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THE PHONETICS OF PIE **D* I: TYPOLOGICAL CONSIDERATIONS

Abstract

While the phonetic details of most PIE obstruents have been the topic of numerous studies, the coronal stops have attracted less attention, possibly as the result of their non-controversial status, vis-à-vis velars or laryngeals. Yet, several early Indo-European languages display asymmetries in the development of the coronal stop series, with the voiced member typically behaving differently from the voiceless and the aspirate. Such an asymmetry may thus well be of PIE origin and in the light of the recent arguments for PIE implosives, could result from the earlier implosive character of Pre-PIE mediae, which finds support in phonetic typology. This paper presents typological background for the phenomena and the situation regarding the reconstructed PIE phonology.

Keywords

Proto-Indo-European; phonology; coronal

1 Asymmetries in phonological systems

Phonology is principally an abstract domain, dealing more with neural representation of speech-sounds than with the corresponding phonetic reality down

I am indebted to Radek Skarnitzl for making available the data from his unpublished research as well as for discussion of the phonetic details. An early version was presented at East Coast Indo-European Conference 32 in 2013 in Poznań and I have benefited much from the comments of Martin Kümmel and Hans Hock. Ronald Kim and Reiner Lipp helped clarify some facts to me and I owe them thanks. Needless to say, I alone am responsible for any errors. I also acknowledge the support of the research program Progres Q10 *Jazyk v proměnách času, místa a kultury*, sponsored by the Charles University.
Editors decided to propose the author split and rework the original single paper. Their decision was based not only on the reviews but also on their judgement since the paper contained two independent methodological approaches better not to mix in a single article. Namely, the first part is principally typological and synchronic, devoted to asymmetries in the phonological systems, complete with the case study of Modern Czech and the general overview on coronals, with the case study on Modern Irish. On the other hand, the second part is a fully diachronic study, analyzing data of given IE languages.

to the minutia of gesture-timing and air-pressure fluctuations. This is largely inevitable, as "phonological constraints tend to ban phonetic difficulty in simple, formally symmetrical ways" (Hayes 1999, 252). This is even more true with reconstructed systems, where phonetic detail is often difficult to establish as evidenced by the long-standing debate on the nature of PIE laryngeals. The ideal featural matrix of PIE stop phonology, with its 3 by 5 systemic tier, is a model which should reflect the phonological system of a real spoken languages some time around 4500 BCE. An abstract system, as represented in diagrams, is by its nature largely symmetrical, and the presupposition of symmetry may even at times find expression in linguistic reconstruction, e.g. Karl Brugmann (1897, 92) posited for the PIE a sibilant series **s *s^{h} *z *z^{h}* with no support in the data, parallel to the stop series **t *t^{h} *d *d^{h}*, which on the other hand rested on ample evidence from daughter languages, or in a similar manner Ringe (1996, 1) positing the values **x́ *x *x^{w}* for the three PIE laryngeals on implicit analogy to the velar series. The reality of the 3×5 system is not guaranteed by its abstract symmetry but by linguistic data and even at this level, the unexpected lacuna in the attestations of PIE **b* has inspired much speculation and re-appreciation of the features of PIE stops and an asymmetrical system lacking the voiced bilabial. Such an asymmetry can be easily documented from other languages and linguistic families, such as Arabic, Japanese, Proto-Celtic, Proto-Armenian, where the voiceless *p* evolved into a fricative φ (later *f, h, Ø*) while the voiced counterpart is left intact. These sub-phonemic asymmetries may remain hidden and undetected for a long period (especially if the data consists of written records) but may be revealed by phenomena which more easily affect some specific sub-regions of a larger psychoacoustic or articulatory area, and may conspire to cause such deviations as the loss of the voiceless labial in Celtic.

On the phonetic level, asymmetry is the norm – only its degree relative to any two phonemes bound within some featural contrast varies. In extreme cases, this asymmetry may reach a level which under different circumstances, or within the history of a single language, is equivalent to a phonological contrast. For reasons of gesture coordination, air-pressure sustenance, muscular tension and various others factors, the phonetic realisation of two stops, or indeed any two segments, distinguished at the phonological level solely by the feature of [voice], and *mutatis mutandis* for other laryngeal features or air-stream mechanisms, is never as symmetrical as the abstract representation (with the important implication that switching of the contrastive phonological feature need not result in acoustic merger). In fact, almost any such pair of segments need not behave in parallel, need not be pronounced at exactly the same position and though they may be conveniently described as, say, velar, for the purposes of phonological analysis or historical reconstruction, their EPGs would differ, sometimes, as with Czech, considerably (section 1.1). The space available for asymmetry in any region depends also on the relative versatility of the articulatory organs in question, and specifically for the

problem at hand, the area of coronal segments is typically more diversified and depending on the number of phonemes or contrasts within this area, relatively more open to substantial sub-phonemic asymmetry.

Since minutia of sub-phonemic contrasts are demonstrably both audible to speakers in language-contact or dialect-contact situation and acquired by bilingual speakers, there is no objection to maintaining that they can be preserved and copied from one generation to the next over a long time. Thus it is possible *in principle* that the asymmetry typical of Czech (1.1) was present in West Slavic as such. Or perhaps in North Slavic? In Common Slavic? It appears that unless separate motivations are found in some stage of its prehistory for this "articulatory split" within the coronal series, this situation should be projected back to the last reconstructed ancestor of Czech, which happens to be Proto-Indo-European. Now, this being possible *in principle*[2] (e.g. there are IE languages which still continue the bilabial nature of PIE **w*, while it was mostly replaced by *v,* so that projecting English *w* to PIE is both possible and in this case correct), Czech alone, or in fact any pre-stage of Balto-Slavic alone would not suffice to prove that this is indeed the PIE situation – it would be even naïve to assume this were the case.

On the other hand, the behaviour of the reflexes of PIE **d* vis-à-vis **t* and **d^h* in situations where symmetry either would be expected by default or is even documented in the velar or labial series (e.g. ranging from the way they are represented in the writing system to effects of palatalization, assibilation or lenition), is well-known. I believe that positing such an asymmetry for PIE could enhance our understanding of a number of such cases and at the same time contribute to the debate on the nature of the original contrast between traditional tenues, mediae, and mediae aspiratae.

1.1 Case study: Czech coronal asymmetry

As the modern phonetic science reaches back to no more than 150 years, synchronic data on sound systems which could support the long-term stability of phonetic asymmetry is scarce. One such example is modern Czech and in this respect both the synchronic facts and the reappraisal of previous scholarship is potentially illustrative.

Skarnitzl (2014) in his study on the articulatory differences between Czech coronal occlusives mentions a number of facts which are relevant for our purpose.

1 Cf. Keating (1991, 29) "[C]oronals include more contrasts of both place and manner than do other consonant classes. For example, with respect to manner, affricates and liquids are most often coronal. With respect to place, Maddieson's survey recognizes five primary places of articulation that are commonly classified as coronal (dental, alveolar, palato-alveolar, retroflex, and palatal), and only five other primary places (bilabial, labiodental, velar, uvular, and pharyngeal), so that coronals account for half of the primary places of articulation."

2 Comp. such an attempt by Kortlandt (1997) to project features of MnE phonology back to PIE.

Building on Maddieson (1984), he writes (p. 101): "It appears to be even rarer for a language to have one *t–d* pair in which the articulation places would differ: Maddieson (1984) mentions only two languages where an asymmetry within the voicing pair is explicitly stated and does not involve any other difference like pre-nasalization. Sundanese is described as having a dental /t̪/ and an alveolar /d/, while Kunimaipa has a dental /d̪/ and a /t/ which is classified as "dental/alveolar"." In this typology, Sundanese would be the single language with a system similar to Czech. Note that the asymmetry in Czech has first been described in the early 20th century and yet it has somehow escaped notice of phonetic typology. Clearly there are other languages for which this description is true, e.g. Finnish[3]. The rarity of the phenomenon is thus hardly established, in fact, such detailed studies as Skarnitzl are simply missing for many languages which would have been catalogued as "alveolar" or "dental" with respect to this articulatory position. But a little difference can go a long way in terms of sound change.[4]

The systematic contrast between Czech [t] and [d] and [n] are such that [t] is laminal and articulated closer to the dental area, while both its voiced and its nasal counterparts are apical or post-apical and articulated against the alveolar ridge. Skarnitzl (2014, 108): "Our results therefore indicate that the place of articulation of [t] and [d] in Czech is indeed different and that the difference is certainly not negligible and caused merely by the aerodynamics of the fortis–lenis distinction, as suggested by Hála (1962) and Borovičková and Malač (1967)." and (p. 110) "A more accurate account of Czech stops would have to state that [t] is a denti-alveolar sound and [d] an alveolar or even post-alveolar sound.[5] *Since the earliest reports about this asymmetry are over 100 years old, it would appear that it forms a stable characteristic of the Czech sound system* [italics JB]. The nasal stop [n] tends to lie closer to [d] as far as its articulation place is concerned", see Skarnitzl (2014) fig. 1.

The preliminary analysis undertaken by Skarnitzl (p.c.) also shows systemic difference between Czech [t] and [d] in neutralizing environments. While both assimilate for +/-[voice], the articulatory position is maintained, so that e.g. /plot byl/ "the fence was" shows the more laminal voiced [t] rather than [d], while /plod byl/

3 Suomi et. al. (2008, 33) "Finnish /t̪/ and /d/ thus differ from each other in a number of respects. The places of articulation are different – /t̪/ is laminal dentialveolar and /d/ apical alveolar – and the place of /d/ is fronted during the occlusion. The duration of the occlusion of /t̪/ is roughly twice that of /d/, and finally, /t̪/ is usually voiceless, /d/ voiced. The differences in place and duration imply that the opposition is not a genuine voice opposition, as the consonants differ considerably from each other." Similar distinction has been reported for Hadrami Arabic (Habtoor 1989).

4 E.g. the assibilation of coronals in modern English vs. French would alone suffice to deduce that their primary place of articulation is different, e.g. English *got you* as [gɔʧə] and Quebeck French *petit* [pet^{s}i] 'small' (Cedegren et al. 1991).

5 Note that the EPG does not show the position of the tip of tongue for [t], which is resting on the back of the lower teeth.

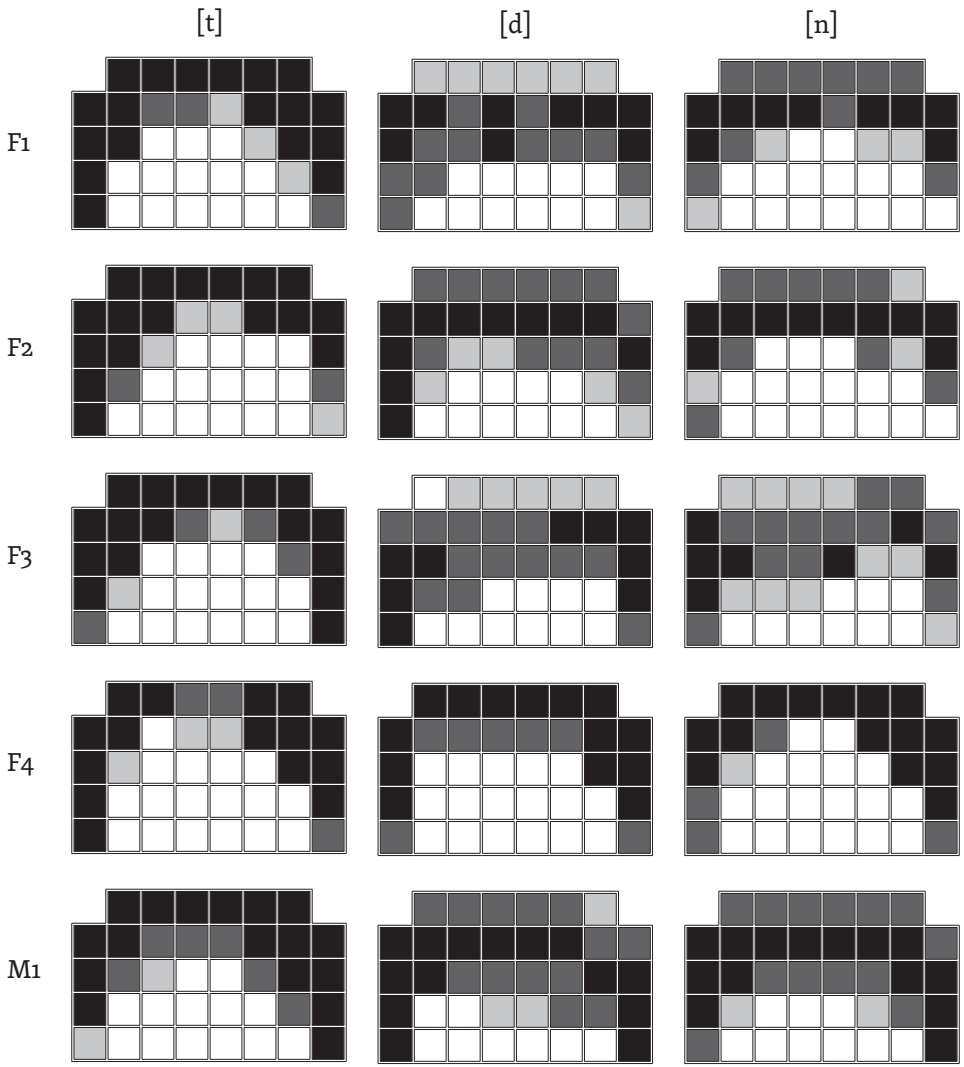

Figure 1. EPG patterns for Cz.[t], [d], [n], in Skarnitzl (2014, 105)

"the fruit was" shows the voiced apical occlusive, and *mutatis mutandis* for voiceless assimilation.

As a separate, but related problem, Skarnitzl presents the data for Czech [n], which patterns with the voiced stop. Since studies for languages with a system similar to Czech are lacking, it is not clear whether this patterning is regular and to be expected, or whether this is a particular fact about Czech. For Finnish, at least, the situation appears to be similar (Suomi et al. 2008, 28–29), even if the origin of the contrasts

must be also taken into consideration: "Languages usually have nasals at roughly the same places of articulation as they have plosives. This is true also in Finnish (but while /t̪/ and /n/ are both broadly coronal, the main allophone of the former is laminal dentialveolar, the latter apicoalveolar)."

Skarnitzl also examined the two Czech stops with respect to their behaviour in co-articulation in intervocalic environment, with the stop flanked on both sides with identical vowel ([iti] [ada] etc.). His conclusions (Skarnitzl 2014, 110) are again interesting for our study: "Since our observations indicate that Czech [t] and [d] also differ in the role of the tongue tip and blade, comparing linguopalatal patterns in different vocalic environments allowed us to indirectly try to disentangle the effect of the apical *vs* laminal character of the stop and of its voicing on the degree of coarticulation resistance manifested by the given speech-sound. Our analyses suggest that the voiced, apical [d] undergoes more coarticulation, which also explains the higher variability observed in the contact anteriority index." This is in fact confirmed by the Finnish data (Suomi et al. 2008, 33).

1.2 Implosives/non-explosives and the PIE stop inventory

In 2009,[6] the implosive (non-explosive) character of PIE voiced stops as a class was proposed by Weiss (2009) as such a system, consisting of a voiceless, voiced, and voiced implosive, apparently gave rise to a situation similar to the traditionally reconstructed PIE triad T-M-MA in Cao Bang. Similar hypothesis was independently formulated by Martin Kümmel, and is further developed in Kümmel (2012a, 294) and is gaining popularity among scholars (e.g. Prósper 2019), for a recent evaluation of this theory see Lipp (2016, 273–288). Thus establishing that PIE also may have had such an asymmetry in its system would lend further support to this hypothesis, on the condition that it could be shown that the voiceless and the voiced aspirated stops operate differently from the "plain" voiced stops, and possibly the corresponding nasal.

Among the possible sources for the asymmetry in PIE coronals, it is of special interest to the research on PIE phonology to mention the effects of implosive, or non-explosive articulation on voiced coronals, as documented in a number of African languages, e.g. Yigezu (2006, 823), for Majang (Ethiopia): "as compared to the non-implosive dental stops, implosives are very often retracted to alveolar or alveo-palatal position and are consistently *apical* [italics JB]." and Demolin (1995, 370) "In Lendu, the non-implosive /t/ and /d/ are dental while /ɗ/ is alveolar *retroflex* [italics JB]."

6 The idea of implosives in PIE phonology is not new, of course. Already Meillet (1937, 137) proposed this articulation for final **-d*, which however was not a phonological feature, and the various glottalic models of PIE stop inventory are to a certain degree compatible with implosives, in some cases in fact the difference may be mainly terminological.

2 Coronals in general and in PIE

Languages, where dentals and alveolars are phonologically contrastive are very few (Maddiesen 1984, 32) and PIE does not seem to have been one of them – which in turn allows for a greater sub-phonemic variation in this area and it should not be surprising to find that different IE branches inclined towards the one or the other, or that shifts in-between these positions occur for various reasons. This relative freedom of articulation also allows for each unique combination of features within this region to accommodate in the most convenient (in terms of perception and articulation) area, be it dental or alveolar.

The PIE series and the reflexes thereof in separate branches are variously referred to by scholars as "dental-alveolar", "dental(s)", "apical(s)", "alveolar(s)", but frequently without any explanation as to this usage (i.e. whether it is a cover up term, or a formulated judgement on the phonetic detail). Thus e.g. Mayrhofer (1986, 101–102) gives no justification to his use of the broader term "dental-alveolar" and apparently is either unwilling to commit to either of the two possibilities or does not consider this problem relevant for his perspective on PIE system. For Beekes (2011, 101) they are simply "dentals", again, without further comments. Sihler (1995, 190–192) for no explicit reason refers to the PIE series in question as "apicals". Meier-Brügger (2010, 258–259) refers to this class as "dental", and in the same way Byrd (2017, 2061). This may simply be a matter of personal taste (the difference between *tectals* and *velars* does not really amount to much more in the 21st century). This list could be easily expanded by other works on the topic.

In the same way, several authors writing on the phonology of diverse older IE languages use "dental" and "alveolar", or a combination thereof, without further comment. This terminological vagueness has little practical importance (if it is, after all, a cover-up term in the same way as **b*^{h} simply represents a position in the PIE system the phonetic essence of which remains a matter of debate). Yet, while much effort has been invested in reconstructing the exact nature of the phonetic and phonological contrast of PIE stops or laryngeals, or the articulatory position of velars, the labials and dentals have so far been, in my opinion, neglected.

2.1 Coronal obstruents

Coronal articulatory area has been the focus of extensive scholarly debate among both phoneticians and phonologists over the last decades. Coronal segments are pronounced with the flexible front part of tongue, the tip and the blade over much of the front part of the oral cavity. As the difference between "dental", "apical", and "alveolar" (within the larger class of coronals) is crucial to this debate, at this point a brief clarification of terms should be made. The four terms "dental", "alveolar", "apical", and "laminal" appearing in linguistic literature (especially outside phonetics proper) are related in a complex and sometimes contradictory, or

at least misleading manner, especially if one needs to tease out the details of the tongue-palate relative position in order to identify correctly the initial stage of a sound change. The "dental", *vs.* "alveolar" distinction gives the impression that contact is made either with the dental ridge or the alveolar ridge – in reality, the principal point of closure is at the alveolar ridge for both (e.g. the acoustic difference between [t] [d] French and English depends on shape of the oral cavity behind the point of occlusion which determines the vocalic transients and the difference in vocalic transients depends on the active articulator and the necessary adjustments of the tongue body behind the point of closure). The important distinction is thus in the active articulator, i.e. between "laminal" and "apical"[7], and, for the various processes related to coronals, the relative compatibility of any of the combinations of the active and passive articulators with other configuration, especially those related to front vowels and the palatal approximant, are crucial, as they in turn mandate the different assimilatory strategies and gestural adjustments.

Given the versatility of the tongue-tip, there are multiple subtypes of coronals which contrast laminal *vs.* apical and alveolar *vs.* dental positions, which can be described with respect to the position of the tip of tongue in the following manner, of which the following are most relevant to this topic:

1) **apico-alveolar** (with the tip touching the alveolar ridge and a lowering of the dorsum), e.g. the Czech [d], English [t]
2) **lamino-dental** (with the tip lowered into the interdental region and the blade in contact with the alveolar ridge), e.g. Spanish [t]
3) **the post-laminal alveolar** (with the tip lowered further to the lower teeth and a contact in the front dorsal area), e.g. Czech [t]

Another important feature, which is relevant to the outcomes of different processes, is the difference in the contact area: it is comparatively narrower for apicals (cf. the EPG for [d] and [n] in fig.1) and broader in laminals (as shown in the EPG of [t]). This has the following implications: laminal stops are more likely to result in laminal fricatives and affricates while apical stops result not only in apical fricatives, affricates, but also frequently (and without any intermediate stage) in approximants (usually alveolar or post-alveolar), which includes rhotics and lateral segments.

2.2 *PIE coronals*

In PIE, the stops **t*, **d*, and **d*^{h}, the single sibilant **s*, and the sonorants **r *l *n* are clearly coronal, but it remains to be assessed whether closer approximation is possible to the level of the distinction between apical *vs.* laminal and alveolar *vs.* dental. First of all, the once popular solution to the PIE thorny problem, that is the original

7 Though, necessarily, these cardinal points are not in reality a +/- distinction, but allow for intermediate position, which may, depending on the language-specific norm (apical or laminal), be described as post-apical or pre-laminal, or simply – and neutrally – apico-laminal.

phonology of various clusters resulting in e.g. Vedic *kṣ* and Greek κτ χϑ as a combination of a velar and a interdental fricative **þ* or **ð* is now mostly disregarded by scholars (decisively since Schindler 1977). Thus there is no direct evidence for a markedly dental segment in PIE, contrasted to an alveolar.

Next, some information could be obtained by examining the dissimilatory process typical of sequences TT, which typically result in T^{s}T, such as **u̯id-tó-* 'seen', phonetically probably *[wit^{s}to-], whereby an intrusive sibilant-like quasi-segment is inserted to facilitate the realization of the bi-phonemic sequence as two distinct intervals of coronal closure rather than a single, geminate sound. This sibilant is most likely to have been a laminal segment, which is a conceivable result of a temporary release of laminal contact, but on the other hand, an apical quasi-segment cannot be completely ruled out as the situation in daughter languages makes it impossible to decide whether such outcomes would have been significantly different to result in different treatment from original **-sT-* sequences, or even different in graphical representation. Given the constraints on PIE roots which rule out a tautoradical sequence of two coronal stops, and the inventory of PIE derivative suffixes, none of which have an onset in **d*, the second element would have either been the very frequent **t*, or, in a limited number of cases, **d^{h}*, both of which would have been dental in my account, and would be expected to trigger corresponding place assimilation in **d*. This rule is subsumed under the more general elimination of geminates in PIE, which in turn presupposes that the two segments were homorganic and that full assimilation was indeed the result. At best, this change is inconclusive for our general question.

Byrd (2015, 24) notes the rare, if not unique, change of PIE **-rd* to **-r* via possible assimilation (the single example being ***ḱérd* to **ḱḗr* 'heart'), which bears the marks of Szemerenyi's law in broader sense and is suggestive of some level of similarity between PIE **r* and **d*. Since PIE **s* was most probably apical, the proximity of **-rs* (typical source of the lengthened grade of final **-ōr* **-ēr*) and **-rd* would be explained by the apical character of the latter. It is to be noted that this is apparently a case of *unus testis*.

A separate problem, which may shed some light on the phonetics of PIE **t* and **d*, is the supposed neutralization of the two (or three, the possible final **-d^{h}* in PIE is, however, dubious for reasons of its distribution, but perhaps could be expected to have existed) in final position. The phonetic motivation for the change of final PIE **-t* to **-d*, a change which contradicts the common phonetic intuition that phonological contrast of voice is neutralized in favour of the voiceless stop in pre-pausa environment, has been studied extensively over the last few decades, the state-of-the-art and a number of new observations are presented in Lipp (2015, esp. 287–289). Within the approach considered here, and in a manner compatible with Lipp, it is possible to speculate whether the feature [voice] is indeed present in this environment, or whether a pronounced difference in articulation between final **-t* and **-d* may not be able to account for the difference in graphic representation, as final Italic (or PIE) **-t*

may have been articulated as (phonetically) a *voiceless* /d/. Lipp (2014 concludes that the features of the final segment were [–tense, –voiced, –aspirated]), but in general agrees with my (Bičovský 2017 §1c) preliminary conclusion, for which this article presents more arguments, that the articulation of this segment was probably retracted and articulated with the apex. The fact that in Czech, the difference between final *-t* and *-d* seems not to be neutralized by all speakers before the following voiced segment as to the articulatory position strongly suggests that the intuition of the writers of early Latin or Sabellic may have been able to detect the different articulation of the final voiceless segment and attribute it (wrongly, on the phonological level) to **d*.

*2.2.1 The remaining PIE coronals: *n, *r, *l, *s*

In the PIE coronal area, there were four other segments: the nasal **n*, probably also the two liquids, and the sibilant **s*. On occasion, their interaction in the PIE or in the daughter languages may reveal the place and manner of articulation for the coronal stops. For **s*, as already stated, the most probable pronunciation is an apical sibilant, typical of Castillian Spanish or dialectal Greek.

The position of **r* (and **l*, for which see 2.3) and its continuants is slightly less clear, as there are a number of different articulations of this segment, some of which may even be non-coronal. The so-called *ruki*-rule, whereby **s* is retracted to **ʃ* by assimilation to the preceding **r*, high vowels/semivowels and velars, is an indication if its retracted, perhaps retroflex, pronunciation at least in certain environment, and the change is typical of the Satem branches. In the Centum group, it cannot be excluded on an allophonic level but since the possible outcome (**ʃ*) is nowhere phonologized, it is difficult to discern and could have just as easily been levelled out by subsequent change, as not present in the early stage. The decisive factor is its apical realization, which (apart from the uvular vibrant) is typical of this class.

The place of articulation for PIE **n* is uncertain and the usual description of this segment in PIE phonology is largely identical to the description of the stops. The observation made above on the patterning of nasals cross-linguistically, i.e. that they usually pattern with stops, does not allow for a more precise reconstruction in PIE once it has been proposed that the coronal series was asymmetrical, unless some kind of patterning can be demonstrated in the daughter languages or PIE itself, which would exclude some members of the coronal class. The PIE **n* may have patterned with the voiced stop, as is the case in Czech and Finnish, but in PIE, there were possibly two classes of voiced stops (in the traditional reconstruction at least). On the PIE level, there is perhaps a single example where an articulatory position similar to **d* would help explain facts: the loss of **n* in auslaut after **ō* (Schindler 1974; Mayrhofer 1986, 159; Byrd 2015, 21), but other explanations are also possible.[8]

8 It should be noted that Kümmel's (2012b) analysis of the possible restrictions of the co-occurrence of nasals and either of the two voiced stop classes indicates that there may have been a constraint on tautosyllabic clusters of PIE nasal+media, as there are far more instances of secured **-ND*^{h} sequences

Thus the sequences of **sd*, **nd*, **ld* and **rd*, if my hypothesis on the character of PIE **d* is correct, were homorganic *[s̪d̪] *[n̪d̪] *[l̪d̪] *[r̪d̪].

2.3 Lambdacism in early Indo-European languages

In numerous languages, the affinity of *l* and *d* is evidenced by either borrowing or sound change (for typology see Kümmel 2007, 77). In terms of articulation, the lateral liquid may cover a large area, from palatal(ized) to retroflex and velarized. The similarity of the palatal λ to the palatal dental is easily documented (e.g. dialectal Spanish pronunciation of <*ll*> /λ/ as [ɟ]) and motivated both acoustically and from the perspective of articulation. One observation to be made is that the chronological sequence favours the change from a palatal lateral to a stop, perhaps because the combination of features [lateral] and [palatal] is relatively more difficult to achieve than -[lateral] and [palatal]. On the other hand, the shift from *d* or *ḍ* to *l* (either by sound change or in language contact situation), which can be demonstrated to have taken place in a number of languages (e.g. Romani and other Indic languages, including Vedic *ḍ*$^{(h)}$) results from the shared apical point of articulation and is motivated by ease of articulation (lenization). It should be noted that data from Italic (Bičovský, this volume 1.4) and Greek (id. 1.2) indicate that the shift can also occur in the reversed order, *l* > *d*. (For more on **d* > **l* and relation to implosives, id. 1.4.)

2.4 Assibilation in early Indo-European languages

Assibilation of coronal segments may result from different processes triggered by different phenomena, either systemic shift (aspirated stops to affricates or fricatives), or a contextual change (lenization), often triggered by neighbouring high vowels or yod (see Kim 2001 for a typology and a phonetic and phonological account of these changes, or Hall et al. 2004). Both types of changes are attested in the early IE languages: in Germanic (see Bičovský this volume 1.1., also Kim op. cit. 83–84), these changes are associated with aspiration in OHG, while in most other languages, the typical trigger is palatalization (for a cross-linguistic perspective, Bateman 2011).

With respect to palatalization and the apical *vs.* laminal opposition, it is necessary to note that the three types of coronals according to the position of the tip of tongue (2.2.) require different degree of contextual adjustment in contact with palatalizing environment and the results of their palatalization may differ considerably (which is also true of assibilation triggered by other phenomena). In terms

than for **-ND*, which is typically the case with implosives, but whether there is any possibility to interpret this pattern to indicate that **d*^{h} rather than **d* was homorganic with the nasal (given that non-labial nasals almost by rule assimilate in position to the following stop) I am sceptical. It is clearly the [nasal] feature rather than [apical] which triggers the shift to a **d*^{h}. At the same time, it is possible that the resulting sequence from ***-nd* would have produced an apical **-nd*^{h} rather than a laminal, but this would have been probably levelled.

of simultaneous compatibility of gestures, the laminal-alveolar contact is compatible with raising of the dorsum against the hard palate, which may in turn result in a laminal sibilant. On the other hand, the apical-alveolars require the lowering of the dorsum away from the hard palate and in order to assimilate the two gestures an adjustment must be made typically resulting in a post-alveolar[9]. Thus the difference between an apical and laminal segment may decide the outcome of the effects of the palatal environment.

In several IE languages, the coronal series is asymmetrical with respect to the outcomes, or even presence, of palatalization and assibilation, often with the voiced **d* patterning with velars in the final outcomes, rather than with coronals. This is the case in Greek, Latin, possibly Vedic, Hittite, or Tocharian. However, it is necessary to stress that multiple factors can influence the process and an eventual merger of the outcomes of palatalization in coronals and velars is no guarantee of shared point of departure. One of these factors is the contrast setting and polarization within the originally very poor sibilant area of PIE, where the original apical sibilant **s* is in most cases contrasted with the new sibilants, which makes it rather more probable that the new sibilants would occupy the contrastive laminal position.

2.4.1 Case study: Irish English

In a study on the synchronic variation of [t] in Irish English, based on 21 speakers of Southern Irish English (Skarnitzl – Rálišová forthcoming), authors note several facts which are of interest to the typology of coronal obstruents and potentially of relevance to the discussion of the Tocharian facts (Bičovský, this volume 1.6.):

1) "the dental fricatives of standard English, /θ/ and /ð/, are realized as dental or sometimes alveolar plosives, [t̪ t] and [d̪ d] in Irish English" (sec. 1 of the manuscript; note that the opposition is also one of aspiration, as the source of [t̪] is not aspirated and neither is [t̪], while the aspiration in [t] is pronounced in the onset of an accented syllable) which means that in the coronal area, Irish English contrast two articulatory areas – in other words, a systemic shift results in a new contrast in articulatory position. It is, however, unclear that the tendency to assibilate [t] is spreading as part of enhancing acoustic contrast between the two phonemes (which would be relevant to the discussion concerning Tocharian) though it clearly has this effect. It also should be noted that the distribution of dentals fricatives *vs.* apical stops and possible homonymic clash is mostly limited to initial position, while Skarnitzl & Rálišová focus on medial and final positions.

9 More precisely: while the assibilated segments resulting from laminal contact are usually "in situ", and the result is determined by the extent of palato-lingual contact over the alveolar to palatal area, apical segments are more varied in their reactions to the problem of smooth transition between the dorsal and apical positions, which may result in the compromise of a laminal position, but may also provoke retraction to the post-alveolar or even retroflex position: one of the decisive factors is the exact contact area on the apex.

2) The typical realization of the /t/ is "a voiceless apico-alveolar fricative" (sec. 1.2., op. cit.), yet the "dataset revealed the presence of another variant: there are 8 items of word-final /t/ which seems to involve laminal articulation and is perceptually very similar to the lamino-alveolar fricative [s]." The authors cite other researchers confirming a transition to final [t^{s}] or [s]. This later outcome is compatible with the result of adjustment between the apical and dorsal area with the laminal position as compromise.

*2.5 Weakening and deletion of *d in early Indo-European languages*

Again, in a number of languages, famously in Tocharian, but to a limited degree elsewhere, the reflexes of **d* (but not of **t* or **d^{h}* at the same stage or in the same environment) are prone to loss, which may be interpreted as resulting from a relatively weak tongue-palate contact area and some level of approximation or articulatory undershoot. As the general assumption among the proponents of the implosive hypothesis (e.g. Kümmel 2012a, 130–2) is that the implosive (non-explosive) character was not inherited into the core PIE (there occurred the shift to the traditional, if short-lived, voiced and murmured segments), it would be difficult to invoke implosion as the feature of **d* responsible for this loss (e.g. Lat. *suāvis* 'sweet, pleasant' for PIE **sweh$_2$du-* 'sweet' and similar cases), unless implosive allophones were inherited in these positions down to Italic or Proto-Tocharian, which, if not completely excluded, would be relatively difficult to support by evidence (see further on this question my objections to Prósper 2019 in Bičovský, this volume sect. 1.3).

Under the typical conditions of weakening in (in pre-consonantal position), apical and laminal elements would be expected to favour different trajectories as again the respective gestures allow for different forms of partial realization and apical segments are more likely to be reduced to a flap, while laminal segments should favour an approximant of a more continuous character. As the final stage in this development is deletion and we lack information on the intermediate steps, we can only speculate that **d* was in some way a weaker element than both the voiced velar, and the rest of the coronal class. It is also noteworthy that no such behaviour is reconstructed for **t* or for **d^{h}*.

*2.5.1 *d > *h$_1$*

A conditioned shift of PIE **d* to **h$_1$* was first proposed by Kortlandt (1983, 98), the so-called "Kortlandt effect", to account for a number of formal discrepancies between the reflexes of PIE numerals and was subsequently adopted especially by the scholars of the so-called Leiden school (e.g. Lubotsky 2012; see also Ligorio 2019, and sceptical Kümmel 2012a, 302–302). It is assumed that PIE **d*, a pre-glottalized segment in the Leiden version of the PIE stop system, lost is oral articulation and the pre-glottalization was reinterpreted as a segment on its own, identifiable by the

speakers as the phonetic content of $*h_1$ (assumed to be the glottal stop). While the equation of $*h_1$ with the glottal stop is not accepted by numerous specialist, it is by no means to exclude the possibility that the outcomes of this change were identical in their later effects on vowels with those of $*h_1$. Again, this change is compatible both with a laminal and an apical **d*, but there are arguments in support of the latter. As shown by MnE, the relatively short contact interval of the intervocalic *t* allows it to either assimilate in voice and become a rhotic flap or, alternatively, to preserve the interval of voiceless closure preceding the release of the stop in the glottal area (i.e. the difference between *city* as ['siri] and *bitter* ['bɪʔə]). If the hypothesis by Kortland could eventually be upheld by a larger dataset it would not amount to more than linking the shift to a weaker closure of **d*. As this change is of relatively low importance to this enquiry, since it cancels oral closure and cannot be in this respect an indicator of its exact position, I will not go into the details of the ongoing debate.

3 Writing systems

A separate and yet equally important problem to the reconstruction of PIE, and of its daughter branches, is the fact that with respect to the phonological or phonetic opposition at hand, the writing systems adopted by early Indo-Europeans, with the exception of Brahmi, Kharosthi, and to a certain extent, Avestan, are ill-equipped to differentiate between multiple articulatory positions in coronals. As the case study of Czech coronal stops and nasals shows, the possibility to trace this type of asymmetry is limited by simple fact of history. Prior to the modern discipline of phonetics, the interpretation of phonetics relies on evaluation of the writing system, complemented by comparative reconstruction, which in some cases may also rely on synchronic evidence – and must at any rate be consistent with it, and phonetic description of the native linguists, where available. The commensurability of any native phonetic description with modern terminology is problematic, as the former is often vague and its impressionistic nature makes it very difficult to draw decisive conclusions in an area which is so variable cross-linguistically. Needless to say, in many cases, neither the native description, nor the modern descendants are available, and the extrapolation of the writing system with reconstruction is the only available tool.

The inadequacy of the adopted writing systems coronal stops (where only the Indic script distinguishes "dental" *vs.* retroflex consonants) and more importantly, with coronal fricatives and affricates. Thus the important difference, both in terms of reconstruction and synchronic fact, between laminal and apical fricatives can only be gleaned indirectly from scribal practice, errors, and from contact phenomena.

In this way, the mapping of both cuneiform to Hittite and Phoenician script to Greek reveal that the single IE sibilant **s* was closer acoustically to the phoneme

represented by the syllabograms *ša še šu* or the grapheme š, respectively, and this in turn allows us to narrow down the possible realization of **s* to an apical sibilant. But the examples of individual characters, such as *tau gallicum*, the exact phonetics of which are a matter of on-going debate, are numerous and whatever light they may shed on the topic at hand is limited by this very fact. As discussed in Bičovský 2021 (this volume), such an asymmetry in representation of coronal stops in Greek may well reflect a significant difference in their realization. And in a similar fashion, the use of <-d> for final apical in Italic may be the result of perceived difference in tongue-palate configuration for *t* and *d* in this branch.

4 Conclusion

With respect to an asymmetry in coronal stops in PIE (possibly the result of earlier non-explosive character of the mediae), it is possible to conclude, that the behaviour of PIE **d* vis-à-vis **t* and **d*^{h} suggests a considerable level of phonetic asymmetry. Typological evidence, limited as it is diachronically, suggests that such an asymmetry can be maintained over several generations – and in principle, over millennia. It can also be concluded with some confidence that the difference between apical and laminal realization of stops may result in major differences in the outcomes of such changes as palatalization, assibilation, and lenition.

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