Appendix to "Computational Anatolian phylogenetics using maximum parsimony"

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The following text describes the characters used for a computational phylogenetic analysis of the Anatolian languages Hittite, Palaic, Lydian, Luwian, and Lycian using maximum parsimony. For citation, please cite the talk itself. Any feedback is welcome!

As stated in the presentation, *uninformative* characters have not been used. Uninformative characters are ones which do not affect the length of any given tree. For example, a character where only one taxon differs from the rest (incl. ancestral state) is uninformative, as the change may be postulated on that terminal node in any tree irrespective of tree topology.

Characters which are interdependent have been excluded. Maximum parsimony is not well suited for situations where a change in one character affects the weights or directionality of another character – each character must be independent. Therefore, a character such as the merger of PA *$*éh_2$* and *$*ó$* (likely valid for Hittite, Luwian, and Palaic) has not been used, as this would bleed e.g. character 22 (*i*-mutation) – previous occurrence of this merger would remove the prerequisites for innovating the *i*-mutated nominal paradigm.

We have used the following categorization to assign weights. The list, the weight values (1-2-3-4), and individual assigned weights reflect our personal (and informed) views as specialists. We currently do not know of any scientifically rigorous way to assess the likelihood of linguistic innovations. However, we expect the hierarchy below to be congruent with the opinions of most specialists. Moreover, the categorization procedure ensures that the chosen weights are *generalizable* and *comparable* across the whole character set.

Weight 1:

- Trivial sound changes
- Generalizations of allomorphs
- Morpheme loss

Weight 2:

- Sound changes
- Analogies

Weight 3:

- Non-trivial sound changes
- Non-trivial analogies

Weight 4:

- Highly non-trivial analogies
- Irregular sound changes

An item by item description of the characters used follow below.

1. Lenis reflected as fricative

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	?	1

0 = plosive 1 = fricative
Weight: 1 (0>1) *trivial sound change* (*lenition*) 2 (1>0) *sound change* (*fortition*)
Ancestral state: 0 *IE outgroup*
Directional: N *no mergers*

The ancestral state is determinable by Indo-European outgrouping. Fortition is not *impossible*, hence no directionality. For Lycian, see Kloekhorst (2009: 125–127), and for Lydian, see Melchert (1994: 335) with further references and Kloekhorst (2023: 126). For Hittite and Palaic, there is no indication of fricative articulation in the cuneiform script, but rather a long-short (or geminate-singleton) distinction. Luwian is a more difficult case: later Hieroglyphic Luwian *does* likely reflect the original lenis consonants as fricatives, at least in the dentals (Rieken 2010; Vertegaal 2019). However, the older language is less certain – Kloekhorst (2019) argues for 18th cent. BCE fricative value. If true, such information is not available in the cuneiform documentation. In light of this uncertainty, Luwian is coded as missing data. Since the sound change is only phonetic, i.e. does not affect the phonological system, directionality is possible. However, lenition is to be considered likelier than fortition, hence the different weightings (1 for 0>1, 2 for 1>0).

2. PA *$\bar{e}$/æ > *$\bar{e}$ vs. *$\bar{a}$

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	?	1

0 = *e*-quality vowel retained 1 = merger of *$\bar{e}$ and *$\bar{a}$ (< *eh_2)
Weight: 1 *trivial sound change*
Ancestral state: 0 *IE outgroup*
Directional: Y *phonological merger*

Luwian is specified with a missing data as this language knows no non-high vowel phonemes other than /a(ː)/. The ancestral state is the PA reflex of PIE *eh_1 (cf. e.g. Rix et al. 2001: 136–138). Directionality holds given that a merger to the reflexes of PIE *eh_2 would render the previous distribution irrecoverable. The best diagnostic case is the outcome of *d^heh_1- (see eDiAna-ID 1902). No explicit stance is taken on the validity of the intermediate PA phoneme *æ reconstructed by Melchert (1994: 56) (contingent on outcome of PIE *$\bar{e}$).

3. **i̯e* > **i̯i*

Hittite	Palaic	Lydian	Luwian	Lycian
0	1	1	1	1

0 = **i̯e* retained 1 = raising of **e* > *i* / *i̯*_

Weight: 2 *sound change*
Ancestral state: 0 *IE outgroup, comparative method*
Directional: Y *original distribution irrecoverable*

There is no law to revert original **i̯i* > **i̯e* back to the original distribution, hence the character is directional. A good diagnostic category to act as a source for each language's coding is found in inherited verbs in **-ié/ó-*: see e.g. Sasseville (2021c: chap. 4) for Lydian, Luwian, and Lycian, see Oettinger (1979a: 343) for Hittite. The Palaic case is not entirely clear. Per Melchert (2003: 269), the law did not occur in Palaic (without argumentation), whereas Oettinger (1979b: 78) adduces 3SG.PRES.ACT. ⟨a-ni-it-ti⟩ 'performs (vel sim.)' (KBo 48.178 l.col. 2′; KUB 35.165 rev. 10′), which ought to continue precisely a verb in **-ié/o-*, cf. Hitt. *aniēzzi* 'id.' (but cf. Yakubovich 2010), Luw. *ānnīti* 'id.', and possibly Lyd. *ani-* 'to erect' (Carruba 1963: 397 n. 22; Yakubovich eDiAna-ID 1655).[1] While the prehistory of this particular verb is complicated, Oettinger's argument is taken here as compelling, and Palaic is accordingly coded with state 1.

Note that cases in which PA **ǵ* > **i̯* (char. 6) potentially feed **i̯e* > **i̯i*, notably Lyc. *izri-*, Luw. *issri-* 'hand' < PA **ǵésr-* < PIE **ǵʰés-r-*, do not constitute a valid source for the coding here – such a case necessitates char. 6 preceding char. 3, and the characters need to be independent. The present coding does not exclude that **i̯e* > **i̯i* occurred twice in any particular language's history. The phonetic naturalness of the sound change could argue for a weight of 1, but given that the change is fairly specifically conditioned and not often found elsewhere in Indo-European, a weight of 2 has been chosen.

4. Centum reflex of **ḱ*

Hittite	Palaic	Lydian	Luwian	Lycian
1	1	1	0	0

0 = retained distinction between **ḱ, *k, and *kʷ* 1 = depalatalization of **ḱ* to **k*

Weight: 1 *trivial sound change*
Ancestral state: 0 *IE outgroup, comparative method*
Directional: Y *phonological merger*

See Melchert (2003: 269) and Kloekhorst (2022: 68). One of the most illustrative example etyma is Hitt. *kittari* 'lies', Pal. *kītar* 'id., Luw. *ziyari* 'id., and Lyc. *sijẽni* 'id., all from the PIE root **ḱéi-*, cf. e.g. Skt. *śáye*, Gk. κεῖται 'lies' (Rix et al. 2001: 320). For Lydian, the best example is to my knowledge *kat-* (PREV.) < **ḱNt-* (cf. Luw. *zanta* 'down' < **ḱNto* and see LW: 145; eDiAna-ID 861). Note that the character could also be formulated in terms of conditioned assibilation of **k* if the *satəm* treatment (i.e. the retention of a three-way distinction in Anatolian) in Luwian and Lycian is rejected (cf. Melchert 2012a). This would rather provide phylogenetic signal in favour of a Luwo-Lycian clade. This sound change has apparently

[1] Cf. perhaps also Pal. ⟨]mar-ḫi-it⟩ (Carruba 1970: 63; Sasseville eDiAna-ID 725).

affected a substantial number of Indo-European primary branches (the *centum*-languages), and should therefore be weighted 1 as a trivial sound change.

5. "Irregular" **#s(h_3?)- > *t*

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	0	1	1

0 = **#s-* retained 1 = **#s-* > **t-*
Weight: 3 *potentially regular sound change* (*cf. below*)
Ancestral state: 0 *IE outgroup*
Directional: Y *phonological merger*

There are a few instances where we can observe a sound correspondence *s* : *t* in initial position. Some (e.g. Melchert 2007: 187 n. 14; Oettinger 2013: 170) have claimed a sound law involving a laryngeal (most likely **h_3*), i.e. **#sH-* > Lyc./Luw. *t-*, but this is not certain. If sporadic, however, a weight of 4 would be more appropriate. A decision in the name of caution has been made here to use the lower weight of 3. The evidence centres on the words for 'urine', 'oil', and 'eye'. Examples include Hitt. *sakuwa-* 'eye', Pal. loan into Hitt. *sēhur/n-* 'urine' (Kloekhorst 2008: 742), Lyd. *šawv* 'towards' < 'to the eye' (Yakubovich eDiAna-ID 277), Luw. *tāin-* 'oil', Lyc. *tawa-* (COLL.) 'eye'. Note that the Lydian reflex *š-* is unique (Hittite and Palaic only know one sibilant phoneme), and thus uninformative, licensing the present coding with 0 for Hittite, Palaic, and Lydian.

6. **ǵ* > **i̯* / _V[front]

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	?	1	1

0 = plosive retained 1 = change **ǵ* > **i̯* before front vowel (**e, *i*)
Weight: 2 *sound change*
Ancestral state: 0 *comparative method, IE outgroup*
Directional: Y *phonological merger*

The evidence most helpfully centres on the word for 'hand' PIE **ǵʰés-r-* > PA **ǵésr-* > Hitt. *kessar-*, Luw. *issri-*, Lyc. *izri-*. Palaic 0 is confirmed by *genu* ⟨gi-nu⟩ 'knee' < **ǵénu-* (see Sasseville eDiAna-ID 564). No pertinent evidence is available in Lydian (Melchert 1994: 359).

7. Initial *g^w > *w

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	?	1	1

0 = plosive retained 1 = outcome in *w
Weight: 1 *trivial sound change*
Ancestral state: 0 *comparative method, IE outgroup*
Directional: Y *phonological merger*

For Luwian and Lycian, cf. Luw. *wawa/i-*, Lyc. *wawa-* 'bovine' < PIE *g^wou-. See Melchert (1994: 211) for Palaic. The Hittite reflex is well established, cf. e.g. *kuen-^{mi}* 'to strike, kill' < PIE *g^{wh}(*é*)*n*-.

The Lydian case is complicated. For liquidization, cf. *wãna-* 'rock-carved grave' < trans. PIE *$g^{wh}on$-eh_2- (with reintroduced initial *w*-, see Rieken & Sasseville eDiAna-ID 1865). However, the famous derivation *kãna-* 'wife' < trans. PIE *g^won-eh_2- (Gusmani 1985; Melchert 1994: 357) rather argues for retention of plosive articulation before **o*, which would imply a separate treatment in Lydian (cf. CLuw. *wāni-* 'woman'). Thus, caution warrants coding Lydian as missing data. On the weighting, cf. Kümmel (2007: 88).

8. Merger of medial *g^w with *w

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	1	1

0 = no merger 1 = identical reflex of *g^w and *w
Weight: 1 *trivial sound change*
Ancestral state: 0 *comparative method, IE outgroup*
Directional: Y *phonological merger*

Lydian has a preposition *šawv* 'toward', which Yakubovich (eDiAna-ID 277) convincingly derives from the word for 'eye', i.e. PIE *$sh_3ók^w$-*o*-, likewise reflected in Luw. *tāwa/i-* and Lyc. A *tawa* (COLL.). Hittite retains a plosive separate from **w*, cf. e.g. *akuwanzi* 'they drink' (*h_1g^{wh}-énti*). Palaic has a unique reflex in /χ^w/, cf. *ahuwanti* 'they drink' < PIE *h_1g^{wh}-énti* (Otten 1945: 81; Melchert 1994: 211). This is a merger with the reflex of the labiolaryngeals, a change which only occurs in one taxon and is thus phylogenetically uninformative. Kloekhorst (2022: 71) argues that the Palaic reflex can be viewed as an intermediary step towards full lenition to **w*. However, such historical scenarios can only be formulated post-analysis – the present analysis cannot account for unobservable intermediate phonemes. The observable phonological processes are separate mergers in Luwian, Lycian, and Lydian vis-à-vis Palaic.

9. Assimilation *-*tn*- > *-*nn*-

Hittite	Palaic	Lydian	Luwian	Lycian
1	1	?	0	?

0 = cluster retained 1 = regressive assimilation
Weight: 1 *trivial sound change*
Ancestral state: 0 *comparative method*
Directional: Y *original distribution irrecoverable*

See Carruba (1970: 4) for Hittite and Palaic. For Luwian, cf. -(*t*)*tar*/-*a*(*t*)*tn*-stems (e.g. CLuw. NOM/ACC.SG. *utar* vs. GENADJ.ACC.SG.C. *ūtnassin* 'word; spell'). There is to our knowledge no conclusive evidence available in Lydian or Lycian.

10. Čop's law (C > C: / *é_)

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	?	1	1

0 = lenis retained, C > C / *é_ 1 = fortis reflex, C > C: / *é_
Weight: 3 *non-trivial sound change* (*but cf. comments below*)
Ancestral state: 0 *comparative method, IE outgroup*
Directional: Y *original distribution irrecoverable*

See Čop (1970) for Luwian, where the law is established beyond doubt. Lycian to my knowledge currently only has one pertinent (yet strong) example, i.e. *ebette* 'these' DAT/LOC.PL. < PA **ʔobédos*, cf. Hitt. *apēdas* (Kloekhorst 2012a: 261 n. 19). Palaic is exempt, cf. e.g. *genu* ⟨gi-nu⟩ 'knee' < **génu*- (not ***gennu*). There is to my knowledge no pertinent evidence available in Lydian. Per Vertegaal (2020), Čop's law participates in a system of consonant gradation, which could increase the specificity of the change and serve as an argument for a weight of 4. However, typological parallels may indicate that the sound change itself is not particularly non-trivial (cf. e.g. Swedish gemination of consonants following accented short vowels). Weight 3 is chosen as it is not inconceivable to regard Čop's law as a *non-trivial sound change*, but a weight of either 2 or 4 could be argued for.

11. Laryngeal articulation (fricative or plosive)

Hittite	Palaic	Lydian	Luwian	Lycian
1	1	0	1	0

0 = plosive 1 = fricative
Weight: 1 (0>1) *trivial sound change* (*lenition*) 2 (1>0) *sound change* (*fortition*)
Ancestral state: none *subject to debate*
Directional: N *no proto-language merger*

For Lydian, cf. Oettinger (2021). The Lycian outcome of fortis PA **hː* is securely established as ⟨x⟩ /k/ (Kloekhorst 2009: 124–125 with further references). The consistent use of *ḫ*-signs in Hittite, Palaic, and Cuneiform Luwian for the laryngeal

reflexes clearly indicate a fricative articulation. Which articulation is to be regarded as ancestral has recently come under debate (Kloekhorst 2018). No particular stance is taken here, hence the unspecified ancestral state. Since there is no uniform merger in any proto-stage, no directionality is coded for either (there is no shared merger of laryngeals with any other consonant in any language, thus these mergers would belong to different changes, always ending up on a single taxon). However, since lenition is more common than fortition, a change 0>1 is weighted 2, whereas 1>0 is weighted 1.

12. Medial assimilation *sh_2 > *s / V_V

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	0	1

0 = cluster retained 1 = progressive assimilation
Weight: 1 *trivial sound change*
Ancestral state: 0 *IE outgroup, comparative method*
Directional: Y *original distribution irrecoverable*

The evidence centres on Lyc. *wasaza-* and Lyd. *wasτa-* '(priestly title)' (syncopated **wasατa*, found in compound verb *šaw-wasτa-*) vs. Luw. *washazza-* 'the one responsible for the *washa-*' (Sasseville 2021c: 111–112). For Hittite and Palaic, cf. the words for 'blood', i.e. NOM/ACC.SG.N. Hitt. *ēshar* and Pal. *ēshur* < PIE *$h_1ésh_2$-r* (cf. also CLuw. *āshar*). The assimilation is regarded as trivial here, but a weight of 2 could conceivably also be argued for.

13. Innovation of NOM.PL.C. ending *-*msi*

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	1	1

0 = no reflex of *-*msi* found 1 = reflex of *-*msi* found
Weight: 4 *highly non-trivial analogy*
Ancestral state: 0 *IE outgroup*
Directional: Y *affected languages lose *-es*

This is a highly non-trivial analogy requiring several specific steps to reach completion. Per Starke (1990: 44–45), the original ACC.PL.C. ending *-*ms* spread to the nominative, followed by a contaminatory addition of *-*i* from the pronominal inflection. Luw. *-nzi* and Lyc. *-Ṽi* are straightforwardly derived from *-*msi*. According to Melchert (1994: 382) and Sasseville (2017: 113), the Lydian ending *-š* goes back to the same ending.[2] The probativity of the Lydian evidence of *-iš* from *i*-mutated stems is questionable, however. If we hypothesize that Lydian would have retained the ending *-*es* in these stems, the outcome *could* also have been *-iš* by the development *-́*es* > *-*is* (post-tonic raising *e > *i*?)[3] > *-iš* (regular palatalization after *-i-*). We would additionally have to assume that any syncope was blocked for phonotactic reasons, as is done by Sasseville (2017: 134–135).[4] The more compelling evidence is available in two forms ending in *-aš*, i.e. *ãnaš* 'those (?)' (LW

[2] See also Gérard (2005: 81), but his alternative *-*i-es* > *-*iš* is unlikely to form the basis of the general ending.
[3] A controversial and to our knowledge unsubstantiated development, but nevertheless possible.
[4] There is no clear NOM.PL. form of an *i*-mutated stem ending in *-d-*, i.e. with desinential *-diš*, which as Sasseville points out would settle the issue in favour of *-iš* < trans. PIE *-*imsi* by lack of syncope in the position *d_š*. Since the originally short NOM.SG. ending *-iš* is

13.1) and *ẽminaš* 'my' (LW 44.7), which are potential candidates of NOM.PL. forms of *a*-stems. While the philological context of either form neither proves nor disproves an interpretation as NOM.PL. (but cf. Sasseville (2021c: 507) for an interpretation of the passage with *ãnaš*, see also Melchert (1991: 138–139)), no other analysis is more compelling (forms of the 2SG.PRES. are excluded by context and morphology). An ending *-aš* would be equatable to Luw. *-anzi* and Lyc. *-ãi*, derivable from trans. PL **-āmsi*. Any derivation from PIE **-es* would be difficult, as **-eh$_2$-(e)s* would to have given ***-akas* or ***-as*. Conversely, a four-part analogy to the *i*-mutated stems as in Table 1 would be *formally possible* to circumvent cognacy to the Luwian and Lycian endings, but direct inheritance is most parsimonious at present (cf. also the apparent ACC.PL. of *ama-* my with *amãs* instead of ***amas*, see Yakubovich eDiAna-ID 847 & 3399). Hence, Lydian is assigned the state 1.

Table 1: Possible four-part analogy with the result -aš

	ACC.PL.	NOM.PL.
i-stem	*-is*	*-iš*
a-stem	*-as*	X = *-aš*

Hitt. *-es* and Palaic *-as* and *-es* both go back to the ancestral ending **-es* (Hittite generalizes the **-es* from the *i*-stems, see Kloekhorst (2008: 249–250) with further references), established by Indo-European outgrouping (cf. e.g. Meier-Brügger 2003: 196). Since all languages with state 1 appear to lose the original ending, and thus lose the model necessary to revert back to the ancestral state, the trait must be coded as directional (but cf. *perhaps* Lyd. *ciwš* < PIE **dieu-es*, Sasseville 2017: 141 n. 26).

14. Generalization of 1SG.PRET.ACT. ending **-h(ː)a*

Hittite	Palaic	Lydian	Luwian	Lycian
0	1	0	1	1

0 = *mi*-conjugating ending **-m* retained 1 = *hi*-conjugating ending **-h(ː)a* generalized

Weight: 1 *generalization of allomorph*
Ancestral state: 0 *comparative method*
Directional: Y *affected languages lose *-m*

Pal. *-ha*, Luw. *-(h)ha*, Lyc. *-xa/ga* all continue PA **-h(ː)a* (< PIE **-h$_2$e*), the regular 1SG.PRET.ACT. ending of the *hi*-conjugating stems (continuing the PIE perfect, cf. Norbruis 2021: chap. 4 with further references). In these languages, the original *mi*-conjugating ending **-m* is completely ousted (Hittite innovates a new conglomerated *hi*-conjugating *-hhun* while Lydian rather generalizes *-ν* < **-m*). Since all languages with state 1 completely lose the original ending, and thus lose the model necessary to revert back to the ancestral state, the trait should be coded as directional.

syncopated to *-dš*, we would likewise expect syncope of a short continuant of **-es*. Thus, **-imsi* would remain the only reasonable option, since the lack of syncope could be attributed to lengthening of the preceding *-i-* by the nasal.

15. Generalization of 1SG.PRES.ACT. ending *-*ū*

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	1	1

0 = endings *-mi* and/or *-hi* retained 1 = ending allomorph *-*ū* generalized to all stems

Weight: 1 *generalization of allomorph*
Ancestral state: 0 *comparative method, IE outgroup*
Directional: Y *affected languages lose all other allomorphs*

Luw. *-wi*, Lyc. *-u*, and Lyd. *-u* share a common ancestor, probably with extension of the present marker *-*i* in Luwian (cf. Norbruis & Billing *apud* Kloekhorst 2022: 73 n. 39). The origin of this ending is not confirmed (PIE *-*oH* remains a possibility, cf. Billing (2019: 13–14)), but its generalization to all verbal stem classes in Luwian, Lycian, and Lydian is incontrovertible. Hittite maintains a stem type-contingent allomorphy between *-mi* and *-h(h)i*. Palaic only has one potential attested 1SG.PRES.ACT. verb, i.e. *lulummi* (e.g. ⟨lu-lu-um-m[i]⟩ on KUB 35.153, 5 (David Sasseville, p.c.)), which indicates a state 0 for this language. Since all languages with state 1 completely lose all other endings, and thus lose the model necessary to revert back to the ancestral state, the trait must be coded as directional.

16. Generalization in the 3PL.PRET.ACT. ending

Hittite	Palaic	Lydian	Luwian	Lycian
1	{02}	1	2	2

0 = no generalization 1 = generalization of *-(*ē*)*r*(*s*) 2 = generalization of *-*nto* from middle endings

Weight: 1 (0>1) *generalization of allomorph* 3 (0>2, 1>2) *non-trivial analogy*
Ancestral state: 0 *IE outgroup*
Directional: allowed: 0>1, 0>2, 1>2 disallowed: 2>0, 1>0, 2>1 *loss of model*

From an Indo-European perspective, the secondary (imperfect) 3PL.PRET.ACT. ending *-*nt* is the expected regular ending for the *mi*-conjugation in PA. Presence of this allomorph is therefore assigned the state 0 and assumed as the ancestral state.

Hittite regularizes the *hi*-conjugating ending *-er* (< PIE *-*ēr*, cf. Kloekhorst (2008: 244–245) with further literature). Per Gusmani (2010), the Lydian ending *-rs* (e.g. *šisirors*, *kaττirs*, etc.) is 3PL.PRET.ACT. and continues PIE *-*r-s*.[5] The Hittite and Lydian generalizations are subsumed under the same development here (*-*ēr* and *-*r* are ablaut variants and for the presence/absence of *-*s* cf. Av. *-arə* < *-*r* vs. Skt. *-ur* < *-*rs* within Indo-Iranian; all variants must be reconstructed for PA and either variant is conceivably secondarily further generalized in each language). This change is assigned the weight 1 in accordance with characters 14 and 15 with no possibility of reversal to 0 due to loss of model (i.e. regaining a reflex of *-*nt*). A change 1>2 is still possible, however, since the middle ending *-*nto* is not affected by generalization in the active voice.

[5] Followed by Sasseville (2021c).

Luw. *-nta* and Lyc. *-ñte* uncontroversially reflect **-nto*. This ending is equatable with the inherited 3PL.PRET.MED. ending, cf. Hitt. *-antat(i)* (Kloekhorst 2008: 186–187). Accordingly, Luwian and Lycian replaced an active ending with a middle ending and generalized it, a much more non-trivial analogy. This change is consequently assigned a weight of 3. Irreversibility holds here as well, given the loss of model (i.e. no remaining model for a reflex of **-nt*, nor of **-(ē)r(s)*).

Palaic represents the most complicated case. Since final *-nt#* clusters are uniquely permitted in Palaic phonotactics (David Sasseville, p.c.), the attested ending ⟨-an-ta⟩ could reflect either the archaic **-nt* or **-nto* from the middle. No diagnostic case with a following enclitic is attested. Moreover, per Sasseville (eDiAna-ID 481), there *may* be some evidence of an inherited ending *-er* (equivalent to the one generalized in Hittite) in the fragmentarily attested ⟨na-aḫ-ḫi-˹ir˺⟩ (KUB 35.164 ii 13′).[6] This word could formally be cognate to Hittite **nahher* 'they feared' (the expected 3PL.PRET.ACT. of *nāh-^{ḫi}/nahh-*), in which case no generalization has taken place, although caution is obviously warranted. For these reasons, the state assigned to Palaic is {02}, meaning that it may either have retained a reflex of **-nt* and/or **-(ē)r(s)* (i.e. state 0) or generalized a reflex of **-nto* (i.e. state 2), but that no generalization of a reflex of **-(ē)r(s)* has taken place (i.e. state 1). Further research into Palaic may very well shed more light on this character.

17. Spread of 3SG.PRET.MED. allomorph **-to* to 3SG.PRES.ACT.

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	?	1	1

0 = retention of **-t* 1 = spread of middle **-to* to the active paradigm
Weight: 3 *non-trivial analogy*
Ancestral state: 0 *comparative method, IE outgroup*
Directional: Y *loss of *-t in affected languages*

Luw. *-t(t)a* and Lyc. *-te/de* go back to **-to*, the regular PA 3SG.PRET.MED. ending, cf. Hitt. *-t(t)at(i)* (Kloekhorst 2008: 839–840). Per Sasseville (2021a), the Lydian ending *-l* has the same origin (through a development **-Vda* > **-Vra* > **-Vr* > *-Vl*). However, Sasseville's account faces problems of relative chronology when the 3SG.PRES. ending *-d* is taken into account – by his own account of Lydian historical phonology, the outcome ought to have been ***-λ*. To rectify this, Sasseville postulates analogical restoration of *-d*, but it is unclear what the model for this restoration would have been, given that it must postdate the change *-Vdi* > *-Vʲi*. Alternative accounts have been proposed (cf. e.g. Melchert 1994: 341; Yakubovich 2022: 210–212). Lydian is therefore coded as missing data. Hittite and Palaic retain the original active allomorph **-t* (Hrozný 1917: 157; Carruba 1970: 45). The spread of a middle ending to the active voice should be regarded as a non-trivial analogy and is as such assigned the state 3 (cf. char. 16).

[6] Cf. also Görke & Sasseville (forthcoming); Kammenhuber (1959: 25).

18. ABL/INS. **-V-di*

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	0	1	1

0 = lack of a reflex of *-*Vdi* as an ABL/INS. ending 1 = reflex of *-*Vdi* as an ABL/INS. ending
Weight: 1 *trivial analogy*
Ancestral state: 0 *comparative method*
Directional: N *it is possible to innovate another allomorph*

Luw. *-adi* and Lyc. *-adi/-edi* function both as ABL. and INS. and go back to PA **-o/ā-di*. While Hittite and *possibly* Lydian (Sasseville 2021a) have reflexes of the same ending (ABL. *-z* and DAT. *-λ* respectively), no other Anatolian language displays this case syncretism in **-ti* between the ablative and the instrumental (but cf. the following character).

Note that post-OH Hittite displays a tendency towards instrumental use of the original ablative (Hoffner & Melchert 2008: 267), but this is clearly a secondary phenomenon in Hittite and quite possibly brought about by L2 interference by Luwian speakers (Rieken 2006: 273–275; Yakubovich 2010: 35 n. 25).

19. ABL/INS. **-nti*

Hittite	Palaic	Lydian	Luwian	Lycian
1	1	0	0	0

0 = absence of ABL. ending reflecting **-nti* 1 = presence of ABL. ending reflecting **-nti*
Weight: 2 (0>1) *analogy* 1 (1>0) *loss*
Ancestral state: 0 *comparative method, IE outgroup*
Directional: N *allomorph may be replaced*

The character coding follows David Sasseville (p.c.). For Hittite, cf. e.g. ^{GIŠ}*luttanza* 'through the window' on KUB 17.6 i 19-20′ and Garrett (1990: 276–277) with further references. For Palaic, cf. KUB 48.69, 3f. ⟨ša-an-na-ar=ku=aš=ta ti-ia-ar=wa a-ši-wa ni-wa=an=ti pa-a-du **ki-ig-ga-an-ti**⟩ "He (scil. the bull) is then being covered. That one is being bound. He(?) must not *pa-*(?) him **with *kigga*** yet". The ending **-nti* originates in old ablatives to heteroclitic stems, i.e. **-n-ti*. Crucially, in both Hittite and Palaic, the combination between suffix and ending has been abstracted and subsequently spread to other stems.

20. Loss of PTC. suffix **-ent-*

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	1	1

0 = presence of a PTC. suffix reflecting **-ent-* 1 = no trace of PTC. suffix reflecting **-ent-*
Weight: 1 *morpheme loss*
Ancestral state: 0 *IE outgroup*
Directional: Y *loss is irreversible*

Hittite and Palaic both preserve a participial suffix *-*ent*- as well known from other Indo-European branches (cf. e.g. Meier-Brügger 2003: 217; Beekes & de Vaan 2011: 219). No trace of such a suffix with participial function is attested in Lydian, Luwian, or Lycian.

21. Enclitic 3SG.DAT. personal pronoun *-*tu*

Hittite	Palaic	Lydian	Luwian	Lycian
0	2	1	2	2

0 = reflex of *-*soi* as 3SG.DAT. enclitic pronoun
1 = innovated =*mλ* (only Lyd.)
2 = reflex of *-*tu* (i.e. original 2SG.DAT.) as 3SG.DAT. enclitic pronoun
Weight: 4 (0>2, 1>2) *highly non-trivial analogy* 2 (0>1, 2>1) *analogy*
Ancestral state: 0 *IE outgroup*
Directional: allowed: 0>1, 0>2, 2>1, 1>2 disallowed: 1>0, 2>0 *loss of model*

Hittite, Lydian, and Lycian all have separate 3SG.DAT. enclitic pronouns (=*sse*, =*mλ,* and =*i*(*je*) repectively). Out of these, only the Hittite state is directly inherited from PIE (see HEG Š: 968 with further references, although it is possible, yet highly uncertain, that the nasal element in Lyd. =*mλ* is ultimately ancestral, cf. e.g. Ved. *a-smái* 'for this'). Lydian and Lycian have each innovated their own novel form. For Lydian, cf. Kloekhorst (2012b), but perhaps with contamination by -*λ* from the nominal paradigms rather than -*λ* < *-*i̯* by sound law (i.e. =*mλ* < *-*smoi*). The Lycian pronoun could easily have been taken over from the ending -*i* of the nominal paradigms. However, Luwian and Palaic share an extension of the original 2SG.DAT. enclitic pronoun to the third person (Oettinger 1979b: 78–79; Kloekhorst 2022: 71).[7] This is a surprising and consequently highly non-trivial analogy and should therefore be assigned a weight of 4.

The Lycian data merits a more in depth discussion. As stated above, Lycian has innovated an enclitic pronoun =*i*(*je*). This is the standard morpheme in Lycian A and also appears in Lycian B. However, the Lycian B poem on TL 44 also displays 4-5 instances of an enclitic morpheme =*tu* (TL 44d.28; 34f.; 35; 58 and possibly TL 44c.56). According to Melchert (2004: 132), this may be an enclitic pronoun which could mean 'to you' (as is expected from a top-down Indo-European perspective), but is perhaps more likely to mean 'to him/her', i.e. reflecting the same analogical extension from 2SG. to 3SG. as we find in Luwian and Palaic, although no philological justification is adduced. Conversely, Sasseville (2018: 109–111) argues that the attestations on the western side (TL 44d) indeed mean 'to you', arguing that the referent is Gergis (the central hero of the poem), adducing a parallel from the small Greek poem on TL 44c (although the referent of Gr. σοι here is Arbina, whereas Gergis is referred to in the third person) and correctly stating that there already is a 3SG.DAT. enclitic pronoun available in =*i*(*je*).[8] However, in a more recent publication, Sasseville (2021b: 183) argues in favour of segmenting the sequence *utetu ñtelija* as *ute=tu ñtelija*, where *ute* is a *hi*-conjugating verb of speaking in the 3SG.PRES.[9] and *ñtelija* is

[7] A cognate morpheme of Hittite =*ssi* has assumed reflexive function at least in Palaic, and possibly also in Lydian (cf. eDiAna-ID 2661 with further references). This is not taken into account here.
[8] Moreover, if *tuwi* on TL 44d.34 is the orthotonic pronoun in the 2SG.DAT., this would lend additional credence to taking the attestations of =*tu* on the western side of TL 44 as 2SG. enclitic pronouns – the two subsequent clauses contain =*tu*. However, on the potential meaning 'laid offering' for *tuwi*-, see Billing (eDiAna-ID 1949).
[9] On this type of inflection, see Vernet (2018) with older references; Billing (2019: 40); Sasseville (2021c: 374–375).

parsed as the NOM.SG. of a DN, equivalent to Hitt./Luw. ^{d}*Antaliya*. The remaining element *=tu* would function here as a 3SG.DAT. enclitic pronoun. The clause would serve to introduce the direct speech of a deity in the assembly of gods which this part of the poem treats. The addresse of the speech would either be the Storm-God, who just spoke, or the enraged god Natri-Apollo. If Sasseville's segmentation is correct, 2SG. is precluded; the adressee in the other places where *=tu* occurs is most likely Gergis (the beneficiary of various divine boons), and in the following speech of *Ñtelija*, Gergis is referred to in the third person. Moreover, a 2SG. adressee would not be contextually appropriate. Crucially, this analysis is contingent on the validity of *ute* as a verb of speaking. Sasseville (2021b: 183 n. 24) suggests a connection to Hitt. *uttar/n-*, Luw. *ūtar/n-* 'speech, thing', which merits further inquiry. Kloekhorst (2008: 932–933) derives Hitt. *uttar/n-* from a root *$^{*}ueth_2$- (see Rix et al. 2001: 694–695). The existence of this root with connotations of speech is now further supported by the Palaic agent noun *wathala-* 'chanter (vel sim.)' (Sasseville eDiAna-ID 2522). It thus becomes possible to attempt to derive Lyc. B *ute* from a *hi*-conjugating verb to this root, i.e. *$^{*}u(ó)th_2$-. The strong form ought to have become Lyc. B **$^{**}wete$. However, vacillation between *wV-/u-* is not without parallel in Lycian, cf. *uwa-* vs. *wawa-* 'bovine'. Alternatively, one could postulate generalization of the weak stem, i.e. *$^{*}uth_2$-.

Since the assigned meaning of *ute* is contextually appropriate and etymologically possible, Sasseville's analysis is adopted here. The consequence is that we have an instance of a reflex of **=tu* functioning as a 3SG.DAT. enclitic pronoun in Lycian. This should be viewed as an archaism, seeing as the innovative allomorph *=i(je)* is spreading, becoming the only one of its kind attested in Lycian A and also appearing in Lycian B. In this analysis, Lycian is therefore coded 2 – the presence of *=i(je)* yields no phylogenetic signal anyway, as it is restricted to Lycian.

From either states 1 or 2 reversal to state 0 is not possible, since the model for analogy has been lost (no language other than Hittite shows a reflex of **soi* serving as a 3SG.DAT. enclitic pronoun). State 2 can be reached from any state (without change in weight), since the 2SG.DAT. pronoun is unaffected by any analogies in the 3SG. Since the origin of Lyd. *=mλ* is not entirely clear, it would seem most prudent to allow attainment of state 1 from any state. Likewise in the name of caution, attainment of state 1 is weighted 2 as a regular analogical innovation here (the mechanics of the innovation are not known, thus it is impossible to say whether it is trivial or non-trivial).

22. Innovation of the *i*-mutated paradigm

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	1	1

0 = no *i*-mutation
1 = merger of *o-*, *i-* and C-stems to the exclusion of *$^{*}eh_2$-stems

Weight: 4 *highly non-trivial analogy* (*requires several steps*)
Ancestral state: 0 *IE outgroup, comparative method*
Directional: Y *original distribution irrecoverable*

The term *i*-mutation refers to the merger of original common gender *o-*, *i-* and C-stems into a novel nominal paradigmatic type where direct cases have endings with *-i-* and oblique cases do not. The *$^{*}eh_2$-stems remain distinct. See Norbruis (2018), *pace* Rieken (2005), for a detailed treatment of the processes involved. See Sasseville (2017) for Lydian. There is no reason to doubt that the phenomenon as observed in Lydian is not cognate to the one in Lycian and Luwian, *pace* Yakubovich (2022: 207–209). Yakubovich points out that thematic stems are kept in Lydian, allegedly contrasting with Luwian. But this is restricted to oxytone thematic stems, cf. *αλa/e-* 'other' < **alió-* (as also acknowledged by Yakubovich). In fact, the fate of the *oxytone* thematic stems in Luwian has to our knowledge not yet been given a thorough treatment.

In Lycian, however, it seems as though oxytone thematic stems receive *i*-mutation, cf. *przze/i-* 'foremost', where the oxytone accent is revealed by the phonotactics. In either case, it is not inconceivable that oxytone thematic stems were affected by *i*-mutation as a secondary development in Luwian and Lycian. Another secondary development in Lydian would be the extension of the *-i-* to the neuter NOM/ACC.SG. in e.g. *qid* 'which', which Yakubovich provides a possible proportional analogy for. The basic criterion of *i*-mutation – common gender stems with an *-i-* in the ending of direct cases and not elsewhere, originating in thematic stems – is manifestly fulfilled by the Lydian data, cf. e.g. the nominal stems in *-l*(*i*)- < **-lo-* (Sasseville 2017: 137–139).

In order for *i*-mutation to occur, the same sound law (loss of intervocalic yod) must occur at a point where the *i*-stems are ablauting. The development should therefore regarded as highly specific and non-trivial, hence its weight of 4.

23. Merger of **eh*$_2$- and **o*-stems

Hittite	Palaic	Lydian	Luwian	Lycian
1	1	0	0	0

0 = inherited **eh*$_2$- and **o*-stems remain distinct 1 = **eh*$_2$- and **o*-stems are reflected in the same type

Weight: 1 *trivial analogy* (*consequence of a trivial phonological merger*)
Ancestral state: 0 *IE outgroup, comparative method*
Directional: Y *original distribution irrecoverable*

For Hittite, cf. *hāssā-* 'fireplace, hearth' < **h*$_2$*eh*$_1$*s-eh*$_2$- (Kloekhorst 2008: 322–323), reflected as an *a*-stem. Palaic only has three vocalic stem types (*a-, u-,* and *i*-stems; Carruba 1970: 43), implying a merger of original **eh*$_2$- and **o*-stems (cf. also the LOC.SG. ending *-a*; Carruba 1970: 42). This development is the natural result of a phonological merger of **eh*$_2$ and **o* into an *a*-quality vowel, and should therefore be regarded as trivial.

24. Innovation of the leniting *e*-stem verbal class

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	1	0	1

0 = no leniting *e*-stem class 1 = innovation of the leniting *e*-stem class

Weight: 4 (0>1) *highly non-trivial analogy* (*requires several steps*) 1 (1>0) *loss*
Ancestral state: 0 *IE outgroup*
Directional: N *class can be lost*

See Sasseville (2021c: 213–214). In Sasseville's scenario, this innovation necessitates a specific analogical levelling in favour of oblique stems in nouns with the stem formant **-eh*$_2$*-i-*, followed by the creation of a novel verbal stem class via conversion, specifically selecting the lenited ending allomorphs. The innovation of the leniting *e*-stem class is thus to be regarded as a highly non-trivial analogical process and is therefore assigned a weight of 4. Given that the character state 0 is simply defined as lack of any leniting *e*-stem class, its loss is possible and rather trivial, motivating a weight of 1 (the attested data indicate that the class is relatively small, hence the low weight, but 2 is conceivable).

25. Change to *hi*-conjugation in verbal *nu*-stems

Hittite	Palaic	Lydian	Luwian	Lycian
0	?	0	1	1

0 = *nu*-stems are *mi*-conjugating 1 = *nu*-stems are *hi*-conjugating

Weight: 2 *analogy*
Ancestral state: 0 *IE outgroup*
Directional: N *flexion type change is possible*

See Sasseville (2021c: 481–482 with further references). No Palaic *nu*-stem is attested, hence the missing data. Since PIE *nu*-stems are restricted to the present aspect (or tense) and does not exist in the perfect, an ancestral state 0 seems most likely.

26. Productive GENADJ. suffix reflecting **-osio-*

Hittite	Palaic	Lydian	Luwian	Lycian
0	0	0	1	1

0 = GENADJ. suffix reflecting **-osio-* is not productive 1 = GENADJ. suffix reflecting **-osio-* is productive

Weight: 1 *generalization/loss of productivity*
Ancestral state: none *deepest PIE state not determinable*
Directional: N *productivity is not a stable nor a directional property*

In Luwian and Lycian, the most frequent way to mark possession in a noun phrase is to employ the genitival adjective (Luw. *-assa/i-*, Lyc. *-a/ehe/i-*), marking the possessor with nominal agreement to the possessed. Kizzuwatna Luwian even generalizes this function as its only way to mark possession. Empire/Iron-age Luwian and Lycian still possess the genitive case as an alternative marker of possession, however. This morpheme goes back to PIE **-osio-* (see Palmér 2021: 191–194 with further references) and is reflected in Hittite as well in a number of isolated lexical items (cf. Kloekhorst 2008: 216 with further references). Palaic retains the genitival case and there is to my knowledge no evidence of general productivity of *-asa-* <**-osio-*. Lydian also employs a genitival adjective, but uses a different morpheme *-l(i)-*, derived from **-lo-* rather than **-osio-* (cf. Gérard 2005: 86; Sasseville 2017: 137–139). There is a Lydian suffix **-š(i)-* that originates in **-osio-* (Shevoroshkin 1967: 31; Gérard 2005: 87; Melchert 2012b: 282–284; Sasseville 2017: 140), but the attested data do not indicate that this morpheme is productive in the formation of possessive noun phrases to the exclusion of *-l(i)-*.

The ancestral state is not determinable by IE outgrouping nor by Anatolian internal comparative reconstruction. It seems possible that the genitival adjective existed in the proto-language, but was later lost in "core"-IE (with a relict in the thematic genitive case ending **-osio*, reflected in e.g. Skt. *-asya*). The suffix itself is likely reconstructable for PAnat., given that all languages attest to it, but whether or not it was productive is impossible to say. Since productivity of a given morpheme is not a directional nor a stable property (i.e. it can increase and decrease through time), change between states 0 and 1 is allowed and not heavily weighted (1).

27. Innovation of stem **tuw-* 'to put'

Hittite	Palaic	Lydian	Luwian	Lycian
0	?	1	1	1

0 = retention of a primary formation from $*d^h(ó)h_1$- 1 = innovation of a new verb *tuw- from $*d^heh_1$-

Weight: 3 *non-trivial analogy* (*but cf. comments below*)
Ancestral state: 0 *IE outgroup*
Directional: **Y** *affected languages lose primary outcome*

For Hittite (*dāi-^{hi}/tiya-*), Lydian (*cuwe-*), Luwian (*tuwa-^{i}*), and Lycian (*tuwe-^{ti}*), see eDiAna-ID 1965. Palaic suffers from absence of evidence (cf. Sasseville eDiAna-ID 1902). Oettinger (1979b: 89) explains the *-*u*- in the new stem as analogical to a 1PL.PRES. form $*d^hh_1$-*uéni*.[10] This solution remains tentative, but is probably the best one available at present. Under this analysis, the ancestral state must be 0. Given the tentative nature of the development, a weight of 3 is assigned despite the high level of specificity.

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[10] Followed by Starke (1990: 380), Sasseville (2021c: 362), and Melchert (2022: 4).

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