

EXPERIMENTS WITH TONGUE-PALATE CONTACTS

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One of the earliest experimental methods employed by those interested in phonetics was that which would reveal in a visual manner the actual tongue-palate contact in the production of the single sound. The experimenter, whether phonetician, linguist, or pathologist has found the tongue-palate study useful to his work, for even though at times the visual picture was not always completely accurate, it still provided one means of answering his questions: What *does* happen when sounds are produced? Where *does* the tongue touch the palate? Is the image the same, or relatively the same, for all individuals? Experiments have ranged from the crude to the relatively complex, both mistakes and important discoveries have been made, and important conclusions have been drawn, but always the phonetician returns to reliance upon the picture of the tongue-palate contact for some of his work. Much has been learned through tongue-palate experiments; much still may be gleaned and taught through future application of the method.

It is my purpose today to summarize briefly the techniques involved in tongue-palate study, to relate the findings, and to conjecture the future use of such techniques and findings.

It was the linguist who first felt a pressing need for a means of showing the articulations of the tongue in the production of speech sounds. In the latter part of the nineteenth century there occurred a revolution in the teaching methods of foreign languages, and hence an interest in palatography. Oakley-Coles and a group of imitators - Grützner, Techmer, Lenz (29, 32, 6) - tried various means of coating either the tongue or the palate before the production of a sound to show the areas of contact. To preserve the image, the contacts were sketched on casts of the subjects' mouths; but because there was no means of an accurate transfer of the markings from the palate to the plaster model, the method was not completely satisfactory (29). Later experimenters - Rousselot, Kingsley, Meyer, Hagelin, Lloyd, Vietor, and others - used an artificial or pseudo-palate to record the areas of contact; but again there was no means of recording permanently the results except by marking the contacts on drawings of the palate or on casts of the palate (29, 32, 12, 18, 16, 9, 36, 15). Rousselot discouraged photographing the pseudo-palate and its wiped-off areas because the lines did not have the accuracy which would justify such a costly method.

In 1899 Dr S. W. Carruthers, in obtaining his medical degree at Edinburgh, devoted his thesis to palatography, "A Contribution to the Mechanism of Articulate Speech." Although the paper was published in the *Edinburgh Medical Journal* and later as a booklet, the study did not appear in the bibliographies in the phonetics field, and remained, therefore, unknown for many years to those interested in phonetic studies. His experiments dealt with the direct method of palatography, although at this time the pseudo-palate method had been adopted generally. In an article on direct palatography, Professor Abercrombie of Edinburgh cites the work of Dr. Carruthers (1).

After the turn of the century the experiments and studies continued, each phonetician or linguist striving to find newer and better methods for carrying on his studies. Josselyn, in 1900, made a study of Italian sounds, noting the different positions of the *i* after *f*, as in the words *fi(ance)* and *fi(glio)*, when only the *fi* was pronounced. He concluded that the same sound is often pronounced in very different ways by the same individual (25). He also wrote a book on Spanish phonetics. Meyer, during this same period, worked out a unique plan to reproduce in his drawings the corresponding perpendicular position, a linguagram, profile view (17, 29). Montalbetti published an article on the use of the pseudo-palate (12); Gombocz wrote about the palatography of the Magyars (14); Gutzman published his *Physiologie der Stimme und Sprache* (28). In 1914 Panconcelli-Calzia (25) published some palatograms on the investigation of some foreign sounds, concluding, as had Meyer and Vietor before him, that identical sounds could be made by contacts over a large range on the palate. Changes in the techniques of procedure began creeping into the studies. Eijkman in his "Tongue Position in the Pronunciation of Some Vowels" used X-rays (5). Chlumsky (1914) made photographs of tongue articulations of French sounds on the artificial palate (4). In 1919 Russell of the Ohio State University published a work on the Spanish *R* in which he mentions a plan of recording the direction of the tongue movement, a method similar to that of Bagster-Collins in which half-palate tongue positions were taken (30). Base-plate wax or thin dental compound was used to make the impression of the hard palate; this palate was cut in two, following the median raphe or natural division of the hard palate, and lead foil strips of one mm. in width were fastened to the roof of the palate about one cm. apart. This artificial palate was inserted into the mouth, the sound was articulated, and the direction of the tongue was thus determined from the direction in which these strips were bent. Heinitz and Panconcelli-Calzia made two other major contributions in the years 1918-1924. In their recording of contacts they used a series of dots one centimeter apart to turn the curved area into a flat one, much after the order of the mercator projector of the global world on a flat surface. Their second contribution was the use of a planimeter to determine the cavity area in one plane (27).

In this same period, 1900-1930, Muyskens of the University of Michigan developed an improved method of preparing the pseudo-palate by making a negative impression of the subject's palate, pouring a positive cast from the impression and from this

positive cast making a filter-paper-cotton-batting pseudo-palate which he coated with black varnish (25). Meantime, Meder and Reichenbach of Munich applied palatography to study of sigmatism (26), and Navarro-Tomás in Madrid employed palatography in the preparation of his *Manual de Pronunciación Español*, though his work made no allowance for individual differences.

Always probing, always experimenting, those interested in phonetics in the years 1930 to the present have succeeded in bringing a once crude technique to a very workable and highly accurate procedure. Between 1925 and 1933, in the University of Michigan laboratory there was developed a pseudo-palate more practical and durable than any heretofore employed, simply by wedging into the palate of a positive cast a square of ash metal # 7, trimming off around the teeth of the cast, and painting the pseudo-palate thus formed with black enamel (20, 21, 22, 24). Any distortion of the pseudo-palate through use was remedied easily by pressing it gently into the cast. Russell at the Ohio State University, too, was continuing experiments with recording articulations shown on the pseudo-palate. Using the commonly employed outline drawings of the palate, he devised a scheme whereby the depth and contour of the palate arch might be designated on the flat surface of the outline. Russell also followed the planimeter method of Heinitz and Calzia, improving upon it, and adding the medium of X-ray. He first gave his precise centimeter measurement of the horizontal cavity as shown by superimposition of the palatogram on mm. cross-section paper, which gave the area more simply than the Heinitz-Calzia planimeter process; second, he gave a parallel centimeter measurement giving the area accurately enough in square centimeters and even more rapidly; third, he combined these with the same computations on X-ray profiles of the cavity made simultaneously to ascertain the cubic capacity and to make reconstruction of the cavity possible; fourth, he indicated for the first time the horizontal lip spread on the palatogram, obtaining this photographically and simultaneously with the X-ray and palatogram; fifth, this, along with the X-ray palatographic record of cavity dimensions in three planes, made possible a reliable reconstruction of the resonator, which theoretically should have produced the sound on artificial vocal cord stimulus, but failed to do so; sixth, he presented his palatograms made according to the technique which shows the height of the subject's palate, its curvature, and any abnormalities such as growths or indentations.

Gumpertz applied palatography in a study of the stutterer's speech difficulties, showing very plainly that the stutterer's speech has more variations than the speech of the normal individual (7). In 1936, using the Gumpertz-type pseudo-palate, Madame Louise Kaiser made a series of experiments which she reported in her paper, "The Shape of the Palate and Its Effect on Speech Sounds", read before the Second International Congress on Phonetic Sciences, London, explaining the shape of the palate and its relationship to speech sounds (11). Several years later, Moses, Jr., and a dental student at the Ohio State University, using the type of pseudo-palate developed in the laboratory of the University of Michigan, made a somewhat similar experiment by studying the effect upon speech when the shape of the palate

is artificially altered by filling the high palatal vault. Their primary interest was that of the dentist's problem when making dentures for patients with a high palatal vault (19). In the latter 1930's, R. H. Stetson, C. V. Hugdins, and Moses, Jr., in the psychology laboratory of Oberlin College first combined kymography and palatography by producing a vulcanite pseudo-palate equipped with flexible windows at the points where the tongue strikes, which in turn were connected by rubber tubing to a kymograph. With their new technique they carried on a study which proved conclusively that palatograms change with the rate of articulation (33). Others, too - Haden at McMaster's University, Hamilton, Ontario (8), Moses, Jr., in his thesis project at the University of Michigan (23), Bloomer of Michigan (3), Crane and Ramstrum (3) - experimented with various means of displaying the palatographic diagrams in print by outline drawings and special dot markings, X-ray, photography. But for some years no markedly new and satisfactory technique was developed until in the phonetics laboratory of the University of Edinburgh there was developed a method of palatography in which there is no pseudo-palate employed, but rather a full swing back to the old methods of coating tongue or palate to show the points of contact in articulation without the disadvantages of possible compensation and the resulting incorrect, unnatural positions by the subject, caused by the presence of the pseudo-palate in the mouth, and the inability of the pseudo-palate to cover the sensitive soft palate. In the Edinburgh method the entire roof of the mouth is coated with a mixture of powdered charcoal and cocoa. To record the contact areas, the palatoscope, a box-like apparatus of lights, mirrors, and camera is set up; thus articulation is made, and an immediate photographic record is taken of the palate and the wipe-off areas. There are some slight disadvantages of the method. Because one mirror is between the camera and the palate, the image on the film is, of course, reversed; but by placing the film "wrong way up" in the negative holder of the enlarger this is overcome. Also, the angles required for the mirrors causes the prints to show themselves slightly elongated; therefore, they cannot be used for accurate measurements, although they can be used for comparisons. Another slight difficulty of this method is that the subject does not see his palate exactly as the camera sees it, because of the difference in angle and position of mirror and camera. Elizabeth Uldall and J. Anthony both have employed this method in recent research (1, 35). Claes Witting of Uppsala also employs a direct method very similar to that of Edinburgh (37). Sapon of the Ohio State University, having observed the Edinburgh procedure, made modifications which will eradicate these difficulties of the procedure practiced there. He fitted a reflex camera with a mirror above the focusing screen. This enabled the subject to view his palate through the camera lens and to focus for each exposure, if necessary. He also housed his equipment in a suitcase, thereby making the first portable palatographic laboratory. Experimental studies employed in the direct method show, so Ladefoged states in *The Use of Palatography* (13), "that it is difficult to correlate physiological data about the positions of the vocal organs with the traditional phonetic categories which are used in most descriptions

of speech." In the Scandinavian countries, too, the study of palatography has kept pace with recent developments. Gören Hammerström of Uppsala has published a study on the comparative analysis of both the direct and the indirect methods of palatography (10); and a dentist interested in palatography as an aid in preparing dentures has employed a reverse method of painting the palate - he has painted the tongue, as some of the very early experimenters had done (34).

From the time that phoneticians and linguists first became interested in tongue-palate contacts in the study of human production of sounds, palatography, in one form or another, has been employed. From crude beginnings, wherein the palate or tongue was coated with various mixtures, usually quite unsavory, so that the tongue-palate wipe-off area might be seen more easily after the sound was articulated, and the result recorded on stone or plaster models of the palate, or outline drawings of the palate, through many versions of the pseudo-palate, X-ray photography, planimeter measurements, the linking of kymography and palatography, to a simple recording device of mirrors and a reflex camera combined once more with the very simple method of coating the palate itself, palatography has been employed from the late 1870's to the present day. It is quite likely that as long as linguists and phoneticians are interested in sounds and their production, palatography, in some form, will continue to be employed. Through its use it has been determined that identical sounds could be made by contacts over a large area of the palate, that the stutterer's speech has more variation than the speech of the normal individual, that the same persons frequently make the same sounds in various ways, that the size and depth of the palate alter the articulation of sound, that there is greater accord between the consonant and the following vowel than between the consonant and the preceding vowel, and that palatograms change with the rate of articulation.

Not too many years ago one might have thought that palatography was no longer a choice method to be used by experimenters in the field of phonetics. Today, however, one might conclude that with the advent of new refinements, it is coming into its own once more.

What discoveries yet may be made gives this particular phase of phonetics an interesting and intriguing future.

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