



Why do palatographic data have to be taken seriously?

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Abstract

In this paper, I argue that palatography is a highly informative tool despite its apparent simplicity. The paper begins with an overview of the evolution of palatography, highlighting its intricate detail and variations. Following this, various techniques of palatography are introduced, along with associated challenges, which partly question established views. Subsequently, I suggest linguistic applications of palatography, focusing on its potential to describe place of articulation and inform phonological typology. Moreover, I propose that the inclusion of palatographic data in linguistic accounts can explain contact-induced changes in phonological systems and intra- and inter-speaker articulatory variation. This proposition is supported by a preliminary panel study of a Shughni speaker who demonstrated changes in articulation over one year.

Keywords: speech production, instrumental phonetics, history of phonetics, phonological typology, palatography.

1. Introduction

In modern-day phonetic/phonological research preference is often given to sophisticated instrumental techniques, often requiring substantial funding, advanced technical skills and/or a lot of equipment. Examples include pneumotachography (measuring nasal/oral airflows; Barry & Kuenzel, 1975; Dewhurst, 2023), electroglottography, laryngeal endoscopy (vocal fold activity; Herbst, 2020), ultrasound/MRI imaging (various aspects of articulation, including tongue and larynx movement; Gick, 2002; Hudu, 2014; Mielke et al., 2017; Takano & Honda, 2007), electroencephalography (brain activity; Mai et al., 2022). For additional methods, refer to (Gick et al., 2013). While these methods undoubtedly further our understanding of language mechanisms, most of them are confined to a laboratory setting.¹ This presents a problem for field linguists, who often give up on instrumental phonetic research because of the costs and complexity involved, restricting the phonetic component of their research agenda to collecting acoustic data.

However, certain techniques, despite being cheap, easy to use, and informative, often go unnoticed by linguists. This paper focuses on palatography and argues for its necessity in any fieldwork project concerned with language documentation. I begin by describing the history and different varieties of this technique; this is followed by the discussion of practical aspects of doing palatography in the field and interpreting the obtained data. Finally, I turn to the question of how palatographic data

can be applied to describing the sounds of a language, changes in articulation, and phonological typology.

2. The evolution of palatography

The first instance of using a substance applied to the mouth to investigate the physiology of speech is believed to belong to James Oakley Coles, a London dentist. The procedure he invented around the 1870s involved spreading a sticky substance over the soft and hard palate as well as the upper teeth and, after articulating ‘a letter [name],’ describing where the mixture has been removed (Abercrombie, 1957). This method, later called *direct palatography*, differs from that introduced by the New York dental surgeon Norman William Kingsley in 1879. Kingsley’s version of palatography involved the use of an artificial palate (Abercrombie, 1957; Ashby, 2016, p. 58).

In the following years, somewhat of a boom in the application of palatography to phonetic research happened. Phoneticians from different countries published articulatory studies based on palatographic evidence (see (Gósy, 2023) on Hungarian phoneticians and (Gordina, 2006) on Vasily Bogoroditsky’s work on Russian) and even devised special apparatuses (as James Anthony at the Edinburgh Phonetics laboratory). As in many other cases (e.g., see (Makarov, 2024) w.r.t. the concept of reduction), Eduard Sievers’s ‘Grundzüge der Phonetik’ (Principles of Phonetics) played a significant role in establishing palatography as a mainstream technique (Ashby, 2016, p. 59).

Classic palatography only gives a static representation of the tongue–palate contact during the production of a sound. Furthermore, if several sounds in the stimulus involve contact with the roof of the mouth, the palatogram will be difficult to interpret because of the superimposition of a series of traces. Despite these limitations, palatography was used for studying coarticulation already at the beginning of the 20th century (Hardcastle, 1981, p. 59). In (Ladefoged, 1957, p. 768) it is even stated that ‘in most phonetic investigations it is advisable to make palatograms showing the effect of pronouncing whole words... [it] is preferable to the artificial procedure of attempting to obtain a record of an isolated speech sound.’ The palatograms of *key* and *coo* are then given as references illustrating a shift in the place of articulation of the velar plosive depending on the following vowel.

In the early 1960s, a new version of palatography, electropalatography (EPG), was developed, now employing an artificial palate with metal electrodes associated with certain anatomical landmarks (Hardcastle, 1972; Kuzmin, 1962). With no paint involved, a dynamic study of tongue–palate contact became possible (for details see Hardcastle & Gibbon, 2014).

¹ It is worth mentioning that field linguists are trying to adjust some of these techniques to the fieldwork setting, particularly ultrasound imaging (Gick, 2002; Timkin, 2022).

Later, when computer-based display systems became available², EPG found multiple applications in speech therapy.

Nowadays, in spite of some attempts to reintroduce classic direct palatography into active use (most notably Ladefoged, 2003) as the most convenient means of collecting data on place of articulation, the technique seems to receive limited attention from both phoneticians (as an old-time, unsophisticated research method) and field linguists (not having enough motivation to apply the technique). While there are a few recent studies using data from direct palatography (e.g., Chen & Guo, 2022; Chirkova et al., 2015; Coretta et al., 2023), there is no impression that palatographic evidence has become an essential part of every language description (cf. its absence in plenty of JIPA's illustrations).

3. Techniques of palatography

Since the invention of palatography in the 19th century, several variants of the technique have been used for studying slightly different aspects of articulation. Palatography is called **direct** when no artificial palate is used (opposite: **indirect**). Another distinction lies between its **static** and **dynamic** variants; the former does not give information about the production of every segment in a stimulus (which is usually a word composed of several sounds), yielding a snapshot of all lingual gestures involved. On the contrary, dynamic palatography, also known as **electropalatography**, traces the articulation of every segment involving tongue–palate contact (Hardcastle, 1972; Hardcastle & Gibbon, 2014). Finally, much variation is related to what the paint is applied to. In classic palatography marks are made on the roof of the mouth and teeth by the tongue covered with non-toxic paint. The resulting pictures of the passive articulators are called palatograms. Conversely, if painted is the roof of the mouth, and marks on the tongue are photographed, such technique is called **linguography**³ and obtained pictures are linguograms (Gick et al., 2013, p. 181). However, if the regions of the roof of the mouth (or the artificial palate) where the marking medium was wiped away are inspected instead, this is still palatography (Ladefoged, 1957, p. 764).

In all kinds of palatography except for EPG some kind of marking medium is used. In the earlier versions of the technique, this substance could include a range of ingredients including meal, mucilage, ink, chalk and even alcohol (Abercrombie, 1957; Gósy, 2023, p. 684; Witting, 1953). However, in modern versions, a mixture of edible cooking oil and powdered charcoal is used as it is non-toxic and almost tasteless (Anderson, 2008, p. 5; Ladefoged, 2003, p. 38). Sometimes instead of the oily mixture a black powder made of charcoal and drinking chocolate is sprayed (Abercrombie, 1957, p. 23; Ladefoged, 2003, p. 45).

² The first techniques of EPG required a high-speed camera to photograph the read-out panel rendering contact areas with a number of circular spots of light corresponding to the electrodes in the artificial palate (Hardcastle, 1972).

³ Technically, it is still palatography, cf. its treatment in (Ladefoged, 2003; Witting, 1953). The term *linguography* emerged as an attempt to clarify what part of the mouth is painted first, though it seems quite unnecessary as eventually both the palate and the tongue get marked. Moreover, when palatography was invented (see Section 2), a sticky substance was spread over the palate, just like the paint in linguography.

4. Issues in palatography

4.1. Analysing the photographs

Since palatography is used primarily for identifying the place of articulation (or sometimes the part of the tongue involved) the palatograms/linguograms need to be mapped onto some kind of articulatory categories (e.g., dental, alveolar, palato-alveolar; apical, laminal; etc.). Concerns were raised regarding the loss of information about palatal morphology. As Ladefoged (1957) puts it, 'A view of the palate from a point at right angles to the dental... preserves the ratio between the length and the width of the palate only at the expense of giving an inadequate impression of the depth of the palate. As a result, palatograms often fail to convey important information concerning the shape and depth of the palatal cavity, and the position and slope of the alveolar ridge.' To solve this problem, Ladefoged suggests that a cast of the mouth be made and sawn along the mid-line. However, it is rather unclear whether this 'important information' is linguistically relevant and essential for drawing conclusions concerning place features.⁴ There is only a limited number of hypotheses on how palatal morphology could influence phonology (e.g., Makarov, 2022, p. 161; Moisiuk & Dediu, 2020) and therefore it seems that for linguistic research the loss of the third dimension in a palatogram is negligible.⁵

A useful practice is using zones of the roof of the mouth as reference points. In spite of differences in dentition, it is usually possible to determine the frontmost contact in the palatogram. While distinguishing between dentals and alveolars is quite straightforward, further articulations can be assessed based on the horizontal lines corresponding to specific teeth as suggested by (Firth, 1948), whose system was successfully used, for example, in (Kim, 2001; Makarov, 2025). Ladefoged (1957, p. 772) criticised Firth's using the teeth as reference points on the basis of (a) 'insufficient correlation between the positions of specific teeth and the positions of anatomical features... which are important in determining the acoustic quality of a speech sound' and (b) 'several teeth may be missing, and there may or may not be gaps between the teeth which remain; sometimes the teeth... overlap; and nearly always the posterior molars are not far enough back to provide adequate reference points on the soft palate.' As for (a), it is doubtful that assigning a place label has to be in any way affected by acoustics (see Section 5.1 on dentals vs. alveolars, which are difficult to distinguish by ear); challenges evoked by dentition in (b) seem to be mitigated if Firth's zones are perceived not as absolute but rather relative reference points. It is usually possible to reconstruct the zones based on their expected widths, even if the teeth are absent or displaced.

It is also noteworthy that attempts were made to call palatograms 'linguagrams' instead (Abercrombie, 1957, p. 22).

⁴ As (Witting, 1953, p. 60) puts it, 'there is a **theoretical** [highlighted by me. — Y. M.] possibility of a correlation between palatal anatomy and articulations taking place in that region.'

⁵ Especially for a field linguist, for whom making impressions means more weight in the backpack and more excuses to obtain an informant's consent.

4.2. Number of speakers and choosing the technique

One of the most important issues to consider when undertaking palatographic research is the number of speakers sufficient for drawing conclusions. As put by Ladefoged (2003, p. 31), ‘a sufficient number of speakers [is required] to make sure that you are describing properties of the language, and not just the personal characteristics of one or two people.’ The problem is that *sufficient* is dependent on many factors, one of the most crucial being how many people there are to work with. Most of the palatographic studies seem to rely on data from only a few speakers, from one to four. Hypothetically, it may be enough to capture a possible articulation but surely does not suffice to detect variation and determine the relative frequency of the variants. Such a small number of participants is especially upsetting when the language in question is not minor but has millions of speakers. For example, in (Kim, 2001), the study of Korean sounds is based on data from only four subjects while the number of Korean native speakers is ca. 80 million. Although getting subjects’ consent can be difficult in some cultures as the procedure involves physical interaction with the mouth, it is not impossible to get a higher number of subjects even for minor languages. For instance, in (Makarov, 2025) data from seven speakers of Shughni are analysed, and Shughni is spoken only by ca. 100,000 people in the Pamir Mountains. It is necessary for the researcher to clearly explain the technique and demonstrate its safety, which usually helps in obtaining consent.

The choice of the specific kind of palatography is also related to the number of subjects one can get. It is obviously not possible for an average field linguist to perform EPG or even indirect palatography since making an artificial palate is too resource-intensive.

4.3. Choice of stimuli

Another important issue is the choice of words to be investigated. As was discussed in Section 2, pronouncing separate sounds should be avoided as it is likely to evoke unnatural articulations. An ideal token for the basic study of sound production (not coarticulation) should have only one lingual consonant paired with an open vowel. Having more than one lingual gesture requiring contact with the roof of the mouth will mar the palatogram and hence decrease its reliability. Open vowels like [a] and labial consonants are good supplements to the target sound.

4.4. Synchronisation with audio recording

In the history of palatography, many attempts were made to synchronise the palatographic procedure with audio recording (e.g. Witting, 1953). While it can be useful in theory, in reality, it seems to be redundant. To make sure that the studied utterance is natural the researcher has to supervise the procedure on-site and ask to repeat it in case of failure. Using the resulting recording for acoustic analysis will not be particularly fruitful as it is only one repetition without any carrier phrase (so it will not even be possible to perform statistical analysis). Moreover, if indirect palatography is used, pronunciation will inevitably be altered because of the artificial palate. The only reasonable application of synchronised audio is for dynamic palatography as it can help inspect particular stages of sound articulation.

5. Linguistic application of palatography

In the following sections, several applications of palatography will be discussed. All of them are linguistically relevant and

useful for both language documentation and theoretical matters.

5.1. Classification of coronal sounds

The attribution of coronals to dentals or alveolars often lacks any clear explanation, not to mention instrumental evidence, though a palatographic study offers an easy solution to the problem. For example, the description of the Shughni phonemic inventory by Edelman & Dodykhudoeva (2009) states that /t d ts dz θ ð s z n r l/ are dental while Olson (2017) considers /ts dz s z n r l/ alveolar and only /t d θ ð/ are said to be dental. In both cases, no reason is given in support of either claim. The subtlety of the dental–alveolar distinction and its absence in the phonemic systems of major European languages, spoken by the scholars, may explain this discrepancy. Nevertheless, they cannot be taken as an excuse for an underworked phonetic description.

Typologically, the dental–alveolar phonemic contrast is a phonetic rarum (Molineaux, 2022, p. 663). For instance, in Urarina, an Amazonian isolate spoken in Peru, there is a distinction between the apical dental /ɖ/ and apical alveolar /d/, cf. /ɖaka/ ‘wife’s brother’ vs. /daka/ ‘yesterday’ (Elias-Ulloa & Aramburú, 2021, p. 144). The contrasts of such kind tend to be marginal and unstable, and often require support from another phonetically salient feature (Molineaux, 2022, p. 662; Wilkins, 1989, pp. 85, 88). There is a set of factors potentially influencing the dental–alveolar distinction in such phonetic systems, which includes language contacts. Provided that there are no accurate phonetic data, not only adequate phonetic/phonological descriptions (see the Shughni example above) but also the study of contact-induced phonological changes is rendered impossible.

Moreover, there is evidence that the same speaker can change their articulatory gestures associated with the same coronal phonemes. For instance, the same female speaker of Shughni, who participated in two palatographic studies in 2022 and 2023, has changed the place of articulation of /d/ and /s/ from alveolar to dental in one year, see Figure 1.

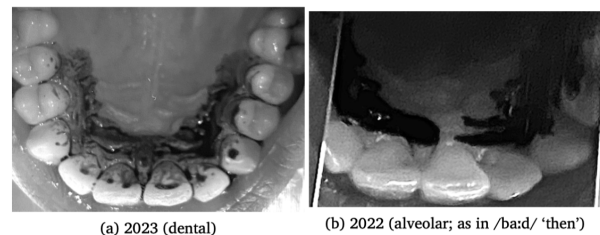


Figure 1: *Palatograms of /d/ in /ba:d/ ‘then’ for the same speaker of Shughni.*

Currently, there is no apparent factor explaining this articulatory shift; possible explanations may be learning a new language and/or physiological changes. Another problem to be considered here is allophonic or free variation within the same language. The study of Shughni coronals (Makarov, 2025) has demonstrated that seven speakers of Shughni unanimously produced /t/ and /ð/ as dentals, unlike /s/, which was alveolar in the speech of five speakers and dental in two other cases. The production of these sounds was neither influenced by the context (always the same word) nor by extralinguistic factors and can be an indication of free variation (oddly selective) or a shift from the dental articulation of /s/ to the alveolar one. The exact answer would require a series of palatographic studies of the same language and, importantly, as many participants as

possible since the variation is barely observable within two or three speakers, usually involved in palatographic research.

5.2. Beyond the front of the mouth: Shughni velars

The usability of palatograms sometimes extends beyond the realm of articulations in the front part of the mouth. The peculiar quality of velar fricatives in Shughni, characterised as ‘the German *ch* of *ich* sibilated so as almost to resemble an English *sh*’ by one of its first scholars (Shaw, 1877, p. 98), has attracted much linguists’ attention in the 20th century. The explanations of the hissing, not typical of velars like /x/, included the grooved shape of the tongue (Sokolova, 1953, p. 137) and the raising of the tip of the tongue (Karamshoev, 1963, p. 69). Both sources, however, provided no instrumental evidence for the claims. A recent study has shown that neither of them works for the nowadays speakers of Shughni (Makarov, 2025): there are neither significant differences in the shape of the tongue compared to the typical /x/ (as in Russian) nor a sign of any front oral constriction.

6. Conclusions

In this paper, I discussed the history, different techniques and applications of palatography. Despite it may seem unsophisticated, palatography has abundant detail and can be used for studying a variety of topics, not limited to articulations of a particular language.

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8. References

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