Ancient Articulations:

Reconstructing Proto-Indo-European from a gestural perspective

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Abstract

Proto-Indo-European(PIE) is a reconstructed language, ancestor of the Indo-European languages. The tradition of the comparative reconstruction method often overlooks the phonetic and articulatory aspect of the language. In this thesis it is argued that analysing potential reconstructions through the method of Articulatory Phonology is beneficial for a better understanding of the sound change processes. This is illustrated through the comparison of two competing hypotheses about the reconstruction of the three "laryngeal" elements.

As elements (marked schematically with h_1, h_2 and h_3) that left very little trace and conflicting evidence in the daughter languages, their phonetic features are the cause of heated debates. The two hypotheses compared in this paper are: 1. that they were either metrically weak vowels or 2. a glottal stop and a pharyngeal fricative and its labialized counterpart.

Through the illustrated with gestural scores analysis of the different possible gradual changes of the gestures needed to produce the forms, the two theories were judged on whether the outcomes in the daughter languages could reasonably stem from what the theories predict and how effort-full would these changes be compared. It was found that both theories face challenges in explaining certain forms, however the Vocalic hypothesis assumes changes which are more straightforward, as opposed to the more complex explanations needed to deal with some changes the Fricative theory suggests.

Contents

1 Introduction

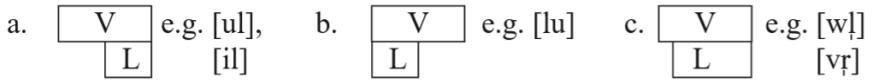
The beginnings of Indo-European comparative linguistics came with the discovery that Sanskrit is related to languages such as Greek, Latin and German when trade routes to India were opened around the beginning of the 16th century. The paradigms found in the ancient texts of the Vedas that date to 1000 B.C. are less obscured by sound changes than those in Greek (Beekes, 2011) and more could be concluded about the structure of the mysterious predecessor of all those languages – the so-called Proto-Indo-European (PIE). Now, through comparing cognate sets from all daughter languages, a supposed sound system, a large number of roots, as well as derivational suffixes, endings and so on have been reconstructed to form a somewhat stable picture of what this language could have sounded like around 6000 years ago.

Despite the tremendous success of the comparative method, many open questions, discrepancies and alternative reconstructions are still object of heated discussions. Due to limitations, such as the occurrences of borrowing, the subgrouping of languages and other issues that obscure the phonological and morphological changes, not much can be revealed further with the help of the comparative method only (Harrison, 2003). However, alternative methodology is rarely considered. Even when phenomena heavily dependent on phonetic features and their interaction such as assimilation, lenition and metathesis are discussed, the phonetic features are not necessarily brought in focus.

A rare example of how the use of phonetic analysis in the context of PIE reconstruction can yield insightful results is found in the work of Reynolds et al. (2000). They employ a temporal analysis of the syllable constituents in the case of metathesis, presenting them as a combination of overlapping tiers - vocalic and consonantal. The interaction between the tiers is what determines the structure of the syllable. The following illustration showcases how the arrangement of the tiers of the vowel and the liquid in the cognate set of the reconstructed PIE word *wlk^{w}- "wolf". cognates of this root are found in Lithuanian (vílkas) and in Gothic (wulfs) where the constrictions, needed to produce the liquid are initiated after the beginning of the vowel, as in the first arrangement in 1. Other cognates are Greek – lukos and Latin lupus where the vowel and the liquid are initiated together (shown in b.) and finally in Sanskrit vrka- the production of the two elements is almost simultaneous leading to the on-glide nature of the vowel.

This approach seems to be able to encompass both the behaviour of syllabic consonants and metathesis in a comprehensive manner, which is known

Figure 1: Temporal arrangement of reflexes of *wĺk^{w}- (Reynolds et al., 2000)



to puzzle linguists since it requires extensions of normally very strict phonological formalisms (Blevins & Garrett, 2004).

As Clackson (2007) mentions, comparative phonologists tend to base themselves off the dated hypothesis that sound-laws are exceptionless (*Ausnahmslosigkeit der Lautgesetze*). However, modern research on sound change has shown that this position is unattainable, with Clackson (2007) going as far as calling it "convenient fiction". Nonetheless, this rigid, abstract framework allows for the reconstruction of a PIE phonological system defined solely by the correspondences within the daughter languages. As a result of its abstractedness, normally only a broad approximation of the phonetic value of the elements is possible within the comparative phonology framework after a high level of accurateness of the phonological representation has been achieved (Beekes, 2011),

Similarly to Reynolds et al. (2000), this study attempts to tackle the lack of understanding of the nature of the "laryngeal" elements of PIE by analysing the two main hypotheses about their phonetic features (gfricatives or vocalic elements?) within the framework of Articulatory Phonology, which models the gestures involved in production and the influence they have on each other. For instance, interactions such as gestural sliding, hiding, etc. have been documented to alter the listener's perception (Browman & Goldstein, 1992). This approach would be optimal for decoding how reflexes in different languages (vocalisation, aspiration, colouring, lengthening) came to be and for testing which theory provides most practical solution.

The structural problems of the traditional comparative methodology and the formulaic representations of the words it yields are reasons why an attempt at a phonetically natural explanation is a promising endeavour, helpful in designing better formalisms and bringing the reconstructed language to life, something that often is pushed to the side. Reaching an agreement on what phonetic features could be reconstructed is improbable, since the sole way of assuring accuracy would be if there were recordings of speakers present. Nonetheless, reaching for the goal of knowing what is on the puzzle pieces that comparative linguists have put together and labelled, is of core importance to figuring out the interactions between them.

2 The "Laryngeal" theory

The Laryngeal Theory was first introduced by de Saussure in the end of the 19th century answering the need to reconstruct elements of PIE that are hardly visible through comparative reconstruction yet influence other elements. His proposition was that those are three vocalic elements with rather undefined phonetic features, respectively *e, *a and *o. Later Cuny (1912) gave them the label "laryngeal", which is now used as a misnomer even if their nature is not assumed to be laryngeal. It is now widely accepted that the three elements were some sort of a 'back of the throat' phonemes and are now labelled as h_1, h_2 and h_3.

However, there is still no consensus on what phonemes the "laryngeals" really are, or even on the number of them. It is mostly accepted that there were three, but there are theories of the existence of a fourth one. Beekes (1989) states that there is only evidence for a second a-colouring laryngeal in Hittite, however it seems to be that this was simply an allophone, appearing in the environment of lengthened preceding vowel. For the purpose of this thesis, we assume that there were indeed three different phones.

Multiple theories about their phonetic features have been in and out of focus and different types of evidence has been put forward, presented in the next sections.

2.1 The vocalic hypothesis

As mentioned earlier, the original understanding was that the "laryngeals" were in fact 'sonant elements' stylized as *E, *A and *O, as proposed by Ferdinand de De Saussure (1879). The young linguist based his discovery on the different vowel alternations (ablaut) in Greek, a very common phenomenon amongst other Indo-European languages, which is of core importance to the reconstructed morphological structure of PIE. The more common system in Greek is the *e, *o, *Ø ablaut system, illustrated in the following example.

(1) leíp-ō / lé-loip-a/ é-lip-on 'to leave' (Beekes, 2013, p.101)

De Saussure's attention was peaked by forms which did not simply obey the first system. An example of a root showcasing a seemingly very different alternation, namely ā/ō/a (eA oA A) is:

(2) phā-mí / phō-nā' 'voice' / pha-tós 'to say' (Beekes, 2013, p.101)

The second system differs by the presence of long vowels and lack of zero grade. De Saussure proposed that all the alternation systems in Greek can be explained as combinations between the actual vowels *e, *o, *Ø and three "vocalic elements" *E, *A and *O (as summarized by Beekes (2011)):

I	e	o	-
	ei	oi	i
II	eE	oE	E
	eA	oA	A
	eO	oO	O

Table 1: Saussure's idea of ablaut in Greek

Soon after the discovery of the "laryngeals" this theory was deemed less likely, mainly due to the evidence from Hittite, a language which was recently recognized as Indo-European, in which we would find fricatives where the "laryngeals" stood. Three points can be made based on the examples given above. First, the "laryngeals" (*h_2 and *h_3 specifically, as *h_1 supposedly did not posses features it could transfer) have the ability to colour the preceding vowel **e* to *a* and *o* respectively, as seen by *phā-mí / phō-nā'/ pha-tós*. Second, in post-vocalic position, they would lengthen the preceding vowel. And lastly, in interconsonantal position, they would usually reflex as vowels (*i* in Sanskrit, *e, a* or *o* in Greek, for example), as illustrated by Avestan: *pita*, Greek: *patr*, Old English: *fæder*, stemming from PIE *ph_2ter-. The last statement leads us to what Keiler (2015) notes - the vocalization of the "laryngeals" is based on an inherent property of the "laryngeals" themselves since there was no other vowel involved. Reynolds et al. (2000) look into the phonetic features of the "laryngeals" and analyse them in terms of generative phonology, concluding that the hypothesis that they were weak metric vocalic elements. According to their account, they can be analysed as a pre-vocalic onglide element of a rising diphthong constituting a weak syllable with one mora (the other part of the diphthong), or as a non-head mora post-vocally, where they would colour the preceding vowel and lengthen it, creating a heavy bimoraic syllable. When in an interconsonantal position, the weak "laryngeal" would become the head of the syllable since there would be no other candidates. Interesting is the account they give for post-?? (or post-sonorant) positions – both the resonant (syllable head) and the "laryngeal" would be moras but as the resonant loses its moraic status, the "laryngeal" becomes a heavy (long) bimoraic vowel. This could be seen in roots such as:

(3) PIE: *strh3- "strew" > Sanskrit: stīr-ná-, Latin: strā-tus, Greek: otro-tos

What is noticeable is the difference of the position of the resonant in Sanskrit as compared with the other two languages. Reynolds et al. (2000) explain this with both the resonant and the "laryngeal" occupying both mora positions an the resonant gesture being initiated later, resulting in it being perceived as following the vowel. Such an account is reminiscent of the Articulatory Phonology framework where production is regarded as overlapping and interacting real physical gestures and the notion of phoneme is rendered unnecessary. The authors specify that in the syllable templates used for the analysis there is nothing to dictate whether the onset or the second mora (where the "laryngeals" are positioned) is vocalic or consonantal and therefore a generalized root structure is possible in the terms of prosody. This is to account for the formalised assumption that all PIE roots had a CVC(C)-structure.

2.2 The Pharyngeal hypothesis

The largely accepted hypothesis that the '*elements sonantiques*' that de Saussure found were in fact "laryngeal" was first proposed by the scholars Möller (1917) and his student A. L. M. Cuny (1943), in an attempt to connect IE languages to the Semitic family. That followed from Jerzy Kurylowicz' discovery that the Hittite *h* corresponds precisely to what de Saussure described as *A (Kuryłowicz, 1927). A. L. M. Cuny (1943) specifically hypothesised that the elements must have been consonantal because in the neighbourhood of resonants, supposedly the resonant became a vowel in most languages. Even though Anatolian (Hittite seems to have preserved the consonantal quality of the elements, the language that preserves the three-way reflex between *h_1, *h_2 and *h_3 the best is Greek, and in the case of vowel environment, Latin as summarized in 2 and 3 (Clackson, 2007).

Further evidence for the reflex of the "laryngeals" before a consonant we find only in early Sanskrit:

(4) *h_2uh_1-nt- / *h_2weh_1-nt- 'wind' (*h_2weh_1- 'blow'): Hittite huwantes 'winds', Latin uentus, Sanskrit vaata- 'wind', Greek á(w)ent- 'blowing' (Clackson (2007), p.58)

This example from the early Vedic texts is important for the consonantal hypothesis. The long vowel, written as *aa*, seems to be present due to the hiatus that appeared between the two vowels a (reflex of PIE *e) and a (reflex of PIE vocalic nasal *n*) after the deletion of the consonantal reflex of *h_1 (Clackson, 2007).

After vowels PIE	Latin	Sanskrit	Greek	Hittite
*iH	$\bar{\imath}$	$\bar{\imath}$	$\bar{\imath}$	*$ih_2 > ihh$
*uH	$\bar{u}$	$\bar{u}$	$\bar{u}$	*$uh_2 > uhh$
*oH	$\bar{o}$	$\bar{a}$	$\bar{o}$	
*eh_1	$\bar{e}$	$\bar{a}$	$\bar{e}$	e, i
*eh_2	$\bar{a}$	$\bar{a}$	$\bar{e}$ (dialectal $\bar{a}$)	ahh
*eh_3	$\bar{o}$	$\bar{a}$	$\bar{o}$	(?)
Before Vowels PIE	Latin	Sanskrit	Greek	Hittite
*Hi	i	i	i	*$h_2i > hi$
*Hu	u	u	u	*$h_2u > hu$
*Ho	o	a	o	*$h_2o > ha$
*h_1e	e	a	e	e
*h_2e	a	a	a	ha
*h_3e	o	a	o	(?)

Figure 2: Reflexes of "laryngeals" in the environment of a vowel, (Clackson, 2007)

		*CHC	*HC-	*$\underset{\circ}{r}H$	*$\underset{\circ}{l}H$	*$\underset{\circ}{m}H$	*$\underset{\circ}{n}H$
*h_1	Greek	e	e	$r\bar{e}$	$l\bar{e}$	$m\bar{e}$	$n\bar{e}$
	Latin	a	*lost*	$r\bar{a}$	$l\bar{a}$	$m\bar{a}$	$n\bar{a}$
	Sanskrit	i	*lost*	$\bar{\imath}r/\,\bar{u}r$	$\bar{\imath}r/\,\bar{u}r$	$\bar{a}$	$\bar{a}$
*h_2	Greek	a	a	$r\bar{a}$	$l\bar{a}$	$m\bar{a}$	$n\bar{a}$
	Latin	a	*lost*	$r\bar{a}$	$l\bar{a}$	$m\bar{a}$	$n\bar{a}$
	Sanskrit	i	*lost*	$\bar{\imath}r/\,\bar{u}r$	$\bar{\imath}r/\,\bar{u}r$	$\bar{a}$	$\bar{a}$
*h_3	Greek	o	o	$r\bar{o}$	$l\bar{o}$	$m\bar{o}$	$n\bar{o}$
	Latin	a	*lost*	$r\bar{a}$	$l\bar{a}$	$m\bar{a}$	$n\bar{a}$
	Sanskrit	i	*lost*	$\bar{\imath}r/\,\bar{u}r$	$\bar{\imath}r/\,\bar{u}r$	$\bar{a}$	$\bar{a}$

Figure 3: Reflexes of "laryngeals" in the environment of a consonant, (Clackson, 2007)

Beekes (1989) summarizes the logical reasoning behind categorizing the "laryngeals" as the following:

(5) *ʔ - glottal stop
*ʕ - pharyngeal fricative
*ʕʷ - labialized pharyngeal fricative

He bases it on the generally accepted assumption that there are three consonantal elements. The vocalization of the "laryngeals" leads him to conclude that velar fricatives would not be good candidates. Therefore, the laryngeal and pharyngeal place of articulation remain sole options. Further, it was noted by Martinet (1955) that the third o-colouring laryngeal differs by the second a-colouring solely by the feature of lip-rounding. This is the reasoning behind the need for only two "laryngeals" to be reconstructed. Martinet (1958) also noticed that non-glottal sounds are less likely to colour other vowels. Thus, the glottal stop was chosen for *h_1. Since PIE did not have voice-voiceless contrast, Beekes appoints the easily vocalized voiced pharyngeal fricative as *h_2 and its labialized variant as *h_3.

As difficult as it is to trace the development of this hypothesis in the daughter languages, it seems to be buttressed by a typological parallel in Maltese, a Semitic language spoken in Malta, where idiosyncratic developments occur wherever guttural sounds were lost due to the influence of neighbouring non-semitic languages (Comrie, 1993).

2.3 Other theories, velar fricatives

For the purpose of this study, the focus will be put on the generally accepted glottal/pharyngeal hypothesis and the fairly controversial vocalic hypothesis.

Other propositions include the aforementioned trio of voiceless velar fricatives, mainly based on the supposedly velar reflexes in Hittite, as proposed by Lindeman (1970).

(6) *x' – palatal
*x – plain
*xʷ – labialized

Beekes (1989) heavily criticizes this theory while providing evidence for why the pharyngeals are more suitable. The already mentioned point that velar fricatives would not be easily vocalized already renders this theory weak. Further, plain obstruents were not frequent in PIE, yet in his system that would be *h_2, the most reconstructed one. Other theories speculate about the number of "laryngeals". In Hittite *h_2 usually corresponds to *h* but sometimes it disappears. This has led to the idea that there might be a

fourth laryngeal, brought forward by Bomhard (1981). He proposes voiceless aspirate *h*, which Beekes firmly rejects.

3 Articulatory Phonology

The methodology used in this paper concentrates on production rather than perception, as it describes the mostly reoccurring patterns of movements that occur during speech (Browman & Goldstein, 1992). Those patterns consist of constrictions of different sets of articulators, such as the lips or the tip of the tongue, or the larynx. The temporary alignment and overlap of those gestures are shown in gesture scores consisting of events, movements toward a certain configuration, organized in tiers, representing the articulators – tongue tip, tongue body, glottis, etc. A simplified version of a gesture score is 1, which has only two tiers denoting vowels and consonants rather than articulatory constrictions. Functional organization is usually restricted to the categories of vowels and consonants (Browman & Goldstein, 1990). The interactions between the gestures have been studied as the cause for deletion, insertion and assimilation in casual speech (Browman & Goldstein, 1989).

An example of the so-called gestural hiding has been described by Browman and Goldstein (1992) – the deletion of the /t/ in the phrase "perfect memory", usually described as final consonant cluster assimilation, was analysed with the help of X-Ray during casual speech and it appeared that the tip of the tongue in fact forms the constriction needed but the overlap with the other constrictions, such as the velar closure for /k/, "hide" it. This process is illustrated in the two gestural scores below (4), with the gestures of the last syllable of "perfect"in light gray and the first gestures of "memory"in darker gray. The first score shows careful pronunciation and the second illustrates the overlap which is the result of fast, casual speech.

The focus on production, however, does not exclude the role of the listener in diachronic changes when analysed within this framework. As suggested by Ohala et al. (1981), the listener needs to reconstruct the input and correct for any phonetical strategies the speaker might have used. Over time, in the case of systematic hypo- or hyper- correction, a change in the lexical gestural structure might occur. An example provided in Browman and Goldstein (1989) is the diachronic change of English words such as "cough" where the diphthong became a monophthong and the [x] became a [f], is illustrated in three steps with the help of gestural scores.

As observable, the shortening of the diphthong due to increasing overlap

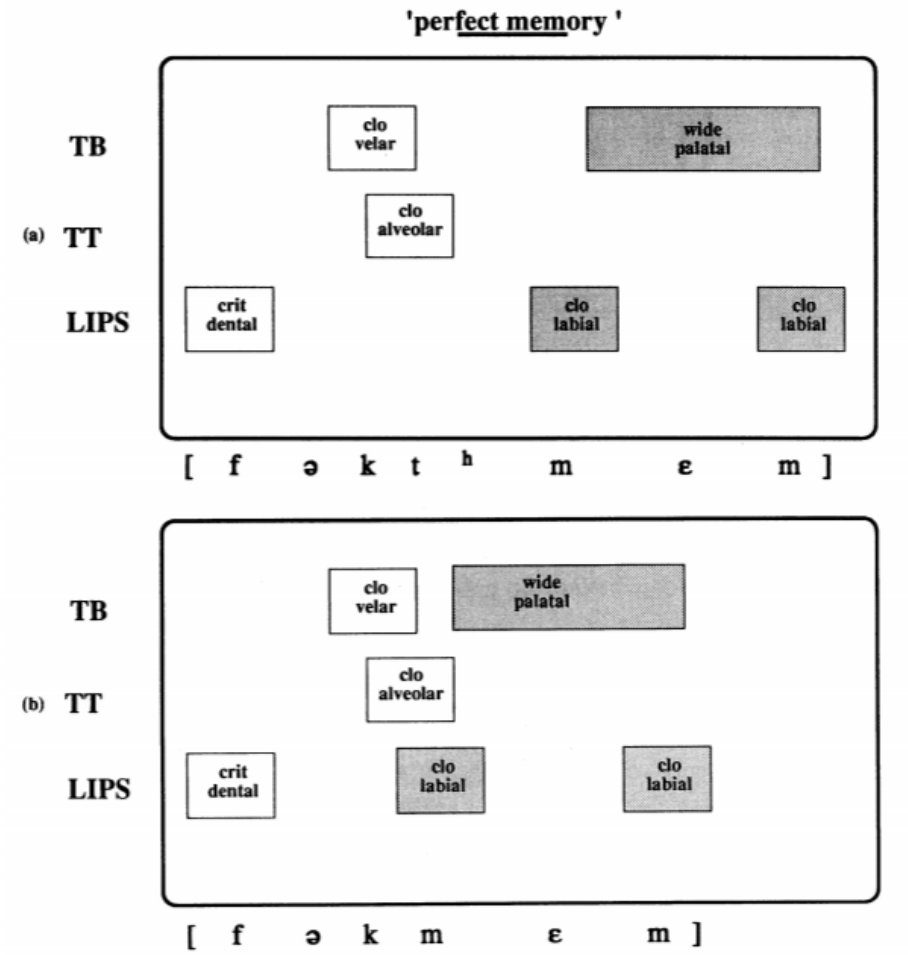
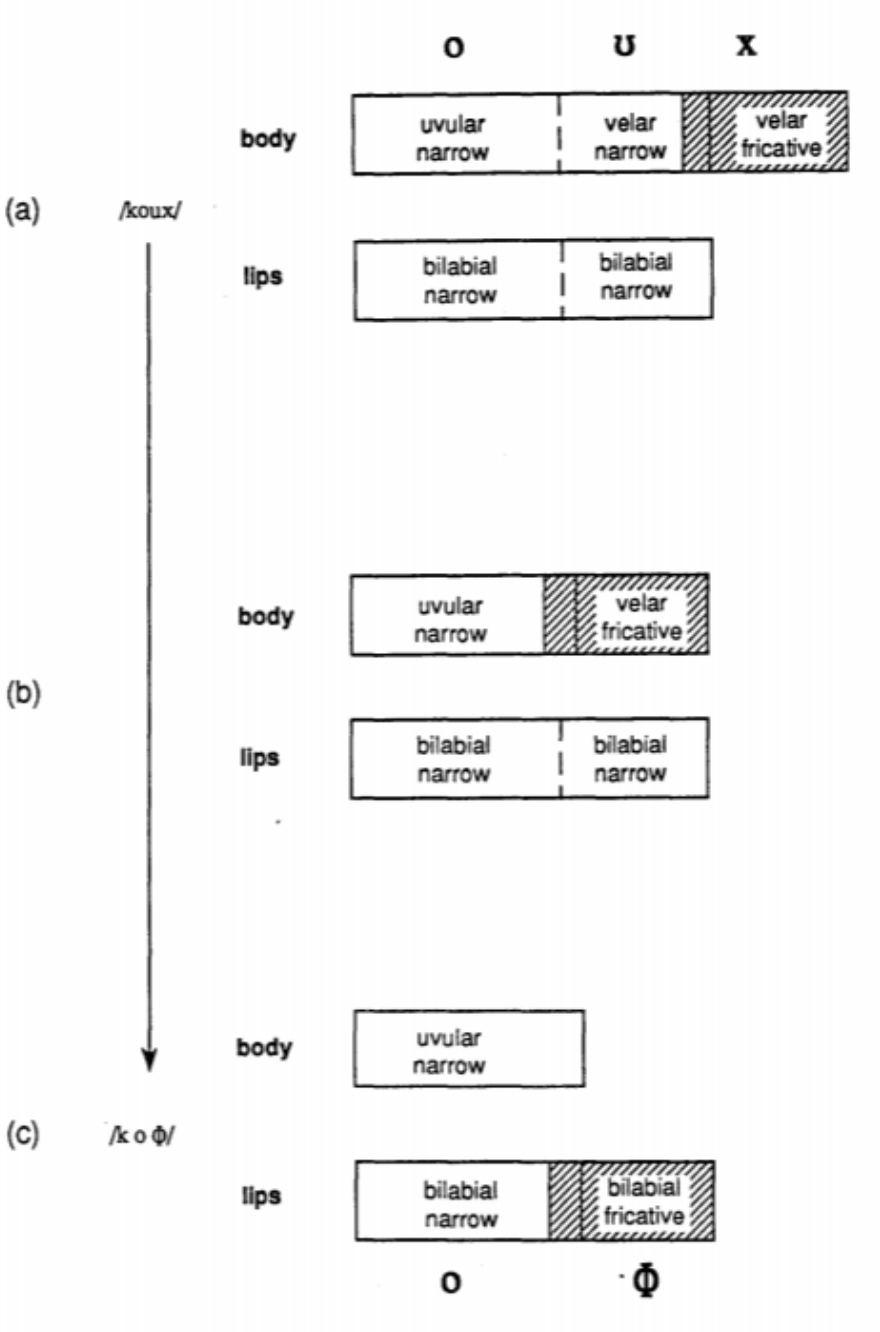


Figure 4: Partial gestural score for two versions of perfect memory, posited from observed articulatory movements, (Browman & Goldstein, 1992)

leads to the co-occurrence of the lip rounding and the frication. The listener would further attribute the frication to the bilabial articulator. Evidence for the role of the listener in historical sound change is provided by another rare example of attempt to reconstruct more precise phonetical features of the laryngeal elements by Sanker (2015). Speakers of Modern Arabic were exposed to recordings of pharyngeal and laryngeal sounds, as well as uvulars and other consonants, masked by background noise to simulate perception in the real world. The results seem to favour the pharyngeal and laryngeal sounds when the patterns of miscomprehension are compared to reflexes of "laryngeals", though not clearly. The author suggests that the vocalic reflexes in the daughter languages come from a vowel anaptyxis and deletion

Figure 5: Illustration of diachronic change [x] to [f] (Browman, 1989, p. 15)



of the laryngeal rather than vocalization. The current study will focus on illustrating how the overlap of gestures could have led to the reflexes we attest in the daughter languages, comparing the vocalic and the pharyngeal hy-

potheses through the analysis of cognate sets where the "laryngeal" elements appear in different environments.

4 Methodology

Handling speech as combinations of gestures, as Articulatory Phonology dictates, provides the opportunity to model it in terms of dynamical system that encompasses the formation and release of a local constriction as a functional goal of a gesture (its 'task') (Browman & Goldstein, 1995). Thus, a task-dynamic model was created and further implemented into a computational system. Multiple software applications employ this model in order to synthesize speech or create gestural scores. Such a software is VocalTractLab 2.2 (Peter Birkholz, 2020), with the help of which gestural scores can be made and edited and, additionally, a 3D model of the vocal tract can be manipulated. This makes possible the modelling of the "laryngeal" elements in all possible environments – intervocalic, word initial, etc. (refer to 2 and 3). The modelling and synthesis options will remain out of focus, as the possibility to create gestural scores is of the biggest importance to our analysis. The crafting of the gestural scores for the exemplary words given below will be done manually.

Regarding the underlying vowel gestures, the adopted approach is what has been described as "vowel-to-vowel" model, developed by Fowler (1983). According to this model, the vowel gestures are continuous, and the consonant gestures overlap with them. Each vowel is coordinated with the previous vowel and so are the consonant gestures. The vowel *e* in 6 overlaps almost completely with the bilabial approximant much like what we saw in 1 (which described metathesis) where the simultaneous initiation of the vowel and the *l* result in the Latin *lupus*.

Similarly to the investigation of the historical change of the word "*cough*" shown in 5, the development will be analysed by modelling what an intermediate stage could look like and whether that path is efficient and reasonable. Focus will be put on relevant forms which illustrate well the issue, mostly from Sanskrit and Greek as they showcase quite different outcomes and they provide a satisfactory number of cognates.

Reconstructing the PIE roots according to the two different hypotheses (the vocalic theory and the fricative theory) leaves us with two options for a starting point of the developments. However, the outcome is the same - the cognate word in the daughter language. Since the aim of the paper is to compare which development would be more feasible, both options will be

explored and the developments and processes described thoroughly.

How these two options differ can be showcased by transcribing a PIE word such as the one for 'red' (adjective), mostly reconstructed as *$h_1$rudhrós. In Greek the reflex is *eruthrós*, as in this language all three "laryngeals" resulted in a vowel – *e*, *a* or *o*. In other languages like Sanskrit and Latin, they were lost. According to the vocalic hypothesis, the PIE word could be vaguely transcribed as [erud$^{\text{h}}$ros] with a metrically weak, non-syllabic initial vowel, marked as such with the diacritic below it. This is in contrast with the other variant beginning with a glottal stop: [Prudros], according to the pharyngeal hypothesis.

An additional feature of the VocalTractLab is speech synthesis based on previously appointed parameters of the gestures. By adjusting those parameters in accordance with the hypotheses studied in this paper and the standard requirements for successful pronunciation of the given phones, we can come close to hearing how PIE could have sounded like. Even though this is non-essential to the purpose of this study, this is without doubt a big leap in the direction of decoding PIE.

It is of great importance to note that the focus of this study does not span over the phonetic nature of the phones of PIE other than the 'laryngeal' elements. Therefore, their features will only be touched upon whenever this is needed for the successful analysis via description in terms of gestures. Phonetic values will be assumed based on the vague reconstruction that is generally accepted. Of importance are the values of the vowels – /e/ and /o/ and the semi-vowels *i* and *u* when they are syllabic - /i/ and /u/. They also have consonantal allophones, sometimes noted as *j* and *w*, which will be noted as the glides /j/ and /w/. These assumptions are necessary in order to have a segmental transcription to use as a base for the gestural scores since no auditory data is available.

5 Material

The data analysed in this study consists of cognate sets of PIE roots containing the laryngeal elements in all possible and attested environments. Wherever possible, it is taken care that the laryngeal is located in the stem and not in the augment, suffix or ending in order to avoid any effect different morphological phenomena may have on the reflexes in the descendant words. Candidates with as numerous as possible cognates in the daughter languages were preferred. Most of the reconstructions were taken from Beekes (2011), with some additions from Clackson (2007).

	PIE	Sanskrit	Greek	Hittite	Latin
Word-initial before a consonant					
#h1C	*h1rudhrós	rudhirá-	eruthrós		ruber
#h2C	*h2ues-	vásati	*aues	huiszi	
#h3C	*h3n(e)id-	níndati	óneidos		
Interconsonantal					
Ch1C	*ish1ros	isirá-	iheros		
Ch2C	*ph2tēr	pitā	patēr		pater
Ch3C	*dh3tos		dotos		datus
In the environment of a resonant (R) – r, l , m, n					
RHC	*mh2krós		makrós	maklant-	macer
CRh1C	*gnh1tó-	jātá-	kasígnētos		
CRh2C	*tlh2tó		tlātós		lātus
CRh3C	*strh3-nó	stīrná-	strōtós		strātus
CRHV	*tnh2-(e)u	tanú-	tanaós		tenius
Following a vowel					
eh1	*seh1-				sēmen
eh2	*peh2-	pāti		pahs-zi	pāstor
eh3	*deh3-	dádāmi, dānam	dídōmi		dōnum
Word-initial before a vowel					
#h1e	*h1es-	ásmi	eimí	esmi	est
#h2e	*h2enti	ánti	antí	hanti	ante
#h3e	*h3eui-	ávi-	óis,		ovis
#Ho	*h2oiu-	āyu	ou		

Table 2: cognate sets displaying the "laryngeals" in different environments, highlighted forms are discussed in detail

6 Analysis of the Fricative hypothesis

6.1 Word-initial before a consonant

Since Greek presents a very clear picture of how the "laryngeals" differed in their nature as a language that preserved the three-way reflex, emphasis will be put on illustrating the Greek developments. In this position there is no trace left in the other exemplary languages, which will therefore be only briefly discussed. The special case of Hittite where we find a fricative reflex

will also be illustrated.

6.1.1 Greek

Schematically, the Greek reflexes examined in this subsection are:
#*h_1C > #eC
#*h_2C > #aC
#*h_3C > #oC

The behaviour of the "laryngeal" elements in Greek has been a subject of debate. It is of particular importance to the "laryngeal" theory that we can observe different reflexes for the three "laryngeals" where they had disappeared in other languages, as evident in 5. It has been suggested that the vowel that is left word-initially is a epenthesized vowel, added by Greek speakers as a result of the vocalisation of the "laryngeal". This is reminiscent of the hypothesis provided by Sanker (2015). Some, such as Schwyzer and Debrunner (1950), suggest that in the case of a word-initial a/e/o, we should envisage prefixes with different semantic values (e.g. a-/o- meaning 'the same'). Another hypothesis (Seiler, 1971) mentions another prefix, a vocalic n-, zero grade of en-, which would have the meaning "in". These hypotheses are easily argued against, mainly by the rather similar frequency of the three different initial vowels e/a/o.

The possibility that these vowels are reflexes of consonantal "laryngeal" elements arose with the idea that all PIE roots started with a consonant (Kuryłowicz, 1927). Beekes (1969) defends this point as it is difficult to conceive that those three different epenthesized vowels are not related to the three "laryngeals", given evidence from Hittite, such as *huiszi* as a cognate to PIE *$h_2$ues- and Greek aues, where we observe a guttural reflex.

Thus, the middle step between PIE and Greek in the case of "laryngeals" before a consonant in the beginning of the word can be analysed as suggested by Sanker (2015), where the "laryngeal" disappears and a vowel is epenthesised. That would lead to the aforementioned issue – why are there three different, equally frequently occurring options for the vowel? Assuming that the "laryngeal" was consonantal and secondary vocalization occurred in Greek, which was a common event, seems to be most reasonable in this environment. A gestural score presenting the gestures needed to articulate the PIE word would be stage 1 of the sound change. Such a score for the PIE word *$h_2$ues-, meaning "to live" or "to dwell". This is a good example of a "laryngeal" preceding a consonant as the u here is consonantal, in some schools transcribed as the symbol for the glide *w*.

On the left of the score, crafted manually in VocalTractLab, listed are

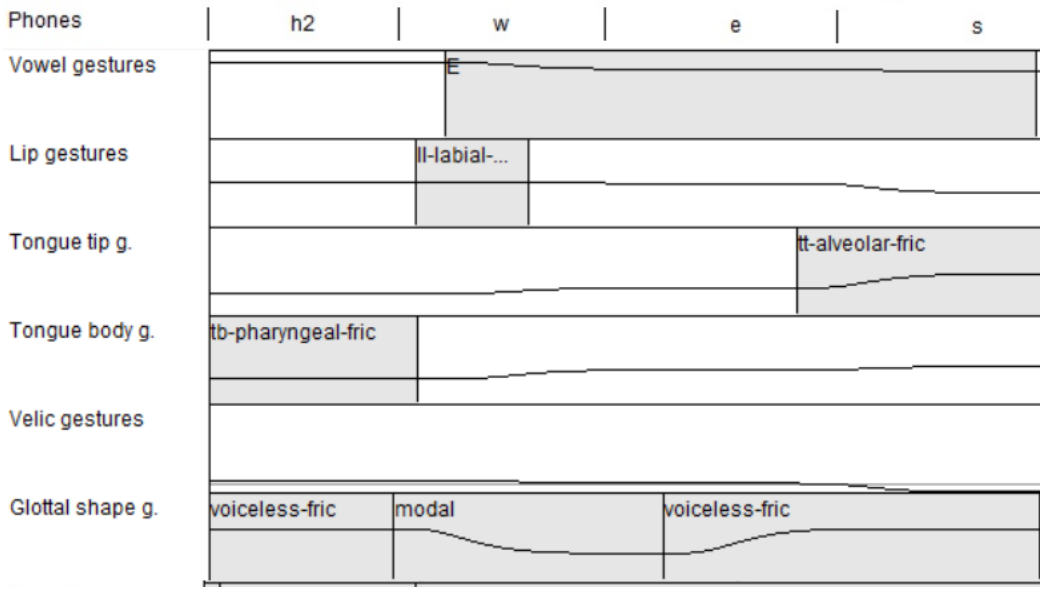


Figure 6: Gestural score for *$h_2$ues-

the different articulators, each of them with a separate tier, as well as tiers for the F0 gestures and lung pressure. On top, given is a transcription of the phones in IPA and the notation of the vowel phonemes is in SAMPA, computer-friendly version of IPA. The gesture which marks the constriction between the tongue dorsum and the pharynx (tb-pharyngeal-fric) was manually created and is based on the description of a pharyngeal fricative provided by Ladefoged and Maddieson (1996).

The black line within the glottal shape tier borders signifies the degree of the constriction. For example, the constriction of the glottis when producing solely the vowel gesture, labelled as modal voice, is rather wide as compared to the constriction for a fricative. Vocalization is characterised by more voicing and lesser degree of constriction, much like the features of approximation. Ladefoged and Maddieson (1996) describes the pharyngeal approximant to be very a-like as it both have low and back features. The following score illustrates such a development, which would be a middle step towards the pharyngeal being realised as the central to back vowel *a*.

The glottis in this score in more open and the closure between the tongue body (root) and the pharynx is more open as well. The sound produced is voiced and more approximant like. Following this tendency, the final outcome of this development in Greek is the vowel *a*, illustrated in the following gestural score (8) – the constriction of the tongue body and pharynx is missing, and the glottis is closed enough to produce a vowel. The bilabial approxi-

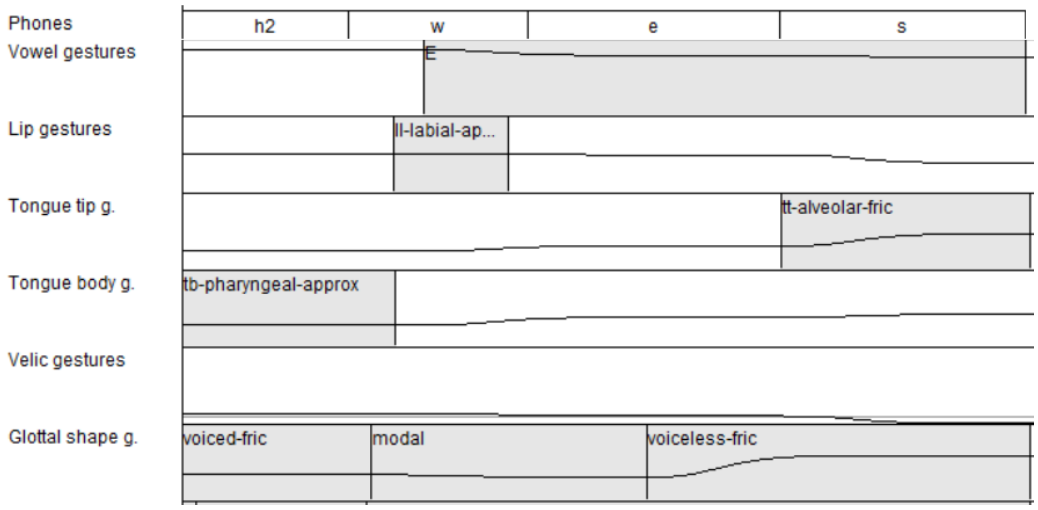


Figure 7: Gestural score of development into vocalized *h_2 in *$h_2$ues-

mant created by the constriction of the lips has also developed into a vowel *u* in Greek, which is the normal reflex of PIE **u* and **w* alike.

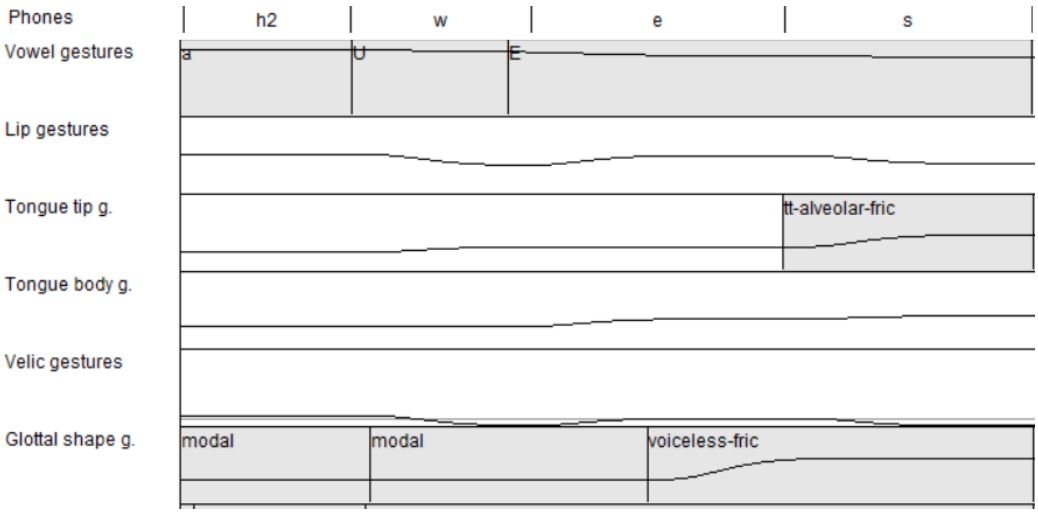


Figure 8: Gestural score presenting the Greek outcome *aues

The gestures needed to produce the two vowels are only slightly different then what is needed for the approximants, which might not be easily visible due to the organization of the vowel tier. The production of the vowel /u/ for example also requires the gesture of the rounding of the lips, even though that is not visible in the Lip Gesture tier. Below follow images of the vocal tract when producing a pharyngeal fricative, its vocalized allophone and finally

the vowel *a* (9), illustrating the minor changes occurring in the position of the articulators.

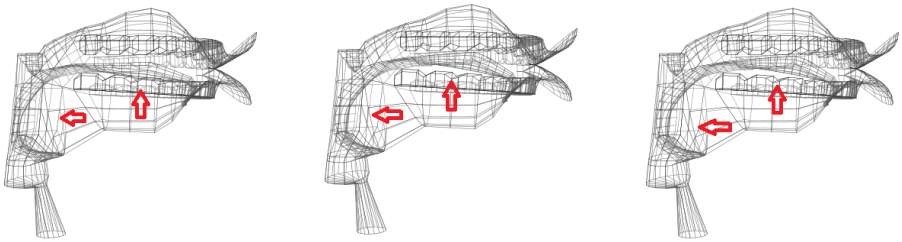


Figure 9: Vocal tract shape of pharyngeal fricative, pharyngeal approximant and the vowel *a*

The glottal stop as *h_1 transformation to the vowel *e* seems less straight forward, however it should be taken into account that due to Greek's stress assignment rules (Probert, 2012) the word initial reflex of the laryngeal would normally not be stressed. This automatically leads to reduced vowel quality and possibly a more schwa-like sound. It is easier to assume that some phonation in the form of creakiness could develop in a schwa. The figure below (11shows the vocal tract when producing a glottal stop, a schwa and an *e*. The tongue body is higher when producing *e* but there is little difference between the schwa and glottal stop as the main difference is the glottal constriction being narrow for modal voice and completely closed for the stop.

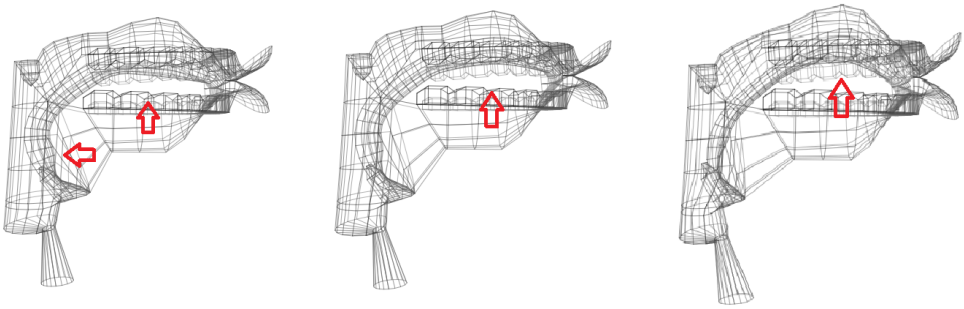


Figure 10: Vocal tract shapes for glottal stop, schwa and *e*

As of the last "laryngeal" *h_3, the development is very similar to that of *h_2 with the addition of the rounded lip gesture. The gestural score for the PIE word follows:

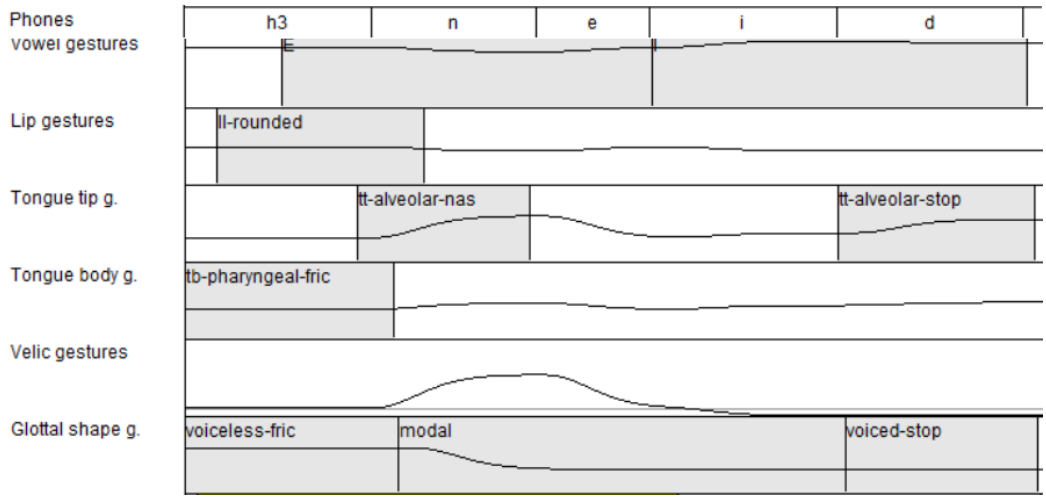


Figure 11: Gestural score for PIE *$h_3$neid-

The outcome in Greek is the rounded back to central vowel marked as *o*. Similarly to the development of *h_2, the fricative is lenited by first appearing as an approximant and finally the constriction is reduced to vowel-yielding gestures. The position and height of the vowel is determined by the features of the approximant – back and low. Additionally, in this case the roundness of the lips is preserved and the vowel in which it develops is an *o*.

6.1.2 Hittite

#*h_1C > #C
#*h_2C > #hC
#*h_3C > #hC

In the case of Hittite, we find a reflex of the "laryngeals" noted as *h*. There are some speculations about the phonetic value of this sign. According to Crossland (1951) the sound of the orthographic *h* in Hittite was a velar fricative based on Akkadian evidence, which is also what we assume for the purpose of this thesis. The following gestural score illustrates the outcome of the same word – *$h_2$ues-.

It is notable that the quality of the vowel *e* has changed and is now the more raised *i*. This tendency is also true for the initial fricative which is also articulated with a constriction at the uvula, which is situated above the pharynx. This rather small change in the articulation of the *h_2 could be influenced by Akkadian and as Ladefoged and Maddieson (1996) describes, it is not uncommon for the languages of the world to have a uvular-pharyngeal

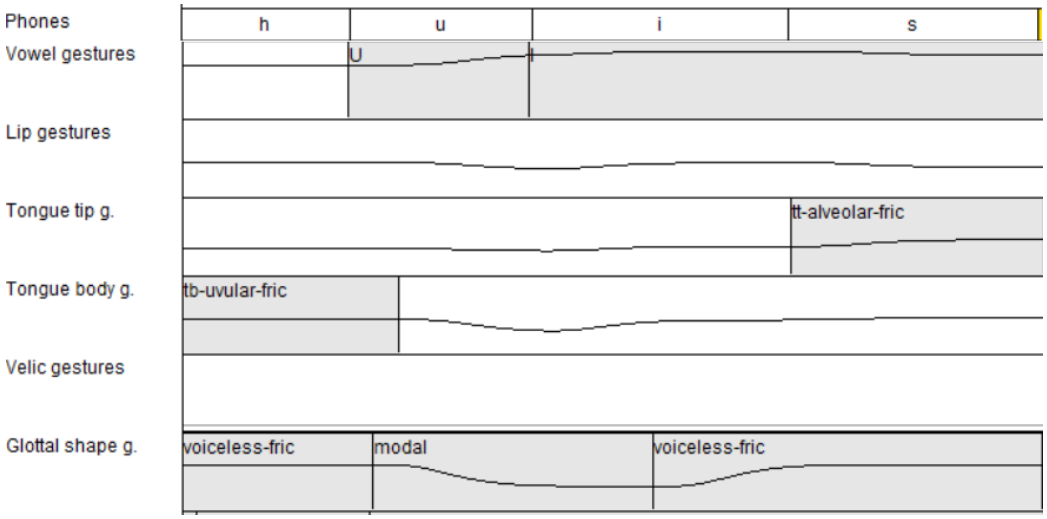


Figure 12: Gestural score for Hittite *huis-zi*

fricatives.

6.1.3 Sanskrit

$\#{*}h_1C > \#C$
$\#{*}h_2C > \#C$
$\#{*}h_3C > \#C$

In Sanskrit there seems to be no trace of the initial $*h_2$ left. As Lubotsky (1981) states, there is evidence that the "laryngeals" merged into a glottal stop in Indo-Iranian and later were lenited. This merger provides a challenge for the methodology used in this paper as it is difficult to showcase a gradual development from the assumed gestures needed for $*h_2$ and $*h_3$ to a glottal stop. This merger could have been the result of analogy, but it remains questionable why they would merge into the least frequent phoneme. Apart from that, the process of lenition of glottal stops is common, especially in fast speech, as in British English where words such as '*better*' are sometimes pronounced as one syllable with slight creaky voice as a remnant of the glottal stop (Ashby & Przedlacka, 2011). Ladefoged and Maddieson (1996) also notes that very rarely can we actually speak about fully achieved target gestures when it comes to glottal stops. This accounts for the disappearance of $*h_2$ in the Sanskrit cognate to $*h_2$ues-.

6.2 Interconsonantal position

In the interconsonantal position the outcomes in Greek are identical to what we observed in the previous section and can be analysed very similarly.

6.2.1 Sanskrit

*Ch_1C > CiC
*Ch_2C > CiC
*Ch_3C > CiC

In Sanskrit, however, we find a different picture, as illustrated above. The *i* reflex for all three "laryngeals" has been an object of discussion with different propositions being made by Cuny (1912), Lubotsky and more. LLubotsky (1981) stipulates that the "laryngeals" have all merged into a glottal stop in Indo-Iranian based on evidence from the oldest Veda texts. If we assume this, two possibilities arise – that the glottal stops were lenited and disappeared and *i* was epenthesized or that the glottal stop developed into an *i*. The second possibility seems difficult to occur because of the grand changes in the vocal tract shape that would have occurred. A comparison of the shapes for a glottal stop and a high front vowel *i* is illustrated below. Compared to Fig. 9 the raising of the tongue blade in the high vowel is even more evident, with the lower jaw raising as well.

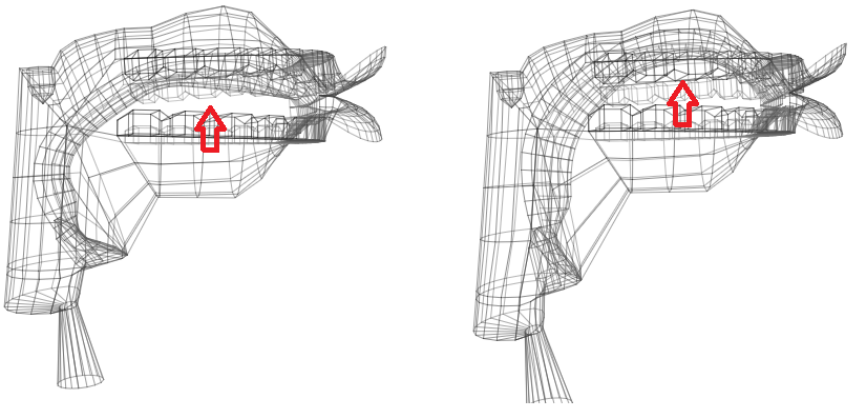


Figure 13: Images of vocal tract for a glottal stop and for *i*

Therefore, the possibility that lenition of the already frequently under-articulated glottal stop occurred is attractive to assume. When in an interconsonantal position, the disappearance of the glottal stop would lead to consonant clusters which is non-favourable in many of the cases. The PIE

root for "father" **phh₂ter-* would have changed to **pta-* in Indo-Iranian, as showcased in the following gestural score. **Ravneas** discusses evidence that despite orthography suggesting that in the Rigveda there were forms *pata*, *patarem*, the meter suggests they stood for *pta*, *ptarem*. This further solidifies the idea that the vowel *i* is epenthesized, which would not be a singular event. In Sanskrit and Greek reduplicated present is formed by duplicating the initial root consonant and adding either *e* or *i* (Beekes, 2011), for example:

(7) Greek títhemen 'we set' from PIE **dhi-dhh1-mé*

and

(8) Sanskrit *dádhati* 'they set' from PIE **dhé-dhh1-nti*

The process of epenthesizing *i* is exemplified in the following scores (14 and 15):

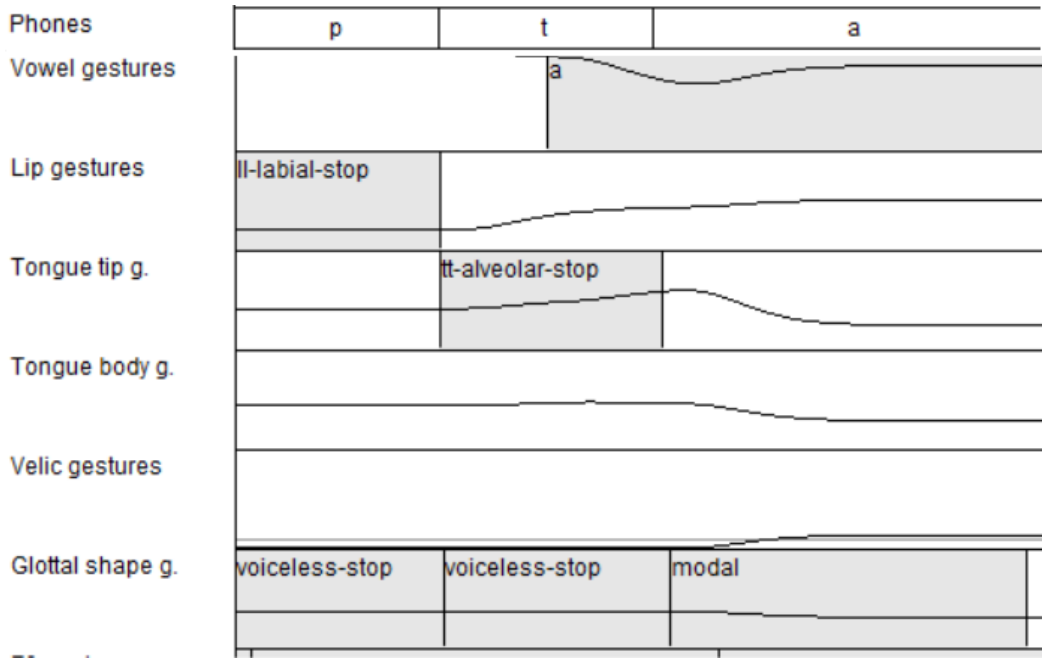


Figure 14: Gestural score for *pta-*

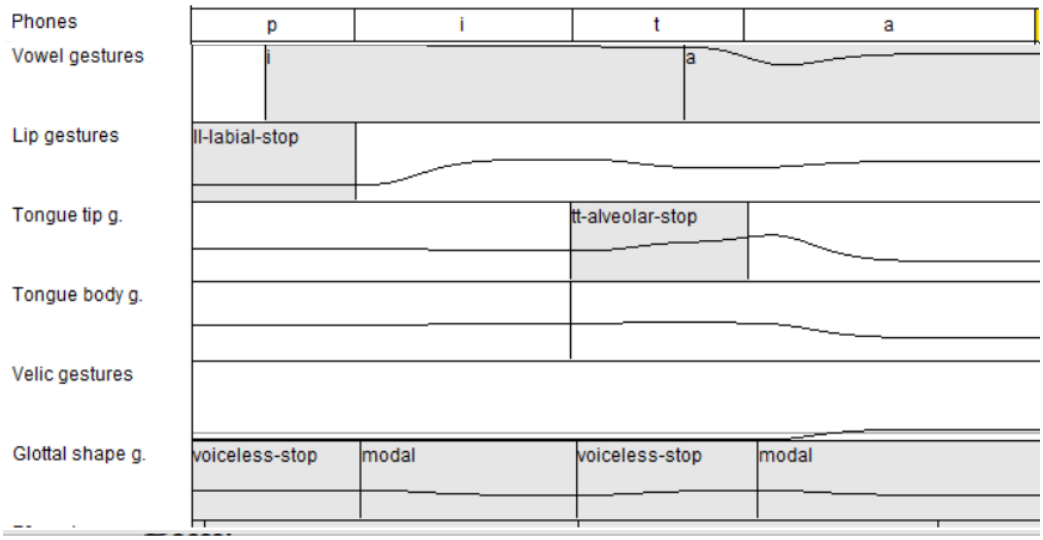


Figure 15: Gestural score for *pita-*

6.3 In the environment of resonants

6.3.1 Greek

*$rh_1C > r\bar{e}C$
*$rh_2C > r\bar{a}C$
*$rh_3C > r\bar{o}C$

As summarized above, roots of the structure CRHC is reflexed as CRVC in Greek. As usual, the three-way reflex is preserved in Greek and lost in Sanskrit. This development is one of the reasons why Cuny (1912) initially assumed the "laryngeals" were consonantal. He speculated that the H lengthens the vocalic resonant and disappears (CLC) and the long vowel reflex comes from the resonant. This led him to conclude that the "laryngeals" are less easily vocalised. Such a development is illustrated in the following gestural scores (16, 17) and 18.

As we can see from the gestural scores, this development is somewhat similar to when they are in word-initial position. The "laryngeal" is lenited but some of its features pertain. Due to the zero grade of the root, the resonant is vocalised and further lengthened and coloured by the H. However, there are some problems surrounding this possibility. When establishing that the resonant is vocalised, Cuny (1912) must assume that there is no other vowel in the root and all other elements are consonantal (including the "laryngeal"). He then uses the conclusion that the resonant is vocalised to

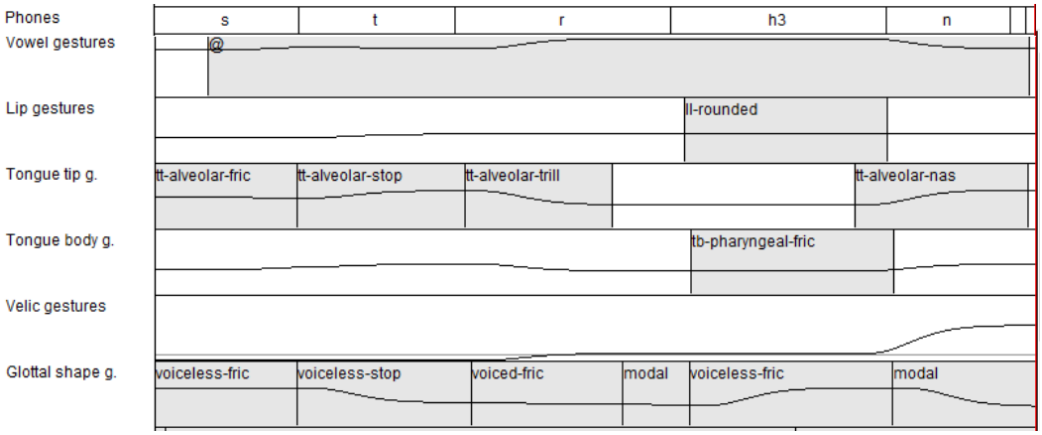


Figure 16: Gestural score for PIE **strh3n-*

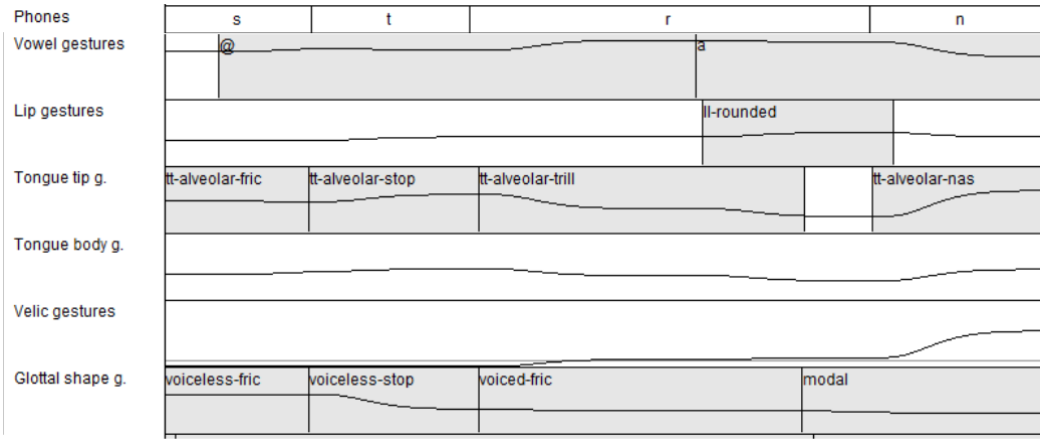


Figure 17: . Gestural score for mid-stage **strn-*

conclude that the "laryngeal" is consonantal. The circularity of this evidence already weakens the basis of the theory.

Further, it remains peculiar that in positions such as interconsonantally, the fricative "laryngeals" are what develops into a vowel, but here they disappear. Nonetheless, under the assumption that the "laryngeals" are consonantal, the path of lenition seems to be reasonable. If the "laryngeals" have vowel reflexes and the vocalic resonant is followed by some phonation, a long vowel could be a logical outcome. However, the methodology employed in this paper could not investigate in depth the process of lengthening since it is not a phenomenon determined by the qualities of the constrictions in the mouth rather than their temporal aspect. Variations in length can happen independently of variations of place or manner of articulation and are

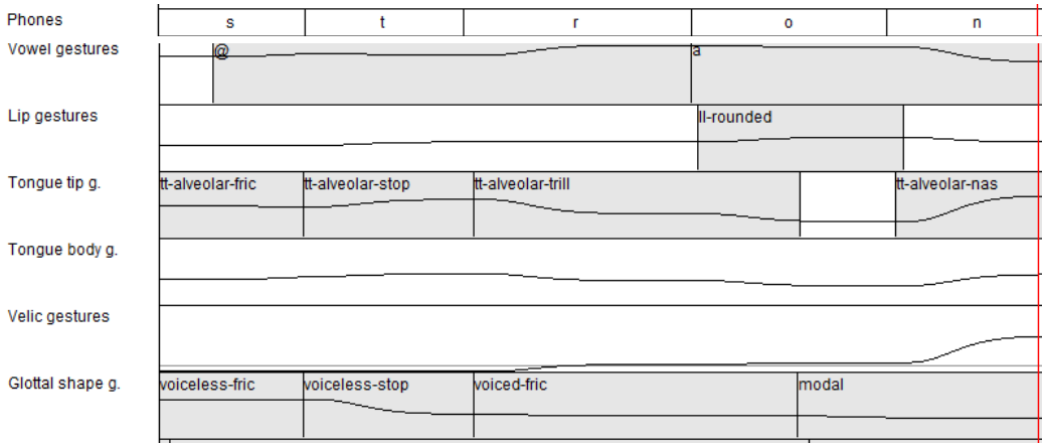


Figure 18: Gestural score for Greek *strot-*

particularly hard to explore with the absence of any recorded material.

6.3.2 Sanskrit

*r/lh$_1$C > īrC
*r/lh$_2$C > īrC
*r/lh$_3$C > īrC

In Sanskrit in this position we find a one-way *i* reflex as in the inter-consonantal position (summerized above). As in the previous section, we could lean into the explanation that the "laryngeals" all merged into a glottal stop early. Therefore, the vowel *i* would again be epenthesized and long because of the vocalic resonant. Here we also observe metathesis – the root in Sanskrit had developed to stīrná with the places of the vowel and the resonant switched. This phenomenon is explained in 1 by Reynolds et al. (2000) with the different temporal alignment of the gestures needed to produce the resonant and the vowel.

6.4 Before and after a vowel

*eh$_1$ > Greek: ē, Sanskrit ā
*eh$_2$ > Greek: ā, Sanskrit ā
*eh$_3$ > Greek: ō, Sanskrit ā

*h$_1$e > e
*h$_2$e > a

*h_3e > o

In both of these positions, the "laryngeal" colours the vowel *e* and in the cases where it follows the vowel it also lengthens it. Given the analysis already performed, this is a development that can be supported by Articulatory Phonology. Features such as backness and rounding of the lips transfer to the following vowel and turn it into *a* or *ɑ*. An example of such a development is the following cognate set:

(9) PIE **deh₃-*, Sanskrit *dádāmi, dānam*, Greek *dídōmi* (reduplicated present form), Latin *dōnum*

The following gestural scores illustrate the PIE root as reconstructed according to the Fricative hypothesis and the outcome in Greek with the background vowel gesture coloured as *a* by the pharyngeal fricative as it was lenited and the lip rounding preserved, resulting in the production of /o/.

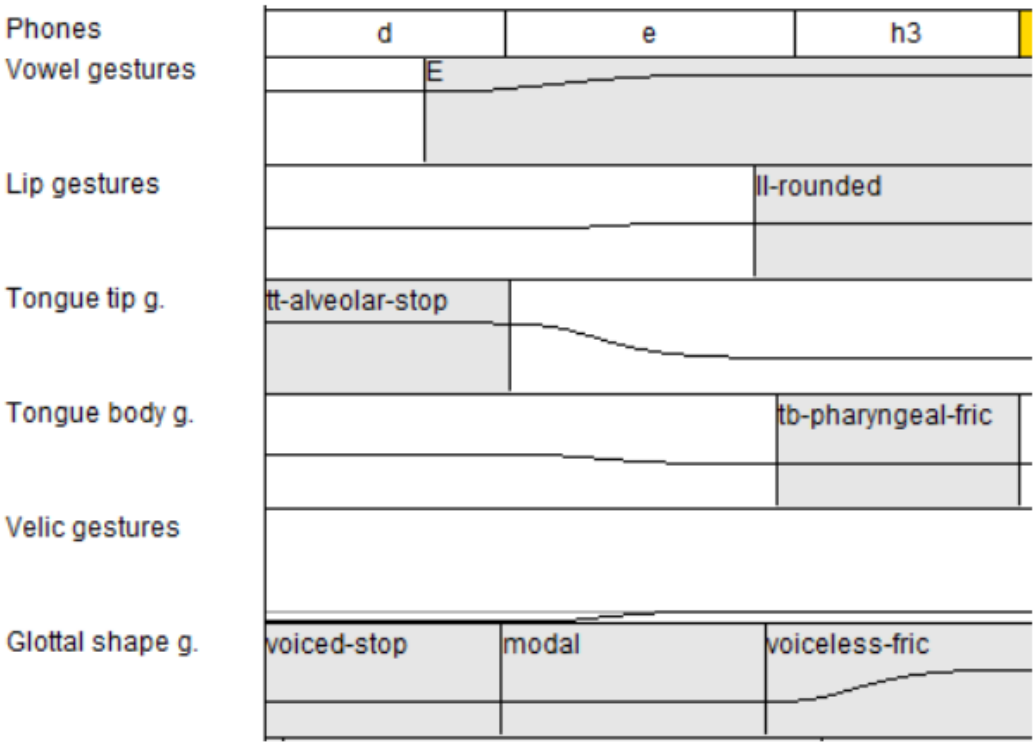


Figure 19: Gestural score for *deh₃-*

In the case of *h_1 no change in the following vowel occurs because, as discussed earlier, a glottal stop is mostly realised as creaky phonation which

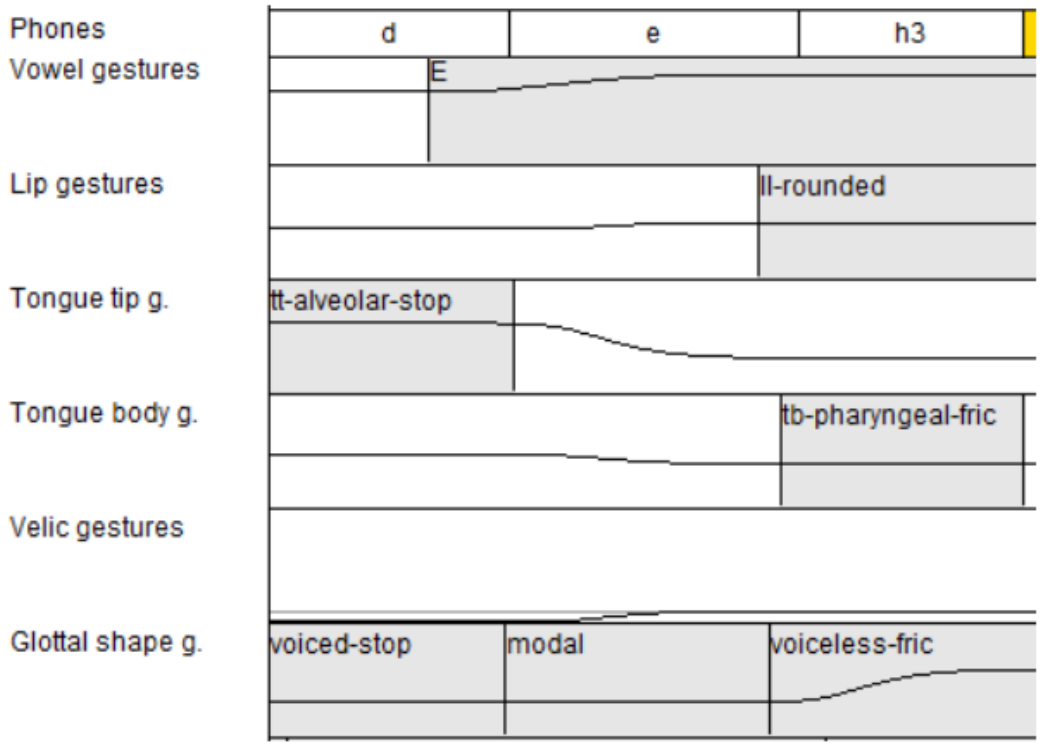


Figure 20: Gestural score for the Greek root *-dō-*

lacks specific features to be transferred to the vowel. The lengthening that occurs when the "laryngeal" follows the vowel will not be put in focus due to the limitations mentioned in the previous section.

7 Analysis of the Vocalic hypothesis

7.1 Word-initial before a consonant

7.1.1 Greek and Sanskrit

#*h_1C > #eC
#*h_2C > #aC
#*h_3C > #oC

Stating that the "laryngeals" were weak vowels leads to a severely simplified picture, especially in the cases of Greek and Latin where the three-way

reflex is preserved. In this position the gestural scores would show little change between the begin and end stage, except for longer lasting vowel gestures. This essentially suggests a much more economic change with no processes such as lenition.
#*h_1C > #C
#*h_2C > #C
#*h_3C > #C

In the case of Sanskrit, the "laryngeals" have disappeared in this position, which is again not inconceivable since they were short and weak.

7.1.2 Hittite

#*h_1C > #C
#*h_2C > #hC
#*h_3C > #hC

The main problem this theory faces is the Hittite reflex for *h_2 and *h_3 in this position, namely what is believed to be velar fricatives. Following the discovery that Hittite is a Proto-Indo-European language, it was assumed that it must have preserved features which disappeared in the mother language prior to the split of the other families. An example of this reflex is the previously discussed word *huiszi* deriving from the PIE **h2ues-*. According to the account of Reynolds et al. (2000) this reflex can be explained with pre-glottalization caused by delayed closure of the glottis when producing the short initial vowel. This is illustrated in the following gestural scores (21 and 22).

As it can be seen by the slight curve of the line in the glottal shape tier in the second gestural score, at first the glottis remains more open, delaying the onset of the vowel and resulting in glottalization. Reynolds et al. (2000) does not assume that the Hittite fricative was a uvular fricative specifically, even though, as mentioned earlier, there is evidence for it. It is possible to assume that after the glottalization followed an additional change where it morphed into a uvular fricative, even though that is a somewhat drastic change.

7.2 Interconsonantal position

7.2.1 Greek

*Ch_1C > CeC
*Ch_2C > CaC

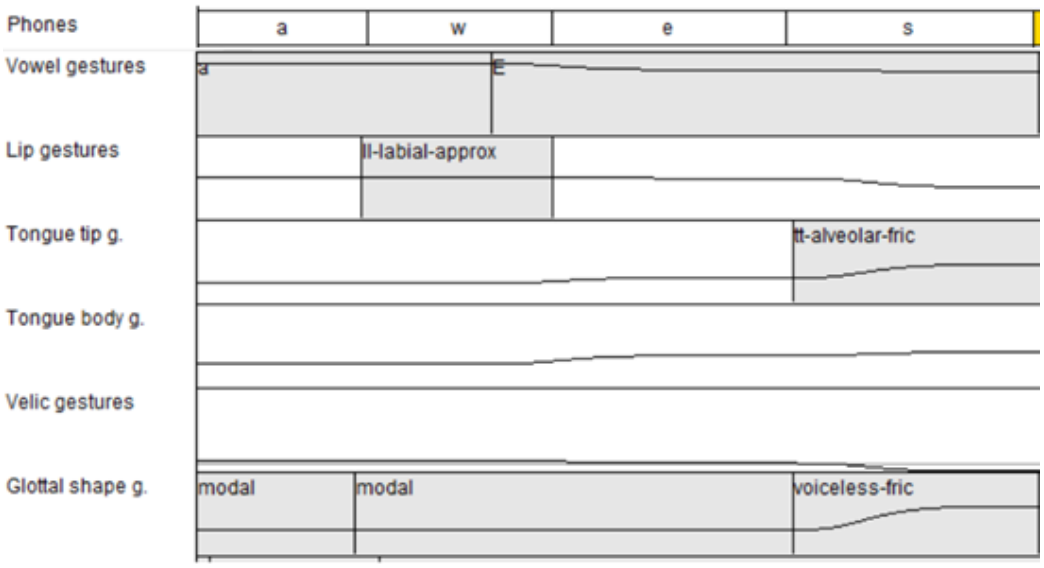


Figure 21: Gestural score for *$h_2$ues- according to the Vocalic hypothesis

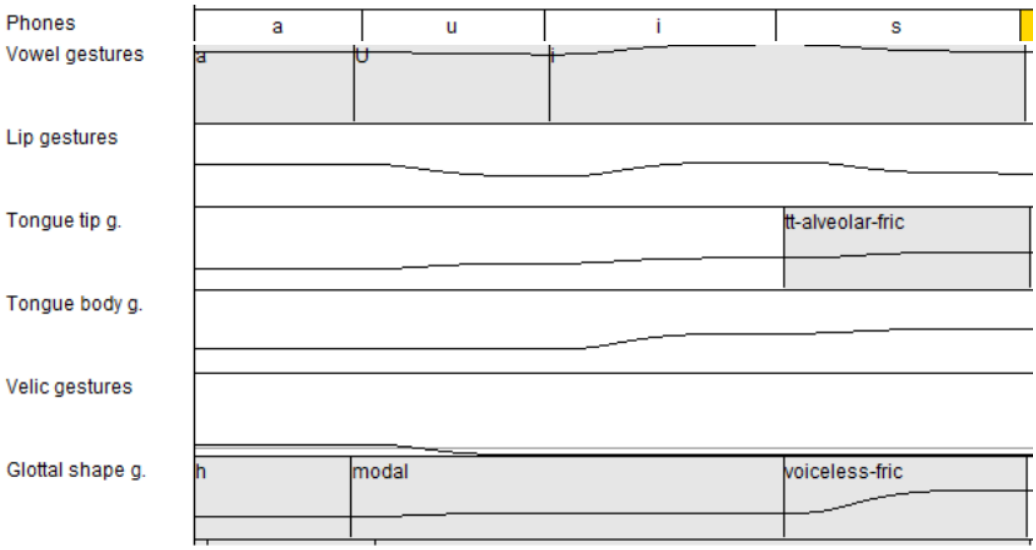


Figure 22: Gestural score for Hittite *huis-* according to **reyn**

*$Ch_3C > CoC$

The Greek reflexes can be straightforwardly accounted for following the Vocalic hypothesis. The following example illustrates the minimal amount of changes which have happened, with the short vowel marked with a diacritic underneath it (as in e̯).

(10) PIE *ish$_1$ros /is̲e ros/ > Greek iheros
PIE *ph$_2$tēr /p̲a̲te:r/ > Greek pater
PIE *dhh$_3$tos /d̲o̲tos/ > Greek dotos

7.2.2 Sanskrit

*Ch$_1$C > CiC
*Ch$_2$C > CiC
*Ch$_3$C > CiC

More curious is the case of the Sanskrit one-way reflex, which, according to Reynolds et al. (2000) is a result of phonological neutralisation. If that was the case, then the Rigveda forms without a vowel discussed earlier would be problematic. We could assume that the weak vowels follow a similar route to that of the fricatives – they are first neutralized, then lenited and later an epenthesized vowel *i* appears. It is, however, interesting that a vowel disappeared in order for a new one to be epenthesized anew. This could mean that an alternative explanation of the Sanskrit reflexes must be looked for.

7.3 In the environment of a resonant

7.3.1 Greek

*rh$_1$C > rēC
*rh$_2$C > rāC
*rh$_3$C > rōC

Following a resonant, the "laryngeals" result in a long *e*, *a* or *o* vowel in Greek. Reynolds et al. (2000) suggests an account where vowel weight and moraic structure plays an important role in order to account for the lengthening. Since this is out of the scope of this paper, it will not be discussed in depth. With this aside, how the quality of the vowel is preserved can be illustrated with the following examples:

(11) PIE *gnh$_1$to /gn̲e̲tos/ > Greek gnētos
PIE *tlh$_2$tó /tl̲a̲tos/ > Greek tlātós
PIE *strh$_3$nó- /str̲o̲tos/ > Greek strōtós

7.3.2 Sanskrit

*r/lh$_1$C > īrC
*r/lh$_2$C > īrC
*r/lh$_3$C > īrC
*mh$_3$C > āC
*nh$_3$C > āC

In Sanskrit we observe different vowel quality in the reflexes of the different resonants. When the "laryngeal" is neighbouring *r* or *l*, the vowel in the reflex is long *i*. However, when the resonant is *m* or *n*, the vowel in the reflex is ā. As these are the usual reflexes of the syllabic resonants, this again leads us to the conclusion that the "laryngeals" must have disappeared at some point, just like in word-initial position, only leaving behind a lengthened syllabic resonant.

7.4 Before and after a vowel

The reflexes in Greek again bring no surprise. The vocalic reflexes of *h$_2$ and *h$_3$ colour the other vowel, because the features of a and o are extended over it. The picture in Sanskrit is also clearer – the reflex is always an *a*, lengthened when it comes from *h$_3$ (or *o*) in open syllables (according to Brugmann's law) and when the "laryngeal" comes after the vowel. Since all three vowels would normally result in *a* in Sanskrit, it is clear that the vowels were preserved before this sound change occurred. Regarding the lengthening - it is not of crucial importance to analyse it since it is easily deductible that the two vowels morphed into one long one. Again, Reynolds et al. (2000) suggest an analysis based on vowel weight.

8 Conclusion and Discussion

Based on the analysis, a couple of conclusions can be made. Unsurprisingly, as both theories in question are fairly well grounded with evidence from comparative reconstruction, there are advantages to both.

The vocalic hypothesis has shown to be very economic since the changes in Greek for example are minimal. On the contrary, the fricative hypothesis sets the scene for a more dramatic change which includes processes such as lenition, epenthesis, neutralisation and so on. Nonetheless, this does not necessarily make the fricative hypothesis less favourable as sound change

can be quite complex. The three sounds in question are not very typologically common, or at least not in such phonological environments such as interconsonantal positions and this could very well be the drive behind their evolution. Ease of production is one of the main factors behind sound change and the lenition of consonants results in less constrictions and less effort to produce.

However, the glottal stop as *h_1 causes more issues than the pharyngeal fricatives as *h_2 and *h_3. Whether there is a better contender for the position of *h_1 fitting within the fricative hypothesis can be explored through the method used in this paper in the future, perhaps stemming from typological parallels and the nature of other changes in PIE.

The vocalic hypothesis, on the other hand, poses different issues, such as the need to possibly reconsider the vowel inventory of PIE and the compromise surrounding the Anatolian evidence. Assigning *h_2 a metrically weak *a* sound could be further researched as one could initially assume that this phoneme would have a full vowel counterpart as do the other two "laryngeals" – there is an *e* and *o* in PIE, but many have reasoned against the reconstruction of an *a* (see Lubotsky (1981)).

On the question regarding the fricative reflex in the Anatolian branch – given the severely differing reflexes in the daughter languages, a compromise must be made either way. The explanation presented by Reynolds et al. (2000) concerning pre-glottalization is not improbable as glottalization was common in PIE obstruents, as discussed by Kortlandt (1978).

Overall, the complex changes that the Fricative hypothesis assumes seem to lead to more uncertainties than the straightforward answers the Vocalic hypothesis is able to provide. This paper is a rare example of the Vocalic hypothesis as Reynolds et al. (2000) see it being put on trial, whereas the Fricative hypothesis has been largely discussed over the decades. It would be interesting to see whether the analysis of Reynolds et al. (2000) could stand being tested by all rare and exceptional forms found in the daughter languages, much alike how we found that it struggles to account for old forms in the Vedic texts.

The investigation of the two hypotheses has led to valuable conclusions but nonetheless, little can be stipulated with absolute certainty. Additionally, Articulatory Phonology relies on the deep understanding of the interaction of different gestures and as the focus of this paper is strictly towards the "laryngeals" and the phonetic value of other phones was not discussed in detail, some aspects of this interactions were not analysed in depth. To conclude - the main aim of this exploratory paper was to compare two theories about the PIE "laryngeals", however not less important was to showcase how modern approaches towards century-old problems could help gain new

insights and systemize the accumulated evidence. This was illustrated by the successful implementation of gestural scores which served to model the sound changes as gradual shift in the production of constrictions. This proved to be useful when exemplifying lenition and metathesis. Undoubtedly, there is a lot of potential in taking this approach when analysing other PIE sound changes and sound laws, as there are many open questions and questionable accounts. Accumulating accounts of said developments would help catalogue typical changes and lead us to learning more about how PIE really sounded like.

Glossary

***** asterisk (*) marks a reconstructed root or phoneme that has not been attested but is assumed to have existed, as in *wlk. 3

ā a horizontal line above a vowel is usually used as a marker for a long vowel in comparative linguistics. 5

ablaut regular vowel alteration, speculated to have been a morphological device in PIE to mark case, tense and so on, In PIE we observe three grades - zero (no vowel), full and lengthened grade (long vowel). 5, 6

Akkadian an extinct East Semitic language that was spoken in ancient Mesopotamia between the 3rd millenium BC to the 8th century BC. The Akkadians had a lot of interaction with the Hittite and this is reflected in the Hittite language. 20

Avestan an early Irnaian language, spoken in the 1st and 2nd millennia BCE. 6

Brugmann's law a sound law which states that PIE $*o$ became long $*a$ in Proto-Indo-Iranian and sunsequently in Sanskrit when it was in an open syllable. 32

cognate words with common etymological origin, sharing the same parent language. 3, 13, 14, 15

Hittite Hittite is an Anatolian language, the oldest attested Indo-European language. It was written on clay tablets in cuneiform, with records dating from the 16th to the 13th centuries BCE. 5, 6, 7, 9, 20

resonant a sonorant; specifically used for /r/, /l/, /m/ and /n/ in comparative linguistics. 6, 7, 15

Rigveda The Rigveda is a collection of hymns containing the oldest known Vedic Sanskrit texts. Its oral tradition dates to the 2nd millenium BC. 23, 31

root a form without prefixes, suffixes or augments. The PIE roots are believed to have always had the structure CV(V)C-. 3, 5, 14

syllabic a consonant that forms a syllable on its own, usually characterized with more approximant-like quality and some vocalization produced before or after it. 3, 14

vocalic see *syllabic*. 2, 3, 4, 5, 6, 7, 9, 14

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