the basic device for this purpose for a long time [14]. It follows the principle to record a waveform on a registration area which is moved by a driving force. Its idea was applied for first time in 1734 for registering the parameters of the wind (Anemograph by Ons-en-Bray). The later standard configuration was introduced by Ludwig 1847 and developed during the following decades. It consists of the main components

- a revolving drum,
- a clock mechanism for rotating the drum,
- blackened paper as registration medium.

This standard device was produced industrially and worldwide used.

If a kymograph is applied, the physiologic movement is normally supplied by a hosepipe where the inner air pressure is changing accordingly. These variations must be converted in the movement of a pin which, in turn, scratches the waveform in the sooted surface of the moving paper. The required transducers date back to Etienne Jules Marey (1830–1904) who developed his “Méthode graphique” in the 19th century [15]. Jean Rousselot (1846–1924) introduced Marey’s “tambours” into the field of experimental phonetics [16].

Due to the variability of the signals to be measured, which refers to the magnitude and the applicable frequency range as well, the selection of the suited transducer capsule was the very crucial point in applying kymographic methods. We have shown this in an investigation of the transfer behavior of Marey’s capsules [17].

Large movements with low frequency like the breathing movement are easily to record. On the other hand, recordings of speech or music required much higher frequency and were difficult to achieve in good quality. Therefore, Marey’s capsules were improved by different phoneticians. A “writer” from Krüger-Wirth was used since 1905 among other constructions. In 1916, Panconcelli-Calzia and Schneider published the description of a “throat sound recorder”, which was able to register vibrations up to 900 Hz which was sufficient for pitch measurements [18]. This was a very delicate construction with a
blade of straw combined with a pig bristle as writing pen. Later, the writer was further improved to work in a frequency range of 200 Hz – 2000 Hz [19].

There are numerous photographs in the collection which demonstrate the different applications of the kymograph in phonetics. We show a selection in Fig. 1 to 4 where the following signals are recorded:

- **Breathing movements**: “Belt pneumograph” from Gutzmann, applied either in a or in a double (Fig. 1) single version (Fig. 2).
- **Phonation stream**: A mouth funnel (with a lateral valve after Gutzmann) is closely put on the mouth while speaking (Fig. 2 and 3).
- **Nasality**: A second phonation signal is measured using a nose olive put in one nostril, leaving the other nostril free (Fig. 3).
- **Throat sound**: Speech signal, recorded with an adapter put from outside onto the larynx (Fig. 4).
- **Lip tension**: Different types of so-called labiographs [3, pp. 132 ff.] enabled to record the movement of the lips directly at the kymograph, i. e. without using a capsule (Fig. 4).

4.2. Experiments with humans

The collection includes also some pictures showing situations with direct observations at humans. They are mainly directed to laryngoscopic tasks. To give an example, Figure 5 which also was included in the textbook [10], demonstrates the procedure of the laryngo-stroboscopy from Hegener. There is an optical bank bearing an electrical light source, a series of lenses, and a small mirror directing the light into the mouth of the patient. The stroboscopic lightening is achieved by a revolving stroboscope plate, the slots of it are moving in the focal point of the first lens.

Other interesting pictures illustrate the use of the “Autophonoskop” which was invented by Panconcelli-Calzia [20]. It allowed the observation of the vocal cords with closed mouth by the patient himself simultaneously with a second person.

Many other procedures are documented further. Among them, we select the photograph of an X-ray investigation in Figure 6. It gives us not only a good impression from a real situation in the historic laboratory, but shows also the unworried handling of the X-ray techniques in that times. We have another picture which shows how X-ray photographs of the articulation tract have been produced, and also some results of these experiments as photographic plates.
4.3. Stereographic and stroboscopic photographs

The photographic stereoscopy was well developed at the beginning of the 20th century. Pairs of stereoscopic photographs were produced by special cameras and could be observed by dedicated viewers. Figures 7 and 8 show two versions of viewers for stereoscopic photographs (stereoscopes) from the collection. Such devices enabled the user to look simultaneously at two separately presented binocular pictures, getting a three-dimensional impression of the contents. The widths of the basis of the pair of pictures must equal the distance of the eyes of the user, which is assumed to be 65 mm in the device shown in Figure 7, while it can be adjusted in the case of the more comfortable device in Figure 8.

Apart from the extreme versatile application in many scientific domains, this method has been used in phonetic research successfully. J. Hegener from Hamburg described as early as 1920, that he photographed the vocal cords from a distance of approx. 400 mm using a large-sized stereoscopic reflex camera (focal length 135 mm) [21]. Evaluating these photographs, he was able to measure the rising movement of the vocal cords and the geometry of the larynx for the first time.

For this purpose, stereoscopes could be equipped with a so-called stereo micrometer. It consists of two pointers which can be arranged in proper way to obtain a so-called spatial mark in the stereo image. Thus, the three spatial coordinates of some point of the photographed object can be determined [22].

The movement of the vocal cords appears at the laryngoscopy with stroboscopic illumination apparently slow or even unmoved. G. Panconcelli-Calzia recorded such observations of the vocal cord vibrations by means of a 16 mm cine-film camera. He obtained films with a big number of pictures of single vibration periods. All single pictures (up to 300) of such a film were enlarged on photo paper. These single pictures were stapled, forming a small, handy booklet. If it is scrolled (or flicked through) manually, the observer perceives the sequence of pictures as a continuous movement – like at a “flipbook”. The HAPS collection includes two such so-called DILEPHOT blocks.

Many stereographic pictures of the vocal cords are part of the collection. Remember that Panconcelli-Calzia acted also as a speech therapist. Therefore these photographs are preferably taken from numerous patients. Figure 9 shows an example which was selected randomly to demonstrate the (limited) quality which was achieved by this method.

5. Conclusions

We have shown that the HAPS collection preserves not only historic devices, but also a big collection of photographic items. They are suited to illustrate the history of phonetics and especially the right application of the historic devices. We have shown this by three examples. It is a task for the future to improve the access to this important part of the collection by extending the cataloguing work to the photographic collection.
6. References


