Re-evaluating the word-medial operation of the Saussure-Hirt effect in Greek

11th International Colloquium on Ancient Greek Linguistics

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June 26, 2025

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Introduction

The Saussure-Hirt Effect

- de Saussure (1905: 511[22]) identified the absence of laryngeal reflexes when adjacent to resonants in *o*-grade environments:

(1) a. ὄρφνη 'darkness', ἔρεφω 'to cover'

b. τόρνος 'compass, turning-lathe', τέρετρον 'borer, gimlet'

c. βροντή 'thunder', -βρεμέτης 'thundering' (secondary derivative from an unattested *βρεμετός [Vine 1998: 70-71[174]])

d. τόλμα 'courage', τελαμών 'broad strap'

(2) Obstruents block the deletion of the laryngeal

a. ἀγορᾱ́ 'marketplace' < *$\boldsymbol{h_2}$*gor-éh*$_2$

b. ποταμός 'river, stream' < *pot$\boldsymbol{h_2}$*-mos*

The Saussure-Hirt Effect

- IE comparanda introduced by Meillet (1908: 68–9) and Hirt (1921: 185–6) and the Greek evidence discussed by Beekes (1969: 238–242), Peters (1980), and Rasmussen (1989: 175–187, 368–372).
- In the most up-to-date formulation (Byrd 2013, Melchert 1994: 49–51; Nussbaum 1997: 185 [w/o ref. to syll. structure]):
  - $*_{\sigma}[h_xRo > *_{\sigma}[Ro$ (Word-initial operation)
  - $*oRh_x]_{\sigma} > *oR]_{\sigma}$ (Word-medial operation)

(3) a. μοιχός 'adulterer' < PIE $*(h_3)moi\hat{g}^hós$ ← $*h_3mei\hat{g}^h$- 'make water' (differently: Rehan, Forthcoming)

b. τόρμος '(peg-)hole' < PIE $*tor\mathbf{h_1}$-*mos*, τέρετρον 'borer, gimlet' < PIE $*ter\mathbf{h_1}$-*trom*

Word-medial Saussure-Hirt effect

(4) Secure examples of forms lacking a laryngeal reflex in *o*-grade contexts:

a. πόρνη ‘prostitute’ « **por(**$\boldsymbol{h_2}$**)néh$_2$* ← **per*$\boldsymbol{h_2}$ ‘sell’ (cf. Gk. πιπράσκω, πέρνημι)

b. τόλμᾱ (Dor.) ‘courage, endurance’ « **tol(**$\boldsymbol{h_2}$**)-m(n)-éh$_2$* ← **tel*$\boldsymbol{h_2}$ ‘raise’ (cf. τελαμών « **tel*$\boldsymbol{h_2}$*-mṓ*)

c. τόρμος ‘(peg)-hole’ (cf. Hitt. *tarma-* ‘nail, peg’, CLuw. *tarma/i-* ‘id.’) < **tór(*$\boldsymbol{h_1}$*)mos* ← **ter*$\boldsymbol{h_1}$ ‘drill’ (cf. Gk. τέρ**ε**τρον, OI *tar**a**thar*)

d. τόρνος ‘lathe-iron (turning tool)’ « **tor(*$\boldsymbol{h_x}$*)nós* ← **ter*$\boldsymbol{h_x}$

- This presentation: re-evaluate the forms showing word-medial Saussure-Hirt effect (henceforth, S-H effect) in (4) and explain the laryngeal-loss through a more restricted version of Szemerényi’s Law.

Roadmap

Introduction

Previous explanations of the S-H effect

Proposal

Discussion

Appendix

Previous explanations of the S-H effect

Phonetic explanations for the Saussure-Hirt Effect

Previous phonetic explanations have attributed the loss of the PIE laryngeals in this context to the phonetic profile of PIE **o*.[1]

- Byrd (2013): laryngeals deleted by Advance Tongue Root (ATR) disharmony, based on Keydana's reconstruction of PIE **o* as /o/.
  - Keydana (2012: 141) reconstructs the feature [+tense] for PIE *o /o/ based on "Brugmann's Law" in Sanskrit (PIE **o* > Indo-Iranian *ā* in non-final open syllables).

1. Rasmussen's theory of laryngeal loss in a consonantal cluster with consonantal **o* (1989: 180) is a non-starter.

Byrd's phonetic explanation of the S-H effect

- Byrd (2013): laryngeals deleted by Advance Tongue Root (ATR) disharmony, based on Keydana's reconstruction of PIE **o* as /o/.
  - Keydana (2012: 141) reconstructs the feature [+tense] for PIE *o /o/ based on "Brugmann's Law" in Sanskrit (PIE **o* > Indo-Iranian *ā* in non-final open syllables).
  - Some issues:
    - No reason to assume PIE **o* was phonetically tense.
    - Open-syllable tensing (Storme 2019: 303–4) can also explain the Indo-Iranian development.
    - Mid vowels phonetically longer and more likely to develop into phonologically long vowels (cf. regular open-syllable lengthening limited to mid vowels [Lahiri & Dresher 1999: 690 on Middle English]).
    - Representation of uvular consonants as [-ATR] presumed; not universally accepted (see Appendix).

Dissimilation of the laryngeal constrictor mechanism Weiss ( )

- Long-distance dissimilation of the laryngeal constrictor mechanism (Weiss 2012) is also questionable (see Appendix):
  - Need to assume PIE *h_1 = /ʔ/ and not /h/ (/h/ does not involve laryngeal constriction).
  - Not universally accepted (cf. Kümmel 2007: 334–6; Rasmussen 1994: 436).
  - Still the issue of obstruent blockers: *h_1, even if /ʔ/, is not its own blocker?[2]

(2) Obstruents block the deletion of the laryngeal

a. ἀγορᾱ́ 'marketplace' < *$\boldsymbol{h_2}$*gor-éh*$_2$

b. ποτα**μ**ός 'river, stream' < *pot$\boldsymbol{h_2}$*-mos*

2. "I'm not sure I believe what I said then" (Weiss, p.c.)

Non-local vowel-consonant harmony

- Byrd and Weiss's explanations make S-H effect an instance of **non-local vowel-consonant (dis)harmony**.
- In the typology of harmonic processes, non-local vowel-consonant (dis)harmony is relatively rare (Rose & Walker 2011: 249).
- "[N]one of these cases exhibit blocking effects." (2011: 250)
- Harmony usually blocked if the output of harmonization would produce marked outputs (Rose & Walker 2011: 270).
    - Spread of uvularization and pharyngealization on obstruents widely attested, but the S-H effect in its widely-accepted version is blocked by obstruents.
    - On the other hand, in Najdi Arabic, uvularization by /q/ does not spread to laterals (Alhammad 2021), which would be at odds with the S-H effect.

Unexpected laryngeal loss when V ≠ PIE *o

- Even though these hypotheses might explain *-oRh$_x$]$_\sigma$ > *-oR]$_\sigma$, there is a set of forms in Greek (and IE generally) not usually considered in the phonetic explanations of the S-H effect.
- These point towards a more general *-VRh$_x$]$_\sigma$ > *-VR]$_\sigma$ (van Beek 2011).

(5) *VRh$_x$]$_\sigma$ > *-VR]$_\sigma$ examples:

a. στέρνον 'chest, breast' < *ster**h$_3$**no-, OHG *stirna* (f.) 'forehead' < *ster(**h$_3$**)neh$_2$ ← *ster**h$_3$**

b. ἐλλός 'deer-calf' < *h$_1$el(**h$_2$**)nó- ← *h$_1$el**h$_2$**

c. τέρνακα 'stalk of the cardoon-plant' < * ter(**h$_1$**)nakéh$_2$ ← *ter**h$_1$**

d. τέρμα 'boundary' < *tér**h$_2$**-mn̥- ← *ter**h$_2$**

e. Ved. *jánman-* 'birth' < *ĝén**h$_1$**-mn̥- ← *ĝen**h$_1$**

A Greek-internal analysis

- To explain laryngeal loss in forms like (5) van Beek (2011) has argued for a sound law PIE *VLHNV > Gk. VLNV.

(5) *VRh$_x$]$_\sigma$ > *-VR]$_\sigma$ examples:

a. στέρνον 'chest, breast' < **stér**$\boldsymbol{h_3}$*no-*, OHG *stirna* (f.) 'forehead' < *ster(**h$_3$**)néh$_2$ ← *ster**h$_3$***

b. ἐλλός 'deer-calf' < *h$_1$el(**h$_2$**)no- ← *h$_1$el**h$_2$***

c. τέρνακα 'stalk of the cardoon-plant' < * ter(**h$_1$**)nakéh$_2$ < ← *ter**h$_1$***

d. τέρμα 'boundary' < *tér**h$_2$**-mn- ← *ter**h$_2$***

e. Ved. *jánman-* 'birth' < *ĝén**h$_1$**-mn- ← *ĝen**h$_1$***

Counterexamples to van Beek's VLHNV > VLNV rule

- This development leaves unexplained the laryngeal reflex in τελ**α**μών < **tel**$\boldsymbol{h_2}$*-món*.
  - τελαμών could have been built to the synchronic full-grade root aorist stem τελα- (van Beek 2011: 166–8).
  - As acknowledged by van Beek, a root aorist stem τελα- only attested in Hesychius (τελάσσαι˙ τολμῆσαι, τλῆναι; cf. Hom. ταλάσσαι).
  - τελάσσαι analogical to ἐλάσαι, κεράσ(σ)αι, κρεμάσαι (Yates 2022: 244[64]).
  - OIr. *talam* 'earth', Lat. *Tellumō* 'P.N.' [Weiss 2017: 386[51]]) indicate that τελαμών can only be an archaic formation.
    - Latin *Tellumō* is not lautgesetzlich (**Tolumō* expected) and the derivational history of *Tellumō* and *tellūs* (f.) 'earth' remains unearthed (de Vaan 2011: 609);"fundamental recreation of the word" (Fortson 2024: 3). For an explanation, see Olsen (2021: 428–9).

Further problems with van Beek's proposal

- van Beek's proposal of a *VLHNV > VLNV sound change for Greek leaves behind a plethora of forms in other IE languages unexplained:

(7) Secure IE examples of the word-medial S-H effect (Nussbaum 1997; contra Pronk 2011)

a. Lat. *sollus* 'whole', Osc. *sullus* (nom. pl.) 'every', Vedic *sárva-* 'all', Att. Gk. ὅλος (Ion. οὖλος) 'whole' < **sólh$_2$-u̯o-*

b. Lat. *medi**tullium*** < PItal. **meθi̯o-**tol(H)u̯-ii̯o-*** '(located) in mid-country'

c. Lat. *collis* 'hill', Lith. *kálnas* 'id.', Latv. *kalns* 'id.' < **kelH*

d. Lat. *collus*/*collum* 'neck', Goth. *hals* 'id.' < **k^{w}elH*

e. Hitt. *palu̯ae-* 'to clap' < **polh$_2$u̯eh$_2$* (cf. Gk. παλάμη 'palm of the hand')

f. Hitt. *kalmara-* 'beam, ray' (←*kalmi-* 'piece of fire wood'; cf. Gk. κάλαμος 'reed')

Interim Summary

- The phonetic explanations given for the S-H effect are problematic and invoke typologically unattested processes.
- In addition to laryngeal loss in *o*-grade contexts ($^{*}\text{oRh}_{\text{x}}]_{\sigma} > {}^{*}\text{oR}]_{\sigma}$), there are examples supporting a general $\text{VRh}_{\text{x}}]_{\sigma} > {}^{*}\text{-VR}]_{\sigma}$ process of laryngeal deletion.
- A Greek-internal explanation leaves behind a plethora of forms adduced by Nussbaum (1997) and Melchert (1994: 49–51) unexplained.
- Thus, we need a different proposal that explains laryngeal loss in $\text{VRh}_{\text{x}}]_{\sigma} > {}^{*}\text{-VR}]_{\sigma}$ contexts already in PIE.

Proposal

Szemerényi's Law in PIE

- Laryngeal loss in e-grade syllabic contexts (e.g., Gk. τέρμα, τέρμων) and *o*-grade syllabic contexts (Lat. *collus* 'neck' < *k^{w}ólh$_{x}$-u̯o-*; Ved. *sárva* 'all' < *sólh$_{2}$-u̯o-*) more economically motivated by a restricted version of Sandell and Byrd's revised account of Szemerényi's Law for PIE (2015).
  - Laryngeals deleted in complex syllable codas in PIE owing to a *CF]$_{\sigma}$ (F = fricative) constraint:
    - Word-finally with compensatory lengthening: */wédor-**h$_2$**/ → *[wédōr] 'waters'
    - Word-medially without compensatory lengthening: */ĝén(**h$_1$**)-mn/ → [ĝén-mn̥]

(8) a. PIE */ĝén**h$_1$**-mn/ ⟶ *[gén-mn̥] 'birth' > Skt. *jánman-*, Doric Gk. γέννα 'race, descent' < **ĝen(h$_1$)-(m)n-éh$_2$*

b. PIE */wér**h$_1$**-d^{h}(h$_1$)-o-/ (cf. Gk. ἐρέω 'I will say') ⟶ *[wérd^{h}(h$_1$)o-] 'speaks' > Lat. *verbum* 'word', Gk. ἔρθει· φθέγγεται (Hysch.)

c. PIE */kér**h$_1$**-d^{h}(h$_1$)-o-/ ⟶ *[kérd^{h}(h$_1$)o-] 'places' > Old Irish [fo-**ceird**] (cf. Ved. *kiráti*)

OT Analysis

To motivate laryngeal loss in these forms, I develop an analysis in Optimality Theory (Prince & Smolensky 1993/2004) along the lines of Byrd (2015: 106–8).

The constraint *CF]$_\sigma$ developed by Sandell & Byrd (2015) remained active in PIE but caused different repairs due to the ranking of other constraints.

MAX-H/R__ : A laryngeal in the input must surface in the output after an input resonant. Assign 1 * for every violation.

MAX-H/O__ : A laryngeal in the input must surface in the output after an input obstruent. Assign 1 * for every violation.

***CF]$_\sigma$** : Input fricatives after tauto-syllabic consonants in syllable codas are not allowed to surface. Assign 1 * for every violation.

DEP-V : A vowel in the output must have a correspondent in the input. Assign 1 * for every violation.

***ComplexOns** : A complex onset is not allowed. Assign 1 * for every violation.

Derivation of τέρμων

(9) (Pre-)PIE derivation of */terh$_2$món-/ (> Gk. τέρμων):

/terh$_2$món-/	*ComplexOns	*CF]σ	Max-H/O__	Dep-V	Max-H/R__
☞ a. [ter.món-]					*
b. [ter.h$_2$ə.món-]				*!	
c. [terh$_2$.món-]		*!			
d. [ter.h$_2$món-]	*!				

- The PIE output [ter.món-] was lexicalized as a morphologically simplex form without a laryngeal reflex, whence Lat. *termō*, and Gk. τέρμων.
- Accent of Gk. τέρμων is unexpected for a PIE **mon*-stem. Switch to default recessive accentuation due to demorphologization (Probert 2006: 300–310; Lundquist 2015; Yates 2015).

Re-ranking of constraints in PNIE

PIE ranking: *ComplexOns » *CF]σ » MAX-H/O__ » DEP-V » MAX-H/R__

This ranking derives the correct outcomes for all Vs in $VRH_x]_\sigma$ sequences:

(10) Lexicalized relics from PIE

a. στέρνον 'chest' « *$ster(\boldsymbol{h_3})$-*nó*-

b. πόρνη 'prostitute' « *$por(\boldsymbol{h_2})$-*n*-*éh_2*

- What of reflexes showing a laryngeal when V = /e/ (e.g. τελαμών 'support band' « *$tel\boldsymbol{h_2}$-*mṓ*)?

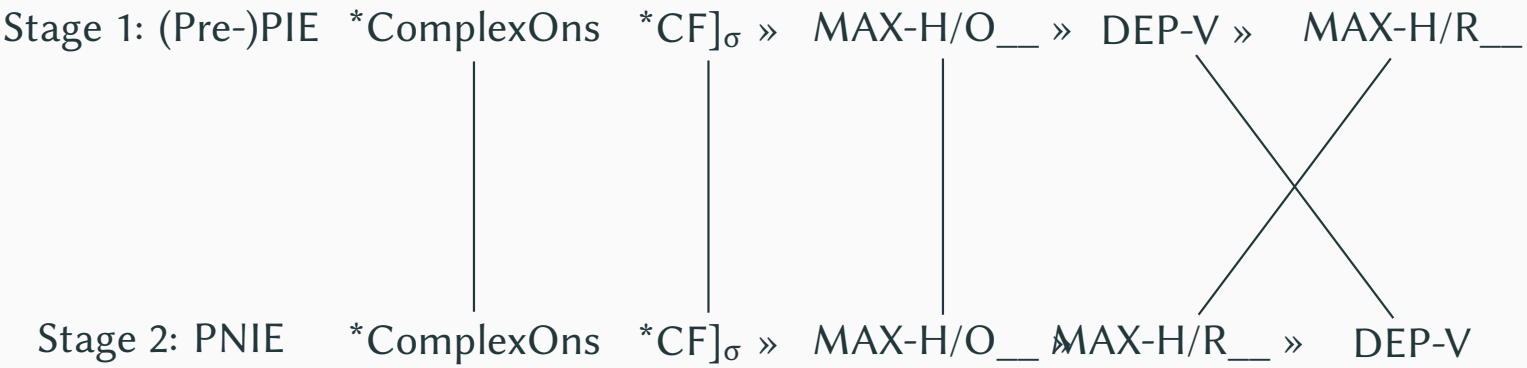

Figure 1: Re-ranking of constraints between PIE and PNIE

PIE vs. PNIE outputs

(9) (Pre-)PIE derivation of */terh$_2$món-/ (> Gk. τέρμων):

/terh$_2$món-/	*ComplexOns	*CF]σ	Max-H/O__	Dep-V	Max-H/R__
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b. [ter.h$_2$ə.món-]				*!	
c. [terh$_2$.món-]		*!			
d. [ter.h$_2$món-]	*!				

(11) PNIE derivation of */telh$_2$-mṓ/ (» Gk. τελαμών):

/telh$_2$mṓ/	*ComplexOns	*CF]σ	Max-H/O__	Max-H/R__	Dep-V
a. [tel.mṓ]				*!	
☞ b. [tel.h$_2$ə.mṓ]					*
c. [telh$_2$.mṓ]		*!			
d. [tel.h$_2$mṓ]	*!				

Why did the constraint ranking change between PIE and PNIE?

- Sound change rooted in synchronic alternations (Ohala 1989) motivated by contextual perceptual asymmetries (Kawasaki 1982; Steriade 2008).
- Uvular consonants frequently lenite in post-resonantal position more so than in post-obstruent position and are harder to perceive due to their resonant-like formant structure in resonantal environments (see Appendix for full discussion and references).
- Weiss (2016: 337) and Kümmel (2007: 336) have argued for the change of PIE laryngeals from uvular to pharyngeal articulation.
- Proposal:
  - In PIE, the laryngeals *h_2 and *h_3 were uvular consonants and deleted after resonants in tautosyllabic codas.
  - IN PNIE, the laryngeals *h_2 and *h_3 were pharyngeal consonants and supported by epenthetic schwas in tautosyllabic codas.

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- Uvular consonants frequently lenite in post-resonantal position and are harder to perceive in resonantal environments (see Appendix for full discussion and references).
- Weiss (2016: 337) and Kümmel (2007: 336) have argued for the retraction of *h_2 and *h_3 from an uvular to pharyngeal articulation.
- Proposal:
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  - IN PNIE, the laryngeals *h_2 and *h_3 were pharyngeal consonants and supported by epenthetic schwas.
- Examples of Hebrew epenthesis in guttural contexts (McCarthy 2003: 27) :

Root (IPA)	**Complex Codas**	**Simplex codas**	**Gloss**
/miʃħ/	[meːs**a**ħ]	[miʃħoː]	'brow' / 'his brow'
/ʔurħ/	[ʔoːr**a**ħ]	[ʔorhiː]	'way' / 'his way'
/gubh/	[goːb**a**h]	[gobhoː]	'height / 'his brow''

Discussion

Conclusions

- There is no need to posit laryngeal loss by the word-medial S-H effect.
- Forms exhibiting its operation can be analyzed as lexical relics of the outputs generated by the restricted version of word-medial Szemerényi's law in PIE (*/VRH]$_\sigma$CV/ → *[VR]$_\sigma$CV]).
- In PNIE, both /RH]$_\sigma$C/ and /OH]$_\sigma$C/ clusters were repaired with epenthetic schwas after PIE laryngeals developed from uvular into pharyngeal consonants.
- The productively-derived words of PNIE surface with reflexes of PIE laryngeals in Greek (e.g., τελαμών « *$telh_2$-$m\acute{o}$), whereas lexicalized relics from PIE do not (e.g., τέρμων « *$terh_2$-$m\acute{o}$).
- If van Beek (2011) and Pronk (2011) are right about the inconclusive nature of the evidence for the reconstruction of the word-initial S-H effect, then the reconstruction of S-H effect as a whole for PIE is on shaky ground.

Thank You![3]

Questions? Comments?

3. Thank you to the members of the PIES Graduate Seminar and UCLA Phonology Seminar for very useful feedback, especially Bruce Hayes, Brent Vine, and Anthony Yates.

Appendix

Featural representation of uvular consonants

- The ATR disharmony theory presumes the representation of uvular consonants as [-ATR] but this is not universally accepted:
  - uvulars: [+dorsal, -ATR] (Vaux 1999)
  - uvulars: [-high, -low, -front, +back] (Hayes 2009: 87)
  - uvulars: [+dorsal, +strident, +low] (Zsiga 2013: 267)
- If we go by the featural representation of Hayes (2009) and Zsiga (2013), we would be dealing with a dissimilatory process targeting vocalic features.
- However, no process of vowel dissimilation or disharmony is securely reconstructible for PIE.
- ATR disharmony is thus a very costly explanation.
- Why the obstruents would block such disharmonic deletion also remains unexplained.

Dissimilation of laryngeal constrictor mechanism

- Long-distance dissimilation of the laryngeal constrictor mechanism. (Weiss 2012)
- Based on the laryngeal articulator model of Esling (2005), Weiss (2012) argues that PIE *o /ɔ/ was a retracted vowel involving the laryngeal constrictor mechanism.

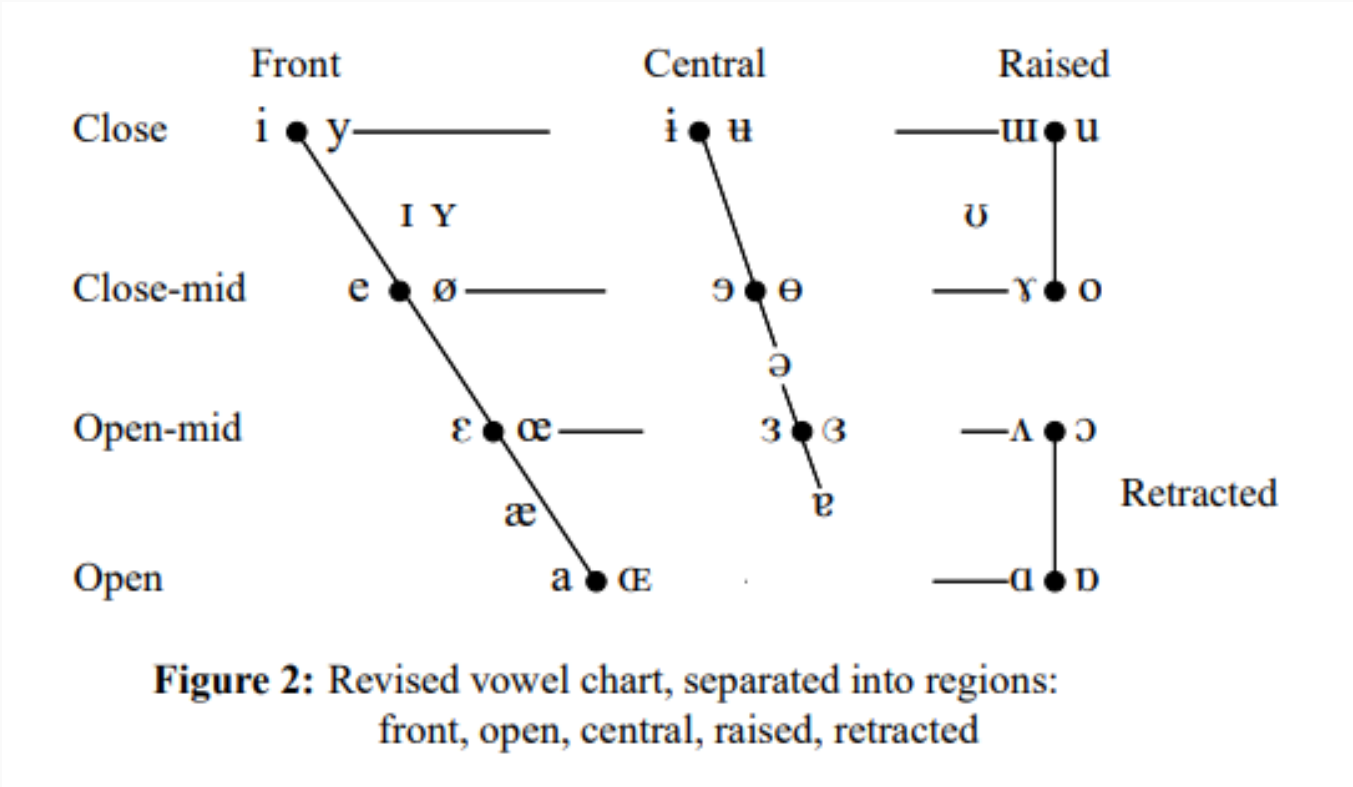


Figure 2: Revised vowel chart, separated into regions: front, open, central, raised, retracted

Figure 2: Esling's updated vowel chart

Nussbaum's tentative explanation for unexpected laryngeal loss in τέρμα and τέρμων

Gk. τέρμα 'end, boundary', Lat. *termen* 'boundary' < PIE **térh₂-mn̥-*, and Gk. τέρμων 'boundary' « **terh₂-mṓ* reflect laryngeal loss in an **ó/é*-ablauting (Acrostatic II) *men*-stem paradigm (Nussbaum 2010: 276[22]):

(6) **tór(h₂)-mn̥* ∼ **tér(h₂)-mn-*

a. */*tórh₂-mn*/ ⟶ *[*tór-mn̥*] (by the S-H effect).

b. */*térh₂-mn-*/⟶*[*tér-mn-*] by the CH.CC > C.CC formulation of Lex Schmidt-Hackstein (Hackstein 2002) in the weak cases

Nussbaum's tentative explanation for unexpected laryngeal loss in τέρμα and τέρμων

(6) *$tór(h_2)$-$mn̥$ ∼ *$tér(h_2)$-mn-

a. */$tórh_2$-mn/ ⟶ *[$tór$-$mn̥$] (by the S-H effect).

b. */$térh_2$-mn-/⟶*[$tér$-mn-] by the CH.CC > C.CC formulation of Lex Schmidt-Hackstein (Hackstein 2002) in the weak cases

- Three issues with laryngeal loss in an Acrostatic II **ó/é*-ablauting paradigm:
  - No evidence for the reconstruction of an **ó/é*-ablauting *men*-stem paradigm for Gk. τέρμα and Lat. *termen*.
  - Not plausible to reconstruct **ó/é*-ablauting *men*-stems for PIE following Vine (2019: 234–6).
  - In Byrd's revision of Lex Schmidt-Hackstein (2015: 107), laryngeal loss in PH.CC > P.CC (P = stop) sequences is due to the laryngeal's extra-syllabicity.
  - *$térh_2$-mn- (RH.CC) does not meet the context for laryngeal deletion.

Derivation of words with VOH.CV sequences in PIE

(12) (Pre-)PIE derivation of *$péth_2$-mor*:

/péth$_2$mor/	*ComplexOns	*CF]σ	Max-H/O__	Dep-V	Max-H/R__
a. [pét.mor-]			*!		
☞ b. [pét.h$_2$ə.mor-]				*	
c. [péth$_2$.mor-]		*!			
d. [pét.h$_2$mor]	*!				

- For PIE then, we can generate epenthesis in VOH]$_\sigma$CV sequences but deletion of the laryngeal in VRH]$_\sigma$CV sequences.

Back fricatives and neutralization

- Sounds that are not sufficiently perceptually distinct in a context predicted to assimilate, reduce, or delete (Kawasaki 1982).
- A 3D/4D ultrasound study of Ukranian back fricatives reveals neutralization of velar fricatives [ɣ], [x] in coda position to uvular fricatives [ʁ], [χ] (Czaplicki & Cavar 2024).
- This is unexpected under theories of markedness based on representational complexity and could be better explained by invoking the P-MAP.
    - The velar fricatives neutralize to uvular fricatives because of a contextual perceptual bias in the coda position.
- Additionally, if the sound source in the phonetic realization of the PIE uvulars was more mixed than aperiodic as argued by Redmon and Jongman (2018) for Arabic (63%) and Persian (75%) voiceless uvular fricative /χ/, then the laryngeals might have had poor perceptual cues alongside resonants that resulted in their deletion, whereas they were still perceptible alongside consonants and supported by an epenthetic vowel.

Back fricatives and neutralization

- Phonetic coding of the realizations of uvular /q/ in South Bolivian Quechua revealed lenition in word-medial position to /ʁ̞/ (Gallagher 2023: 871, 875).
- Morpheme-specific deletion of /q/ (e.g., the past tense marker /-rqa/ [120/130] tokens with deletion).

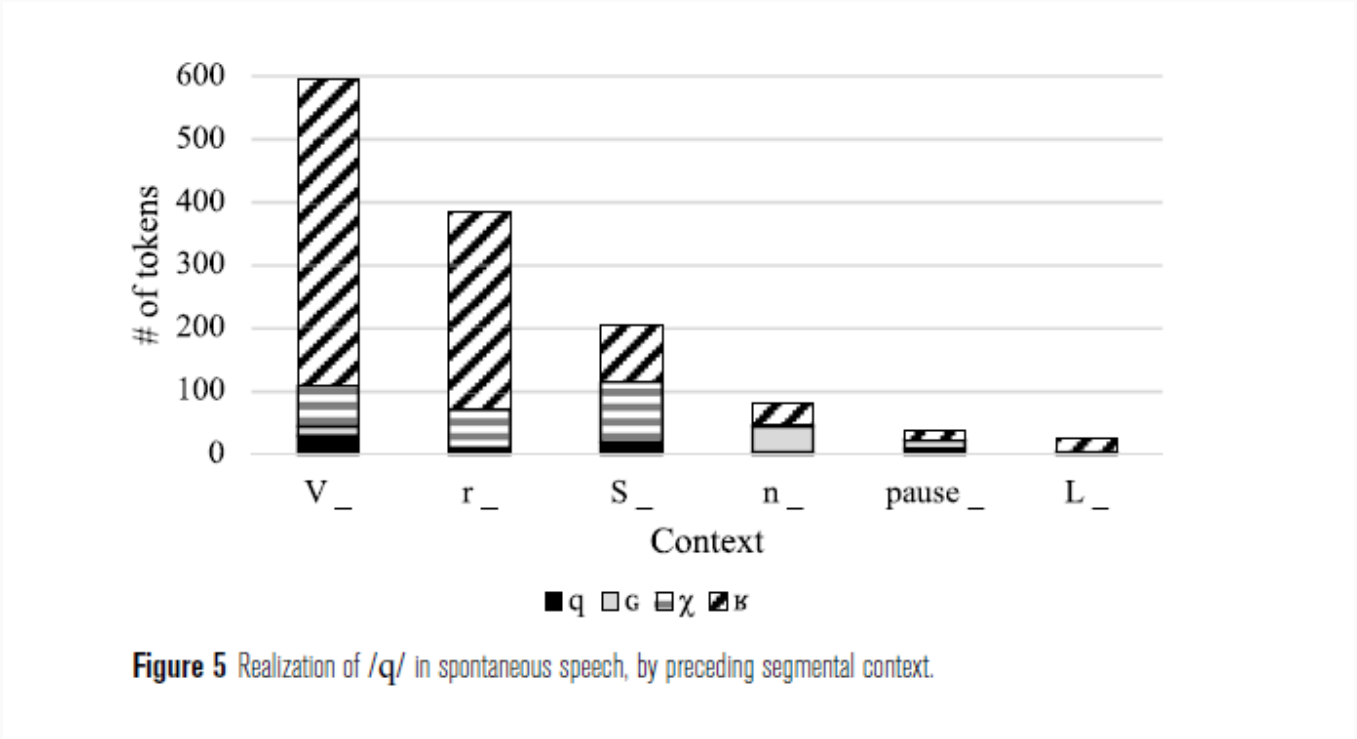
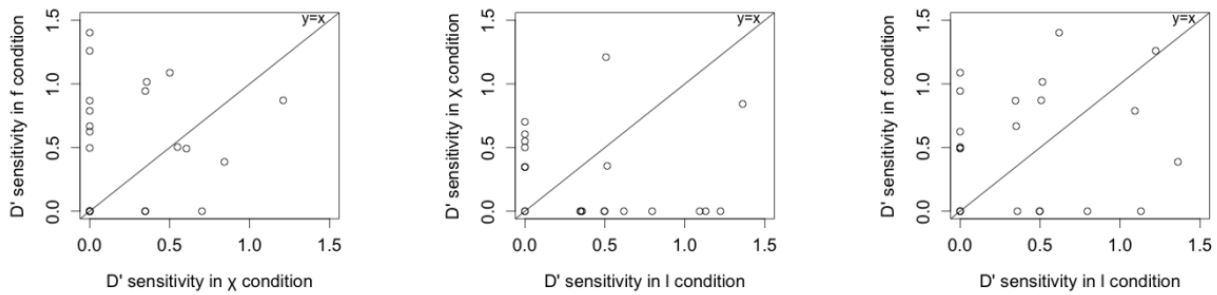


Figure 5 Realization of /q/ in spontaneous speech, by preceding segmental context.

Figure 4: Productions of South Bolivian Quechua /q/

Back fricatives and neutralization

- In a study of uvular production of 4 European Portuguese speakers /ʀ/ often realized as [χ,ʁ] with approximant-like formants.
- In French, /χ/ argued to supply more cues for the perceptibility of adjacent consonants than other fricatives and show less sensitivity to the presence of preceding stop burst release possibly due to a large opening of the front cavity (Bakst & Katz 2014).



(a) f vs χ (b) χ vs l (c) f vs l

Figure 3: Plots comparing listeners' sensitivity to absence or presence of a burst in each continuant condition; each point represents a single participant. In (3a) the y-axis charts sensitivity to the presence of a burst in the f context, and the x-axis charts sensitivity in the χ context; (3b) shows sensitivity in the χ context on the y-axis and in the l context on the x-axis; (3c) charts sensitivity to f on the y-axis and to l on the x-axis. The $y = x$ line is overlaid. Points lying on the $y = x$ line indicate subjects who are equally sensitive in both conditions.

Figure 5: D´ scores of burst identification across continuant conditions

Back fricatives and neutralization i

- The sonority of /χ/, which makes stops more perceptible before it, might also hinder its perceptibility after resonants
- In fact, lenition of uvular stops and fricatives to approximant-like productions is widely attested:
  - Because of a smaller cavity behind the closure and greater air pressure, lenition expected in uvular consonants (Ariyaee & Kochetov 2021: 2) even more so in velar consonants (Ohala 1989).
  - In South Bolivian Quechua micro-variations in the relatization of uvular stops involve approximant or elided (=deleted) realizations (Pierrard 2016).
  - Similar lenition to a fricative/approximant is seen for /q/ in Hijazi Arabic in pre-rhotic position (Al Taisan 2022: 160–1):

Input	Output	Gloss
/tɑq.rɨ:ban/	[tɑʁ.rɨ:ban]	'almost'
/fˁɑq.rˁɑ/	[fˁɑʁ.rˁɑ]	'a paragraph'

Back fricatives and neutralization ii

- In Persian, fricative and approximant productions of /G/ in word-medial intervocalic and pre-consonantal position (Nourbakhsh 2015; Reza Asa 2016).
  - /ɑɢel/ ⟶ [ɑʁel] ∼ [ɑ̞e̞l] ‘wise’
  - /æʁɾæb/ ⟶ [æʁɾæb] ∼ [æ̞ɾæb] ‘scorpion’
- There is also the cross-linguistic generalization by which post-consonantal position is strong after obstruents in word-medial position but not after sonorants: heightened degree of lenition in post-consontal position after sonorants (Recasens 2016; Scheer & Ségéral 2008).
- A study of the production of Persian /ɢ/ in consonantal clusters revelead a statistcally significant difference in the degree of lenition after liquids when compared to other manners of articulation and after coronals including /ɾ, l/ (Ariyaee & Kochetov 2021: 7–9).
- Altogether there is abundant evidence for post-resonantal lenition of uvular stops and fricatives that can be used as motivation for their deletion in post-resonantal codas in PIE.

Pharyngealization and intrusive schwas

- Characteristics of pharyngealization predominantly manifested in the formant structure of adjacent vowels.
- Secondary pharyngealization is usually considered to be 'approximant-like' (Ladefoged & Maddieson 1996: 354) or 'vowel-like' (Ladefoged & Johnson 2011: 234).
- A study of pharyngealization reveals lowered F2 of vowels and intrusive schwas.
- Similarly, in a study of American English schwa, significant mid-pharyngeal constriction relative to lingual rest position was found. (Gick 2002)
- These findings suggest that in VCCCV sequences, intrusive schwas might have developed phonetically with subsequent phonologization in PNIE.
- A consequence of this phonological change was the insertion of schwas in VCCCV sequences which results in double reflexes in the daughter languages.

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