EXPERIMENTAL PHONETICS AS AN AID TO THE STUDY OF LANGUAGE

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Within the last twenty-five or thirty years a new science has sprung up, the science of Experimental Phonetics, an outgrowth of the efforts of men of very varied interests to investigate the nature of speech sounds and their relations to the organs of speech. Philologists, physiologists, physicists, psychologists, special physicians for the throat and nose, singing teachers, teachers of the deaf and dumb, all have contributed to the development of the new science; and there has been an inclination to classify Experimental Phonetics as a branch of one or more of the allied sciences and to deny it an independent existence. The friends of Experimental Phonetics, however, contend that it should be considered as a separate science, just as chemistry, although it draws from and completes other sciences, has an independent existence.

There are probably something more than twenty-five phonetic laboratories in existence, most of which are in Europe. Abbé Rousselot, of the Collège de France, in his somewhat primitive laboratory in Paris, has done remarkable pioneer work in Experimental Phonetics, and has been undoubtedly of greatest service in establishing and developing the new science. The most noted work in Experimental Phonetics in the United States has probably been done by Prof. E. W. Scripture, who is connected with the department of Psychiatry in Columbia University.

I spent last winter working in the Phonetic Laboratory in Hamburg which, it seems to me, may be regarded as a model laboratory. The Phonetic Laboratory in Hamburg was founded in 1910, through the efforts of Prof. Meinhoff, Professor of the African Languages in the Colonial Institute, and Dr. Pancencelli-Calzia, who was at that time in charge of the Phonetic Cabinet in Marburg, was called to be its first director. The new department, with its very modest equipment, was at first housed in a part of the Physical Laboratory of the Colonial Institute, but it soon outgrew its small quarters, and a fifteen-room building was provided for it by the city, and fitted up with the thoroughness of Germany and the lavish generosity of Hamburg. Already, after three years, the new

building is proving inadequate, and larger quarters must soon be found, while new assistants are continually being added to the working force. In addition to Dr. Calzia, the staff consists of a philologist, a vocal teacher, a teacher for the deaf and dumb, two mathematicians, a special physician for the throat and nose, and three technicians. The laboratory is the center of all the related activities of the city; teachers and students of language and singing, teachers for the deaf and dumb, physicians, bring their problems and the result of their experience to the laboratory, and the children of the public schools who have speech defects come to have their speech examined and to learn proper articulation. In fact, the laboratory has proved itself to be a living and indispensable factor in the city educational system.

The equipment of the laboratory is most complete. There is a Roentgen-ray room, with rooms for developing and drying photographic plates, and much valuable information regarding the action of the larynx and the velum has been obtained from experiments with the Roentgen apparatus. There are phonographic rooms with instruments for making and playing the records, with a large collection of records and many different kinds of phonographs and gramophones; there are lioretgraphs for converting the grooves of the gramophone records into sound curves; there are kymographs and instruments for measuring pitch and force. Besides the experimental apparatus, there are all possible instruments for demonstration purposes such as laryngoscopes and kinematographic records for showing the vocal chords and their activity. These moving pictures of the larynx were made by Dr. Calzia and his colleagues in the laboratory, and give a wonderful exhibit of the strenuous activity of the vocal chords in the production of sound. There is also apparatus for demonstrating the physical properties of sound, and innumerable models to help give a clear comprehension of the construction of the vocal organs and their functions.

The instruction is by means of lectures and laboratory practice, the course being carefully planned to give the student technical control of the instruments together with an intelligent comprehension of the phenomena as they are gradually revealed to him. The course of instruction includes briefly: the study of the breathing organs and their functions; the study of the larynx, including the dissection of the human larynx; the investigation of speech sound by the kymograph, lioretgraph and gramophone; the measuring of pitch, quantity and force, with practical exercises in ear-training and sound imitation. As there are usually students of many dif-

ferent nationalities working in the laboratory there is plenty of opportunity for practice in ear training and sound imitation. Even last year, which was of course a most unfavorable time, we had a Hollander, a Spaniard, an Austrian, an American, besides Germans from three different provinces. There are also always native Africans studying in the Colonial Institute who allow themselves to be used as "*Experimentierkaninchen*." Their speech is especially interesting, not only because they have sounds not found in European languages, but also because many words, otherwise identical in sound, can be distinguished only by the pitch. For instance, the same word "*fu*" means *hair* or *white* according to the pitch of the vowel *u*. The African language is therefore a valuable means of training the ear to perceive difference in pitch.

Dr. Calzia himself is an Italian, a native of Rome, whose parents however came from Tuscany, so that he speaks not only the standard Italian but the Roman dialect. He studied for several years in Paris, so that he is very familiar with French, and has been for the last thirteen years in Germany. He speaks therefore three languages fluently and has a first hand acquaintance with their sounds, so that he is especially well fitted for his position. Dr. Calzia is a competent and inspiring instructor who knows how to impart his knowledge and enthusiasm to his hearers, and who has a profound belief in the mission of his chosen field of work. He is assisted at present by Mr. W. E. Peters, an Australian holding a Carnegie fellowship, who is doing remarkable work in intonation curves.

But one who has heard a few lectures on Experimental Phonetics or watched a few experiments will perhaps say: "This is all very interesting and may well have its value as pure science, but of what practical use can it be to the student of language? I could work a year with these instruments and be tremendously interested, but I do not see how my own pronunciation can be in the least influenced by it." My work in Experimental Phonetics has convinced me that it can and does have an actual and permanent value to the student and teacher of language.

In order to be able to teach successfully the pronunciation of a foreign language, one must have first of all a correct pronunciation himself, must have a keen ear, and a knowledge of how the sounds are formed, not only in the foreign language, but in the native language of the pupil. Experimental Phonetics helps one to gain a thorough acquaintance with the nature of speech sounds, and one's hearing becomes trained to distinguish shades of difference in sounds which were

before imperceptible. The ear is an unreliable recorder of sound, the impressions are of short duration, but if we can get a permanent record of speech in the form of a sound curve which is visible to the eye, we can obtain a clearer idea as to the real character of speech sounds.

Fig. 1—SPEECH KYMOGRAPH

A speech kymograph is an instrument which records speech sounds in the form of sinusoidal curves. It consists of a rotating cylinder connected with a motor. On this cylinder is pasted a strip of smoked paper. Beside the instrument stands an upright support to which is attached horizontally a metal tube having at the end a tambour, a tiny box covered with a tightly stretched rubber membrane; above this and resting lightly upon it, or attached to it, is a delicately balanced lever, carrying at the end a light pencil or brush. At the other end of the metal tube is a piece of rubber tubing to which is attached the apparatus transmitting the sound waves from the organs of speech: for the mouth, a mask covering it entirely; for the larynx, a tambour; for the nose, glass olives which can be inserted into the nostril. It is possible thus to record simultaneously the sound waves in the larynx, the mouth and the nose. This is really a new and direct way of

writing, in which instead of words being inscribed by the hand in the conventional spelling, they are recorded by the instrument as they are formed by the organs of speech.

Let us see what can be learned from a few kymograph records of speech sounds. In general we may say that the chief difference between the sounds known as voiced and voiceless stops, as for instance *b* and *p*, depends on the part that the vocal chords play in the formation of the sounds. Examination of the curve for the larynx shows that the participation of the vocal chords in the production of speech may be of varying degrees. They may vibrate during the entire

Fig. 2

sound as in line 1; they may vibrate only at the beginning of the sound, as in line 2; they may be silent altogether, as in line 3; or they may vibrate only at the end of the sound as in line 4.

To our ears there often seems to be very little difference, especially in some parts of Germany, between a German *p* and *b*; the German seems to have no *b*. The German himself is not always quite sure of the difference and talks about a hard or soft *b*. My landlady in Leipzig handed in a bill in which I was charged for Gebäck instead of Gepäck. At the same time we often fail to distinguish a *p* as spoken by a Frenchman or an Italian from a *b*; they seem to have no *p*. A Hollander told me that he had always felt that the English way of pronouncing *p* and *t* or *k* was affectation and yet he never knew just what it was in the English sounds that offended him.

Figures 3, 4, 5, 6 show the record of the stops *b* and *p* as pronounced by an Italian and a German. In the Italian record for *b* we observe that the larynx vibrates throughout the en-

Fig. 3
Italian *b*. in *bisca*

Fig. 4
German *b*. in bald

Fig. 5
Italian *p*. in più

Fig. 6
German *p*. in pip

tire period of articulation, beginning before the explosion, while for the German pronunciation of the same sound, the vibration begins with the explosion. But the record for Italian *p* gives almost identical results as for German *b*, which explains why the Italian hears the German *b* as a *p*, while to the German ear, the Italian *p* is like a *b*. In the record for German *p* we see that there is a slight aspiration before the vowel sets in. This habit of following a *p*, *t* or *k* by a slight *h* is also shared in general by the English in the pronunciation of voiceless stops, which shows what the Hollander, who pronounces *p* and *t* practically in the same way as the Italian or Frenchman, dislikes in the English sounds.

These records give us information, it is true, of only one of the various factors which together produce the different acoustic effects of the French, German and English voiced and voiceless stops. There is also the difference in the lip pressure and the energy of articulation in general, as well as the difference in the place where the sounds are formed in the different languages. They must be investigated by means

of other instruments. The records do help us however to a perception of certain differences in the sounds, which it is hard for the unaided ear to distinguish, which however if not observed, call attention to the speaker's sounds as those of a foreigner. The first step in the correct pronunciation is taken when the ear has begun to *hear* the sounds accurately.

The kymograph record represents to the eye also the differing character of the various sounds, as can be seen in the following figures:

Fig. 7
t in two.

Fig. 8
n in ten.

Fig. 9
s in bisca

Fig. 7 shows the characteristic curve for a stop, the distance a—b representing the closure, b—c the explosion, while the falling line marks the beginning of the next sound. In the case of the corresponding nasal, however, as we see in Fig. 8, the explosion does not take place, but the air comes out through the nose, as is shown by the lower line, which represents the curve for the nose. A fricative gives a sinuous line, as in Fig. 9.

We can thus obtain information as to our habits of speech, often with very surprising and not always with pleasing results.

Fig. 10
pt in *kept*.

In Fig. 10 we see that the speaker's articulation was slowly, as the final stop was not exploded. In Fig. 11, the record of "*two little kittens*," we observe that the vocal chords vibrate throughout the whole word *little*, which was spoken with very slight stress, showing that the *t* was pronounced to all intents and purposes as a *d*, though the *t* in *kittens*, which received the main stress, was spoken without voice. Examination of the mouth-curve for *kittens* however fails to show the sharp rising line that we expect for a stop; a comparison with the corresponding curve for the nose shows that the *t*, for which the closure was made as usual, was exploded in the nose. That is, it was begun as *t* and finished as *n*, which is very easy to explain, for *t* and *n* are articulated practically in the same place. Such irregularities in pronunciation may perhaps throw some light on some of the changes that have taken place in language in the course of time, such as consonant shifting, the phenomena explained by Verner's Law, or the dropping of *b* after *m*, as in the pronunciation of *lamb*.

But one may have a knowledge of the individual sounds of a foreign language, and yet speak with a marked foreign accent, because one has no perception of the varying length of the sounds, nor of the sentence melody. The kymograph records give us a means for determining and presenting to the eye these peculiarities of the language in such a way that they are more effectively heard by the ear, and can therefore be more easily imitated.

Fig. 12 shows the difference in the length of single and double consonants in Italian. The *t* in *fato* is approximately one-third as long as the *t* in *fatto*.

Most difficult of all for the ear to distinguish is the sentence melody. Beginners in German almost invariably give the sentence: "Ich weiss es nicht," with the same intonation as the sentence: "I don't know," in spite of the fact that the instructor's intonation is different. The student's ear fails to perceive the difference in the sentence melody.

kittens

Fig. II

little

Two

th nx

Fig. 12—*fatto* and *fato*, spoken by an Italian.

outh
ynx

outh
ynx

Fig. 13 shows intonation curves for: "I don't know," spoken by an American and: "Ich weiss es nicht," spoken by a German. Such intonation curves, especially when accompanied by gramophone records of the same sentences as spoken by a native, are most useful in learning the sentence melody of the language.

Kymographic records furnish also a means of control over phonetic transcriptions which have been made according to rules of pronunciation without sufficient consideration of the influence of the sounds upon each other. In Vietor's "Deutsches Lesebuch in Lautschrift I," we find on page 90 the following transcriptions:

'ain hunt | tru:k | 'ain ftyk flai/ 'im maul || 'unt fvam
da:mit | dʊrç 'ainən bax. ||

A transcription based on a kymograph record of the sentence, which was spoken by a German, reads as follows:

'ain^hunt :^hru:k^h'ain/tykflai/'im :aul | 'unt/vamda :mid :ʊrç'ain-
ənbax.||

The sentence seems in the second transcription to resolve itself into two long words, or word groups. The *h* in *Hund*, we discover to be scarcely perceptible, while after the voiceless stops we find a tendency to slight aspiration. The final sound of *Hund* and the initial *t* of *trug* are spoken as one sound, as are the two *m*'s in *im Maul*; the *t* of *mit* is merged in the *d* of *durch*, a *d* of the variety of the stop shown in Fig. 4. If this were a French record it would, I suppose, be classified as *t*. A complete practical phonetic transcription would consist of the theoretical transcription, complemented by a transcription based on a kymograph record of the selection, and intonation curves.

Thus we see that while Experimental Phonetics has no immediate effect upon the pronunciation of the experimenter, he obtains an insight into the nature of speech sounds and how they influence each other and are related to the organs of speech, he gains a keenness of ear perception, so that his efforts to improve his own pronunciation have more rapid and more satisfactory results, while the drudgery of teaching pronunciation is transformed into a pleasure. The trained ear of the instructor detects quickly the difficulties causing the faulty pronunciation, and he can save the student's time by preventing his making mistakes which he would later have to correct; while the student, realizing that his organs of speech are but a wonderful musical instrument of which he must

NOTE.—In the usual spelling the sentence reads as follows:

Ein Hund trug ein Stück Fleisch im Maul, und schwamm damit durch einen Bach.

learn the technique, if he is to use it intelligently, becomes interested in his task and is willing to devote time and pains to it.

In these days we are demanding in all callings and professions efficient methods of work, and in my opinion, which is based on my experience, training in Experimental Phonetics adds to the efficiency of the teacher and student of language to an extent which quite justifies the time and exertion devoted to it. And while we can not all of us become experimental phoneticians, we can all of us make use of the facts revealed by the experiments, as far as they will lighten our labors in the learning or teaching of pronunciation.