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The Reconstruction of the Proto-Indo-European Stop System

Alwin Kloekhorst and Tijmen Pronk

1 Introduction

In this chapter, we will bring together the insights of the individual chapters in this book in order to assess which of the proposed reconstructions of the stop system of Proto-Indo-European require fewer and typologically less problematic assumptions and to identify remaining questions that will have to be answered in the future. As elsewhere in this volume, we will refer to the PIE consonants under investigation as “stops”, even though the reflexes of these consonants are fricatives or affricates in some of the daughter languages.

We will operate with the following three considerations regarding the Indo-European family tree:

1. The view that Anatolian was the first branch to split off from Proto-Indo-European seems to be widely accepted.
2. The view that Tocharian may have been the second to split off is considered as a good possibility by most specialists, but generally not regarded as proven.
3. The following pairs of branches probably form sub-branches together: Indic and Iranian (Indo-Iranian); Baltic and Slavic (Balto-Slavic); Italic and Celtic (Italo-Celtic); and Greek and Phrygian (Graeco-Phrygian). Italo-Celtic and Balto-Slavic have traditionally been controversial, but these groupings seem to be accepted by most scholars nowadays.

For a discussion of these issues we refer to the relevant chapters in Olander (2022a). Whenever we need to distinguish between diachronically distinct stages of Proto-Indo-European, we will use the term “Early Proto-Indo-European” to refer to the stage of the ancestor language from which all known Indo-European branches derive,¹ and “Later Proto-Indo-European” for a stage that is the ancestor language of only a (specific) subset of branches.

1 For adherents of the Indo-Anatolian model, “Early Proto-Indo-European” would be equivalent to what some scholars call “Proto-Indo-Anatolian” (e.g. Kloekhorst & Pronk 2019).

2 The Outcomes of PIE Stops in the Indo-European Branches

In the preceding chapters of this volume, the outcomes of the Proto-Indo-European stops in the different branches have been discussed. This discussion has been summarized in Table 20.1, using the dental stops as the representative for all stop series, in the order **t* (*tenues*), **d* (*mediae*), **d^h* (*mediae aspiratae*). Note that in some cases we have added conceivable alternative reconstructions to those of the authors of the preceding chapters on the basis of the existing literature. Some of the (potential) positional variants discussed in the chapters in this book have been ignored in Table 20.1 for reasons of clarity.

There are several types of features that are used to realize the distinction between the three obstruent series in Indo-European (proto-)languages: voice, voice onset time, phonation, closure duration, airstream mechanism, and level of occlusion (stops versus fricatives). In the traditional reconstruction of Proto-Indo-European, i.e. **[t]*, **[d]*, **[d^h]*, the stops are distinguished by voice and phonation. In the “glottalic” approaches, airstream mechanism has a distinctive function, and in some models closure duration as well. In the following sections, we will first discuss the three series *tenues*, *mediae*, and *mediae aspiratae* one by one in isolation. For each of the series, we will discuss which of the attested realizations would provide a natural starting point from which all reflexes could be derived without resorting to typologically rare or unparalleled sound changes. For each series, it cannot be ruled out that the realization of the PIE stops was different from that in any of the attested languages.² However, this option will only be explored if it leads to the assumption of more natural evolutionary pathways than any alternative reconstruction. After the treatments of the individual series, we will discuss the reconstruction of the PIE stop system as a whole.

² The reconstruction of the Proto-Indo-European palatovelars, which are not reflected as palatovelars in any of the attested languages, is an example of such a reconstruction.

TABLE 20.1 Stop systems in the proto-languages of the branches of Indo-European. The symbol + denotes an additional pre- or post-closure feature that characterizes the stop, either spread glottis (aspirated, murmured) or constricted glottis (ejective, implosive, preglottalization)

<i>Anatolian</i>	Proto-Anatolian *[t̥], *[t], *[t] < pre-Proto-Anatolian *[t̥], *[t̥ʰ], *[t̥]
<i>Tocharian</i>	Proto-Tocharian *[t], *[ts], *[t] < pre-Proto-Tocharian *[t̥fortis], *[t̥+], *[t̥lenis]
<i>Italo-Celtic</i>	Proto-Italic *[t], *[t̥~ʰd], ³ *[θ-, -ð-] ⁴ and Proto-Celtic *[t], *[d], *[d] ⁵ < Proto-Italo-Celtic *[t], *[t̥ʰd], *[ð] ⁶

3 Schrijver [this volume, Ch. 13] reconstructs the Plt. outcome of PIE *mediae* as a voiced stop, *[d], which would derive from a Proto-Italo-Celtic preglottalized *[ʰd]. However, Lachmann's Law, which is a specifically Latin vowel lengthening before *media* + *tenuis* or **s*, has been explained as having been caused by preglottalized stops (Kortlandt 1989). Lachmann's Law is traditionally attributed to the lengthening effect on preceding vowels of voiced stops (Weiss 2020: 190–191), but this raises the question how the voice was realized before a voiceless obstruent and why the *mediae aspiratae* did not have the same effect. As Kortlandt's reconstruction offers a plausible answer to these questions, it is conceivable that the preglottalized realization of the *mediae* that is reconstructed by Schrijver for Proto-Italo-Celtic was still present in Proto-Italic. Given its voiceless outcome before *tenuis* and **s* but voiced outcome before resonants and vowels, we may then reconstruct it as *[ʰt̥~ʰd].

4 The Proto-Italic reconstruction of the outcomes of the PIE *mediae aspiratae* as *[θ-, -ð-] follows that of Schrijver [this volume, Ch. 13]. Alternative reconstructions are, however, conceivable. The pre-Latin distribution between word-initial *[θ-] and word-medial *[θ-] as the outcomes of PIE *mediae aspiratae* could as easily be understood as deriving from an earlier situation *[θ-, -θ-] with voicing of word-medial *[θ-] to *[θ-] due to lenition, as from an earlier *[θ-, -ð-] with subsequent devoicing of word-initial *[θ-] to *[θ-] as is assumed by Schrijver. In Sabellic, the outcomes of *mediae aspiratae* seem to have (originally) been voiceless fricatives in all positions in the word: PIE **b^h, *d^h, *g^{wh}* > Sab. *f-, -f-* (allophonically [-β-], cf. Stuart-Smith 2004: 91, 108); PIE **ǵ^h, *ǵ^h* > Sab., Lat. *h-, -h-*. Moreover, the pre-Latin distribution *[θ-, -ð-] matches that of **[s-, -z-]* < PIE **s*. It is thus quite conceivable that the Proto-Italic outcomes of PIE *mediae aspiratae* were initially voiceless fricatives: PIE **d^h* > Plt. **[θ]*.

5 This Proto-Celtic reconstruction follows that of Schrijver [this volume, Ch. 13]. Note that other phonetic interpretations of the two Proto-Celtic stop series have been proposed as well. E.g. Stifter (2024) states that “[p]honetically, the contrast between the D-series and the T-series may rather have been that between ‘lenis’ voiceless consonants and ‘fortis’ aspirated voiceless consonants” (with references to Stifter 2017: 1191 and Eska 2018), which would imply a Proto-Celtic stop system without voice, i.e. **[t̥^h], *[t̥], *[t̥]*. Similarly van Sluis (2019: 3–36), who adds length to the reconstruction of the fortis series, **[t̥^h]*.

6 This reconstruction of the Proto-Italo-Celtic stop system follows that of Schrijver [this volume, Ch. 13] and is based on the assumption that Italic and Celtic underwent shared innovations in the stop system, in any case the introduction of voiced fricatives. The proposed Italo-Celtic system with only voiced fricatives may seem odd because the feature voice would seem to be redundant, but the presence of voiced fricatives does not necessarily imply the

TABLE 20.1 Stop systems in the proto-languages of the branches of Indo-European (*cont.*)

<i>Germanic</i>	Proto-Germanic *[θ], *[+t/t ⁺], *[t/d/ð] ⁷
<i>Indo-Iranian</i>	Proto-Indic *[t], *[[?] d], ⁸ *[d ^h] (with an additional *[t ^h] < *t ^h) and Proto-Iranian *[t], *[d], *[d] < Proto-Indo-Iranian *[t], *[[?] t~ [?] d], ⁹ *[d]
<i>Balto-Slavic</i>	Proto-Baltic *[t], *[d], *[d] and Proto-Slavic *[t], *[d], *[d] < Proto-Balto-Slavic *[t], *[d], *[d] < pre-Proto-Balto-Slavic *[t], *[[?] d], *[d]
<i>Albanian</i>	Pre-Pre-Proto-Albanian *[t], *[+d/ [?] d], *[d] ¹⁰

presence of voiceless fricatives in the same system (Maddieson 1984: 47–48). If we depart from alternative reconstructions of Proto-Italic and Proto-Celtic, and compare PIt. *[t], *[[?]t ~ [?]d], *[θ] (see footnote 4) with PCl. *[t(:)^h], *[t], *[t] (see footnote 5), we may rather reconstruct PItCl. *[t:/t^h], *[[?]t], *[t].

- 7 In almost all North and West Germanic languages, the reflex of the PIE *mediae* is voiceless with an additional feature (preaspiration, postaspiration, preglottalization, postglottalization, affrication, or gemination), sometimes depending on phonotactic conditions. The varieties of West Germanic where the PIE *mediae* are reflected as plain voiceless stops (Dutch, English dialects in Scotland, Westphalian dialects of German, and Swedish dialects in Finland) are all spoken in the vicinity of non-Germanic languages (e.g. Romance, Finnish), and Schrijver (2013: 122–123) therefore cogently argues that the absence of an additional feature in their voiceless stops is the result of language contact (*pace* Kümmel 2007: 295; 2012: 298, who views it as an archaism). This implies that the reflexes of the PIE *mediae* may be reconstructed for Proto-Germanic as voiceless stops that contain an additional feature, which may be characterized as spread glottis (Salmons [this volume, Ch. 14]) or preglottalization (Kortlandt 1995: 101–104 = 2010: 15–18). The PIE *mediae aspiratae* are reflected in Germanic as voiceless stops, voiced stops, or voiced fricatives. There is no consensus which of these reflexes are more archaic (see, e.g., Goblirsch 1999; 2001 and Kortlandt 1985; 2007 for competing reconstructions).
- 8 De Vaan [this volume, Ch. 15] is not explicit about whether the outcomes of the PIE *mediae* in Proto-Indic need to be reconstructed as plain voiced stops, *[d], or as preglottalized / implosive voiced stops, *[[?]d] / *[d]. He does, however, refer to implosives in Sindhi as possibly inherited.
- 9 De Vaan [this volume, Ch. 15] reconstructs the PIIt. reflex of PIE *mediae* as preglottalized voiceless stops, *[[?]t]. And although this reconstruction may indeed be valid for a pre-stage of Proto-Indo-Iranian (see also Pronk [this volume, Ch. 9]), the fact that both in Iranian and Indo-Aryan the default outcomes of this series are voiced (except when standing before *s or *tenues*, where they are voiceless), would rather invite a PIIt. reconstruction as preglottalized voiced stops *[[?]d] (except before *s or *tenues*, where they were *[[?]t]).
- 10 See Kloekhorst [this volume, Ch. 17] for the term “pre-Pre-Proto-Albanian” and for arguments that may indicate that the pre-Pre-Proto-Albanian outcomes of the PIE *mediae* were voiced stops that contained “a pre-closure feature that in one way or another was laryngeal-like”, and that it is possible that this feature was preglottalization, *[[?]d].

TABLE 20.1 Stop systems in the proto-languages of the branches of Indo-European (*cont.*)

<i>Graeco-Phrygian</i>	Proto-Greek *[t], *[d], *[tʰ] and Phrygian [t], [t], [d] < Proto-Graeco-Phrygian *[t], *[ʔt/ʔd], *[d] ¹¹
<i>Armenian</i>	Proto-Armenian *[tʰ], *[t/tʰ], *[d]

3 The Reconstruction of the PIE *Tenues*

Investigating the development of the PIE *Tenues* in the Indo-European branches, we observe the following outcomes:

- a. short voiceless stop: *[t] (PItCl., PIIr, pre-PBSl., pre-PAlb., PGrPhr.)
- b. long voiceless stop: *[t:] (pre-PAnat.)
- c. short voiceless fricative: *[θ] (PGerm.)
- d. short voiceless aspirated stop: *[tʰ] (PArm.)
- e. unclear (pre-Toch. *[t^{fortis}] as opposed to *[t^{lenis}] < PIE *d^h)

Unless we are forced to assume otherwise, our default assumption is that one of the attested outcomes is that of the Proto-Indo-European *tenues*. Of these options, two can be relatively easily dismissed. If the PIE *tenues* had been voiceless fricatives, like in Germanic, most branches would have had to have undergone “hardening” of these fricatives to stops. Such a hardening of fricatives to stops as an unconditioned development is otherwise unattested for the velar and labiovelar places of articulation (Kümmel 2007: 147–148). In the same vein, the likelihood that the Armenian voiceless aspirates preserve the original realization of the PIE *tenues* seems very low. It would imply that all branches except Armenian independently underwent de-aspiration, which is not particularly attractive.¹² Moreover, the voiceless aspirates of Armenian can easily

11 The reconstruction given by Ligorio [this volume, Ch. 18] specifically has *[ʔt] or *[ʔd] for the *mediae*, but given the outcome *t* in Phrygian, it may be better to reconstruct PGrPhr. *[ʔt]. The additional (glottalic) feature would account for the distinct reflexes of the *mediae* in Greek and Phrygian, and potentially also for the initial vowel of Gr. ἰχθῦς ‘fish’ and ἰκτίς ‘kite’ (van den Oever *apud* Kloekhorst 2016a: 58–59; Kloekhorst & Lubotsky [this volume, Ch. 8]). See Kloekhorst [this volume, Ch. 4] for a scenario as to how Gr. [tʰ] may have developed out of PGrPhr. *[d].

12 It is often assumed that the Germanic voiceless fricatives derived from the PIE *tenues* through an intermediate aspirated stage: PGerm. *[θ] < pre-PGerm. *[tʰ] < PIE *t (e.g. Krause 1968: 121–123; Ramat 1981: 34–35; Stiles 2017: 890). This does not seem to be an absolute necessity, however: they could in principle be the direct result of spirantization of plain voiceless stops, as well (thus e.g. Ringe 2006: 94–97).

have emerged relatively late in the prehistory of Armenian due to language contact with Kartvelian in view of the similarity of the Classical Armenian and Georgian stop systems. Having thus eliminated voiceless fricatives and voiceless aspirates as likely reconstructions of the PIE *tenues*, only two viable options remain.

3.1 *Option 1: PIE *t = *[t]*

Within the traditional model, the PIE *tenues* are reconstructed as short voiceless stops, e.g. $*t = *[t]$. This is based on the fact that in the majority of branches (Indo-Iranian, Balto-Slavic, Italo-Celtic, Graeco-Phrygian, and Albanian), the outcome of PIE $*t$ is a short voiceless stop $[t]$, so for these branches we can assume a retention of PIE $*t = *[t]$ as $[t]$. Moreover, for two of the branches that show an outcome other than $[t]$ —Armenian $[t^h]$ and Germanic $[\theta]$ —the assumed development from a PIE $*[t]$ is typologically unproblematic: $[t] > [t^h]$ and $[t] > [\theta]$ (possibly through $[t^h]$) are cross-linguistically reasonably well attested changes (cf. Kümmel 2007: 55–67, 168–172).

Things are somewhat more complicated when we take into account the third branch in which the outcome of PIE $*t$ is not $[t]$, i.e. Anatolian. In this branch, the outcomes of the PIE *tenues* are long voiceless stops, PIE $*t > \text{PANat. } *[t:]$. Within the traditional model that posits that PIE $*t = *[t]$, this amounts to the assumption that PIE *tenues* were unconditionally lengthened in Anatolian, yielding $*[t:]$, which has been claimed to be the result of a reinterpretation of the original voice distinction between PIE *tenues* and PIE *mediae* (*aspiratae*) as a length distinction: PIE $*t$ vs. $*d^{(h)}$ > PANat. $*[t:]$ vs. $*[t]$ (Sturtevant 1933: 74; Melchert 1994: 18–21; Yates 2019). Kloekhorst [this volume, Ch. 10] has argued that no unambiguous examples of such an unconditioned voice-to-length shift seem to exist cross-linguistically, and that the postulation of such a shift for the prehistory of Anatolian is therefore unattractive.

The traditional reconstruction therefore treats the most common reflex, $[t]$, as the most archaic one, but at the expense of having to assume a typologically awkward sound shift to account for the Anatolian reflex $*[t:]$.

3.2 *Option 2: PIE *t = *[t:]*

The alternative option is that PIE *tenues* were long voiceless stops, e.g. PIE $*t = *[t:]$. This would imply that these stops were retained as such in Anatolian, but that all other Indo-European languages underwent a shortening of long stops, which is typologically unproblematic (Kümmel 2007: 133–136; Kloekhorst [this volume, Ch. 10]). In view of the fact that, on independent grounds, the earliest split in the Indo-European language family is thought to have been between

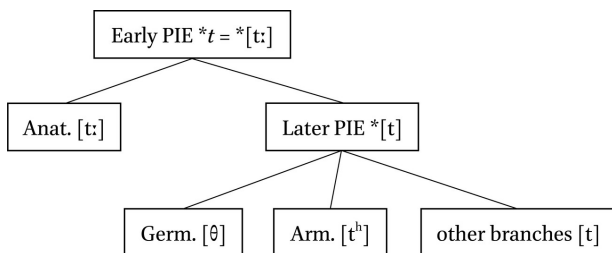


FIGURE 20.1

The development of PIE *tenues* within the scenario that Early PIE $*t = *[t:]$, which has been preserved as such in Anatolian.

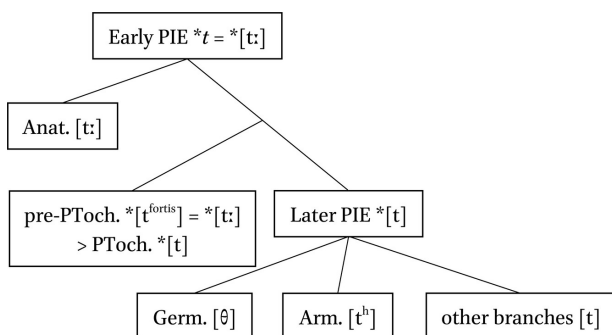


FIGURE 20.2

The development of PIE *tenues* within the scenario that Early PIE $*t = *[t:]$, which has been preserved as such in Anatolian as well as in Tocharian.

Anatolian and the rest, the shortening of PIE $*t$ may have been a single shared innovation of those branches (Figure 20.1).

It should be noted, however, that a reconstruction $*[t:]$ would also account for the Tocharian data. Although not all phonetical details regarding the outcomes of PIE *tenues* in Tocharian are known, it is clear that they are voiceless stops that can historically be regarded as *fortis* stops when compared to the voiceless stops that in Tocharian are the outcomes of PIE *mediae aspiratae* and that historically can be regarded as *lenis* stops (Peyrot [this volume, Ch. 12]). Since the two types of stops are both voiceless in the attested Tocharian languages, it is quite possible that the *fortis-lenis* distinction between these two consonants that can be reconstructed for the pre-Proto-Tocharian stage was not based on the presence or absence of voice. Given these circumstances, the reconstruction of a length opposition is a serious option. If it is indeed the case that pre-PToch. $*[t^{fortis}]$ was $*[t:]$, it is possible that the PIE stop system at the time of the Tocharian split was still identical to that of the Anatolian split. Since it is often thought that Tocharian may have been the second branch to leave the Proto-Indo-European linguistic community, such a scenario would not affect our reconstructions too much. It would then imply that the innovation of Early PIE $*[t:] >$ Later PIE $*[t]$ took place after Tocharian had split off: cf. Figure 20.2.

3.3 *PIE Tenues: Conclusions*

It follows that the most promising candidate for the reconstruction of the PIE *tenues* is a series of long voiceless stops, PIE $*t = *[t:]$, which were shortened after Anatolian and, possibly, also Tocharian had split off. This requires a single innovation in the prehistory of the other branches that has clear typological parallels: $*[t:] > *[t]$ (with subsequent changes to Germ. $*[\theta]$ and Arm. $*[t^h]$). The reconstruction of PIE *tenues* as short voiceless stops (PIE $*t = *[t]$) comes at the cost of assuming typologically unparalleled shifts in one or more daughter languages.

4 The Reconstruction of the PIE *Mediae*

If we investigate the development of the PIE *mediae* in the Indo-European branches, we observe the following different outcomes:

- a. preglottalized voiced stop: $*[ʔd]$ (pre-PBSl., pre-PPalb.)
- b. preglottalized stop with voice allophony: $*[ʔt^{\sim}d]$ (PIIr., PIItCl.)
- c. preglottalized stop with unclear voice: (PGrPhr. $*[ʔt/ʔd]$)
- d. voiceless stop with additional pre- or post-closure feature: $*[t^{+}\sim^{+}t]$ (PGerm., pre-PToch.)
- e. preglottalized voiceless stop: $*[ʔt]$ (pre-PAnat.)
- f. voiceless ejective or plain stop: $*[t']$ or $*[t]$ (PArm.)¹³

Several additional considerations play a role when trying to determine the original nature of the PIE *mediae*. First, there is a growing body of evidence that pre-Proto-Indo-European underwent a development that has been coined the “Kortlandt Effect”, which entails that, in pre-Proto-Indo-European, the dental *media* $*d$ developed into $*h_l$ in some environments that are yet to be determined more precisely. As was argued for by Eskes [this volume, Ch. 7], from a cross-linguistic perspective this development can be understood phonetically if we assume that, at the relevant pre-PIE moment, (a.) $*h_l$ was a glottal stop $*[ʔ]$; and (b.) $*d$ was either a voiceless stop $*[t]$, a (voiceless) ejective $*[t']$, or a voiceless preglottalized stop $*[ʔt]$. Significantly, in order to account for the phonetic side of the development pre-PIE $*d > *h_l$, reconstructions of pre-PIE $*d$ as a voiced stop are virtually excluded (in the case of modal $*[d]$) or are typologically far less attractive than their voiceless counterparts (in the case of $*[d']$ or $*[ʔd]$).

13 Sayeed & Vaux [this volume, Ch. 19] point out that most observations about the realization of these stops as ejectives are based on auditory reports and that there is at present little experimental evidence for ejective realization.

Second, a direct unconditional sound change from ejectives to voiced explosive stops would be typologically unparalleled, while a shift from non-explosive stops or voiced glottalized stops to voiced explosive stops would be unproblematic (Miller [this volume, Ch. 3]).

Third, in several branches, all stops merge into a single type in word-final position, which in Latin, Germanic, and Old Irish is identical to the reflex of the PIE *mediae*.¹⁴ This has been interpreted as reflecting an unreleased stop, according to Lipp (1996) specifically a lenis unreleased stop.

Finally, there are distributional arguments that play a role in the reconstruction of the PIE *mediae*. First, there is the famous *b*-gap, i.e. the (almost?) complete absence of reliable etymologies which lead to the reconstruction of a PIE form containing the sound **b* (Olander 2022b). The second is the constraint on PIE roots that combine two *mediae* (**DVD*-) (van Lieburg [this volume, Ch. 5]). Although it is reasonable to assume that both constraints ultimately have a phonetic explanation, it is difficult to decide whether the relevant phonetic conditions must have existed at the latest reconstructible stage of PIE or whether the constraints were inherited from an ancestor of PIE that may have had a stop system that was completely different from that of late PIE (Haider 1985: 8–10).

4.1 *Option 1: Traditional Model: PIE *d = *[d]*

Within the traditional model, PIE *mediae* are reconstructed as short voiced stops, i.e. PIE **d* = **[d]*. This reconstruction is based on the plain voiced stops that are found as the reflexes of the PIE *mediae* in Sanskrit, Iranian, Italic, Celtic, Baltic, Slavic, Albanian, and Greek. At the same time, there are language- or branch-internal reasons that can and have been used to argue that the synchronically attested voiced stops were in fact characterized by an additional feature at an earlier stage in all these languages or branches. In some cases this feature may have been preglottalization or can be described more vaguely as causing a similar effect on preceding segments as laryngeals (pre-Proto-Balto-Slavic, Proto-Indo-Iranian, Proto-Italo-Celtic, pre-Proto-Greek, pre-Pre-Proto-Albanian). If some or all of these arguments are accepted, it becomes much less attractive to reconstruct PIE *mediae* as plain voiced stops.

14 It is not fully clear whether this is also the case in Anatolian. In Lydian, all word-final stops seem to have merged into a lenis stop, but in Hittite the distinction between word-final fortis stops (< PIE *tenues*) and lenis stops (< PIE *mediae* (*aspiratae*)) may have been preserved (Kloekhorst [this volume, Ch. 11]). If this is indeed the case, we may assume that the Lydian merger reflects an innovation that is parallel to but independent from that found in other Indo-European languages.

4.2 Option 2: PIE $*d = *[d]$ or $*[ʔd]$

An alternative proposal that can be found in the literature is that the PIE *mediae* may either synchronically have been implosive stops, i.e. PIE $*d = *[d]$ (Kümmel 2012: 303–306), or are synchronically voiced stops that derive from earlier, pre-PIE implosives, i.e. PIE $*d = *[d] < \text{pre-PIE } *[d]$ (Haider 1985: 10 f.; Weiss 2009).¹⁵ These reconstructions have in common that they are based on typological arguments and take as a starting point that the traditional reconstruction of the PIE stop system, with the three series $*[t]$, $*[d]$, $*[d^h]$, is cross-linguistically unattested, and that especially the presence of a breathy voiced series $*[d^h]$ is problematic (see also the treatment of the *mediae aspiratae*, below). They therefore posit that *mediae aspiratae* derive from earlier plain voiced stops, PIE $*d^h < *[d]$, which implies that the PIE *mediae* must go back to a series that does not consist of plain voiced stops, but rather of marked voiced stops. Haider's (1985: 10) reasons for assuming that these marked voiced stops were in fact implosives are the observations that (1.) cross-linguistically, implosives often develop into voiced stops ($[d] > [d]$), and that (2.) “/b/ tends to change to /m/” (1985: 12), which would explain the Proto-Indo-European *b*-gap. Haider does note however, that in systems with an implosive series, “/b/ is the favoured point of the articulation—i.e. we do not expect a gap there” (1985: 12), which means that the value of the *b*-gap argument in favour of reconstructing the PIE *mediae* as reflecting earlier implosives is relatively low.

Kümmel (2012: 303) argues that, when looking at the typology of three-stop systems, most systems that have two voiced series contain a series of plain voiced stops next to a series of “implosive, or rather “non-explosive” stop[s]”, and that we therefore may assume that PIE *mediae* derive from implosives. Kümmel adds that such a reconstruction may explain “why PIE stops were neutralized to “mediae” in final position [...]: stops were probably not released in this position, and non-released stops were more similar to non-explosive stops than to explosives” (2012: 303). The shift of non-explosive stops to plain voiced stops would be part of a systemic shift of earlier $*[t, d, d]$ to $*[t, d, d^h]$. This is Michael Weiss's “Cao Bang shift”, which is discussed by Kloekhorst in this volume [Ch. 4]. While Haider and Weiss assume that the implosive nature

15 Weiss uses the term “nonexplosive” (2009: slide 58), which in fact describes a larger category of consonants that includes implosives (Clements & Osu 2022: 339–340; Miller [this volume, Ch. 3]). Yet, since the parallel that Weiss adduces for his reconstruction of pre-PIE is a language in which voiced stops have developed out of earlier implosives (Cao Bang $d < \text{Proto-Tai } *[d]$), Weiss' proposal can be compared to that of Haider 1985. See Kloekhorst [this volume, Ch. 4] for the argument that the Proto-Tai series in question was rather preglottalized, $*[ʔd]$, implying that Weiss' scenario in fact points at the reconstruction of specifically preglottalized voiced stops for PIE; see also the discussion below.

of the PIE *mediae* concerns a pre-PIE stage, Kümmel leaves open the possibility that the *mediae* were implosives in PIE itself. He proposes that their shift to plain voiced stops could be “a central 1E innovation that spread to most, but not all dialects” (2012: 304).

From a phonetic and phonological point of view, the term “implosive” is relatively imprecise, however, since at least two different types of consonants are gathered under this term, which can be phonologically contrastive: plain (modally voiced) nonexplosive stops ($[d]$); and laryngealized/(pre)glottalized nonexplosive stops (produced with glottal creak, $[ḍ]$, or glottal closure, $[ʔd]$).¹⁶ A specifically preglottalized reconstruction of the PIE *mediae*, i.e. PIE $*d = *[ʔd]$, has been proposed by Kortlandt (2012, with references to earlier literature) on the basis of comparative evidence, primarily Winter’s Law in Balto-Slavic, Lachmann’s Law in Latin, Lubotsky’s Law in Sanskrit, and the presence of glottalized implosives in Sindhi.

A reconstruction of the PIE *mediae* as $*[d]$ / $*[ʔd]$ implies the same independent phonetic devoicing to $[ʔt]$ or $[t]$ as is also assumed for the traditional reconstruction $*[d]$ in Anatolian, Tocharian, Germanic, Armenian and Phrygian. In theory, this is then a potentially shared innovation, but these branches do not otherwise share innovations that are not also found in other branches of Indo-European. It is therefore worth exploring whether the voiceless reflexes retain an archaism.

4.3 Option 3: PIE $*d = *[ʔt]$ or $*[tʰ]$

A reconstruction of PIE $*d$ as $*[ʔt]$ ¹⁷ would posit the reconstructed pre-Proto-Anatolian state for Proto-Indo-European as well. The Proto-Germanic $*[t^+ \sim t]$ could then be a (partial) retention of PIE $*[ʔt]$. The voiced reflexes in Italo-Celtic, Indo-Iranian, Balto-Slavic, Albanian, and Greek would have to be due to a shift from $*[ʔt]$ to $*[d]/*[ʔd]$ with a subsequent shift to $*[d]$ in individual daughter languages as was also argued for in the previous section. This would have happened independently in at least Greek in view of the voiceless reflex in Phrygian (unless one assumes a shift $*[ʔt] > *[d]/*[ʔd] > [t]$ for Phrygian, which seems unnecessarily complicated).

The fact that Armenian and Tocharian and a part of Germanic show reflexes of a potentially glottalic feature *after* the release of the stop may be taken as evidence in favour of a reconstruction of ejective $*[tʰ]$. This reconstruction would also account for the *b*-gap, as it is not unusual for labial ejectives to be

16 Greenberg 1970: 124; Clements & Rialland 2007: 57.

17 I.e. a preglottalized voiceless plosive, comparable to the preglottalized stops of Standard English.

absent in languages with ejective stops (e.g., Akkadian). It is difficult to decide whether PIE is more likely to have realized the *mediae* as *[t'] or *[ʔt], especially because the timing of laryngealization on consonants can vary even within a single language, cf. Tsimshian (British Columbia, Canada) *na:q' ~ na:ʔga* 'dress, skirt' (Dunn and Hays *apud* Fallon 2002: 301). The Tsimshian example also shows that the preglottalized variant may well have been subphonemically voiced. This brings option 3 very close to the reconstruction of the *mediae* as laryngealized/(pre)glottalized nonexplosive stops (see option 2 above; similarly Salmons [this volume, Ch. 14, p. 304]).

Furthermore, there may have been inner-PIE synchronic or diachronic variation (Kümmel [this volume, Ch. 2]). Kortlandt (1985) defended this view and argued for an inner-Proto-Indo-European shift from ejectives to preglottalized voiced stops. It is also possible that there were positional variants in view of the fact that almost all comparative evidence for preglottalized stops concerns stops in word-medial and word-final position, but not in word-initial position (with the possible exception of Albanian; see Kloekhorst [this volume, Ch. 17]).

4.4 *PIE Mediae: Conclusion*

We can conclude that the PIE *mediae* were probably characterized by constricted glottis and that there is no forceful reason to assume that voice was a contrastive feature of these stops. However, in order to explain the "Kortlandt Effect", we have to assume that in pre-Proto-Indo-European the *mediae* were specifically voiceless, i.e. *[ʔt] or *[t'], and this may also have been the realization of the *mediae* in Early Proto-Indo-European, i.e. the proto-language that existed at least until Anatolian and possibly also Tocharian split off.

5 The Reconstruction of the PIE *Mediae Aspiratae*

Looking at the development of the PIE *mediae aspiratae* in the Indo-European branches, at least three different outcomes can be reconstructed for the proto-languages of the individual branches or for a predecessor of these proto-languages:

- a. short voiced stop [d] (Iir., BSl., Alb., Arm.)
- b. short voiceless stop [t] (Anat., Toch.)
- c. short voiced fricative [ð] (ItClt.)
- d. unclear (GrPhr.): Gr. [tʰ] contrasts with Phr. [d]¹⁸

18 But see Kloekhorst [this volume, Ch. 4] for a scenario that derives Gr. [tʰ] from PGrPhr.

- e. unclear (PGerm.): PGerm. may have had [t], [d] or [ð] (see footnote 7 above)

There are again several possible reconstructions for PIE. The voiceless aspirate [tʰ] of Greek is unlikely to be an archaism because of the number and nature of the shifts that would then have to be assumed for all other branches. The same holds for a hypothetical reconstruction *[ð] for PIE on the basis of its Italo-Celtic and possibly Germanic outcome. The other reflexes, however, as well as the breathy voiced [dʰ] that is traditionally reconstructed for PIE, all deserve a brief discussion.

5.1 *Option 1: Traditional Model: PIE *dʰ = *[dʰ]*

The traditional reconstruction of PIE *mediae aspiratae* as breathy voiced stops (“voiced aspirates”) takes Sanskrit as a starting point, where we do indeed find breathy voiced stops as the outcome of this series: PIE *d > Skt. [dʰ]. Additionally, some central Armenian dialects have breathy voiced stops as the outcome of PIE *mediae aspiratae*, whereas some neighbouring dialects that synchronically show voiced stops may have had breathy voiced stops in the past in view of Adjarian’s law (but Sayeed & Vaux [this volume, Ch. 19], explain the latter development with plain voiced stops). Within the traditional model, the breathy voiced stops are thought to straightforwardly explain, on the one hand, the voiceless aspirates of Greek through devoicing, and, on the other, the voiced stops of Iranian, Balto-Slavic, Armenian, Albanian, and Phrygian through loss of breathiness (“deaspiration”). And indeed, there seem to be no typological objections to a shift from a breathy voiced stop to a voiceless aspirated stop or plain voiced stop.¹⁹

The problem with this scenario is, however, that there are reasons to assume that the Sanskrit and Armenian situations are not archaic. Breathy voice is

*[d] through an intermediate stage *[dʰ] (the so-called “Siamese shift”).

19 Kümmel 2007: 95–96, 144–145. Note, however, that Kümmel’s examples for the development $D^h > D$ (2007: 95–96) are confined to three main groups: North-West Indo-Aryan languages; Armenian dialects; and the Indo-European branches that show D as the outcome of PIE $*D^h$. Of these latter two groups, it is questionable whether their ancestor languages did indeed contain breathy voiced stops (cf. Sayeed & Vaux [this volume, Ch. 19] for Proto-Armenian; cf. below for Proto-Indo-European). In the case of the North-West Indo-Aryan languages, it has been argued that these may derive from an ancestor language that had not yet developed breathy voiced stops (Kortlandt 2021: 4), implying that breathy voiced stops would have developed in only a part of the Indic branch. Regardless of whether the latter view is correct or not, it may be clear that an investigation into the diachronic behaviour of breathy voiced stops in language families other than Indo-European is a desideratum.

clearly an areal feature of the Indian subcontinent (Ladefoged & Maddieson 1996: 57–58), and in several Tai languages we find the rise of breathy voiced stops from earlier plain voiced stops, for instance in Cao Bang (Weiss 2009). It is attractive to think that, in Indo-Aryan, too, breathy voiced stops arose from earlier plain voiced stops,²⁰ and according to Kloekhorst [this volume, Ch. 4], this development was dependent on the rise of voiceless aspirates [t^h] in Indo-Aryan from earlier sequences of a voiceless stop and a laryngeal (see below for “Jakobson’s universal”). Because the latter innovation is specifically Indo-Aryan, the rise of breathiness must be so as well. In the case of Armenian, Sayeed & Vaux [this volume, Ch. 19] have argued that the breathy voiced stops in some of its dialects arose from earlier plain voiced stops since “breathiness is easy to innovate as a low-level phonetic consequence of plain voicing”. Kloekhorst [this volume, Ch. 4] remarks that, like in Indo-Aryan, the development of Armenian breathy voiced stops was dependent on the rise of voiceless aspirates [t^h], which in Armenian developed out of PIE *tenues* (see above). Similarly, there is no particular reason why the breathy voiced stops that yielded the Greek voiceless aspirates must have been an archaism. Kloekhorst has sketched a potential scenario for the rise of these pre-Proto-Greek breathy voiced stops from earlier plain voiced stops²¹ in reaction to the rise of pre-Proto-Greek voiceless aspirates in **TsT*-clusters [this volume, Ch. 4]. Since in Phrygian we find plain voiced stops corresponding to the pre-Proto-Greek breathy voiced stops,²² it is a distinct possibility that breathiness arose within the prehistory of Greek after it had split from Phrygian.

Another problematic aspect of the traditional reconstruction of PIE *mediae aspiratae* as breathy voiced stops is “Jakobson’s universal” (Miller [this volume, Ch. 3]; Kloekhorst [this volume, Ch. 4]), which states that, cross-linguistically, breathy voiced stops are only found in systems that also contain voiceless aspirated stops. Since there is no reason to assume that PIE *tenues* or *mediae* should

20 This is of course dependent on the idea that the Indo-Aryan reflexes of the PIE *mediae* were not plain voiced stops during the relevant period. See footnote 9 above for the argument to reconstruct the reflexes of *mediae* in Indo-Aryan as preglottalized stops.

21 This implies that at that moment in time the outcomes of the PIE *mediae* were not plain voiced stops, as they are in attested Greek, but something else. See Kloekhorst & Lubotsky [this volume, Ch. 8] for arguments that the reflexes of the PIE *mediae* in pre-Proto-Greek were preglottalized stops.

22 There is no reason to assume that the Phrygian outcomes of *mediae aspiratae* were in fact breathy voiced stops; it would be typologically odd if the two-way stop system of Phrygian would have had a contrast between voiceless plain stops and breathy voiced stops.

be reconstructed as voiceless aspirates (cf. the sections above), it is typologically very difficult to reconstruct the PIE *mediae aspiratae* as breathy voiced stops.

5.2 Option 2: PIE $*d^h = *[d]$

An alternative option is to reconstruct the PIE *mediae aspiratae* as plain voiced stops, as this is their reflex in Iranian, Balto-Slavic, Celtic, Armenian (most dialects), Albanian, and Phrygian. For the languages where we find breathy voiced stops as the outcomes of PIE *mediae* (Sanskrit, some dialects of Armenian, and pre-Proto-Greek (with later devoicing to voiceless aspirates)) we then have to assume a development of plain voiced stops to breathy stops, for which we find clear parallels cross-linguistically, and which can be understood as having been triggered by the rise of voiceless aspirates in these languages (see Kloekhorst [this volume, Ch. 4]). For the languages where we find voiceless stops as the outcomes of the PIE *mediae*—Tocharian and Anatolian—, we would have to assume a general devoicing of $*[d] > [t]$. For Tocharian, it has been argued that such a devoicing was the result of a general loss of voice, possibly due to language contact with Uralic (see Peyrot [this volume, Ch. 12]). For Anatolian, it has been argued that such a devoicing can be seen as part of a chain shift in which an original voice distinction was reinterpreted as a length distinction: $D > T > T̃$, but see Kloekhorst [this volume, Ch. 10] for the fact that no unambiguous examples of such a voice-to-length development can be found cross-linguistically. The PIE $*d^h = *[d]$ scenario is therefore not entirely unproblematic.

5.3 Option 3: PIE $*d^h = *[t]$

Both in Tocharian and in Anatolian the PIE *mediae aspiratae* have yielded voiceless stops: PIE $*d^h > [t]$. Since the reconstruction of *mediae aspiratae* as voiced stops (more specifically, as breathy voiced stops according to the traditional model) was already well established when Anatolian and Tocharian were not known yet, it has traditionally been assumed that in both languages a devoicing must have taken place: $*[d^{(h)}] > [t]$. However, as was discussed above, in the case of Anatolian this is not unproblematic. In view of the likelihood of an early split of Anatolian and possibly Tocharian from the Indo-European ancestor language, the reverse scenario deserves serious consideration: PIE *mediae aspiratae* were originally voiceless stops, $*[t]$, and have been preserved as such in Anatolian and Tocharian, but were voiced after these two branches had split off: $*[t] > \text{Later PIE } *[d]$. This does, however, require the additional assumption that the PIE *tenues* originally were not short voiceless stops, as is usually reconstructed, but something else: see section 3 above for the possibility that they were long voiceless stops in Early Proto-Indo-European, $*[t:]$.

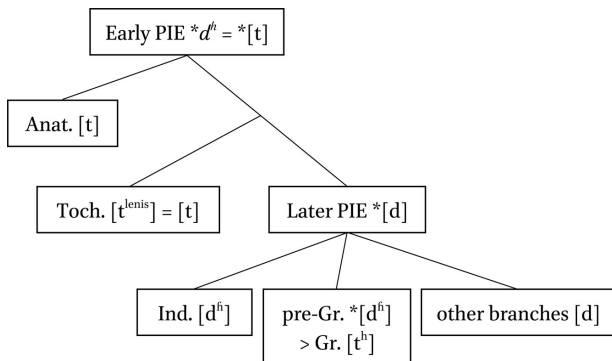


FIGURE 20.3

The development of PIE *mediae aspiratae* within the scenario that Early PIE $*d^h = *[t]$, which has been preserved as such in Anatolian as well as in Tocharian.

Cross-linguistically, the voicing of original short voiceless stops, $[t] > [d]$, is often attested in word-medial position, especially when they contrast with long voiceless stops, which are then often subsequently shortened, $[t:] > [t]$ (e.g. in Dravidian, Uralic, and Romance languages; see Kloekhorst [this volume, Ch. 10]). However, in word-initial position such a voicing of voiceless stops is less often attested, and if it is, it is usually conditioned. Yet, since the distribution of *mediae aspiratae* in Proto-Indo-European roots is limited (roots of the shape $**D^heT-$ do not exist; roots do not contain the clusters $**sD^h$ or $**D^hs$), it seems possible to view the voicing of Early PIE $*[t] > \text{Later PIE } *[d]$ as a conditioned development within this scenario (see Kloekhorst [this volume, Ch. 10] for more details), which would make the reconstruction of PIE *mediae aspiratae* as voiceless stops a distinct possibility. This would imply the development presented in Figure 20.3.

5.4 *PIE Mediae Aspiratae: Conclusion*

Although most Indo-European branches show outcomes of the PIE *mediae aspiratae* that are best explained from earlier plain voiced stops, $*[d]$, the Anatolian and Tocharian data are better explained from plain voiceless stops, $*[t]$. These two considerations can be combined if we assume that in Early Proto-Indo-European the *mediae aspiratae* were realized as voiceless stops, which underwent voicing after Anatolian and Tocharian had split off. This voicing may then be seen as a shared innovation of the other branches. The subsequent developments towards breathy voiced stops $*[d^h]$ as found in Sanskrit, some Armenian dialects, and pre-Proto-Greek (with later devoicing to Proto-Greek $*[t^h]$) can be explained as parallel but independent processes that have clear cross-linguistic parallels.

6 Conclusion

The most likely realizations of the PIE stops were the following:

$$\begin{aligned}\text{PIE } *t &= *[t:], \text{ perhaps } *[t] \\ \text{PIE } *d &= *[?t], *[t'], \text{ perhaps } *[d]/*[?d] \\ \text{PIE } *d^h &= *[t] \text{ or } *[d]\end{aligned}$$

Although some of the details remain a matter of debate, it is clear that the Traditional Model, which reconstructs PIE $*t$, $*d$, $*d^h$ as $*[t]$, $*[d]$, $*[d^h]$, is unlikely to be correct for any stage of Proto-Indo-European. The main uncertainty in our reconstructions lies in the question whether the feature that distinguished the fortis stops (traditional $*t$) from the lenis stops (traditional $*d^h$) was voice or length. When we take into account the most likely order in which the branches of Indo-European split off from Proto-Indo-European, it becomes clear that it is possible to reconstruct several different stop systems that are diachronically related to one another. A fortis-lenis opposition that was originally characterized primarily by length appears to have been recharacterized as a voice distinction. For Early Proto-Indo-European, the stop system would in that case have looked as follows:

$$\begin{aligned}*t &= *[t:] \\ *d &= *[?t], \text{ possibly with positional allophony } *[t', -?t-, -?t] \\ *d^h &= *[t]\end{aligned}$$

This system is very close to the ones reconstructed by Kortlandt (2010: 38), Kloekhorst (2016b), and Matasović [this volume, Ch. 6]. In this system, the main phonological distinctions are length (closure duration) and presence / absence of laryngealization (glottalization). This reconstruction would straightforwardly account for Anatolian (pre-PAnat. $*[t:]$, $*[?t]$, $*[t]$) and Tocharian (pre-PToch. $*[t^{\text{fortis}}]$, $*[t^+]$, $*[t^{\text{lenis}}]$). After Tocharian had split off, the length opposition between $*[t:]$ and $*[t]$ seems to have shifted to a voice opposition:

$$\begin{aligned}*t &= *[t] \\ *d &= *[?t], \text{ possibly with different allophonic realizations } *[t' \sim ?t] \\ *d^h &= *[d]\end{aligned}$$

This system is very close to the PIE systems of Rasmussen (1974), Miller (1977), and Bomhard (1979). It can account for Germanic (yielding PGerm. $*[\theta]$, $*[+t/t^+]$, $*[t/d/\delta]$ after lenition of $*[t] > *[d]$ due to Verner's law and subsequent

spirantization of the remaining cases of $*[t]$ to $*[\theta]$), Graeco-Phrygian (PGrPhr. $*[t]$, $*[ʔt]$, $*[d]$, with Greek undergoing a later voicing of $*[ʔt]$ to pre-PGr. $*[ʔt \sim ʔd]$ and rise of breathy voice in $*[d] > \text{pre-PGr. } *[d^h] > \text{PGr. } *[t^h]$), and Armenian (PArm. $*[t^h]$, $*[t/t']$, $*[d]$, with rise of aspiration in $*[t] > *[t^h]$).

For an even later stage of Proto-Indo-European, we may assume that the *mediae* had become a voiced preglottalized stop or implosive, $*[ʔd]$ or $*[d']$, except when standing before $*s$ and voiceless stops, where it remained a voiceless preglottalized stop $*[ʔt]$:

$$\begin{aligned} *t &= *[t] \\ *d &= *[ʔd/d, ʔtC_{[-voice]}] \\ *d^h &= *[d] \end{aligned}$$

This is the system that was reconstructed for PIE by Kümmel (2012). This system can directly account for the systems of Indo-Iranian (PIIr. $*[t]$, $*[ʔt \sim ʔd]$, $*[d]$, followed in Indo-Aryan by the introduction of aspiration and breathiness and in Iranian by the merger of $*[ʔd]$ and $*[d]$ into $*[d]$), Balto-Slavic ($*[t]$, $*[ʔd]$, $*[d]$), and Albanian ($*[t]$, $*[ʔd]$, $*[d]$). If one follows Schrijver's reconstruction of the Proto-Italo-Celtic stop system as $*[t]$, $*[ʔd]$, $*[\delta]$, this branch could also be derived from this stage without great difficulties. If it is accepted that Italo-Celtic split off from the rest of Indo-European at an earlier stage (thus e.g. Weiss 2022: 108–111), the voicing of the *mediae* $*d = *[ʔt] > *[ʔd]$, but $ʔtC_{[-voice]}$ in Italo-Celtic must have happened independently from the same development in some of the other branches.

7 Outlook

Over half a century after the publication of the first criticism of the traditional reconstruction of the Proto-Indo-European stop system, much progress has been made. It has become clear that the traditional model cannot be retained, but also that finding consensus about an alternative is challenging. The papers in this volume have shown that the current lack of consensus about the Proto-Indo-European stop system has not hindered progress in our understanding of many aspects of the evolution of the Indo-European stop systems.

The potential for progress in the study of the evolution of the Indo-European stop systems is by no means exhausted. Several areas where progress can be made can easily be identified. There are two branches in which the reconstruction of the stop system of the proto-language of the branch itself is particularly

challenging: Germanic and Italo-Celtic. For these, additional in-depth studies of the branch-internal comparative material can be expected to provide more clarity in the future.

A better understanding of the stop system(s) of Proto-Indo-European itself will also provide more insights in the origins of the Indo-European root constraints. As argued by van Lieburg [this volume, Ch. 5], the root constraints are better understood in a glottalic framework. At the same time, she also argued that the constraints seem to have arisen during the transition from a phonemic system with only two series of stops into a system of three series of stops. This pushes the rise of the root constraints back to a period well before the oldest stage of PIE that can be reconstructed with the comparative method. A closer evaluation of the root constraints in relation to the various proposed reconstructions of the PIE stop system discussed above may lead to new insights.

As Kümmel has pointed out [this volume, Ch. 2], the reconstruction of the PIE stop system, including possibly different systems for different chronological stages, could impact the phylogeny of the language family. The scenario described in section 6 above starts from the relatively uncontroversial notion that Anatolian and possibly Tocharian were the first branches to split off from the rest of Indo-European. The order in which the remaining Indo-European speech community dissolved is much less clear and the evolution of the stop system may help to understand which groupings are more likely and which less so.²³

Another topic that touches upon phylogeny is Kloekhorst's proposal (2018; [this volume, Ch. 11]) that the Proto-Anatolian outcome of PIE $*h_2$ and $*h_3$ was a uvular stop, $*[q:]$, on the basis of which he argues that these phonemes probably were stops at the Early Proto-Indo-European stage, as well: $*h_2 = *[q:]$ and $*h_3 = *[q^w:]$? (differently Kümmel 2022: 208: $*h_2 = *[q]$ and $*h_3 = *[g]$). These stops would then have undergone spirantization and possibly backing at a later moment in time, after Anatolian had split off, yielding Later PIE $*h_2 = *[h]$, $*h_3 = *[h^w]$? (Kümmel: $*h_3 = *[ʕ]$). If the reconstruction of these laryngeals as EPIE (labio-)uvular stops can be substantiated, it would add one or two more places of articulation to the EPIE stop system. It would moreover add credibility to the view that different chronological stages of the proto-language may have had different stop systems.

23 For instance, if the PIItCl. stop system did not contain the feature voice (cf. footnote 6 for the possible reconstruction $*[t:/t^h]$, $*[ʔt]$, $*[t]$), the Italo-Celtic branch may phylogenetically be grouped with Anatolian and possibly Tocharian in this respect, supporting an early split-off from the family tree.

A related issue regards the correlation between stops and accentuation. As Lubotsky (1988: 170–174) has shown, evidence from Sanskrit, Greek, and Germanic indicates that accentuation patterns in nominal stems depend on whether the root contains voiceless stops (**T*) or voiced (aspirated) ones (**D^(h)*). Lubotsky therefore argues that these stops had tonal effects on the root, with voiceless stops causing a high tone and voiced ones a low tone—a behavior that is indeed typologically well attested. According to Lubotsky, these effects may have been present in Proto-Indo-European, but this is difficult within the scenario outlined in section 6 that Proto-Indo-European originally knew only voiceless stops. This scenario rather predicts that the tonal effects that are visible in Sanskrit, Greek, and Germanic arose at a relatively late stage, after the rise of phonological voice, i.e. after Anatolian and possibly Tocharian had split off. Researching the question whether or not Anatolian and/or Tocharian show a similar correlation between stops and accentuation as found by Lubotsky for Sanskrit, Greek, and Germanic may therefore substantiate or invalidate the scenario as sketched above.

Another area where progress can be expected is the typology of phonological changes. Many of those languages of which the stop systems are best understood, both from a synchronic and a diachronic perspective, belong to the Indo-European language family. As a result, many examples of sound shifts in typological literature like Kümmel's *Konsonantenwandel* (2007) come from Indo-European languages. New reconstructions of Proto-Indo-European, but also of the proto-languages of the individual branches, will provide additional evidence for some changes, while reducing it for others.

Finally, a better understanding of the stop system of Proto-Indo-European may be helpful in assessing possible genealogical relationships between Indo-European and other language families, which may ultimately result in the reconstruction of an ancestor language preceding Proto-Indo-European.

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