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INSTRUMENTS USED IN EXPERIMENTAL PHONETICS AT THE BEGINNING OF THE 20TH CENTURY AT THE INSTITUTE OF PHONETICS IN PARIS

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Abstract: This article deals with the restoration project of instruments used in experimental phonetics by phoneticians at the Institut of Phonetics in Paris around 1930. It describes the patrimony and the various stages in restoration of the instruments found when the laboratory was moved, the discovery of their origin and usefulness, and their dissemination. A game inspired by Trivial Pursuit has been designed to enhance the value of this little-known instrumental heritage.

1 Introduction

The Institut de Linguistique et Phonétique Générales et Appliquées (ILPGA) was established at 19 rue des Bernardins in Paris in the fall of 1928 under the impetus of Ferdinand Brunot and André Gayot. It closed its doors definitively at rue des Bernardins and relocated to 5 rue des Irlandais (near the Panthéon) on July 1st, 2022. During the move, several instruments that had escaped two donation campaigns (in 1975 and 2000) to The Charles Cros Collection (<https://archivesetmanuscrits.bnf.fr/ark:/12148/cc97705f>) were found in the attic of the old building. At a time when scientific heritage is being celebrated by various French research organizations, a Foundation for Heritage Sciences was created in 2013 (<http://www.sciences-patrimoine.org/>), and several laboratories are implementing a policy to enhance the value of their scientific collections. It seemed important to us to take stock of these experimental instruments and to preserve them.

In this article, we will take stock of all the recovered instruments and try to answer the following questions: How can they be dated? What is their origin? Who did they belong to? What were they used for? How can they be restored and promoted?

To answer these questions, we had to look at the various phonetic laboratories in Paris at the beginning of the 20th century, the various phoneticians, the equipment they used and the people who built them.

2 Graphical representation of sounds

Experimental phonetics is intrinsically linked with the graphic representation of sound waves. Historically, it wasn't until the early 19th century that the first graphical representation of a wave emerged. This achievement is credited to the English physicist Thomas Young in 1807.

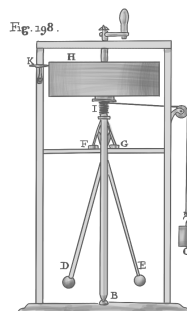


Figure 1: First device for graphically representing sound waves from [9: 191]

Figure 1 shows the first system attributed to Young, which operated using counterbalanced weights. Etienne-Jules Marey described Young's process as the starting point of chronography, which involves recording any movements in relation to time [10: 110]. Jean-Marie Duhamel, seeking to experimentally verify consequences of string theory, developed a device for graphical representation inspired by Young's apparatus. This device, known as the Vibroscope, involves scratching a blackened paper with a stylus that follows the vibrations of a sounding body [4].

Graphical representation enabled Marey to illustrate numerous physiological phenomena: "the movement in the functions of life" [10: 10]. Although he was primarily interested in biology, he wanted the graphical method to be applied to the study of functions beyond physiology. To this end, he commissioned Charles Verdin to build a recording polygraph. Verdin was not the inventor of cylinder inscription, but he greatly improved its functioning [16]. Marey's contribution also lies in the invention of lever drums, also known as Marey drums. Marey drums significantly increase the sensitivity of recording systems and improve their linearity. They became an integral part of experimental phonetics experiments, until the kymograph went out of use.

In 1875, Léon Vaïsse, president of the Société de Linguistique de Paris, along with Louis Léger, Eugène Fournier, Louis Havet, and Henri Gaidoz, approached Marey to determine whether the graphical method could be applied to study speech movements. Many members of the Société de Linguistique de Paris were teachers at the Institut National des Jeunes Sourds (INJS) in Paris, seeking methods to understand speech functioning to aid in the rehabilitation of their pupils.

Marey, though interested in speech, delegated the task to one of his students, Doctor Charles-Léopold Rosappelly, whose mission was to replace the auditory sensations produced by speech sounds with an objective expression of phonation acts. Havet assisted him in this endeavor. Together, they focused on developing graphical devices applicable to speech production. Figure 2 displays the first known multilinear representation of a phonatory act, showcasing simultaneous recordings of nasal pressure, larynx vibration, and lip movements.

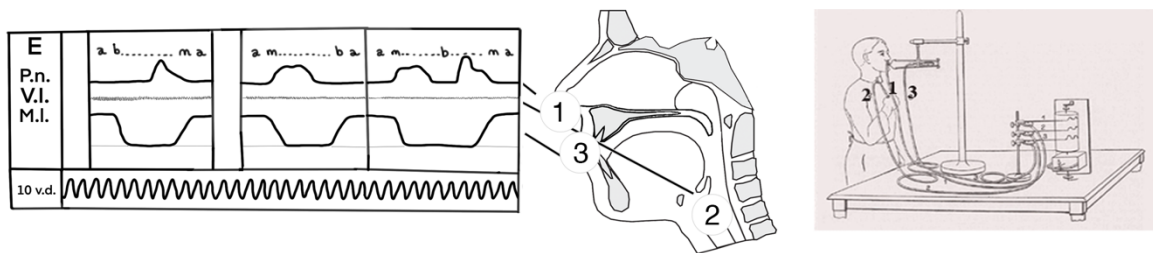


Figure 2: First representation of speech sounds by Rosappelly and Harvet, E = statement, P.n. = nasal pressure (see n°9 Table 1), V.I. = laryngeal vibration (see n°5 Table 1) and M.I. = lips movements (see n°11 Table 1), adapted from [12: 125]

These early instruments were unable to visualize the rapid movements of the speech organs. From 1885, Abbé Rousselot, Verdin, and Rosappelly collaborated to develop an "electric membrane inscriber" capable of analyzing rapid movements. In the first part of his thesis, Rousselot detailed all the instruments he used and the modifications he made to them. He also proposed a method to turn phonetics into an experimental discipline [13], based on physiological analyses corresponding to the realization of speech sounds. Some of the instruments described in [13] are included in our inventory Table 1.

3 Laboratories in Paris, manufacturers, and instruments

To trace the origins of our instruments, we need to examine the context of experimental phonetics between the end of the 19th century to the early 20th century.

3.1 Laboratories

Marey had caused a sensation with his graphical method and chronophotography in the 19th century. Many students from around the world attended his classes to learn his methods and use the same instruments he employed.

By the 1920s, there were no fewer than five speech laboratories in Paris (created by Marey's students) three of which were directed by Rousselot (at the Collège de France (1897), at the Institut Catholique de Paris (ICP) (1889) and at the Alliance Française (date unknown). Rousselot also had instruments that he kept at home. In addition to these laboratories, an Institut de Phonétique created in 1911 by Ferdinand Brunot, Emile Pathé and Léon Gaumont at the Sorbonne, as well as a Laboratoire de Parole was founded in 1912 by Victor Collignon for the INJS.

It's difficult to obtain a precise inventory of the equipment used in these facilities. Most photographs from that period show Lioretgraphs, which were used to record and duplicate speech (see Figure 3). Rousselot can also be seen posing in front of his speech inscriber and a tonometer, but that's about it.



Figure 3: a) Use of a lioretgraph at the inauguration of the Speech Laboratory at INJS [9: 7], b) Rousselot in front of the Tonometer [2]

3.2 Manufacturers

When Marey or Rousselot commissioned the fabrication of envisioned instruments, they turned to Verdin, who was himself a student of Marey. His workshop was based in Paris. His first catalogue, dating from 1890, includes the instruments he commercializes. Initially, there is not specific section for phonetics in this work, and the instruments probably commissioned or envisioned for Rosapelly appear in the medical section (from page 59) [17]. By page 123 of the 1895 catalog, there will be a section for instruments used in the study of phonation [18]. Verdin was assisted by Georges Boulitte, who took over instrument manufacture in 1905. Boulitte's catalog dedicated to phonetics was published in 1924 [15], and the first instruments built by Boulitte, which retained the annotation ('Boulitte Maison Verdin'), suggest that most of them were manufactured from 1905 onwards.

Many of the instruments in Boulitte's catalog were already listed in Verdin's catalogue; in such cases, we will specify this in the instrument description to an attempt to provide a potential manufacturing date.

3.3 Instruments

It's hard not to draw a parallel between the instruments we found and Rousselot's instrument collection. Rousselot, tells us that he owned: [15]

"...a recorder with two new drums, and one old discarded, explorers of the larynx and lips, Marey's pneumograph." In his personal laboratory (at home?), he had his electric speech inscriber, a larynx explorer, a lip explorer, an artificial palate (the first had been built by Kingsley

in 1887), a spirometer, and a sliding-tuned fork [14]. Koenig's large tonometer was likely part of his personal collection. The inventory of the Collège de France laboratory lists several devices either created specifically for phonetic studies or applied to them: artificial palate, recording devices, organic movement inscribing devices, speech inscribing devices, spirometer, glossodynamometer, laryngoscope, resonators, sliding-weighted tuning fork, Koenig's wave sirens.

Rousselot's instrument collection has been extensively discussed and speculated upon. In his will, he explicitly requested that his instruments remain in France. According to Meunier's writings, a significant portion of these instruments remained at the Collège de France when he succeeded Rousselot [11]. Meunier himself was an experimentalist, heading the laboratory of experimental phonetics at the Collège de France and serving as a professor at the ICP. His sudden death in 1929 complicated matters, leading to the loss of trace of the instruments.

[6: 49] inventoried the equipment belonging to the ILPGA. He mentions having several recording cylinders, including two large models (Verdin weight-driven recorder; Boulitte universal recorder, electrically driven), with their accessories: Rousselot's inscribing ears, electro-tuning forks, Desprez signals, etc. Also included is a collection of devices intended for the study of physiological phenomena of speech: Poirot's and Rousselot's labiographs (*see n°11 Table 1*), Rousselot's explorers of horizontal lips movements (*see n°12 Table 1*), Rosapelly's explorer of larynx vibrations (*see n°5 Table 1*), Weeks' explorer of the palate veil (*see n°10 Table 1*), pneumograph explorers. Additionally, there is equipment for acoustic studies: disk siren, complete set of Koenig tuning forks, sound level meter, blower, sound pipes, etc.

In 1956, Marguerite Durand confirms that for several years, the Institut de Phonétique in Paris has been enriched with equipment from the Laboratory of the Collège de France, which had recently acquired equipment from the phonetician Zünd-Burguet and Koenig's tonometer [5: 158].

[1: 2] points out that most of Rousselot's instruments are stored at the Academy of Sciences and the INJS. He regrets that these are difficult to access and therefore even more challenging to bring to the provinces for an exhibition. However, during a visit by the first author to the Institute, we found no trace of experimental phonetic instruments as such.

[7: 70] indicates that practically all of Rousselot's instruments returned to the ICP, except for the wave siren and Dr. Struycken's apparatus, which remained the property of the Collège de France. To continue Rousselot's scientific work, the Archbishop of Paris and the Rector of the Catholic Institute decided to maintain the chair of experimental phonetics and reinstate his laboratory, starting with the recovery of Koenig's tonometer repurchased from Rousselot's heirs. However, during a visit by the first author to the ICP, it was found that apparently no experimental phonetic instruments are currently in their inventory; everything seems to have disappeared.

Marianne Deraze and Xavier Loyant present instruments that belonged to the ILPGA and enriched the Charles Cros Collection, including Rousselot's electric speech inscriber and Koenig's flame analyzer [3]. When examining the list of instruments and their descriptions in the Charles Cros Collection, it becomes challenging to determine their origins as not all are illustrated to aid in identification and provenance (<https://archivesetmanuscrits.bnf.fr/ark:/12148/cc97705f>).

[8] indicates that upon assuming responsibility at the Laboratory of Phonetics at La Sorbonne, Jean Poirot undertook improvements to its technical setup, suggesting he acquired instruments related to experimental phonetics.

Adolphe Zünd-Burguet, who continued some of Rousselot's teachings and experiments, particularly at the Alliance Française, donated instruments used in speech therapy that he himself invented to the Institute of Phonetics, including Rousselot's tonometer of 80 tuning forks. The date of Zünd-Burguet's donation of these instruments is not documented.

Many of the instruments we found had a manufacturer's name: Boulitte. Identifying them in

Boullitte's catalogs from 1924 and 1928 was not difficult.

Our hypothesis regarding the instruments found in the attic of the ILPGA and those transferred to the Charles Cros collection is twofold: 1. Zünd-Burguet acquired some of Rousselot's instruments, which he retained before donating them to the Institut de Phonétique. 2. Others were acquired by Poirot upon assuming his duties.

4 Restoration et inventory

4.1 Restoration

The first step involved cleaning all the instruments that were discovered. Having likely sat in the attic for over 50 years, they were covered in dust and some were broken. We carefully re-soldered the broken parts back together. Once cleaned, most of them revealed the name of their manufacturer, which made it relatively easy to identify them using manufacturers' catalogs. In cases where the descriptions were too brief, we consulted Rousselot's thesis to understand the purpose and usage of each instrument. For instruments where pieces were missing, we used Fusion 360 software (Autodesk®) to design and 3D printed the replacement parts.

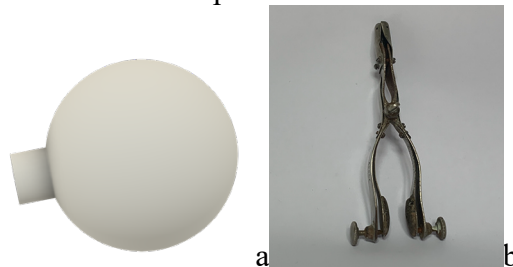
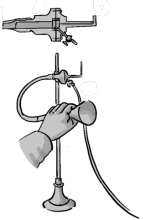
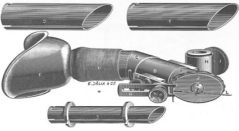



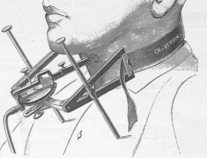
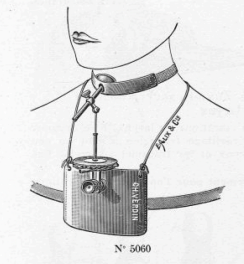
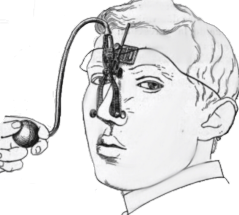
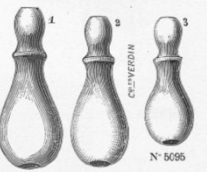


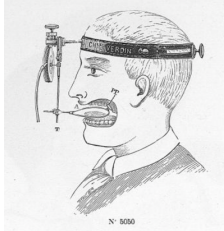
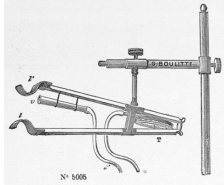

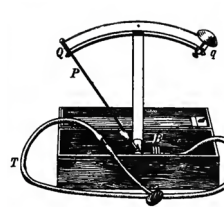
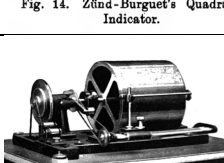
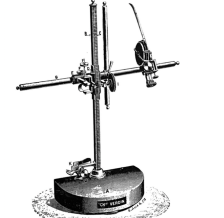

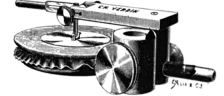


Figure 4: a) Element of the Zünd-Burguet nose pliers, redesigned (by ourselves) the found drawing [20: 661], b) nose clip restoring (see n°8 Table 1).

4.2 Inventory

The description, utilization, dimensions, photos, and videos of the instruments are available on the links in the fifth column of the table.

Table 1: List of instruments inventoried and archived, those identified to date:

	N°	Name	Picture	Link to description and illustration
Acoustic of speech	1	Manometric capsule for Koenig analyzer		Link
	2	Inscription ear		Link
Larynx investigation	3	Larynx capsule		Link
	4	Palmer's larynx capsule		Link
	5	Double-cup laryngograph		Link
	6	Laryngograph		Link
	7	Stabiliser		Link
Nasal Cavity	8	Nasal clip		Link
	9	Olive nasal		Link

	10	Weeks device		Link
Lips investigation	11	Labiograph		Link
	12	Explorer capsule		Link
	13	Indicator quadrant	 Fig. 14. Zünd-Burguet's Quadrant Indicator.	Link
Tongue	14	Recording cylinder		Link
Inscription	15	Bracket		Link
	16	Receiver drum		Link
	17	Lever drum		Link
	18	Deprez electro-magnetic signal		Link
	19	Drum diaphragm		Link

5 « Phonetic Pursuit »: Experiment phonetics with Abbé Rousselot

« Follow in the footsteps of Abbé Rousselot and discover the instruments he used to study speech ». We have devised a game to introduce the first instruments used in experimental phonetics and to showcase more recent instruments used in current phonetics laboratories. Through this game, participants can manipulate the devices and try to understand why and how they were used.

5.1 The game

5.1.1 Game board

The board is based on the classic game of *Trivial Pursuit*, with players moving around the board to the rhythm of their roll of the dice, answering questions or completing challenges.

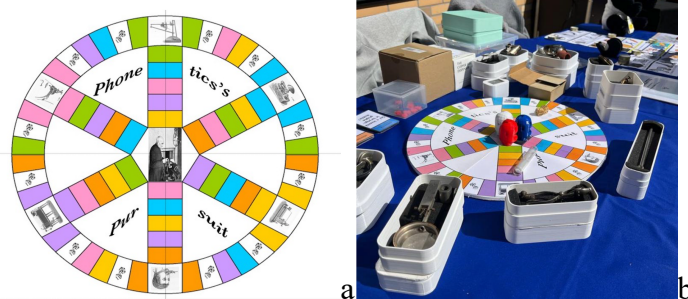


Figure 5: a) Game board, b) Complete game board used at an open day of Maison de la Recherche (Sorbonne Nouvelle) in 2023

5.1.2 Cards

Four categories of questions have been devised:

- Inventor: who is the inventor of a particular instrument,
- Workshop: practical instrument reassembly exercises,
- Now: what the instrument has replaced the first,
- Experimentation: tell what the instrument was used for.

5.1.3 Characters

The pawns have been drawn in 3D, they are characters that need to be given back the ability to "speak". With each correct answer, the player has the option to give them back their ears, tongue, or nose. There are three characters of different colors: blue, green, and red. People can play in teams.

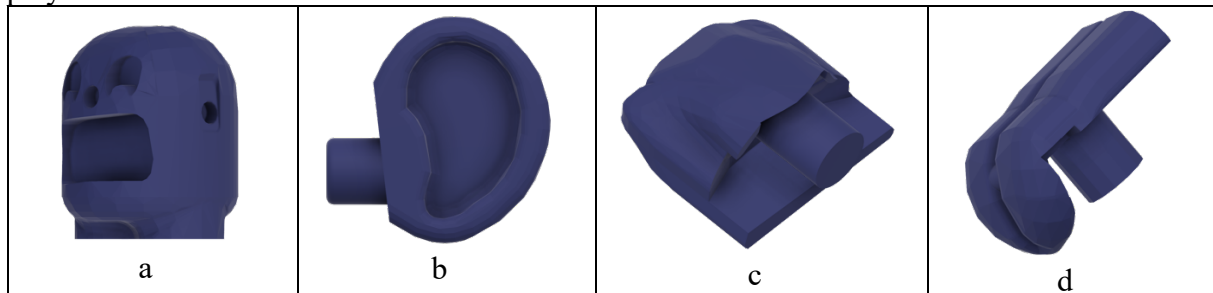


Figure 6: The blue pawn that makes up the game, along with the various accessories that need to be won to rebuild the character, 3D-modeled from Fusion 360 and 3D-printed: a: character, b: ear, c: nose and d: tongue.

6 Conclusion

There is still work to be done. Some pieces have been restored but not yet identified, while others have not been cleaned or restored. It would be beneficial to establish a close collaboration with the BNF and the INJS. This collaboration could take various forms:

- Identifying and dating the instruments from the Charles Cros collection,
- Enhancing their value by proposing to enrich the description to detail how they were used, and for which purpose, and the results obtained, by Rousselot and others,
- Creating a valorization website to showcase the devices stored in various locations (BNF, INJS, Laboratory of Phonetics and Phonology), similar to what some universities have done for sciences in general, for example (<https://photo3d.univ->

lille.fr/360/index.php?/category/262) or for experimental phonetics in particular, as seen here (<https://culture.univ-grenoble-alpes.fr/linguistique/phonetique-experimentale-681102.kjsp?RH=1589290521888>). The website could include virtual tours with videos demonstrating the operation of the instruments,

- d) Finally, the three institutions could organize a joint exhibition, allowing the experimental phonetics instruments, so dear to Rousselot, to be discovered by the widest audience possible.

7 Acknowledgments

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