

# EARLY ACTIVITIES IN THE FIELD OF X-RAY IMAGING IN EXPERIMENTAL PHONETICS AND SPEECH TRAINING

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## ABSTRACT

This year is the 100th anniversary of the death of WILHELM C. RÖNTGEN. With his discovery of the X-rays in 1895, phonetics received a powerful tool for observing the articulation process. The history of the resulting development was described by several authors. Nevertheless, there are some aspects of the early years of this technology and their application in the deaf-mute education, which were never discussed before. This paper has the aim to present such details using the archival material from the former Hamburg Phonetics Laboratory, which is now in the historic acoustic-phonetic collection (HAPS) of TU Dresden, and hitherto unpublished material from several German archives and libraries.

**Keywords:** X-rays in phonetics; sagittal sections; sound charts; Hamburg Phonetics Laboratory.

## 1. INTRODUCTION

The description of the positions of the articulators for the speech sounds forms an essential task in phonetics. A sagittal cross section of the head proves to be a very useful representation which was firstly applied by LEONARDO DA VINCI (1452–1519) (Fig. 1 a). Later, FRANCISCUS MERCURIUS VAN HELMONT (1614–1699) used this type of imaging when he tried to prove his idea, that the position of the articulators for the different sounds is coded in the shape of the Hebrew letters (Fig. 1 b). WOLFGANG VON KEMPELEN (1734–1804) used it to justify the construction of his talking machine (Fig. 1 c).

With growing importance of the “deaf-mute education”, supporting material for lip-reading and speech training was required. It included views on the lower part of the face, which were at first carried out as drawings [5] [4], later as photographs (ca. 1885, cf. [22, p. 82]). FRANZ HERRMANN CZECH, professor at the deaf-mute institute in Vienna, added sagittal sections as one of the first (Fig. 1 d), and the physiologist ERNST BRÜCKE (1819–1892) used them in his famous book [3] (Fig. 1 e).

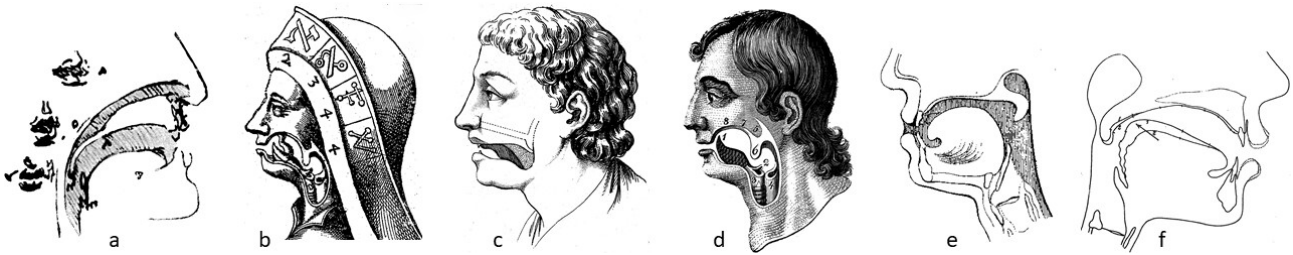
The development of experimental phonetics at the

end of the 19th century enabled improved representations. OTTO BREMER (1862–1936), the founder of the speech science education at Halle-Wittenberg University, published a set of 15 precise sagittal sections, accompanied by palatograms, which must be counted as a milestone (Fig. 1 f).

Later, such illustrations were manufactured in large size for usage in the classroom, called sound charts. A set of 16 sound charts was designed for the Munich deaf-mute institute. They combined a photograph of a speaker with a sagittal section and a palatogram, performed by the well-known painter and scientific illustrator GUSTAV KELLER (1860–1911) following the design (mentioned in 1906 [10, p. 17]) of the deaf-mute teacher MAX KOLLER. They were published in small size as appendix of a book of another teacher of this institute, FRANZ XAVER RÖTZER, in 1908 [24].

The acquisition of the sagittal sections by means of mechanical tools (including palatography) was complicated to perform. Additionally, the measurements influenced the speakers physically and mentally. Therefore it was an important event when the detection of the so-called X-rays was published by WILHELM CONRAD RÖNTGEN (1845–1923) at the end of 1895. This promised to map the articulators in action in a contactless and easy way.

MICHAEL ASHBY found out that “the earliest surviving X-ray image of any part of the vocal tract was made by the Glasgow laryngologist JOHN MACINTYRE as early as April 1896” [1, p. 103]. The corresponding development in Germany, which will be partially pursued in this paper, started five months later with a paper of the Berlin laryngologist MAX SCHEIER (1864–1921) at the *68th Meeting of German Natural Scientists and Physicians* [25]. His work will be considered in Section 2. In the following, it will be shown how the X-ray technology influenced the development of sound charts for educational purposes (Section 3) and the research activities at the Hamburg Phonetics Laboratory, that was an important place for the development of experimental phonetics (Section 4). Section 5 describes the relics of this historic development, which are preserved in the HAPS of the TU Dresden.



**Figure 1:** Historic sagittal sections in phonetics and deaf-mute education before X-ray technology was invented. (a) LEONARDO ca. 1500 [21, p. 148]; (b) HELMONT 1667 [6]; (c) VON KEMPELEN 1791 [9]; (d) CZECH 1836 [4]; (e) BRÜCKE 1856 [3]; (f) BREMER 1893 [2].

## 2. LIFE AND WORK OF MAX SCHEIER

Although the work of MAX SCHEIER is widely cited, little is known about his biography. The following data are based mainly on the habilitation file [38] and the Berlin address books [31]. He was born in Jastrow (West Prussia) on December 4, 1864, and studied medicine at the universities of Greifswald, Berlin, Würzburg, and again Berlin, where he received his doctorate in 1889. He specialized in rhinolaryngology in Berlin and Frankfurt.

Since 1890, he had a medical practice in Berlin which was specialized for diseases of neck and nose in 1893. Additionally, he founded an outpatient department for diseases of neck and nose at the Berlin Johanneum in 1898.

SCHEIER was active in the Berlin Laryngological Society and published a lot. His own list of publications from the beginning until 1902 includes 37 entries. One of his main topics was the ossification of the larynx. He gave courses in rhinolaryngology for practitioners since 1899. He was elected as a member of the French society of otorhinolaryngology. Due to this successful carrier, he applied for his habilitation at Berlin University in 1902. However, the assessments of the reviewers were negative. It seems that this setback caused SCHEIER to change his focus. Apart from a number of summarizing papers in 1908/09, few publications can be found since then. His medical specialization was extended by otology in 1902. His office moved from Friedrichstraße to the noble area of Tauentzienstraße (1910) and Kurfürstendamm (1915). The (hitherto unpublished) date of his death is July 3, 1921 [34]; he was buried at the Jewish cemetery in Berlin-Weißensee.

Regarding the contents of his papers since 1896, a considerable part deals with the application of X-rays to rhinolaryngology, but only few are immediately directed to the requirements of speaking and singing. They include 7 papers in the years 1897/98 and 3 papers in 1909 and are discussed in more detail in several reviews (e.g. [11], [29]).

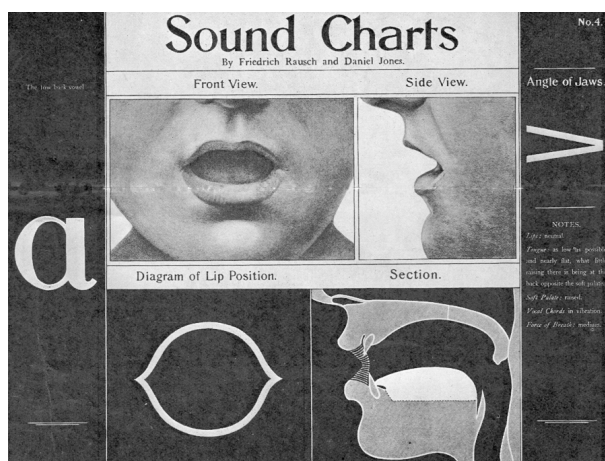
SCHEIER published his observation that X-rays can be useful to show the positions of the articulators as a rather short paper at the *15th Congress of Internal Medicine* in June 1897 [26]. A more elaborated version was published in a phonetic journal [27]. The results based on the observation of the fluorescent X-ray screen and were explained verbally. X-ray photographs still needed an exposure time of several minutes which was unsuited for phonetic experiments. When SCHEIER delivered an updated version ten years later [28], he also added photographs because the exposure time was then reduced to several seconds due to the technical progress.

## 3. F. RAUSCH AND HIS SOUND CHARTS

The improved knowledge about the articulation of sounds raised the quality of the teaching material for deaf-mute institutes and similar applications. The sound charts of the deaf-mute teacher FRIEDRICH RAUSCH (1871–1956), the first edition of which appeared in 1903, must be mentioned because a reference is made in the accompanying booklet, that the sagittal sections are based “on the X-ray photographic observations of Dr. SCHEIER on the articulators” [23].

The biography of RAUSCH was investigated for this paper, but due to the limited space, it will be published in more detail at another place. The question arises in the present context, where he acquired his special phonetic knowledge. It is known from a short curriculum [36], that he studied at Halle-Wittenberg University “in his leisure time”, while he worked as a teacher at the deaf-mute institute in Halle 1894–1896 [37]. Indeed, he was inscribed as a guest student for the study of philosophy at April 20, 1894 [39]. There is no further information, but a connection to the aforementioned OTTO BREMER, who acted as an outside lecturer at the German Seminar in Halle since 1888 [7], could be assumed.

Howsoever the scientific network of RAUSCH



**Figure 2:** Example for the sound charts (No. 4 of the English version); original size 18 × 23 inches. Reproduced from a flyer of the publisher Dent & Sons in the Dresden HAPS collection.

might have been, when he came as a teacher to Nordhausen (Thuringia, Germany) in 1900, he started activities in deaf-mute education and in teaching aids manufacturing. The first edition of his 20 big-sized sound charts was elaborated in cooperation with the renowned photographer CARL SCHIEWEK (1871–1934) and appeared in Nordhausen with a print run of 2.000 copies in 1903 [23]. It seems that there is only one complete copy left in public institutions, namely in the library of Halle-Wittenberg University. An English version of nine charts was prepared in cooperation with the British phonetician DANIEL JONES (1881–1967), who was with the University College London since 1907, and appeared in London as a volume of “Dent’s Modern Language Series” in 1911 (Fig. 2). A specimen copy is listed in the catalogue of British Library.

In 1911, the publisher was changed to N. G. Elwert in Marburg [35]. The charts were redesigned in portrait size and extended by six charts for French and English sounds. Elwert published 18,000 of the big-sized charts in two editions (1911 and 1926), which were still available after WW II. A complete set of the 2nd edition is preserved in the HAPS. Additionally, a “handy” version in postcard size was available in several editions.

## 4. EARLY X-RAY STUDIES IN HAMBURG

### 4.1. The Hamburg Phonetics Laboratory

After some advances in X-ray technology, some phoneticians felt encouraged to apply it for own investigations, thus starting a process which intensified over the years. As a prominent example, ERNST A. MEYER (1873–1953) should be mentioned who



**Figure 3:** G. PANCONCELLI-CALZIA with his co-workers doing X-ray inspections of the articulation organs. Photograph no. 1501 from the Hamburg negative archive, now in the HAPS.

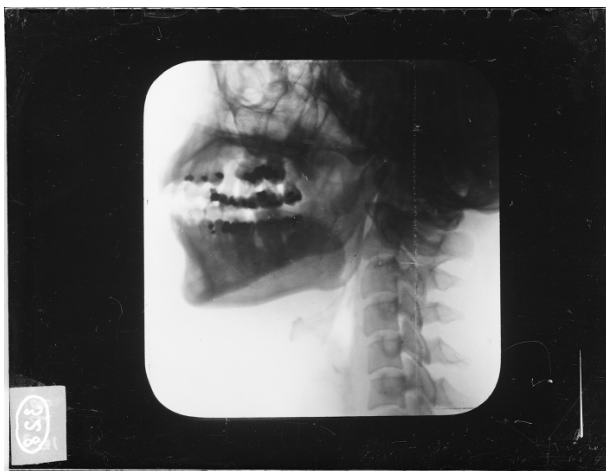
tried rather early to verify the alleged efficiency of the new method [13] [14]. All researchers in this phase had in common that they made their investigations in X-ray laboratories of medical facilities. There is only one exception: the Hamburg Phonetics Laboratory.

After the Hamburg Colonial Institute was founded in 1908, the Africanist CARL MEINHOF (1857–1944) demanded a Phonetics Laboratory, which was installed in 1910 and directed by GUIDO PANCONCELLI-CALZIA (1878–1966), a postgraduate from Abbé PIERRE-JEAN ROUSSELOT (1846–1924). He developed this laboratory to an excellent place for research and teaching in experimental phonetics, from 1919 as a part of Hamburg University. Already in the third year of existence, the following departments were established [15]: the phonographic center, the cinematographic department, and the X-ray department with own equipment (Fig. 3).

### 4.2. X-ray investigations and publications

Except from the study of different “colonial languages” [15], an early application case for the brand-new X-ray equipment in Hamburg came from outside. The Hamburg “pedagogue for hygienic speaking and singing” [32] CLARA HOFFMANN cooperated with the Lübeck “special doctor for diseases of the lung, the neck, and the nose” [33] ALFONS OTT with the aim to control the progress in the education process in speaking and singing by X-ray images since ca. 1910. Both came in contact with PANCONCELLI-CALZIA who contributed his phonetic expertise and the laboratory. They jointly published a paper at the *First International Congress of Music Pedagogy* in 1913 [8], which was hitherto ne-





**Figure 4:** X-ray photograph of the articulators of CLARA HOFFMANN, singing the sound /a/ with pitch  $a^1$ . Photograph no. 328 from the Hamburg negative archive, now in the HAPS.

glected by historic reviews [11] [29]. They investigated the singing and the speaking voice of as much as 186 people.

For the *First International Congress of Experimental Phonetics*, held in Hamburg in April 1914, X-ray methods played no prominent role. An overview lecture of MAX SCHEIER was announced, but not presented. In the following WW I, the focus of PANCONCELLI-CALZIA shifted to phoniatic tasks in a military hospital where he also published a note about X-ray techniques [17]. Nevertheless, he still published a detailed paper on the X-ray analysis of the production of certain sounds in African languages [18], and another on X-ray polygrams [19].

#### 4.3. The “secret book” of Panconcelli-Calzia

Anyone who studies the work of PANCONCELLI-CALZIA will sometime discover the citation given here as [16], which prompts him to a monograph on the application of X-rays in phonetics as volume 33 of a series. If he orders this 33rd volume in his library, he receives a monograph on the X-ray investigation of the hand, foot, and elbow. How to explain this?

Indeed, PANCONCELLI-CALZIA wrote the book in 1914. It consists of chapters on phonetic examination techniques (including a description of the Hamburg X-ray laboratory), on the elements of articulation, and on the application in education (by CLARA HOFFMANN). The appendix includes 29 X-ray photographs which were previously unpublished.

*Habent sua fata libelli.* As in the case of the proceedings of the congress of 1914, WW I prevented the publication of this important book. The publisher used the number of the volume for another ti-

tle in 1918. Luckily for posterity, a proof with many notes by the author has survived. It is preserved in the State and University Library in Hamburg. The author valued his own work so highly that he included it (although unpublished) 1941 in his survey on the history of phonetics as “the first work of this kind” [20, p. 70].

#### 5. MEMORABILIA IN THE HAPS

When the Hamburg Phonetics Institute was closed in the Winter Term 2006/07, the collection of historic devices was transferred to the historic acoustic-phonetic collection (HAPS) of the TU Dresden along with many documents and audiovisual material, including a collection of approx. 2.000 photographic glass negatives which were digitized in 2018. Among them are ca. 80 early X-ray photographs, of which Fig. 4 shows an example.

Although PANCONCELLI-CALZIA was very interested in the production of educational films, there is only one cinematographic X-ray film left in the HAPS. Is is undated and shows the articulation of several sound sequences. It was digitized to accompany the presentation of this paper.

In the time following WW II, X-ray investigation experienced a revival in Hamburg in the time of PANCONCELLI-CALZIA’s successor OTTO VON ESSEN (1898–1983). The phonetician HANS-HEINRICH WÄNGLER (1921–2001) worked there 1954–1964 and published the first edition of his *Atlas of German speech sounds* in 1958, including 29 sound charts with X-ray photographs [30]. Besides other similar material, the HAPS preserves a set of original X-ray photographs from this project, which were produced by the X-ray department of the University ENT clinics in Hamburg.

Even the tradition of the big-sized sound charts was continued in Hamburg in conjunction with the phonetic teaching material of CARL MARTENS (employee of the Phonetics Laboratory since 1913) and his son PETER MARTENS (1919–2012; professor for German phonetics at Hamburg University 1977–1985) [12]. They developed a convolute of 31 scrolled tables (sized 83 cm × 58 cm) which was edited by the publisher Hanex in Hamburg. Apart from this complete set, the HAPS owns 62 tables from cardboard, too, which use the same pictorial material but are manufactured individually.

It can be assumed that the tables by MARTENS were the last classical sound charts which were regularly published. With the development of electronic media, new types of phonetic teaching material were introduced.

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