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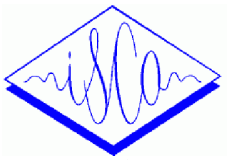

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Hugo Pipping – a pioneer phonetician at the University of Helsinki

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Abstract: Hugo Pipping was the first person to officially function as a phonetics teacher at the University of Helsinki. His most important contribution to Finnish phonetics was the introduction of scientific physiological research methods into the study of speech. Especially, he used the Phonautograph/Sprachzeichner developed by Victor Hensen in Kiel to manually analyse the spectral structure of vowel sounds, mostly the vowels of his native Finland-Swedish language but also those of Finnish. Pipping held the position of "docent" of phonetics in Helsinki until 1903, when he was invited to the university of Gothenburg to the position of docent of Nordic languages and phonetics. After four years in Sweden, he returned to Helsinki in 1907, but this time as a professor of Swedish language and literature (later professor of Nordic philology). Pipping retired in 1929, but remained academically active until his death in 1944.

1. Introduction

Knut **Hugo Pipping** (5 November 1864 – 31 July 1944) was appointed the first teacher ("docent") of phonetics in Helsinki in 1891 [1–3]. At that time, the University was still called the Imperial Alexander University of Finland, and in the 19th century, several new disciplines were created as a result of a generally more scientific orientation of the University [4].

Before reaching this position, Pipping had, in the course of his student years that included even studies of English, psychology and social anthropology in London [2], come into contact with Prof. Hällsten at the Institute of Physiology in Helsinki in 1886. In the late 19th century, ordinary physiological research instrumentation also made it possible to study some topics concerning speech production, and phonetic applications of physiological measurements were a common trend in European phonetics. With a recommendation from prof. Hällsten, Pipping traveled to study physiological phonetic methods in Kiel under Victor Hensen, whose Phonautograph/Sprachzeichner he used in 1888–1889. The result of these experiments was Pipping's doctoral dissertation *Om klangfärgen hos sjungna vokaler* [On the timbre of sung vowels] [5], which he defended in Helsinki on 22 January 1890.

In connection with Pipping's appointment in 1891, a phonetics laboratory was also founded in the Institute of Physiology [3], and during his years as a fulltime phonetics teacher (1891–1903), Pipping also took care of this phonetics lab. Within the University of Helsinki, the "Historical-Philological Section" (predecessor of the modern Faculty of Arts) also started to pay attention to the importance of phonetic studies, and, in 1903, gave special funding for the purchase of phonetic equipment (e.g. a kymograph). But at that time Pipping's career was already moving towards philological topics and positions, and the main responsibility for phonetic instrumentation fell on Pipping's successor as teacher of phonetics, the Frenchman Jean Poirot (1873–1924), who held that position from 1903 to 1920.

In the following, the phonetic studies of Hugo Pipping are described in some detail. To a modern reader, Pipping's articles seem to contain a surprisingly high amount of unprocessed raw data. For example, the publication *Über die Theorie der Vocale* (1894) contains only 30

pages of text, followed by a 30-page table of individual measurement values of the waveforms, plus a 4-page mathematical appendix written by Dr. Ernst Lindelöf.

2. Acoustic studies with Hensen's Sprachzeichner

Victor Hensen's Sprachzeichner or Phonautograph was one of the early methods of transforming soundwaves into visible form [6]. It consisted of a mouthpiece into which the subject spoke, a vibrating membrane at the far end of the tube, and a sharp diamond to register the movements of the membrane on to a glass plate. The curves on the glass plates were then read and measured with a microscope [5, 1]. All Pipping's early publications show the laboriousness of the time-consuming manual spectral analysis; it was already an achievement to manually measure the amplitudes and frequencies of the components of a single vowel sound, period by period [6]. But in spite of the thoroughly physical nature of the experiments he performed, Pipping saw (and especially liked to present) the Sprachzeichner primarily as a "tool for linguistics" [7].

2.1. Doctoral dissertation in 1890 (*Om klangfärgen hos sjungna vokaler*)

As the topic of his doctoral dissertation [5] Pipping chose acoustic measurements of the timbre of sung vowels. In this study, Pipping was more interested in the physical structure of vowels in general, rather than in the vowels of a specific language or dialect. The material consisted of a total of eight different vowels. Seven isolated vowels (as in the example words *lag*, *år*, *är*, *öl*, *yr*, *ed*, *is*) were sung by Pipping himself and by his wife (A. P.), both representing the Finland-Swedish dialect spoken by the educated classes in Helsinki. The only non-Swedish vowel studied was the vowel [u] ("as in German *du*") sung by "Miss C. S-P." and by "Dr. W. M.", both from Kiel. In early vowel studies like this, sung (rather than spoken) vowels were often used in order to obtain a less variable production of a given vowel quality, not because of special interest in singing.
A German translation of the dissertation – with an additional "Nachtrag" – was printed in *Zeitschrift für Biologie* [8, 9]. In both the Swedish and German versions example waveforms are presented of the vowels studied (see Fig. 1). Pipping's [8] description of the way in which the harmonic partials of the vowels are affected by resonances still sounds relatively adequate:

- In Uebereinstimmung mit Helmholtz habe ich gefunden, dass jeder Vocal sich durch ein oder mehrere Verstärkungsgebiete constanter Tonhöhe auszeichnet. Die Intensität seines Theiltones ist, caeteris paribus, grösser, je genauer er mit dem Maximalpunkte eines solchen Verstärkungsgebietes zusammentrifft.

Pipping [5] summarized his general observations in four statements:

1) sung vowels are composed exclusively of harmonic partial tones;
2) the intensity of a harmonic does not correlate significantly with its number in the order;
3) vowels differ from each other with regard to the number and width of the resonance areas and to their position on the frequency scale;
4) in many cases, different individuals speaking the same dialect produce nearly identical renderings of the same vowel.

On the basis of the data reported by Pipping [5, 8], it is not possible to represent the complete acoustic vowel system in a F1/F2 diagram. The following tendencies, however, were observed [10]:

[u]: the two "amplification areas" (förstärkningsområden) are at about 265 Hz and 800 Hz.
[i]: the characteristic frequencies are about 320 Hz and 2200 Hz.
[y]: the characteristic frequencies are about 340 Hz and 2150 Hz.
[ø]: the characteristic frequencies are about 400 Hz and 1060 Hz.

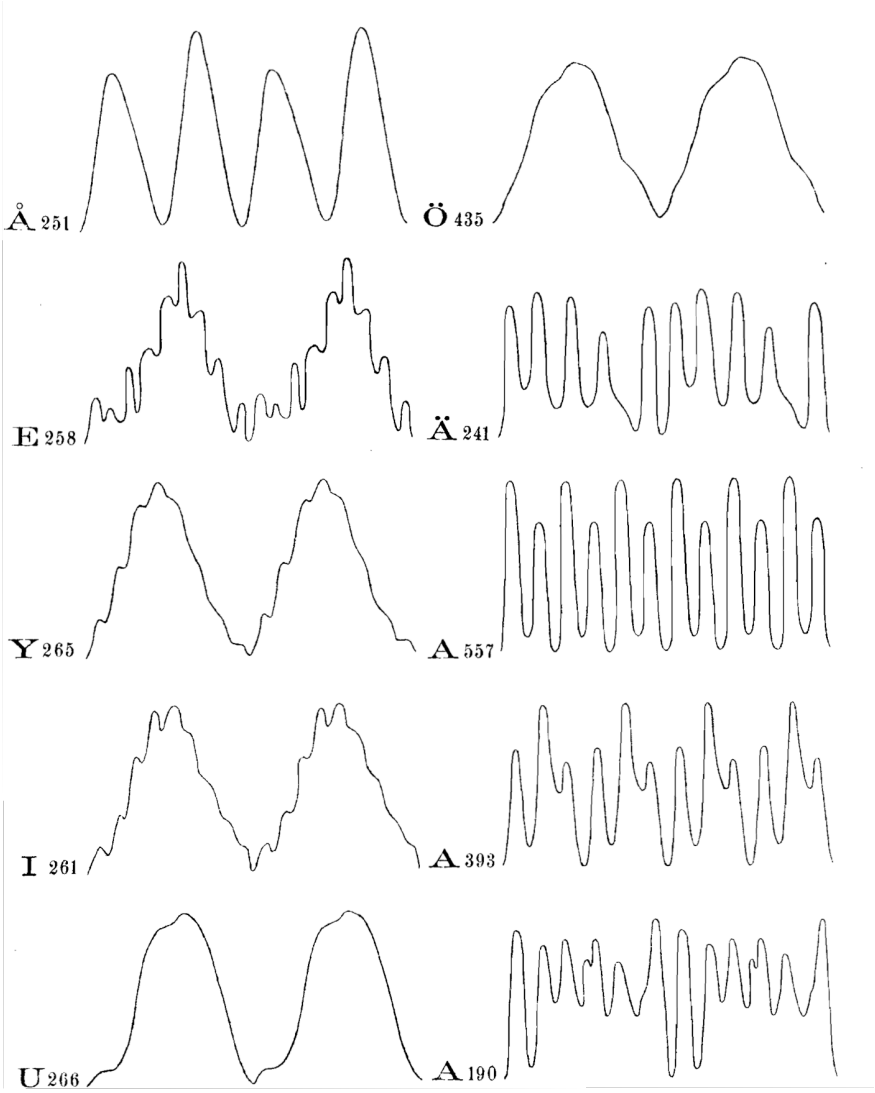

Figure 1: Pipping's [5] "original curves" of eight different vowels, the three A-curves on the right showing that "the resonance tone of a vowel remains the same even if the fundamental frequency varies". (The letter symbols have the following IPA values: Å [o], E [e], Y [y], I [i], U [u], Ö [ø], Ä [æ], A [ɑ].)

[e]: the characteristic frequencies are about 350 Hz and 2350 Hz.

[ɑ]: the characteristic frequency is about 1140 Hz, and a secondary amplification, of minor importance, is at about 2300 Hz. (In today's terms, the lower frequency would perhaps be F2, and the higher F3; i.e. Pipping did not find a "proper F1".)

[æ]: the characteristic frequency is about 1400 Hz, a secondary peak about 2400 Hz. (Thus, also with this vowel, Pipping failed to find the correct F1.)

[o]: the characteristic frequency is about 520 Hz. (No other resonance maximum could be found by Pipping.)

Later in the same year, Pipping published another article [7], where he was concerned with the applicability and usefulness of the phonautographic method to linguistics. In this study Pipping's topic was not the timbre of vowels but the quantities of speech sounds and the "musical and expiratory accents" in Finland-Swedish. More results on the same topic were published four years later [11], this time illustrated with pitch curves of the test words and sentences.

2.2. Second trip to Kiel

After spending one more year in Kiel (1893–1894), Pipping published two new studies on vowels. The material in these articles included the ten vowels of the Swedish dialect spoken in Helsinki. All the ten vowels were sung by Pipping and his wife, and five of them were also spoken by H. P. In the first of these studies [12], Pipping discussed the stable and variable characteristics of different vowels and presented the results of some new measurements. Pipping reflected upon the possible articulatory and/or acoustic differences in men, women and children producing a given vowel, and stressed the importance of determining how the human ear sorts out the relevant characteristics for vowel identification. The publication also contained a four-page mathematical appendix written by Ernst Lindelöf. Figure 2 reproduces Pipping's "vowel prism" which shows the different vowels in a diagram with the horizontal and vertical axes representing "Abstimmung des vorderen Resonanzraumes" (i.e. F2) and "Resonanzton des hinteren Raumes" (F1), respectively.

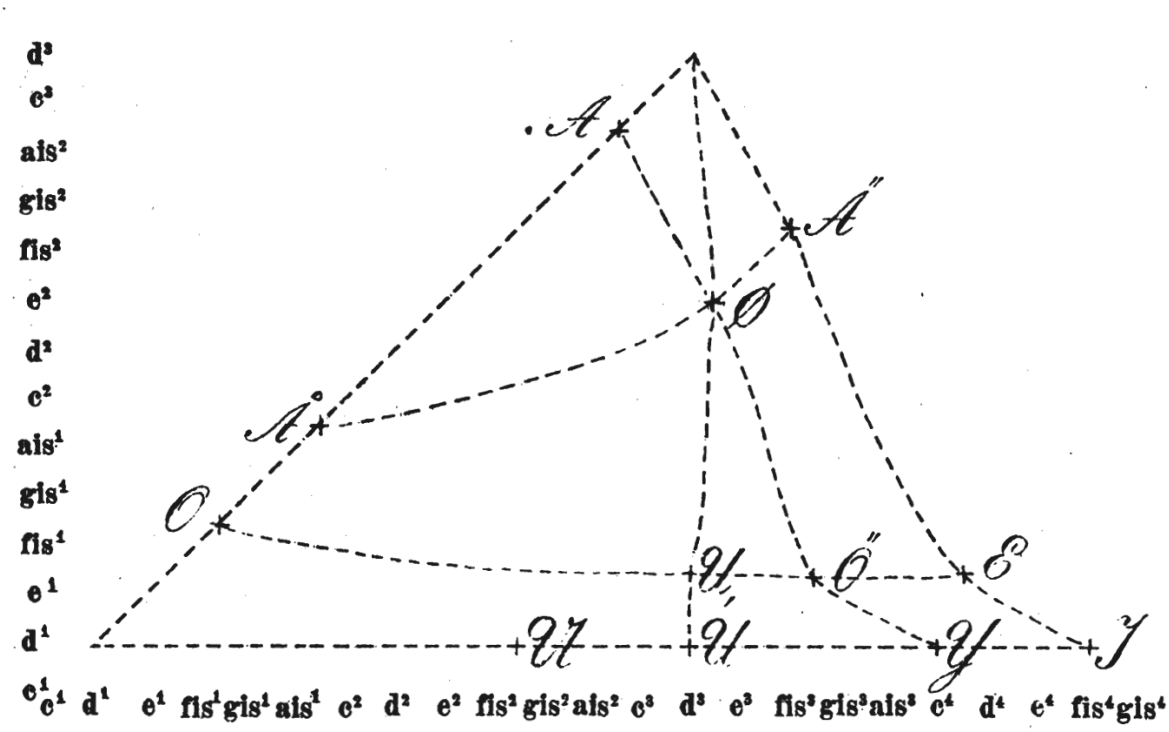

Figure 2: Pipping's [12] "vowel prism". The horizontal axis represents the resonance of the "front cavity", the vertical axis that of the "back cavity". The letter symbols have the following IPA values: Å [o], O [u], E [e], Y [y], I [i], Ö [ø], Ä [æ], A [ɑ]; "U" and "U$_1$" are two variants of the Finland-Swedish [ʉ], and the leftmost symbol on the bottom line is the German [u]. It should be noted that the vowels [u], [o], and [ɑ] fall on the diagonal, i.e. their F1 and F2 lie very close to each other.

In the second study [13] Pipping presented the results of analysing altogether 177 curves. He also dealt with the perception of fundamental frequency in vowel sounds. The measurements reported were actually only average values of the raw data published in [12]. In general, the material gives a much better chance to find the resonance maxima than the data analysed in earlier studies, because the fundamental frequency used in singing the vowels is now lower. Consequently, Pipping is, for instance, able to separate two peaks in the vowel [ɑ], where only a single wide resonance area was seen previously. Figure 3 shows the measured vowel resonances ("Resonanzhöhen und Resonanzbreiten") [13]. According to Pipping, the characteristic tones (≈ formants) tend to be slightly higher in spoken than in sung vowels.

Pipping also gave a very brief comparison of the Finland-Swedish vowels with the German ones, but in auditory terms only.

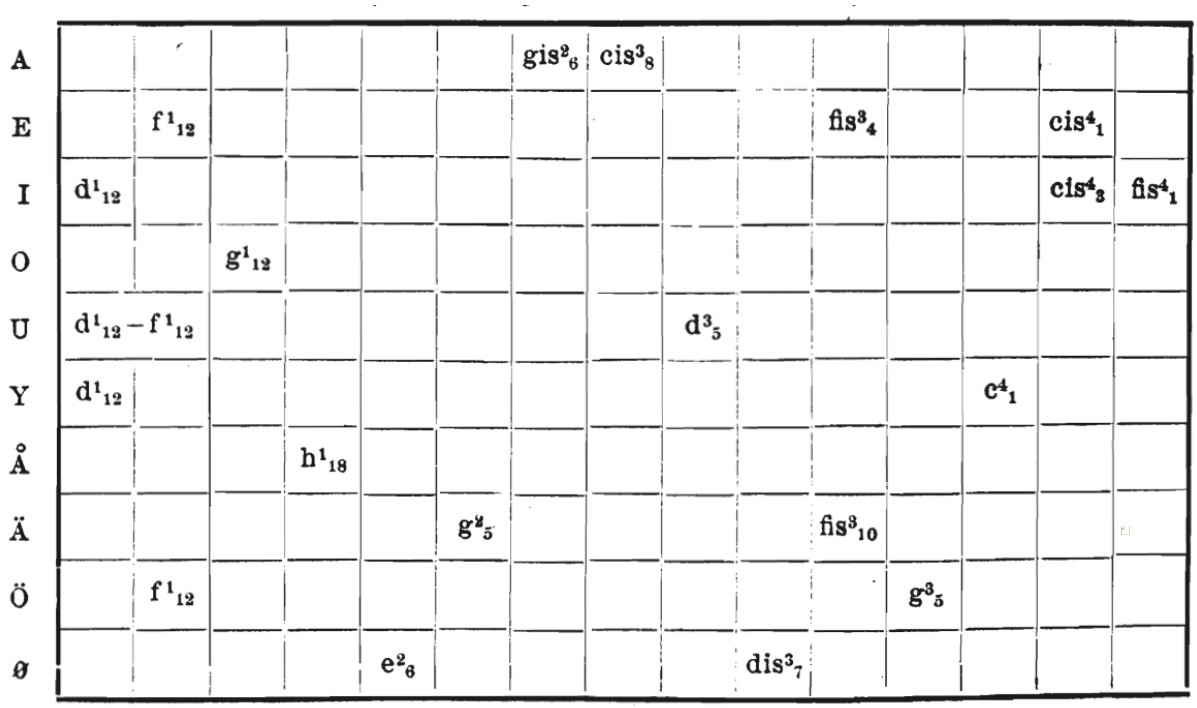

Figure 3: Heights and widths of vowel resonances from Pipping [13]; the horizontal axis is like a musical scale from low to high notes; "$c^4{}_1$", for instance, indicates that the resonance maximum is on the note c^4 (= 2112 Hz) and has a width of 1 semitone. (The letter symbols have the following IPA values: A [ɑ], E [e], I [i], O [u], U [ʉ], Y [y], Å [o], Ä [æ], Ö [ø], Ø [œ].)

2.3. *Zur Phonetik der Finnischen Sprache*

Nine years after his doctoral dissertation, and on the initiative of the Finno-Ugrian Society [1] Pipping published a study [14] on "the phonetics of Finnish", consisting mainly of acoustic analyses of spoken and sung Finnish vowels and some short notes on certain consonants and prosodic phenomena ("musical and dynamic accents"). In this work, Pipping's aim was to analyse and describe all Finnish vowels (short and long) and diphthongs spoken by one informant, and to shed light on the dialectal differences of Finnish by analysing the vowels sung by five male informants from different parts of the country. In addition to the differences in timbre, Pipping also intended to measure the durations of the vowels.

Recordings of the **sung** vowels were made in January–February 1896. According to Pipping [14], the number and position of resonances can be measured the more accurately, the more harmonic overtones there are, i.e., the lower the fundamental pitch is. In this respect, Pipping considered his optimal material to be the vowels sung on the note G# (Gis = 104 Hz) by "Mr. O. Nevalainen (bass) from Nurmes". However, although the resonance maxima reported for these vowels form a neat vowel system as such, they give the impression of an unnaturally reduced vowel space [10] (see Table 1).

Contrary to his wishes, Pipping could not draw any conclusions about dialectal differences on the basis of the sung vowels. What seemed to be decisive were the individual differences between the informants, e.g. between tenor and bass voices [14]. On the other hand, it is possible that, even when the singers have similar voice ranges, sung vowels need not necessarily reflect dialectal differences.

Table 1: The average values (in Hz) of the resonance maxima for the eight Finnish vowels sung by O. Nevalainen deduced from the data reported by Pipping [14].

Vowel	F1	F2
[ɑ]	492	1040
[æ]	492	1303
[o]	412	1009
[ø]	412	1310
[e]	412	1456
[u]	208	830
[y]	208	1432
[i]	208	1641

The results for the **spoken** vowels show a more interesting pattern. For the different vowels in spoken words, the speaker was "Mr. E. Ekman (tenor barytone) from Längelmäki". In the production of the following example words, Mr. Ekman's fundamental frequency varied from 98 Hz to 266 Hz [14]:

[ɑ]: *satama, saadaan, taide, hauskuus*;
[æ]: *pöytään, keihäitä, käytös*;
[o]: *riemuitkoon, keino, neuvoin, Kuopio, houreet*;
[ø]: *lyököön, käytös, pöytään, löit*;
[e]: *siteet, houreet, keltä, kelta, tiede, taide, riemuitkoon, keihäitä, keino, neuvoin*;
[u]: *hauskuus, kiuru, Kuopio, neuvoin, houreet, riemuitkoon*;
[y]: *myllyyn, viipyi, käytös, pöytään, lyököön*;
[i]: *viipyi, kiuru, neuvoin, Kuopio, keihäitä, löit, riemuitkoon, keino, taide*;

For the spoken vowels, Pipping tried to measure three different resonances for each vowel, the "thoracic", "pharyngeal", and "oral" resonances. The pharyngeal and oral resonances are here taken to correspond to the formants F1 and F2 in present-day terms. Unfortunately, Pipping does not present a clear summary of the resonance frequencies, but one interpretation of the results for the spoken vowels is shown in Table 2 and Figure 4. (The values of each vowel as the second component of a diphthong have been excluded from the averages calculated for theses presentations.)

Pipping [14] also made some observations on the effects of neighbouring consonants on vowel formants: A dental consonant makes the pharyngeal resonance (F1) descend and the oral resonance (F2) ascend, whereas a labial consonant makes the oral resonance descend.

Table 2: The average values (in Hz) of the "pharyngeal and oral resonances" (= F1 and F2) for the eight Finnish spoken vowels calculated from the data given by Pipping [14].

Vowel	F1	F2
[ɑ]	740	1220
[æ]	650	1560
[o]	510	940
[ø]	490	1600
[e]	470	1840
[u]	340	810
[y]	260	1780
[i]	310	1910

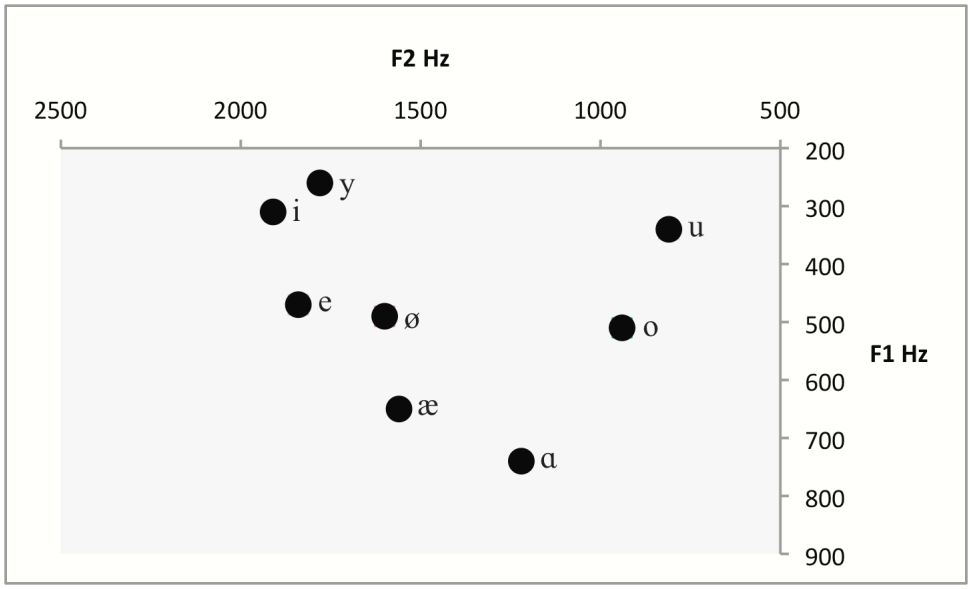

Figure 4: The Finnish vowels spoken by Mr. E. Ekman. Average formant values are shown in Table 2 [14, 10].

3. Other phonetic and philological studies

In spite of moving largely to philological studies after 1903, Pipping maintained his wide interests in phonetic topics, publishing articles on, e.g., the sound structure of Nordic languages, and especially on questions of metre. Pipping's later studies include a paper published in 1913 [15], where he dealt with the effects that the phase differences of overtones might have on the perception of timbre. Pipping wanted to draw conclusions on the functioning of the tympanic membrane of the human ear on the basis of the behaviour of the membrane of Hensen's Phonautograph. Among Pipping's later publications that lie somewhat further away from the phonetic focus, are his numerous philological articles on runic inscriptions and Edda poetry.

4. Pipping's impact on phonetics in Finland

It is generally held that experimental phonetics was introduced to Finland by Hugo Pipping [1–3, 16]. The impact that Pipping had on the phonetic (and philological) field in Finland can also be estimated from the impressive list of his publications that was included in his Festschrift (*Festskrift tillägnad Hugo Pipping på hans sextioårsdag den 5 november 1924*, Helsinki 1924), which was edited by his son Rolf Pipping, the list of publications compiled by his other son Hugo E. Pipping. As a phonetician, Pipping concentrated on strictly empirical and experimental methods, and even in his philological studies he maintained the phonetic point of view.

It is noteworthy that all through his career Pipping tried to bridge the gap between the methods of natural sciences and the humanistic problems of linguistics and philology [1]. He even envisaged the possibility of a physical understanding of historical sound changes [7, 17] on the basis of "acoustic analysis, which will preserve its value through millennia" (*...den akustiska analysen bibehåller sitt värde genom årtusenden och sålunda i framtiden kommer att möjliggöra en återblick öfver språkets utveckling*).

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