

The Phonology of Anatolian Reduplication: Synchrony and Diachrony

Abstract

In this paper we develop a synchronic and diachronic analysis of the phonology of partial reduplication in the Anatolian branch of Indo-European. We argue that the reduplicative patterns of Hittite and Luwian differ from Proto-Anatolian, which exhibited an asymmetric treatment of verbal stems with initial consonant clusters: full copying of sibilant-stop clusters, but partial copying of stop-sonorant clusters. We contend that the phonological constraint driving this asymmetry, NO POORLY-CUED REPETITIONS (Zukoff 2017a), was demoted within the separate prehistories of Hittite and Luwian due to independent phonological changes eliminating the distinction between these cluster types. Furthermore, we show that the proposed set of diachronic constraint re-rankings in Hittite and Luwian can be explained under Maximally Informative Recursive Constraint Demotion, a minor reformulation of the Recursive Constraint Demotion algorithm (RCD; Tesar 1995, Tesar and Smolensky 1998, 2000) that favors the high ranking of maximally informative winner-preferring constraints.

KEYWORDS: Hittite, Indo-European, phonological learning, diachronic phonology, language change

The Phonology of Anatolian Reduplication: Synchrony and Diachrony

1 Introduction

In this paper, we aim to provide a comprehensive synchronic and diachronic account of partial reduplication in the extinct Anatolian branch of the Indo-European (IE) language family, a reckoning now made possible by Dempsey’s (2015) recent compilation and philological treatment of Anatolian reduplicated verbal forms. Accordingly, we have four primary goals:

- First, to establish the patterns of partial reduplication that obtain in Hittite and Luwian — the two Anatolian languages which are sufficiently well-attested to make significant generalizations about — as well as in their reconstructed common ancestor, Proto-Anatolian (PA).
- Second, to develop synchronic analyses, framed in terms of Optimality Theory (Prince and Smolensky 1993/2004), of the phonological systems that generate these patterns.
- Third, to explain the diachronic changes that the Hittite and Luwian systems have undergone relative to PA, yielding the observed differences in their reduplicative patterns, focusing on the ways in which sound change interacts with changes in constraint grammars.
- And lastly, to assess the implications of the Anatolian data for the reconstruction of partial reduplication in Proto-Indo-European (PIE) and, more broadly, to assess its implications for the understanding of morphophonological change from the perspective of phonological theory and phonological learning.

We will begin in Section 2 by laying out the available data on partial reduplication from the attested languages. We will argue that Hittite and Luwian exhibited the copying patterns schematized in (1a) and (1b), respectively.¹

* We would like to acknowledge our gratitude to the members of the Indo-European & Modern Linguistic Theory research group (especially Ryan Sandell), as well as to Craig Melchert, Adam Albright, and Donca Steriade. We would also like to thank the audiences of the 35th Annual East Coast Indo-European Conference and the 28th Annual UCLA Indo-European conference, where earlier versions of this work were presented. All mistakes and infelicities are of our own doing.

¹ We employ the following abbreviations for segment type: *C* = any consonant, *T* = obstruent, *R* = sonorant consonant, *S* = [s], *V* = vowel, *X* = optional string of additional segments. Segments considered to be part of the reduplicant are underlined. This paper builds upon and updates the recent treatment of Anatolian reduplication presented in Zukoff (2017a: Ch. 3).

(1) Anatolian partial reduplication patterns by base shape

Base Shape	a. Hittite	b. Luwian	c. Proto-Anatolian
CVX–	<u>CV</u> -CVX–	<u>CV</u> -CVX–	* <u>CV</u> -CVX–
TRVX–	<u>TRV</u> -TRVX–	<u>TV</u> -TRVX–	* <u>TV</u> -TRVX–
STVX–	<i>i</i> <u>STV</u> -STVX–	(<u>TV</u> -STVX–)	* <u>STV</u> -STVX–
VCX–	<u>VC</u> -VCX–	<u>VC</u> -VCX–	<i>does not exist yet</i>

Significantly, Hittite (1a) differs from all other ancient IE languages in that it shows cluster-copying for all types of initial consonant clusters ($TRVX- \rightarrow \underline{TRV}-TRVX-$, $STVX- \rightarrow i\underline{STV}-STVX-$), *modulo* the normal phonological treatment of word-initial *ST* clusters (namely, prothesis of [i]; see further Section 3.3 below). Luwian (1b), on the other hand, shows a more typical IE distribution, exhibiting C_1 -copying for bases with initial obstruent-sonorant clusters ($TRVX- \rightarrow \underline{TV}-TRVX-$). While Luwian appears to attest C_2 -copying for *STVX-* bases, we will demonstrate (in Section 5.1) that this pattern is not synchronically generated, but rather a frozen relic reflecting the effects of regular sound change. With the relevant distributions established, Section 3 details the synchronic analysis of the reduplicative system of Hittite, and Section 4 briefly demonstrates that the same constraints and considerations employed for the analysis of Hittite can be deployed to analyze the minimally different reduplicative system of Luwian.

In Section 5, we turn to the reconstruction of the reduplicative system of Proto-Anatolian. Based on (i) the diachronic treatment of PA initial **ST* clusters (Section 5.1), (ii) considerations of parsimony in reconstruction with respect to *TRVX-* bases (Section 5.2), and (iii) both theory internal and diachronic considerations regarding the relative chronology of **h₁* loss and the advent of vowel-initial roots (Section 5.3), we argue for the reconstruction of Proto-Anatolian provided in (1c). This reconstruction fits neatly into the typology of partial reduplication in the ancient Indo-European languages (Zukoff 2017a; cf. Steriade 1988, Niepokuj 1997, Fleischhacker 2005, Keydana 2006, 2012). Specifically, the reconstructed reduplicative patterns for the respective cluster-initial base types — C_1 -copying for *TRVX-* bases ($TRVX- \rightarrow \underline{TV}-TRVX-$), but cluster-copying for *STVX-* bases ($STVX- \rightarrow \underline{STV}-STVX-$) — are identical to those attested in Gothic. What is significant about this reconstruction is that Proto-Anatolian reflects the asymmetric treatment of bases with different types of initial clusters that is characteristic of the IE family.

Zukoff (2017a) has argued that this asymmetric behavior can be explained by the operation of the NO POORLY-CUED REPETITIONS constraint (**PCR*), which is defined in (2).² Section 6 spells out the **PCR*-based analysis of the asymmetric pattern in PA.

(2) **NO POORLY-CUED REPETITIONS (**PCR*)** [$\approx *C_\alpha VC_\alpha / _C_{[-\text{sonorant}]}$]

For each sequence of repeated identical consonants separated by a vowel ($C_\alpha VC_\alpha$), assign a violation mark *** if that sequence immediately precedes an obstruent.

When the reduplicative grammar of PA is compared to those of its daughter languages, a striking analytic puzzle presents itself. While **PCR* is essential in generating the cluster-dependent copying patterns of PA, it appears to play no role in the synchronic grammars of its daughter languages Hittite and Luwian, neither of which show evidence that different cluster types are treated differently with respect to reduplicant shape by the synchronic grammar. In fact, the VC-VCX– reduplication pattern of vowel-initial roots in each language directly *violates* **PCR*. Therefore, **PCR* must be *inactive* in both languages. That is to say, **PCR* must be situated at the very lowest stratum of the ranking in the grammars of both languages. This situation raises the following question: how did Anatolian develop from a system in which **PCR* was active in shaping reduplication patterns to one in which it is completely inactive?

² The nature of this constraint will be discussed further in Section 3.5.2 below. See Zukoff (2017a: esp. Ch. 6) for the full proposal.

In Section 7, we will argue that phonological changes within the independent histories of Hittite and Luwian eliminated the distinction between *TRVX*- and *STVX*- bases in reduplication. This in turn made it possible for learners to converge on a *PCR-free analysis, allowing for the subsequent emergence of *PCR-violating reduplication patterns. This scenario poses substantial problems for our current understanding of phonological learning, as it appears to constitute a diachronic counterexample to the “Subset Principle” (see Prince and Tesar 2004): learners evidently learned a less restrictive grammar than warranted by the evidence. We propose that this particular type of learning scenario can be accommodated through a minor reformulation of the Recursive Constraint Demotion algorithm (RCD; Tesar 1995, Tesar and Smolensky 1998, 2000) that favors the high ranking of maximally informative winner-preferring constraints (Section 7.2). We term this Maximally Informative Recursive Constraint Demotion (MIRCD). In Sections 7.3–7.6, we show that employing MIRCD as a means of determining constraint ranking yields a satisfactory step-wise account of the relevant diachronic developments from PA to Hittite and Luwian, respectively. Section 7.7 briefly treats some additional Hittite forms that may shed further light on the diachrony of *PCR in the post-PA period.

Finally, Section 8 summarizes the main claims of the paper. We then conclude by considering the implications of our reconstruction of PA reduplication for the reconstruction of the reduplicative system of PIE, and by discussing how the methodology employed here can be used to complement traditional approaches to recovering historical sound change.

2 Hittite and Luwian Reduplication Data

This section provides a nearly exhaustive list of forms from the Anatolian languages displaying partial reduplication, assembled primarily from Dempsey (2015). Partial reduplication is one of what appear to be two distinct types of verbal reduplication attested in Anatolian. Dempsey (2015:331) concludes that partial reduplication — the type of reduplication that we are concerned with here — generally indicates imperfective/pluractional morphosemantics.³ On the other hand, Anatolian also exhibits a type of reduplication that indicates “expressive” or “intensive” morphosemantics (Dempsey 2015:332). The data for this type is much more limited, but on the basis of the forms that are attested, it looks like the process involves (at least) total reduplication of the root, e.g., Hitt. *wariwar-* [*war-i-war-*] ‘burn up’. We will not examine the properties of this type here. However, it should be noted that, given the prototypical monosyllabicity of roots in Anatolian (as in PIE) and the well-known ambiguities of the Anatolian cuneiform and hieroglyphic writing systems, it is not always entirely clear whether a reduplicated form ought to be identified as the partial reduplication type or the total reduplication type. This issue arises, in particular, in *TRVX*- bases, and, accordingly, will be discussed in detail in our treatment of this base type in Section 2.3 below.

With respect to the phonological properties of partial reduplication in Anatolian (as in the other ancient IE languages; see, e.g., Zukoff 2017a), there are four relevant categories to consider based on the phonological shape of the base:⁴

³ Two exceptions to this generalization are Hitt. *eš/aš-* ‘sit’ and *tīye/a-* ‘step, assuming a standing position’, whose reduplicated stems — *ašaš/ašes-* and *titti-*, respectively (cf. (4), (6) below) — unexpectedly have transitive semantics with respect to their bases, i.e. ‘cause to sit; seat’ and ‘cause to stand’. On the former, see also n. 18 below.

⁴ Throughout this article, we will consistently speak of the *base* (by which we mean the base of reduplication within a surface reduplicated form) rather than the *root*, as cluster-initial reduplicative bases — which are of primary interest here — often result from syncope of a root vowel.

- (3) Base types⁵
- a. Single-consonant-initial bases (*CVX-*)
 - b. Vowel-initial bases (*VCX-*)
 - c. Obstruent + sonorant-initial bases (*TRVX-*)
 - d. *s* + obstruent-initial bases (*STVX-*)

In Sections 2.1–2.4, we examine these base types in turn. In each case, we provide a table that lists all partially reduplicated verbal stems that stand beside an independently occurring verbal base in the language (“paired stems”).⁶ Each form is notated with an approximate phonetic transcription of the reduplicated stem; where aspects of these transcriptions may be controversial, we include specific discussion in defense of the interpretations presented. The data for the less well-attested base types (*VCX-*, *TRVX-*, and *STVX-*) are annotated with the source of their entries in Dempsey (2015) (abbreviated D) and, where appropriate, Kloekhorst (2008) (abbreviated K). Finally, we note that Section 2.1 in particular dwells on some finer points of Hittite (morpho)phonology and philology that are largely peripheral to the main goals of this article; the reader interested primarily in our analysis may prefer to skip ahead to Section 3.

2.1 CVX- Data

In both Hittite and Luwian (and also Lycian, although the evidence is quite limited), whenever the base begins in a *CV* sequence, the reduplicant takes the shape *CV*, where the *C* (and sometimes the *V*) are identical to the corresponding base-initial segments. The table in (4) below lists all such reduplicated forms that stand beside an independently occurring verbal base in these language (“paired stems”).⁷ The table in (5) shows other attested reduplicated forms whose presumed verbal base is attested elsewhere in Anatolian. As might be expected, *CVX-* bases constitute the vast majority of the available data on partial reduplication in Anatolian.⁸

While consistent *C*₁-copying is clearly observed in (4–5), certain aspects of this data call for further comment. First, several different sub-patterns are observed for the reduplicative vowel. While most forms show identical copy vocalism (e.g. Hitt. *kikkiš-*, *mammalt-*; virtually all of the Luwian forms), there appear to be at least a few forms with fixed [e] (e.g. Hitt. *wewakk-*) or fixed [i] (e.g. Hitt. *wiw(a)i(ške-)*, CLuw. *lilūwa-*).⁹ Given that [e] and [i] are the most common fixed vocalisms found in the other Indo-European languages (especially Greek; see Keydana 2006, Zukoff 2017a,b), it is likely that these represent archaisms, and that copy vocalism should be identified as the productive pattern for Hittite and Luwian.¹⁰ In any event, as will be shown in the analysis of *TRVX-* bases in Section 3.2 below, the reduplicative vowel in Hittite *must*

⁵ In Hittite, there is additionally one isolated case of a *TTVX-* base and one isolated case of a *RTVX-* base. It is doubtful that these forms should be treated as productively generated forms within synchronic Hittite, so discussion of these forms will be postponed until Section 7.7.

⁶ Several “unpaired” stems — i.e., likely reduplicated forms without synchronically identifiable bases — are omitted (see especially Dempsey 2015: Ch. 4 for data and discussion). Such forms do not generally seem to display any divergent characteristics, with the exception of a few forms that will be referenced at appropriate points in the proceeding discussion.

⁷ The notation *-(a)i-* in (4) and subsequent examples indicates that the verbal stem exhibits ablaut, showing *ai*-vocalism in some paradigmatic forms and *i*-vocalism in others (for a complete description of this stem allomorphy, see Hoffner and Melchert 2008:222–226). These alternations are largely orthogonal to the points taken up below and so we do not consider them further.

⁸ On the distinction between the homophonous reduplicated stems *titti-* and *titti-*, see Melchert (to appear b) (cf. Jasanoff 2010).

⁹ The reduplicant vocalism of the hapax form cited in (4) as *lelakki* — but by *CHD* (L–N: 58) as *lilakki* — is in fact ambiguous, potentially showing either [e] or [i] fixed segmentism. In our interpretation we tentatively follow Jasanoff (to appear), who assigns the form historically to a class of “iterative-intensive” **h₂e*-conjugation reduplicated present stems (along with *wewakk-* and *mēm(a)i-* ‘speak’).

¹⁰ Potential further support of copy vocalism as the productive pattern is provided by Hitt. *kukkurške-* in (4), a reduplicated form of the imperfective stem *kur(a)ške-* [k^wurské:-] (cf. Kloekhorst 2008:491), which itself is an inner-Hittite renewal of the older imperfective *kuwarške-* [k^warské:-] (on the phonological interpretation of these stems, see Yates 2017:121 n. 30). The likeliest explanation for the *u*-vocalism of the reduplicant is that it is copied from the innovative base *kur(a)ške-*.

(4) Reduplication with CVX– bases (paired stems)

	Gloss	Base	Reduplicated stem	
Hitt.	‘happen’	<i>kiš–</i>	<i>kikkiš–</i>	[<u>ki</u> -k:iš-]
	‘cut’	<i>kuwarške–</i>	<i>kuwakuwarške–</i>	[<u>k^wa</u> -k: ^w ar-]
		<i>kuraške–</i>	<i>kukkurške–</i>	[<u>k^wu</u> -k: ^w ur-]
	‘bend’	<i>lak–</i>	<i>lelakk–</i>	[<u>le</u> -lak:-]
	‘chant’	<i>mald–</i>	<i>mammalt–</i>	[<u>ma</u> -malt-]
	‘fall’	<i>mau(šš)–</i>	<i>mum(m)iye–</i>	[<u>mu</u> -m-]
	‘shoot’	<i>šiye/a–</i>	<i>šišiye–</i>	[<u>si</u> -s(i)-]
	‘place’	<i>d(a)i–</i>	<i>titti–</i>	[<u>ti</u> -ti-]
	‘step’	<i>tiye/a–</i>	<i>titti–</i>	[<u>ti</u> -ti-]
	‘cry out’	<i>wai–</i>	<i>wiw(a)i(ške–)</i>	[<u>wi</u> -w(a)i-]
	‘wipe’	<i>warš–</i>	<i>wawarš–</i>	[<u>wa</u> -wars:-]
	‘demand’	<i>wēk–</i>	<i>wewakk–</i>	[<u>wē</u> -wak:-]

CLuw.	‘run’	<i>huiya–</i>	<i>huihuiya–</i>	[<u>χ^wi</u> -χ ^w i-]
	‘take’	<i>la–</i>	<i>lala–</i>	[<u>la</u> -la-]
	‘pour’	<i>lūwa–</i>	<i>lilūwa–</i>	[<u>li</u> -lu:-]
	‘give’	<i>pī(ya)–</i>	<i>pipišša–</i>	[<u>pi</u> -pi-]
	‘break’	<i>malhu–/</i>	<i>mammalhu–/</i>	[<u>ma</u> -m(:)alχ ^w -] /
		<i>malwa–</i>	<i>mammalwa–</i>	[<u>ma</u> -m(:)alwa-]
	‘strike’	<i>dūp(a)i–</i>	<i>dūdupa–</i>	[<u>tu</u> :-tupa-]
HLuw.	‘exalt’	<i>sarla–</i>	<i>sasarla–</i>	[<u>sa</u> -sarla-]
	‘release’	<i>sa–</i>	<i>sasa–</i>	[<u>sa</u> -sa-]
	‘fill’	<i>su(wa)–</i>	<i>susu–</i>	[<u>su</u> -su-]
	‘stand’	<i>ta–</i>	<i>tata–</i>	[<u>ta</u> -ta-]

Lyc.	‘give’	<i>pije–</i>	<i>pibije–</i>	[<u>pi</u> -βi-]

(5) Paired CVX– stems reconstructible for PA by Anatolian-internal comparison

Hitt. <i>lipp–</i>	‘lick’	:	Luw(o-Hitt). <i>lilipa(i)–</i>
Hitt. <i>pašš–</i>	‘swallow’	:	Luw(o-Hitt.) <i>papašša–</i>
Hitt. <i>nai–</i>	‘turn’	:	CLuw. <i>nana–</i>
Hitt. <i>tar–</i>	‘say’	:	CLuw. <i>tatariya–</i> ‘curse’ / HLuw. <i>ta-ta-ra/i-ya–</i> [tatar(i)ya–] ‘id.’

be standing in correspondence with the base vowel, whether or not it is an identical copy. For the remainder of this article, however, we focus primarily on reduplicant shape, leaving a fuller investigation of reduplicant vocalism in Anatolian as a question for future inquiry.

In the data in (4) it can also be observed that some partially reduplicated verbal stems show orthographic gemination of the base-initial consonant. Such gemination is observed regularly in Hittite for stop-initial bases, as seen in paired stems like Hitt. *kikkiš-* and *titti-* in (4), as well as in synchronically unpaired but historically reduplicated stems like Hitt. *papparš-* ‘sprinkle’ and *pippa-* ‘overturn; destroy’ (on which see Dempsey 2015:198–203). We assume that these consistent intervocalic orthographic geminates represent phonological geminates just as elsewhere in the language, and accordingly transcribe them as long in (4) and in subsequent forms cited below.¹¹ It remains an open question how these base-initial geminates — which historically resulted from the operation of Sturtevant’s Law in Pre-Hittite (Sturtevant 1932; cf. Pozza 2011, 2012) — should be analyzed synchronically.¹² We provisionally assume here that they arise synchronically from a morphophonological gemination process specific to the context of reduplication, but the issue merits a fuller investigation elsewhere.¹³

While non-stop consonants generally do not show this gemination pattern, it is attested for verbal stems that begin with [m], including all of the paired stems in (4) and the unpaired reduplicated stem *mem(a)i-* ‘speak’. In these cases, however, the phonological reality of the orthographic geminate is dubious. The geminate *-mm-* spellings occur only in New Script (NS) manuscripts, by which period such spellings more broadly “are not always reliable indicators of a genuine geminate” (Hoffner and Melchert 2008:19). Moreover, the oldest attestation of *mummiye-* in (4) shows an orthographic singleton stop (3SG <*mu-mi-e-ez-zi*>; KUB 36.44 iv 8, OH/MS⁷ per *CHD L-N*: 328), and *mem(a)i-* is well-attested in Old Script (OS) and Middle Script (MS) manuscripts with consistent singleton spelling (see *CHD L-N*: 254–63 for attestations).¹⁴ In view of these facts, we interpret the geminate *-mm-* spellings in these stems as a purely orthographic effect and thus transcribe them with [m] in (4).

A third and final point concerns a few examples in (4) in which the formation of a verb’s reduplicated stem involves more than simply the addition of a reduplicative prefix. Both *šišiye/a-* and *mum(m)iye-* show further suffixation of *-ye/a-* (< PIE **-ye/o-*), with historical syncope of the root vowel in at least the latter.¹⁵

¹¹ That Hittite has a contrast between orthographic geminate (“fortis”) and non-geminate (“lenis”) stops in intervocalic position has been accepted at least since Sturtevant (1932); however, there is no consensus about what precise phonological/phonetic feature(s) are actually distinguished (see, e.g., Hoffner and Melchert 2008:35). We adopt the commonly held view that the contrast was one of length, as argued by Melchert (1994:14–21) and by Kloekhorst (2014:544–547) (cf. Yates 2017:39–40). However, the possibility that the contrast was rather one (primarily) of voicing or aspiration can hardly be excluded. This question is ultimately orthogonal to the questions addressed in this article.

¹² With respect to these base-initial geminates, we follow the traditional historical explanation of Melchert (1994:18–20, to appear a). He argues that devoicing of initial voiced stops spread across Anatolia in the post-PA period, and that these voiceless stop-initial roots served as the input to reduplication in Pre-Hittite. In such reduplicated forms, these stops were then subject to Sturtevant’s Law, whereby Pre-Hittite intervocalic voiceless stops developed into the voiceless geminates regularly observed in Hittite.

¹³ A similar morphophonological gemination process is observed when the imperfective suffix *-ške-* is added to most verbal roots that end in a non-geminate stop. At an earlier stage, these roots had a final (breathy) voiced stop, which was subject to devoicing by the initial **s* of the suffix, and the resulting voiceless stop developed diachronically into a voiceless geminate by Sturtevant’s Law. Synchronically, however, gemination must be understood as a morphophonological process conditioned by the suffix *-ške-* (Melchert 1994:57, 62–63), in particular, since it does not affect all non-geminate stop-final roots; compare, e.g., *akkuške-* (IPFV to *eku/aku-* ‘drink’) and *wekiške-* (IPFV to *wek-* ‘demand’).

¹⁴ Given the late (i.e., NS) and limited attestation of CLuw. *mammalhu/mammalwa-*, its base-initial geminate may similarly be purely orthographic. Yet it is also possible that its geminate is phonologically real, a result of the Pre-Luwian operation of Čop’s Law (Čop 1970), which caused consonant gemination after short stressed **é*. Our transcription [m(:)] in (4) reflects this uncertainty.

¹⁵ See Dempsey (2015:270–271) for arguments that *mummiye-* derives historically from **mú-mu-ye-*, as well as a critique of older views. Orthographic ambiguity makes it impossible to tell whether the same syncope occurred in *šišiye/a-*, which can be interpreted as either [sisyē-] or [sisiye-].

A different problem is presented by Hitt. *lilakk-* and *wewakk-* in (4): the stem-final geminate of their reduplicated forms are synchronically irreconcilable with the final singleton stops in their bases (cf. 3SG.NPST *lāki*; 3SG/PL.PST *wekun/weker*).¹⁶ This discrepancy awaits a satisfactory explanation. Lastly, there is CLuw. *dūdupa-*, which appears to have a long vowel in the reduplicant and a short vowel in the base, the latter mismatching the long vowel observed in the simplex form *dūp(a)i-*. The phonological interpretation of this is unclear, especially in view of CLuw. *lilūwa*, where the reduplicant appears to be short and the long vowel of the base remains long.¹⁷ Yet such issues, however they are ultimately resolved, do not materially affect the present study; these stems conform to the regular C₁-copying pattern observed everywhere in Anatolian and elsewhere in Indo-European for CVX- bases.

2.2 VCX- Data

For each of the remaining base types, the data is much more scarce. Vowel-initial bases in both Hittite and Luwian show a VC-VCX- reduplicative pattern, as shown by the forms in (6). The forms of the shape VR-VRTX- will be especially significant for understanding the development of the *PCR constraint within Anatolian (cf. Section 7).

(6) Reduplication with VCX- bases

	Gloss	Base	Reduplicated stem	
Hitt.	‘mount’	<i>ark-</i>	<i>ararkiške-</i>	[<u>ar</u> -ark-] (D:58–60, 260)
	‘seat’	<i>ēs-</i>	<i>asāš-</i>	[<u>as</u> -a:s-] ¹⁸ (D:61–65, 282–284; K:218–219)
CLuw.	‘wash’	<i>īlḥa-</i>	<i>ililḥa-</i>	[<u>il</u> -ilḥa-] (D:218–219, 263)

2.3 TRVX- Data

For *obstruent + sonorant*-initial bases (TRVX-), Hittite has a cluster-copying pattern TRV-TRVX-, while Luwian exhibits the more typical IE C₁-copying pattern TV-TRVX-. The attested forms are shown in (7) below. If analyzable as reduplicated forms, the Lycian verbs *pabra-* and *pabla-* (of unknown meaning; cf. Dempsey 2015:273–274), would be consistent with the Luwian and Indo-European pattern of TV-TRVX- reduplication.¹⁹

¹⁶ For the singleton root-final stop as basic in *wek-* ‘demand’, see Melchert (2014:255 n. 8) (contra Kloekhorst 2008:996–997).

¹⁷ We provisionally take these forms at face value and transcribe the vowels that are marked with plene spelling as long in (4).

¹⁸ This form is included for completeness, as it seems to synchronically mirror the other vowel-initial forms. However, it is all but certain that it has a somewhat different history than the others; see now Covini (2018) and references therein (cf. Dempsey 2015:282–284).

¹⁹ Following Dempsey (2015:329), we assume that the verbal stems *tatrahḥ-* ‘incite’ and *paprahḥ-/papre(šš)-* ‘make/be(come) impure’ are deadjectival in Hittite rather than synchronic partial verbal reduplication to unattested verbal bases. While these forms therefore do not constitute evidence for the synchronic reduplicative system of Hittite, their adjectival bases *tatrant-* ‘sharp-edged; prone to goring’ and *paprant-* ‘impure’ nevertheless may preserve traces of an earlier TV-TRVX- C₁-copying pattern; see further Section 5.2 below.

(7) Reduplication with TRVX– bases

	Gloss	Base	Reduplicated stem
Hitt.	‘blow’	<i>par(a)i-</i>	<i>parippar(a)i-</i> [pri-p:r(a)i-] (D:121–126, 275–276; K:631–632)
	‘kneel’	<i>ḫal(a)i-</i>	<i>ḫaliḫal(a)i-</i> [χli-χl(a)i-] (D:66–71, 319–320; K:273–274)
CLuw.	‘carry off’	<i>par(a)-</i>	<i>papra-</i> [pa-pra-] ²⁰ (D:230, 272–273)

Due to the well-known limitations of the Hittite cuneiform script — specifically, its inability to faithfully represent word-initial consonant clusters (cf. Hoffner and Melchert 2008:12–13) — the Hittite forms in (7) are potentially ambiguous, reflecting either: (i) partial reduplication, with a purely graphic “empty” vowel after the word-initial consonant; or (ii) “intensive” total reduplication, with a real *a*-vowel after this word-initial consonant (cf. Hitt. *wariwar* ([war-i-war-]) ‘burn up’ from *war/ur-* ‘burn’).²¹

For *parippar(a)i-*, there is both formal and functional evidence in support of the former analysis. First, as discussed in detail by Dempsey (2015:121–126), its meaning is consistent with partial (rather than “intensive”) reduplication: it occurs in contexts in which iterative or habitual readings are appropriate, and like other partially reduplicated stems, shows an affinity for the imperfective suffix *-ške-* (~20% of attestations; see *CHD* P: 155), which “reinforces” these semantics. In addition, the reduplicated stem is twice attested with gemination of the base-initial stop (<*pa-ri-ip-pa-ri-ya-an-zi*>, KBo 13.177 i 16; <*pa-ri-ip-pa-ra-a(-i)*>, KBo 25.60 ii 3); this feature is characteristic of partial reduplication (as noted in Section 2.1 above), but is unattested in unambiguous examples of “intensive” reduplication (cf. *kunnikunk-* ‘sway back and forth’; see Dempsey 2015:87–88, 320–321).²² We therefore follow both Dempsey (2015:275–276) and Kloekhorst (2008:273–274) in assuming partial reduplication in *parippar(a)i-*.

Partial reduplication is also likely for *ḫaliḫal(a)i-* (cf. Kloekhorst 2008:273–274), although less certain. There is no positive evidence that the orthographic *a* in the word-initial or base-initial cluster of the reduplicated stem is phonologically real. Moreover, the reduplicated stem exhibits a similar affinity for the suffix *-ške-* (~33% of attestations; see *HW*² *H*: 34), and in all of the examples treated by Dempsey (2015:67–70) has semantics appropriate to partial reduplication.

Regardless, the broader analysis advanced in this paper does not depend on the morphological status of *ḫaliḫal(a)i-* alone; it is necessary only that at least one of *parippar(a)i-* or *ḫaliḫal(a)i-* is derived by partial reduplication. Given the relative security of *parippar(a)i-* as partial reduplication, the phonological generalization set out at the beginning of this section — i.e., that TRVX– bases show cluster-copying in Hittite — can be maintained.

²⁰ For a more detailed treatment of this verb (including etymological discussion), see Melchert (2016b). The base-initial [pr] cluster is unambiguous (3SG.IMP <*pa-ap-ra-ad-du*>), arising via syncope of the root *a*-vowel (present in unreduplicated *par(a)-*).

²¹ Under the second view, the bases would be [par(a)i-] and [χal(a)i-] and their corresponding reduplicated stems [paripar(a)i-] and [χaliχal(a)i-]. Interpreting the latter base as [χal(a)i-] is conceivable in view of attestations like 3PL.PST <*ḫa-a-li-er*> (KBo 3.34 iii 12; OH/NS) or 3SG.NPST.MID <*ḫa-a-li-ya*> (KUB 10.11 ii 17; OH/NS) with apparent plene spellings of the initial *a*-vowel; see Dempsey (2015:319–320) for arguments in support of this view, and Kloekhorst (2008:273–274) for arguments in favor of [χl(a)i-]. Interpreting the former base as [par(a)i-], however, is highly unlikely. Not only are plene spellings of the sort observed in *ḫal(a)i-* wholly absent despite more than two dozen attestations (see *CHD*, P: 133), but across the IE family only “state II” derivatives are attested for the verbal root **preh₁-*: Ancient Greek *pímprēmi* ‘fan; burn’; Russian *préju* ‘sweat’ (see *LIV*²: 489). We therefore assume that the base is [pr(a)i-], and that this derives historically from an original **i*-present **pró/éh₁-i-* (following Kimball 1998 and Melchert 2015).

²² Given the poverty of examples, however, it is possible that this absence is just an accidental gap.

2.4 STVX– Data

For inherited *s* + *obstruent*–initial roots (PIE/PA *STVX–), Hittite and Luwian again diverge, as shown in (8). Hittite shows copying of the full cluster (as in TRVX– bases), plus a prothetic [i]. The word-initial [i] must be epenthetic, and outside of the reduplicant proper; if the root were underlyingly vowel-initial, it would be expected to exhibit the copying pattern for VCX– roots, thus yielding ^x*is-istu–*, contrary to fact.²³ Luwian synchronically lacks STVX– bases; the Luwian reduplicated forms in (8) are relics of the Proto-Anatolian *STV-STVX– pattern, with deletion of *s in Pre-Luwian according to regular sound change (see Section 5.1 below for further discussion).

(8) Reduplication with STVX– bases

	Gloss	Root/Base	Reduplicated stem
Hitt.	‘become evident’	<i>ištu–</i> (/stu/)	<i>išdušdu-ške–</i> [istu-stu-] (D:71–73, 263; K:419)
CLuw.	‘become evident’	PA * <i>stu–</i>	<i>dušdu-ma/i–</i> [tu-stu-] (K:419–420)
	‘bind’	PA * <i>sh₂(o)i–</i>	<i>hišhi(ya)–</i> [χi-sχi-] (D:212–213, 261–262)

Two additional Hittite forms should be mentioned here: (i) Hittite *šišd–* ‘prosper’ (Dempsey 2015:204–205, 301–302), and (ii) Hittite *šišha–* ‘decide, appoint’ (Dempsey 2015:206–207, 303–304). If these were to be viewed as productively generated reduplicated forms within synchronic Hittite, they would clearly run counter to the generalization presented above, showing C₁-copying rather than cluster-copying. Dempsey (2015:301–304), however, argues convincingly on both semantic and formal grounds that neither of these was synchronically analyzed by Hittite speakers as reduplicated, and we follow him on this point. If these verbs are rightly analyzed as reduplicated stems formed at some earlier stage,²⁴ they could be showing the same inner-Hittite syncope process seen in Hitt. *titha–* and *lilhuwai–* (see Section 7.7 below).

3 Synchronic Analysis of Hittite Copying Patterns

With the data established, we now proceed to the formal analysis of these patterns, which is couched within Base-Reduplicant Correspondence Theory (McCarthy and Prince 1995, 1999). We begin in this section with Hittite, treating the copying patterns observed for each base type; we then extend our analysis to Luwian in Section 4. The two subsequent sections treat Proto-Anatolian: we motivate our PA reconstruction in Section 5, then analyze the reconstructed PA data in Section 6.

3.1 CVX– Bases in Hittite

First, we consider the most basic type, the CV- copying pattern to CVX– bases. Most of the interesting analytical points arise only in other base types, but this pattern can serve to illustrate one noteworthy point, namely, that post-nuclear segments (e.g. C₂ and V₂ in a C₁V₁C₂V₂– base) are not generally copied. (The crucial, principled exception to this generalization will be with vowel-initial roots, where exactly one post-nuclear consonant does get copied; see Section 3.4 below.) This fact can be derived in part by using a “size minimizer” constraint (see Spaelti 1997, Hendricks 1999, among others) that prefers smaller reduplicants.

²³ Kloekhorst (2008:419) makes a similar observation.


²⁴ This analysis is by no means certain, especially for *šišd–*, which LIV²:337 instead derives from a reconstructed root **sesT–*.

In this article, we will employ the size minimizer constraint ALIGN-ROOT-L for this purpose.²⁵ As defined in (9), this is an alignment constraint (cf. McCarthy and Prince 1993) dictating that the output exponent of the root be as far to the left as possible. Since the reduplicant necessarily intervenes between the root and the left edge of the word, ALIGN-ROOT-L will prefer the smallest reduplicant possible (subject to the requirements of higher-ranked constraints). ALIGN-ROOT-L trades off with the Base-Reduplicant faithfulness constraint MAX-BR, defined in (10). This constraint prefers maximal copying from the base, which is directly at odds with the goals of ALIGN-ROOT-L. The fact that maximal copying is not observed shows that ALIGN-ROOT-L must outrank MAX-BR.

- (9) **ALIGN-ROOT-L**
Assign one violation mark * for each segment which intervenes between the left edge of the word and the left edge of the root.
- (10) **MAX-BR**
Assign one violation mark * for each segment in the base without a correspondent in the reduplicant.
- (11) **Hittite Ranking:** ALIGN-ROOT-L \gg MAX-BR

This ranking is demonstrated in (12) with the root *wars-* ‘wipe’. Copying one post-nuclear consonant (candidate (12b)) or both post-nuclear consonants (candidate (12c)) increases the number of violations of ALIGN-ROOT-L, since there are now more segments preceding the root than necessary.²⁶ This ranking will generally promote minimal copying in reduplication in Hittite.

- (12) CVX– bases: *wars̥-* ‘wipe’ \rightarrow *w̄a-wars̥-*

/RED, wars-/	ALIGN-ROOT-L	MAX-BR
a.  <u>w̄a</u> -wars-	**	**
b. <u>war</u> -wars-	***!	*
c. <u>wars</u> -wars-	***!*	

3.2 TRVX– Bases in Hittite

Bases with initial *obstruent + sonorant* (TR) clusters copy both base-initial consonants, plus the reduplicative vowel; for example, *prai-* ‘blow’ \rightarrow *pri-prai-*. The constraint that is crucial in preferring the desired cluster-copying candidate (16a) *pri-prai-* over a cluster-reducing CV reduplicant candidate (16b) *pi-prai-* is CONTIGUITY-BR, defined in (13). In order to select the cluster-copying candidate, CONTIGUITY-BR must dominate ALIGN-ROOT-L, as cluster-copying introduces additional segments intervening between the root and the left edge of the word.

- (13) **CONTIGUITY-BR**
Assign one violation mark * if two segments which are contiguous in the base have correspondents in the reduplicant that are not contiguous.

To make use of this constraint for the example under discussion, we must assume that the reduplicative vowel corresponds either to the entire diphthong of the base [ai], or the first base vowel [a], such that the base correspondent of the reduplicative vowel is contiguous with the base-second consonant. Alternatively, we

²⁵ See Zukoff (2017a) for other size minimizer constraints that may be appropriate for Anatolian, and for the systems of the related IE languages.

²⁶ Copying fewer than two segments (e.g. **a-wars-* or **w-wars-*) is disallowed by other, higher-ranked constraints (e.g. ANCHOR-L-BR; see below), even though they could further reduce the number of ALIGN-ROOT-L violations.

could assume that the reduplicant is calculated relative to the weak stem (see n. 7 above), which regularly exhibits zero-grade ablaut for this type of verb, i.e. *pri-pri-*. Either way, this problem does not arise with monophthongal nuclei, as in the *STVX-* example below. Nevertheless, since this constraint is crucial in the analysis, we must assume that in all cases, whether or not the vowel of the reduplicant is identical to the base vowel, the vowel of the reduplicant stands in BR-correspondence with the vowel of the base.²⁷

A third candidate considered here is (16c) *ri-prai-*, which copies just the second root consonant rather than the first. This strategy avoids creating a reduplicant cluster and thus improves satisfaction of ALIGN-ROOT-L without violating CONTIGUITY-BR. However, it does so at the expense of another constraint, ANCHOR-L-BR — defined in (14) — which is undominated in Anatolian. With the ranking shown in (15) below, the cluster-copying candidate is selected, as demonstrated in the tableau in (16).

(14) **ANCHOR-L-BR**

Assign one violation mark * if the leftmost segment of the reduplicant does not correspond to the leftmost segment of the base.

(15) **Hittite Ranking:** ANCHOR-L-BR, CONTIGUITY-BR \gg ALIGN-ROOT-L

(16) TRVX– bases: *prai-* ‘blow’ \rightarrow *pri-prai-*

/RED, prai-/	ANCHOR-L-BR	CONTIGUITY-BR	ALIGN-ROOT-L
a. p^{h} <u>pri</u> -prai-			***
b. <u>pi</u> -prai-		*!	**
c. <u>ri</u> -prai-	*!		**

This copying pattern is quite noteworthy from the Indo-European perspective. Hittite appears to be the only Indo-European language that attests reduplication to TR-initial bases but does not maintain the C_1 -copying pattern for them.²⁸ While the motivation for this change remains largely mysterious (cf. Sections 5.2 and 7.1), its ramifications for the ranking of *PCR relative to other constraints will have serious implications for the reduplication patterns of other base types — in particular, of vowel-initial bases.

3.3 STVX– Bases in Hittite

Bases beginning in *s-obstruent* (*ST*) clusters constitute a special case of cluster-initial bases. In Hittite, they exhibit the same cluster-copying pattern as do TRVX– bases, but additionally display prothesis of [i] to the (word-initial) reduplicant cluster: simplex *istu-* ‘become evident’ \rightarrow reduplicated *istu-stu-*. This complication follows directly from the independent process of prothesis to initial ST clusters.

(17) **Hittite prothesis:** $\emptyset \rightarrow [i] / \#_ST$

Prothesis must be a synchronically active process in Hittite (as opposed to a sound change which has run its course and altered underlying representations). This is clear from reduplication: this root (simplex *istu-*) does not behave like the real vowel-initial roots laid out in Section 2.2 (analyzed in Section 3.4 below). If it were underlyingly vowel-initial (i.e. /istu/), the reduplicated form should be $^x\text{is-istu-}$, contrary to fact. Moreover, the facts of stress assignment in Hittite provide additional evidence for the synchronic status of prothesis. As discussed in detail by Yates (2017:137–139), the prothetic vowel [i] is “invisible” to stress assignment: the regular phonological preference for word-initial stress that arises in the absence of lexically stress-attracting morphemes ignores the prothetic vowel, placing stress instead on the root vowel immediately following the ST cluster; for example, Hitt. /skar-i/ \rightarrow *iškāri* [iská:ri] ‘pierces’ (not x [ískari]). Such

²⁷ Consult Alderete et al. (1999) on fixed segmentism in reduplication.

²⁸ Latin lacks reduplicated forms to TR-initial bases entirely; see Cser (2009).

invisibility is a characteristic property of epenthetic vowels cross-linguistically (see, e.g., Hall 2006:396, 2011:1586), and offers a neat explanation for the otherwise aberrant stress patterns of verbs with historical **#ST* clusters.²⁹ In view of this convergent evidence, we assume that Hittite surface forms like [istu-] are stored with an initial ST-cluster (i.e., /stu/), and that the prothetic vowel arises in the course of the derivation: /stu-/ → [istu-].

To generate this pattern of prothesis, the constraint militating against initial ST clusters (**#ST* in (18a)) must outrank the constraint militating against epenthesis (DEPV-IO in (18b)), as illustrated in (20). DEPV-IO must also be dominated by other faithfulness constraints whose violation could repair an initial ST cluster — for instance, MAXC-IO (18c), which penalizes consonant deletion.³⁰

(18) Constraints involved in epenthesis

- a. ****#ST***
Assign one violation mark * for each word-initial ST cluster.³¹
- b. **DEPV-IO**
Assign one violation mark * for each output vowel without an input correspondent.
- c. **MAXC-IO**
Assign one violation mark * for each input consonant without an output correspondent.

(19) **Hittite Ranking:** **#ST*, MAXC-IO ≫ DEPV-IO

(20) Epenthesis to ST roots: /stu-/ → [istu-]

/stu-/	<i>*#ST</i>	MAXC-IO	DEPV-IO
a. stu-	*!		
b. istu-			*
c. su-/tu-		*!	

Epenthesis could solve the **#ST* problem in one of two ways: (i) prothesis (i.e., external epenthesis), as is attested; or (ii) anapyxis (i.e., internal epenthesis), as in an unattested output like ^x*situ-*. To select prothesis over internal epenthesis, we need to consider the ranking of **#ST* and two additional constraints: CONTIGUITY-IO and ONSET.³²

(21) Constraints for epenthesis site

- a. **CONTIGUITY-IO**
Assign one violation mark * for each pair of segments which are adjacent in the input that have non-adjacent correspondents in the output.
- b. **ONSET**
Assign one violation mark * for each onsetless syllable.

CONTIGUITY-IO prefers external epenthesis, as internal epenthesis would disrupt adjacency relationships. ONSET, on the other hand, prefers internal epenthesis, because external epenthesis would create a

²⁹ Close parallels for the Hittite situation are found in Spanish (Harris 1970; McCarthy 1980), Brazilian Portuguese (Mateus and d’Andrade 2000:45–46), and Classical Armenian (DeLisi 2015:72–74, 96–98), all of which show insertion of an epenthetic vowel in word-initial /ST/-clusters (→ [#VST-]) that is ignored in the phonological computation of word stress.

³⁰ Both DEPV-IO and MAXC-IO probably dominate **CC* (the general anti-cluster constraint), as clusters are generally permitted, though this matter is complicated by the independently necessary activity of CONTIGUITY-IO.

³¹ It is probably appropriate to view this as a more general phonotactic restriction that requires [s] to surface adjacent to a vowel, as medial sequences of CsC (when s is not part of the affricate [t͡s]) are also actively avoided (see Kavitskaya 2001, Yates 2014, 2016b). This extension would have no effect on our analysis, so we employ the more limited formulation here.

³² Consult Yun (2016) and references therein for more sophisticated approaches to the determination of epenthesis site.

word-initial (and thus syllable-initial) vowel. Furthermore, ALIGN-ROOT-L actually prefers internal epenthesis as well, since external epenthesis introduces a new segment between the root and the left edge of the word. Since external epenthesis is selected, it is clear that CONTIGUITY-IO must dominate both ONSET and ALIGN-ROOT-L, and also that *#ST dominates ONSET and ALIGN-ROOT-L, or else epenthesis would not constitute harmonic improvement. This ranking is shown in (22) and illustrated in the tableau in (23) below.

(22) **Hittite Ranking:** *#ST, CONTIGUITY-IO \gg ONSET, ALIGN-ROOT-L

(23) Epenthesis site in ST roots: /stu-/ \rightarrow [istu-]

/stu-/	*#ST	CONTIGUITY-IO	ONSET	ALIGN-ROOT-L
a. stu-	*!			
b. istu-			*	*
c. situ-		*!		

Since ST roots are stored underlyingly with an initial ST cluster, these roots can act just like other cluster-initial roots (i.e. TRVX-), subject only to the additional condition of prothesis, which applies now to the reduplicant cluster rather than the base cluster. This results from combining the constraints and rankings already established independently for TRVX- roots in reduplication (cf. (16) above) and STVX- roots in isolation (cf. (20) and (23) above). The tableau in (24) illustrates this prediction.

(24) Reduplication of STVX- bases: /stu-/ \rightarrow [istu-stu-]

/RED, stu-/	*#ST	ANCHOR-L-BR	CONTIG-BR	DEPV-IO	ALIGN-ROOT-L
a. <u>stu</u> -stu-	*!				***
b. istu -stu-				*	****
c. <u>su</u> -stu-			*!		**
d. <u>tu</u> -stu-		*!			**

The simple cluster-copying candidate (24a) — which is equivalent to the pattern exhibited by TRVX- bases — is impossible here, because it would result in an initial ST cluster (prohibited by the undominated markedness constraint *#ST). Copying a non-base-initial consonant as in (24d) is also suboptimal, as it violates ANCHOR-L-BR. Lastly, candidate (24c), which just copies the root-initial *s*, is not permitted because it violates CONTIGUITY-BR, since the *s* and the vowel are not adjacent in the base while they are in the reduplicant. (It also violates *PCR, but this constraint must be lower ranked; see further below.) This leaves (24b), which is equivalent to the cluster-copying candidate (24a), except that it additionally has prothesis before the reduplicant. As long as DEPV-IO and ALIGN-ROOT-L (and indeed ONSET, which is also violated in the winning candidate due to its prosthetic vowel) are dominated by the three highest ranked constraints, this candidate remains optimal.

(25) **Hittite Ranking:** *#ST, ANCHOR-L-BR, CONTIG-BR \gg DEPV-IO, ONSET, ALIGN-ROOT-L

It is crucial that the epenthetic *i* does not belong to the reduplicant proper, as this would lead to a fatal ANCHOR-L-BR violation. This is reflected below in the difference between candidates (28b) and (28c) (indicated notationally with a difference in underlining). In desired candidate (28b), the epenthetic vowel is analyzed as being external to the reduplicant; it is thus irrelevant for the calculation of ANCHOR-L-BR, and the constraint is satisfied because the reduplicant-initial *s* corresponds with the base-initial *s*. On the other hand, in suboptimal candidate (28c), the epenthetic vowel is parsed as part of the reduplicant, and indeed as

its leftmost segment; this creates a mismatch between reduplicant-initial and base-initial segments, yielding a fatal violation of ANCHOR-L-BR.

Given that the epenthetic vowel must not be treated as part of the reduplicant, this shows that the constraint which militates for the reduplicant to be at the left edge of the word — ALIGN-RED-L, defined in (26) — is violable, and indeed is violated in service of prothesis (in candidate (28b)).³³ (ALIGN-RED-L must outrank ALIGN-ROOT-L in order to ensure that the reduplicant precedes rather than follows the root.) The tableau in (28) shows that, given these assumptions and rankings, we continue to select the desired output.³⁴

(26) **ALIGN-RED-L**

Assign one violation mark * for each segment that intervenes between the left of the reduplicant and the left edge of the word.

(27) **Hittite Ranking:** *#ST, ANCHOR-L-BR ≫ ALIGN-RED-L ≫ ALIGN-ROOT-L

(28) Reduplication of STVX- bases: /stu-/ → [istu-stu-]

/RED, stu-/	*#ST	ANCHOR-L-BR	CONTIGUITY-IO	ALIGN-RED-L
a. <u>stu</u> -stu-	*!			
b. <u>is</u> tu-stu-				*
c. <u>istu</u> -stu-		*!		
d. <u>is-tu</u> -tu-			*!	**

3.4 VCX- Bases in Hittite

Vowel-initial roots/bases in Hittite show VC copying: for instance, *ark-* ‘mount’ → *ar-ark-isk-*. This pattern follows completely from the ranking necessary to generate the *iSTV-STVX-* pattern above. This is demonstrated in the tableau in (29) below. In addition to revealing several new rankings (ONSET ≫ ALIGN-ROOT-L ≫ *PCR), this pattern for the first time gives occasion to consider the status of *PCR in Hittite (Section 3.5.2 immediately below).

(29) VCX- bases: *ark-* ‘mount’ → *ar-ark-*

/RED, ark-/	ANCHOR-L-BR	CONTIG-BR	ONSET	ALIGN-ROOT-L	*PCR
a. <u>ark</u> -ark-			*	***!	
b. <u>ar</u> -ark-			*	**	*
c. <u>a</u> -ark-			**!	*	
d. <u>ak</u> -ark-		*!	*	**	
e. <u>r</u> -ark-	*!			*	*
f. <u>k</u> -ark-	*!			*	

Copying from non-root-initial position (29e,f) provides ideal syllable structure (i.e., no ONSET violations), but incurs a fatal ANCHOR-L-BR violation. Copying the vowel and the second root consonant as

³³ The admission of ALIGN-RED-L into the grammar does not make any perverse predictions, since it has already been established that CONTIGUITY-IO is active in the grammar, and this constraint will forestall any candidates with an infixal reduplicant (e.g. *TRVX-* → *T-RV-RVX-*), even if there were some potential phonotactic benefit to doing so. (An infixal candidate for STVX- bases without further modification, i.e. *S-TV-TVX-*, would be eliminated by *#ST.)

³⁴ Additional relevant candidates, including ^x[s-i-stu-] and ^x[is-i-stu-], are discussed and accounted for in Zukoff (2017a:97–98).

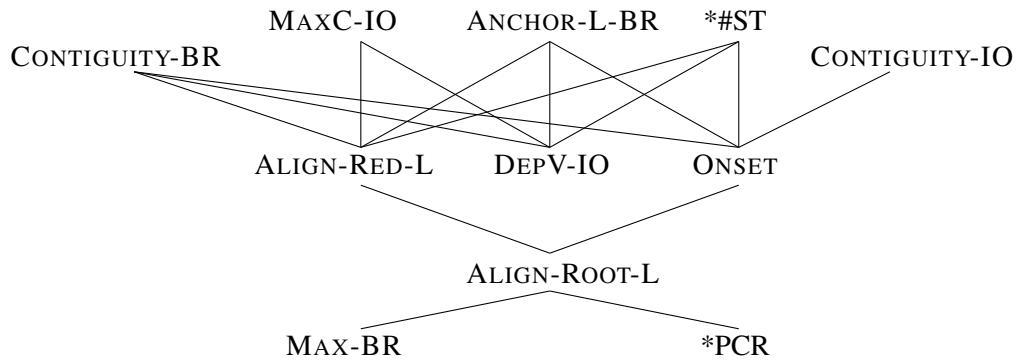
in (29d) violates CONTIGUITY-BR. Copying just the root-initial vowel as in (29c) creates hiatus, and thus an additional ONSET violation. (This justifies the ranking $\text{ONSET} \gg \text{ALIGN-ROOT-L}$.) Copying the full post-nuclear cluster (29a) leads to having three segments in the reduplicant, and thus three violations of ALIGN-ROOT-L. Since copying just the root-initial vowel and the first post-nuclear consonant — the pattern observed in the winning candidate (29b) — only incurs two ALIGN-ROOT-L violations and does not violate any of the higher-ranked constraints, ALIGN-ROOT-L selects it as optimal.

3.5 Hittite Summary

3.5.1 Ranking Summary

The Hasse diagram in (30) summarizes the rankings needed to generate the copying patterns of Hittite. We have now demonstrated that the Hittite reduplication patterns sketched in Section 2 can be analyzed with a consistent constraint ranking, largely making use of the same constraints employed for reduplication in the other Indo-European languages (cf. Zukoff 2017a,b).

(30) **Hittite total ranking**



3.5.2 Hittite Reduplication, *PCR, and the Indo-European Context

As alluded to earlier, most of the ancient Indo-European languages with reduplication exhibit a distinction in the copying behavior of different types of cluster-initial roots (see Steriade 1988, Niepokuj 1997, Fleischhacker 2005, Keydana 2006, 2012, Zukoff 2017a): TRVX– roots/bases show C_1 -copying (*TV-TRVX–*), while other cluster types (always including STVX– roots/bases) show an alternative pattern. These distributions can be explained by the constraint *PCR (Zukoff 2017a), whose (simplified) definition is provided in (31) (repeated from (2) above).

(31) **NO POORLY-CUED REPETITIONS (*PCR)** [$\approx *C_\alpha VC_\alpha / _C_{[-\text{sonorant}]}$]

For each sequence of repeated identical consonants separated by a vowel ($C_\alpha VC_\alpha$), assign a violation * if that sequence immediately precedes an obstruent.

*PCR penalizes transvocalic consonant repetitions ($C_\alpha VC_\alpha$ sequences) in particular contexts. The definition provided here, which will be sufficient for the analysis of Anatolian, identifies the penalized context as *pre-obstruent*. Across (and beyond) the Indo-European languages where this constraint is active, however, we require a more fine-grained approach to the context referenced by the constraint. Zukoff (2017a: Ch. 6) ultimately argues that the proper formulation of the *PCR constraint is one which circumscribes the context(s) of repetition avoidance in phonetic terms: namely, repeated consonants are specially avoided when they lack robust acoustic/auditory cues to their presence (i.e., the contrast between that consonant

and \emptyset), the most central cue being a rising intensity contour (cf. Parker 2002, 2008, Yun 2016) between the consonant and the following segment. While space prevents us from providing a fuller exposition of the proposal, the important take-away for the purposes of this article is the following: the cluster-type asymmetries observed in Indo-European reduplication patterns are driven by *PCR, a markedness constraint which likely has perceptual underpinnings.³⁵

The analysis in this section of cluster-initial roots and the \underline{VC} - VCX - reduplication pattern reveals something very interesting about Hittite from the Indo-European perspective: unlike virtually all other ancient Indo-European reduplication systems, *PCR is *completely inactive* in Hittite. For one, *PCR plays no role in shaping any of the Hittite copying patterns; specifically, the across-the-board cluster-copying for all types of cluster-initial roots does not require a high-ranked *PCR constraint (though the patterns are not in and of themselves inconsistent with such a ranking). But, furthermore and more importantly, *PCR must in fact be very low ranked in order to generate the \underline{VC} - VCX - pattern. This can be seen from tableau (29) above. As indicated in winning candidate (29b), the \underline{VC} - VCX - pattern, when applied specifically to $VRTX$ - bases, *violates* *PCR, because it places a consonant repetition (*rar*) before an obstruent (*k*). In order to select this pattern, *PCR must be outranked by ANCHOR-L-BR, CONTIGUITY-BR, and ONSET. This places it at the very bottom of the ranking of the constraints relevant for reduplication, rendering it essentially *inactive* in the grammar. The same statement holds of its status in Luwian, which shows the same behavior (e.g. CLuw. *ilḫa-* ‘wash’ → *il-ilḫa-*).

Therefore, Hittite differs from most of the other ancient IE languages not only in not showing *PCR effects, but in directly showing *PCR violations. Even more significantly, both Hittite and Luwian diverge in this respect from their proximate common ancestor, Proto-Anatolian. As we will show in Section 6 below, Proto-Anatolian is itself to be reconstructed as having exhibited *PCR effects (i.e., as having *PCR ranked relatively high in the grammar). The obvious question is, then, how to explain the unexpectedly low ranking of *PCR in both Hittite and Luwian: why was *PCR demoted such that the *PCR-violating \underline{VC} - VCX - pattern could (independently) emerge in the two languages? We address this question in Section 7, where we contend that this is the result of independent phonological changes that eliminated *PCR’s explanatory power, which led to its demotion in their respective constraint rankings.

4 Synchronic Analysis of Luwian Copying Patterns

Hittite and Luwian display the same surface reduplicative patterns for CVX - and VCX - bases (\underline{CV} - CVX - and \underline{VC} - VCX -, respectively). They diverge only in their treatment of cluster-initial bases. Unlike Hittite, Luwian exhibits the typical IE C_1 -copying pattern for $TRVX$ - bases, i.e. \underline{TV} - $TRVX$ -. Luwian also has verbal forms of the shape \underline{TV} - $STVX$ - (with apparent C_2 -copying). However, we argue in Section 5.1 that these forms are not synchronically generated via reduplication (perhaps not even synchronically compositional); rather, Luwian synchronically lacks / $STVX$ -/ roots in its lexicon and thus lacks any synchronic reduplication pattern associated with $STVX$ - bases. Therefore, in this brief section, we provide an analysis of the Luwian \underline{TV} - $TRVX$ - pattern, and then confirm that it poses no problems for the analysis of the \underline{VC} - VCX - pattern.

4.1 $TRVX$ - Bases in Luwian

Whereas Hittite shows cluster-copying for $TRVX$ - bases (\underline{TRV} - $TRVX$ -), Luwian shows the more typical IE C_1 -copying pattern: \underline{TV} - $TRVX$ -. The Luwian pattern can be generated straightforwardly by taking the ranking proposed for Hittite (cf. (16) above) and reversing the ranking of CONTIGUITY-BR relative to

³⁵ Consult generally Hayes et al. (2004) on phonetically-based approaches to phonological constraints.

ALIGN-ROOT-L, as illustrated in (33). This is the pattern that we will argue is reconstructible for Proto-Anatolian in the next section, and we will use the same ranking to generate it there.

(32) **Luwian Ranking:** ALIGN-ROOT-L \gg CONTIGUITY-BR

(33) TRVX– bases: *para-* ‘carry off’ \rightarrow *pa-pra-* (cf. Hittite *prai-* \rightarrow *pri-prai-*)

/RED, pra-/	ANCHOR-L-BR	ALIGN-ROOT-L	CONTIGUITY-BR
a. <u>pra</u> -pra-		***!	
b. <u>pa</u> -pra-		**	*
c. <u>ra</u> -pra-	*!	**	

4.2 VCX– Bases in Luwian, and the Ranking of *PCR

Just like in Hittite, vowel-initial bases in Luwian show VC copying: *ilha-* ‘wash’ \rightarrow *il-ilha-*. As shown in (34), this reduplicative pattern can be analyzed just like the identical Hittite pattern (cf. Section 3.4). The difference in the relative ranking of ALIGN-ROOT-L and CONTIGUITY-BR between Hittite and Luwian does not affect the outcome of the derivation. Each ranking shown in (34) is crucial, and represents the total ranking for Luwian reduplication (with the addition of the ranking ALIGN-ROOT-L \gg MAX-BR).

(34) VCX– bases: *ilha-* ‘wash’ \rightarrow *il-ilha-*

/RED, il χ a-/	ANCHOR-L-BR	ONSET	ALIGN-ROOT-L	CONTIG-BR	*PCR
a. <u>ilχ</u> -il χ a-		*	***!		
b. <u>il</u> -il χ a-		*	**		*
c. <u>i</u> -il χ a-		***!	*		
d. <u>iχ</u> -il χ a-		*	**	*!	
e. <u>l</u> -il χ a-	*!		*		*
f. <u>χ</u> -il χ a-	*!		*		

5 Reconstructing Proto-Anatolian

The reduplication patterns of Hittite and Luwian — which have been analyzed above in Sections 3 and 4, respectively — are schematized in (35) below. Luwian’s pattern for STVX– bases is given in parentheses because — as we will argue in 5.1 below — it should not be interpreted as a synchronically productive pattern; rather, surface forms exhibiting this pattern are fossilized relics shaped by sound change, which may not even have been construed by Luwian speakers as reduplicated forms. In this section, we take these patterns as the basis for the reconstruction of the reduplicative behavior of Proto-Anatolian (PA).

(35) Reduplication patterns of Hittite and Luwian

Base type	CVX–	TRVX–	STVX–	VCX–
Hittite	<u>CV</u> -CVX–	<u>TRV</u> -TRVX–	<u>iSTV</u> -STVX–	<u>VC</u> -VCX–
Luwian	<u>CV</u> -CVX–	<u>TV</u> -TRVX–	(<u>TV</u> -STVX–)	<u>VC</u> -VCX–

There is no question that PA displayed CV copying for CVX– bases, as this pattern is found in all of the attested Anatolian languages, and is easily reconstructible for PA’s own parent language, Proto-Indo-European (PIE). With respect to the other three types of bases discussed in this article (TRVX–, STVX–, and VCX–), however, the task of reconstructing their reduplicative patterns in PA is non-trivial. Using a combination of evidence from sound change and the principle of economy, we will argue in this section for the reconstruction in (36).

(36) Reconstruction of Proto-Anatolian reduplication patterns

Base type	CVX–	TRVX–	STVX–	(VCX–)
Proto-Anatolian	<u>CV</u> -CVX– (C ₁ -copying)	<u>TV</u> -TRVX– (C ₁ -copying)	<u>STV</u> -STVX– (cluster-copying)	<i>does not exist</i>

This reconstruction claims that Proto-Anatolian had the prototypical Indo-European C₁-copying pattern (TV-TRVX–) for TRVX– bases (thus implying that Hittite’s cluster-copying pattern is an innovation), but had cluster-copying (STV-STVX–) for STVX– bases (with Luwian’s apparent C₂-copying pattern deriving from this via sound change, not change in the reduplicative grammar). As illustrated in (37), the reduplicative patterns of PA are entirely parallel to Gothic (see, e.g., Jasanoff 2007). Zukoff (2017a: Ch. 4) demonstrates for Gothic that this distribution is motivated by *PCR, which diverts the derivation away from the target C₁-copying pattern just when the base begins in an ST cluster. Accordingly, we reconstruct an active *PCR constraint for PA, even though it is active in neither Hittite nor Luwian.

(37) Proto-Anatolian and Gothic

	<u>CV</u> -CVX–	<u>TV</u> -TRVX–	<u>STV</u> -STVX–
a. Proto-Anatolian	* <u>gi</u> - <i>gis</i> –	* <u>bV</u> - <i>brV</i> –	* <i>stu</i> - <i>stu</i> –
b. Gothic	<u>hε</u> - <i>hεt</i>	<u>gε</u> - <i>grot</i>	<i>stε</i> - <i>stald</i>

Note also the hypothesized absence of the VC-VCX– pattern in PA (36), despite its presence in both Hittite and Luwian. We argue in Section 5.2 below that this pattern is an independent development in the two languages and, moreover, that this innovation sheds important light on the development of *PCR within Anatolian.

5.1 Reconstructing the Behavior of STVX– Bases

Hittite and Luwian appear to show incompatible behavior for STVX– bases. It can be observed in (38) that both languages attest a reduplicated stem to the PA root **st(e)u*– ‘become evident’ (< PIE **steu*–; see LIV²: 600–601). The Hittite form shows copying of the entire ST cluster (just like in Gothic), plus the prothetic vowel *i* (cf. Section 3.3 above). In Luwian, on the other hand, it seems that just the second member of the cluster (i.e., the non-sibilant obstruent) has been copied. On the surface, this looks like the C₂-copying pattern that is productive for STVX– roots in Sanskrit (see, e.g., Steriade 1988, Zukoff 2017a: Ch. 5) where, for instance, the root *stamb*^h– ‘prop’ forms a perfect stem *ta*-*stamb*^h– ‘PERF-prop’. Given that both the Hittite cluster-copying pattern (ignoring the prothetic vowel) and the apparent Luwian C₂-copying pattern are attested elsewhere in Indo-European, either pattern would *a priori* be a possible reconstruction for PA. However, once the effects of sound change are taken into account, it becomes clear that the Hittite pattern must be closer to the original situation.

(38) Reduplication with STVX– bases (repeated from (8) above)

	Gloss	Root/Base	Reduplicated stem
Hitt.	‘become evident’	<i>istu– (/stu/)</i>	<i>išdušduške–</i> [istu-stu-]
CLuw.	‘become evident’	PA * <i>stu–</i>	<i>dušduma/i–</i> [tu-stu-]
	‘bind’	PA * <i>sh₂(o)i–</i>	<i>hišhi(ya)–</i> [χi-sχi-]

In Section 3.3, it was demonstrated that the prothetic vowel which marks reduplicated STVX– bases in Hittite must be synchronically epenthetic; that is to say, if the prothetic vowel were analyzed as part of the underlying representation of the root, these roots would incorrectly be predicted to show a VC-VCX– reduplication pattern rather than the attested cluster-copying pattern. Yet while prothesis to word-initial ST clusters remained a synchronic process in Hittite, it can also be viewed from a diachronic perspective as a sound change relative to PA. The fact that not all of the other Anatolian languages show prothesis in this environment (either as synchronic process or historical change), strongly supports viewing it as a post-PA, pre-Hittite innovation.³⁶ Historically, then, a simple way to account for Hittite reduplicated forms of the shape *iSTV-STVX–* is to assume that they were inherited as such from PA but without the prothetic vowel (i.e., PA **STV-STVX–*), which was subsequently inserted by regular Hittite sound change.

Given that Hittite forms like those in (38) diverge from their inherited forms only by the application of regular sound change, it is worth considering whether the Luwian forms in (38) can be analyzed in the same way. We pursue this hypothesis below, starting from the observation that Luwian differs from Hittite in its historical treatment of word-initial **ST* clusters, showing deletion of the initial **s* rather than prothesis.³⁷ These differing developments are illustrated in (39a) with non-reduplicated Luwian forms and their Hittite cognates: wherever a Hittite form has #*iSTV*, the corresponding Luwian form has just #*TV*. The same holds for the reduplicated forms in (39b): Hittite #*iSTV* stands in correspondence with Luwian #*TV*. Meanwhile, the table in (40) shows that these developments are restricted to word-initial position; intervocalic **-ST-* sequences are retained faithfully in both languages.

(39) Treatment of PA #*ST* (cf. Melchert 1994:30–32, 2016a:187–188; Yates 2014, 2016b)

PA	CLuw.	Hitt.
a. * <i>[sp]or–</i>	> <i>[p]arritti</i>	‘spreads’
* <i>[st](e)h₃men–</i>	> <i>[t]ummān</i>	‘ear’
b. * <i>[sh₂]i(-sh₂i)–</i>	> <i>[h]išhiyanti</i>	‘bind’
* <i>[st]u(-stu)–</i>	> <i>[d]ušdu(miš)</i>	‘manifest’

³⁶ It is possible (although uncertain) that Lydian and Palaic also attest prothesis in inherited **#ST* clusters (see Melchert 1994:206, 371), but since different treatments are found in Luwian (see below) and perhaps Lycian (see now Melchert to appear b, who argues that **#STV* may have been preserved as Lyc. #*stV–*, if *stati* ‘stands; is placed upright’ is inherited and not a loanword from Greek), and neither of these can be easily derived from a sequence **#VST–*, prothesis is clearly to be analyzed as a post-PA development, either independently in each language or — as suggested by Kavitskaya (2001:294–295) — as a common innovation of a post-PA subgroup that includes Hittite, Lydian, and Palaic.

³⁷ Rieken (2010:657 n. 1) argues that **#sk* is retained as such in Luwian. If her proposal is correct, our analysis predicts that a synchronic /*skVX–*/ root would reduplicate as *sV-skVX–* in Luwian (cf. n. 40 below). Since there is no known evidence in Luwian for the treatment of inherited **#sk* in reduplication, we cannot test this prediction here.

(40) Treatment of PA medial ST-clusters

PA	CLuw.	Hitt.
* <i>h</i> ₁ <i>é</i> [<i>sh</i> ₂]- <i>r</i>	> <i>ā</i> [<i>šh</i>]ar(-sa) ‘blood’	cf. <i>ē</i> [<i>šh</i>]ar
*-o[s-t]i-	> <i>lump</i> -a[<i>št</i>]i- ‘regret’	<i>dalug</i> -a[<i>št</i>]i- ‘length’
* <i>h</i> ₁ <i>é</i> [s-t]i	> <i>ā</i> [<i>št</i>]i ‘is’	<i>ē</i> [<i>sz</i>]i

The major take-away from (39) is that the historically reduplicated *TV-STVX* Luwian verbal stems in (39b) can be traced back directly to PA forms of the shape **STV-STVX-*, which — by the regular Luwian sound change deleting **s* in inherited **#ST* clusters — would yield their attested forms.

We summarize these Hittite and Luwian developments in (41), where (41a) gives the diachronic correspondences (i.e., sound changes), and (41b) gives the synchronic phonological processes that were operative in effecting these sound correspondences. Prothesis was continuously synchronically active in Hittite from the inception of this sound change in Pre-Hittite through all attested periods of the language. For Luwian, it is possible to demonstrate only that the **s*-deletion process was operative in some period of Pre-Luwian, as this process appears to have altered underlying representations by the time of attested Luwian.

- (41) a. **Sound Changes:**
- i. Proto-Anatolian **#ST* > Hittite *#iST*
 - ii. Proto-Anatolian **#ST* > Luwian *#T*
- b. **Synchronic Processes:**
- i. (Pre-)Hittite $\emptyset \rightarrow [i]$ / *#__ST*
 - ii. Pre-Luwian */s/* $\rightarrow \emptyset$ / *#__T*

The precise diachronic developments in Luwian call for further comment. Under the proposed scenario, the crucial innovation of Pre-Luwian was the **s*-deletion process in word-initial **ST* clusters, which would most likely have begun its life as a gradient, postlexical phenomenon (see, e.g., Bermúdez-Otero 2015). However, this innovative Luwian deletion rule eventually became categorical, at which stage the */s/* of **ST*-initial roots would no longer have surfaced in simplex verbal forms. This */s/* might have been recoverable if supported by alternations, but Luwian has no productive prefixing morphology other than reduplication. In principle, reduplicating verbal stems like (39b) could have sustained an underlying root-initial */s/*. However, the historical simplex verbs corresponding to the attested reduplicated forms of Proto-Anatolian **ST*-roots appear to have been lost exceptionlessly; thus, for instance, while Luwian attests reduplicated *hišhi(ya)-*, it does not attest a simplex **hai-* equivalent to Hittite *išh(a)i-* ‘bind’. The lack of direct evidence for *[s]* then led to *restructuring* of historically **ST*-initial roots, with */s/* uniformly lost from underlying representations — i.e., PA **/STVX-/* > Luw. */TVX-/*. **STVX* and **TVX* roots would then have merged as */TVX/* synchronically.³⁸

Meanwhile, historically reduplicated verbs like Luw. *hišhi(ya)-* which synchronically lacked an independently occurring base came to be interpreted as non-derived stems(/roots) in Luwian rather than stems derived via reduplication. Whether such stems were still perceived as reduplicated by Luwian speakers cannot of course be known for certain; however, it is at least suggestive that the author of the ritual of Zarpaya (CTH 757) used the Luwian reduplicated stem *hišhi(ya)-* (3PL.NPST *hišhiyanti*; KUB 9.31 obv.

³⁸ A prediction of our analysis (as developed in Section 4 above) is that synchronically generated reduplicative forms to roots of either historical shape (**STVX* or **TVX*) would at this stage show the same *CV-CVX-* pattern. That is to say, PA **/STVX/*, **/TVX/* > Luw. */TVX/* \rightarrow *TV-TVX-*. Clear evidence for or against this claim is so far lacking; a possible positive example is CLuw. *dūp(a)i-* ‘strike’ (< PIE **(s)teup-*; cf. LIV²: 602–603) \rightarrow *dūdupa-* (hapax, KUB 35.65 iii 8; see Melchert 1993:238), but the issue is confounded by cognate Lycian *tub(e)i-* ‘id.’ and the broader problem of “**s*-mobile” in the IE languages.

ii 24) and the Hittite simplex stem *išḫai-* (PTCP.ANIM.NOM.PL *išḫiyanteš*; KUB 9.31 obv. i 31) in what appear to be Luwian and Hittite versions of the same incantation.³⁹ The equivalence of these stems in this context may support the idea that *ḫišḫi(ya)-* had lost the semantics associated with reduplicated stems and thus that it may no longer have been viewed as such by speakers. The historical scenario that we propose does not depend on this point, however, and we leave it as an open question here.

We conclude, then, that Luwian does not actually provide direct evidence for a synchronic treatment of STVX- bases, as its lexicon lacked them entirely.⁴⁰ Nonetheless, the fact that both languages display the diachronically regular outcome of a Proto-Anatolian *STV-STVX- pattern — especially given the necessary non-productivity of that output within Luwian — is strong evidence in favor of reconstructing this pattern for Proto-Anatolian.

5.2 Reconstructing the Behavior of TRVX- Bases

Hittite and Luwian disagree also on the treatment of TRVX- bases, as illustrated in (42) below. Hittite shows full copying of the initial TR cluster: *TRV-TRVX-*, as in *pri-prai-* ‘blow’ (*^xpi-prai-*). Luwian, on the other hand, copies only the initial obstruent: *TV-TRVX-*, as in *pa-pra-* ‘carry off’ (*^xpra-pra-*). The primary argument for reconstructing the Luwian pattern rather than the Hittite pattern for PA comes down to considerations of parsimony.

(42) Reduplication with TRVX- bases (repeated from (7) above)

	Gloss	Base	Reduplicated stem	
Hitt.	‘blow’	<i>par(a)i-</i>	<i>parippar(a)i-</i>	[pri-p:r(a)i-]
	‘kneel’	<i>ḫal(a)i-</i>	<i>ḫaliḫal(a)i-</i>	[χli-χl(a)i-]
CLuw.	‘carry off’	<i>par(a)-</i>	<i>papra-</i>	[pa-pra-]

Luwian reflects the pattern that is clearly reconstructible for PIE based on the comparative evidence outside of Anatolian. This C₁-copying pattern is clearly found in Ancient Greek (e.g., *ke-kri-* ‘PERF-judge’ not *^xkre-kri-*), Sanskrit (e.g., *pa-prac^h-* ‘PERF-ask’ not *^xpra-prac^h-*), Gothic (e.g., *ge-grōt* ‘PRET-weep.3SG’ not *^xgre-grōt*), and elsewhere. If the Hittite cluster-copying pattern were to be reconstructed for PA, it would be necessary to posit a change between PIE and PA (*C₁-copying* > *cluster-copying*), and then posit another change — in fact, the exact opposite change — between PA and Luwian (*cluster-copying* > *C₁-copying*). On the other hand, if the Luwian C₁-copying pattern is reconstructed for PA, it would require positing only a single change between PA and Hittite (*C₁-copying* > *cluster-copying*) and no change at all in this domain between PIE and PA.

Based on comparative evidence from across the ancient Indo-European languages, Zukoff (2017a: Ch. 7) has argued that PIE should be reconstructed as having displayed C₁-copying to STVX- roots (i.e., *SV-STVX-*), which would entail that PIE did not show basic *PCR effects in reduplication (see Section 8.1 for further discussion). If this hypothesis is correct, then the PA treatment of STVX- bases (i.e., the cluster-copying *STV-STVX-* pattern) is innovative relative to PIE (*C₁-copying* > *cluster-copying*). Adopting the C₁-copying pattern for the reconstruction of PA TRVX- bases would then provide a unitary direction of change within the development of Anatolian — schematized in (43) — from C₁-copying to cluster-copying:

³⁹ The relevant Luwian and Hittite passages are treated by Dempsey (2015:212–213). See also Yakubovich (2010:18, 282–283) for identification of the ritual’s author as a speaker of Kizzuwatna Luwian, as well as for discussion of the mixed use of Hittite and Luwian incantations in the ritual.

⁴⁰ If an STVX- root/base were input to the synchronic Luwian phonological grammar (via richness of the base), our analysis would predict C₁-copying (i.e., *SV-STVX-*). At least at present, this does not appear to be a testable prediction.

the STVX– bases change first (explainable with *PCR), then the TRVX– bases follow in the same direction (explainable with CONTIGUITY-BR). While the motivation for adopting cluster-copying to satisfy *PCR at that particular moment in time (i.e., at the point when the innovative cluster-copying pattern arises) may be mysterious, it is also not at all unexpected from a comparative Indo-European perspective, since the same innovation occurs in (the prehistory of) all of the Indo-European phonological systems that show basic *PCR effects. Yet, for whatever reason the change to cluster-copying in STVX– bases occurred in PA, this innovation may itself offer an explanation for the subsequent change in Hittite to cluster-copying for TRVX– bases, which might be motivated by a misanalysis of the newly emergent *SV-STVX–* pattern. This hypothesis will be explored further in Section 7.

(43) Change in cluster-initial bases from PIE to Hittite (assuming PA TRVX– C₁-copying)

	PIE	>	PA	>	Hittite
TRVX–	C ₁ -copying	=	C ₁ -copying	>	Cluster-copying
STVX–	C ₁ -copying	>	Cluster-copying	=	Cluster-copying

An alternative scenario in which cluster-copying for TRVX– bases (*TRV-TRVX–*) is reconstructed for PA is outlined in (44) below. As can be clearly observed, the result of this reconstruction for Luwian TRVX– bases would be a diachronic “Duke of York” scenario: PIE *A > PA *B > Luwian A. Under this view, it is necessary to assume that, not only was there a wholesale change from across-the-board C₁-copying in PIE to across-the-board cluster-copying in PA, but, in addition, that this change was then immediately undone in the prehistory of Luwian. This scenario therefore requires more assumptions than the one represented in (43), and the latter change, in particular, lacks any obvious motivation. Accordingly, we view reconstructing cluster-copying for TRVX– bases in PA as an unparsimonious and unattractive solution.

(44) Change in cluster-initial bases from PIE to Luwian (assuming PA TRVX– cluster-copying)

	PIE	>	PA	>	Luwian
TRVX–	C ₁ -copying	>	Cluster-copying	>	C₁-copying
STVX–	C ₁ -copying	>	Cluster-copying	(>)	(Ø)

Beyond the argument from parsimony, there may be archaisms in Hittite that support the reconstruction of an earlier **TV-TRVX–* C₁-copying pattern (cf. n. 19 above). One is Hitt. *tatrant–* ‘sharp-edged; prone to goring’ (cf. Melchert 1984:33 n. 68, Kloekhorst 2008:857), which serves as the derivational base for the verbal stem *tatrah_h–* ‘incite’. Another is Hitt. *paprant–* ‘impure’, which serves as the derivational base for the verbal stems (factive) *paprah_h–* ‘make impure’ and (fientive) *papre(šš)–* ‘be(come) impure’. If either of these adjectives were to derive diachronically from an earlier reduplicated formation, it can be expected to reflect the synchronic treatment of TR-clusters in reduplication at the historical stage at which it was formed. While it is certainly conceivable that the relevant stage is PIE itself, if it could instead be demonstrated that the formation was properly of PA antiquity — i.e., produced for the first time in PA or renewed according to the productive PA pattern — it would constitute evidence for reconstructing the C₁-copying pattern to TRVX– bases in PA.

For *tatrant-*, in fact, there is reason to think that this may be the case.⁴¹ While the *a*-vocalism of the (historical) reduplicant is extremely difficult to motivate from a PIE perspective, a straightforward inner-Anatolian explanation is available: it might show copy vocalism which — as discussed in Section 2.1 — is likely to have become the productive pattern in (Proto-)Anatolian. Accordingly, the Hittite adjective *tatrant-* may continue PA **dó-dr-ont-*, the expected participle of a reduplicated *hi*-verb derived from the root **der-* (< PIE **der-*; see *LIV*²: 119–20);⁴² this participle was then subject to lexicalization and preserved in Hittite among the productive class of *-ant*-adjectives. If this analysis is correct, it would provide further confirmation that the **TV-TRVX-* reduplicative pattern should be reconstructed for PA.

5.3 Against Reconstructing VCX- Bases

Since the *VC-VCX-* reduplicative pattern is found in both Hittite and Luwian, it might be natural to assume that it should also be reconstructed for Proto-Anatolian, as well. In this section, however, we present arguments against this reconstruction, contending instead that the *VC-VCX-* pattern observed in Hittite and Luwian was independently innovated in each language. While we acknowledge that the principle of parsimony has an important role to play in guiding historical reconstruction (and indeed, it was applied to this end especially immediately above), it is nevertheless not the only factor that must be taken into account, and in the case at hand, there are independent reasons to believe that the *VC-VCX-* pattern did not yet exist in PA.

The first argument against reconstructing the *VC-VCX-* pattern for PA comes from the phonological grammar itself. In Section 6 below, we develop an analysis of PA reduplication that successfully generates the *CV-CVX-*, *TV-TRVX-*, and *STV-STVX-* patterns (to *CVX-*, *TRVX-*, and *STVX-* bases, respectively), all of which were shown to be reconstructible for PA in the immediately preceding sections. The constraint ranking necessary to produce these patterns, however, is *incompatible* with the *VC-VCX-* pattern. Specifically, generation of the *STV-STVX-* pattern alongside the *TV-TRVX-* pattern requires **PCR* to be ranked high, while the *VR-VRTX-* sub-type of the *VC-VCX-* pattern would require **PCR* to be ranked low. The presence of this pattern in the language would therefore give rise to an insurmountable ranking paradox.

The fact that our analysis predicts that the *VC-VCX-* pattern should not exist in PA does not on its own constitute sufficient grounds to reject this reconstruction, since there is an obvious alternative possibility — namely, that the analysis itself is incorrect. Yet this prediction encourages a closer examination of the data relevant to this reconstruction, and in the remainder of this section, we argue that this re-examination vindicates our analysis: the *VC-VCX-* pattern did not exist in PA because PA did not yet have the vowel-initial bases (i.e., *VCX-*) from which it was generated.

5.3.1 Evidence

It is standardly assumed that PIE lacked vowel-initial roots (see *LIV*²:5–7, among others), and thus that vowel-initial roots arose in its daughter languages only after the loss of root-initial laryngeals. Since **h₂* and **h₃* are preserved as consonants in word-initial pre-vocalic position in Hittite and Luwian,⁴³ the primary historical source of vowel-initial roots in these languages is therefore PIE roots of the shape **h₁eX-* after

⁴¹ Less likely is Hitt. *paprant-*, which is generally compared either to words like Goth. *fairina* ‘guilt’ (= OHG *firina* ‘crime’) and CLuw. *paratta-* ‘impurity(?)’ (Melchert 1984:33 n. 68; cf. Kloekhorst 2008:628–629) or — more plausibly, in our view — to words like Skt. *babhrú-* ‘brown’ and Lith. *bėbras/bėbrus* ‘beaver’ (Puhvel 2011:105–106; cf. Dempsey 2015:329). Since the latter consistently appears reduplicated across the IE languages, it is plausible to assume it was reduplicated already in PIE; moreover, synchronic renewal in PA is highly unlikely, given the lack of any clear connection to a verbal root and the non-productivity of nominal reduplication in PIE and its descendants (see, e.g., Lundquist and Yates 2018: §2.4). It is probable, then, that the reduplicated adjective was inherited as such into PA and then into Hittite.

⁴² For the stressed reduplicant and zero-grade root, compare the Vedic Sanskrit **-nt*-participle *bí-bhr-at*.

⁴³ See now Melchert (to appear a) (updating Melchert 1994:68–74, 122–123, 257–258) and references therein.

the loss of **h₁*.⁴⁴ All of the Anatolian languages have lost **h₁* in this position (see Melchert 1994:65–68, to appear a),⁴⁵ and accordingly, it has generally been thought that this loss had already occurred in PA (Melchert 1994:65). However, there are at least three pieces of evidence that suggest that **h₁* was retained (in certain environments) beyond the break-up of PA proper. If word-initial pre-vocalic **h₁* were indeed retained beyond PA, then it is very likely the case that PA lacked vowel-initial roots, and in turn, that the emergence of the *VC-VCX-* pattern shown by vowel-initial roots in Hittite and Luwian was a later development in the individual languages.⁴⁶

The first point that may support the post-PA loss of **h₁* is the historical development of inherited nasal-sibilant clusters vis-à-vis **-nh₁s-* sequences: the former regularly undergo assimilation to *-šš-* [-s:-] in Hittite, but the latter instead appear to yield Hittite *-nz-* [-nts-] — compare (45a) vs. (45b).⁴⁷ These differing developments suggest that, at the historical stage when nasal-sibilant clusters were first subject to assimilation, **h₁* was still present, intervening between the nasal and sibilant and thus blocking the application of this process. The further question, then, is when exactly nasal-sibilant assimilation developed. On the basis of Lycian evidence, Melchert (1994:63) argues that **-ns-* assimilation is a post-PA innovation. If this chronology is correct, (45b) would argue for the retention of **h₁* beyond PA and thus into (Pre-)Hittite — and, by the same logic, into (Pre-)Luwian.

- (45) Nasal-sibilant (non-)assimilation in Hittite
- a. PA **dé/óns-u-* > Hitt. *daššu-* ‘strong’
 - PA **h₂óns-o-* > Hitt. *ḫāšša-* ‘offspring’
 - b. PA **géh₁-su* > Hitt. *kēnzu* ‘lap’ (not **kēššu*)

A second piece of evidence for the post-PA loss of **h₁* comes from the development of PIE/PA coronal stops (abbreviated here D), which display sibilant reflexes across Anatolian when preceding a palatal glide: **D / _yV* > Hitt. *-z-*, Luw. *-z-*, Lyc. *-z-* (= [t̪s]), as illustrated in (46a–b). Such pan-Anatolian agreement strongly suggests that this assibilation should be reconstructed for PA (cf. Melchert 1994:62). On the other hand, when **h₁* intervened between a coronal stop and a palatal glide, assibilation failed to occur: **-Dh₁y-* > Hitt. *-Dy-* (Kimball 1999:404; cf. Melchert 1983:14), as in (46c–d).⁴⁸

- (46) Coronal (non-)assibilation in Anatolian
- a. PIE/PA **-tyo-* > Hitt. *šarāzziya-*, Lyc. *hrzze/i-* ‘upper’
 - b. PIE/PA **h₂et-ye/o-* > Hitt. *ḫazziya-* ‘strike (an instr.)’, HLuw. *ḫazi-* ‘incise; write’
 - c. PIE/PA **dh₁-yé/ó-* > Hitt. *tiye/a-* ‘bind’ (not **ziye/a-*)
 - d. PIE/PA **d^(h)h₁y-énti* > Hitt. *tianzi* ‘place’ (not **zianzi*)

The contrast between (46a–b) and (46c–d) requires that **h₁*-loss post-dates the period during which this assibilation process was operative. It thus implies that this loss was a relatively late development in Anatolian, although one still potentially dateable to PA. However, the further fact that the forms in (46c–d)

⁴⁴ On the more complicated set of developments that led to the creation of CLuw. *ilḫa-* ‘wash’ (whence reduplicated *il-ilḫa-*), see Melchert (2011) and n. 73 below.

⁴⁵ This standard view has been challenged by Kloekhorst (2004, 2006, 2008:75–76) and Simon (2010, 2013), who argue that word-initial *<(V)VC>* spellings may be the orthographic representation of a glottal stop plus vowel sequence ([#ʔé:-]). This alternative position has been refuted by Melchert (2010), Weeden (2011:62–68), and Yates (2016a:247–249).

⁴⁶ Melchert (to appear a) now rejects the evidence for “limited Čop’s Law” (Melchert 1994:65), which would specifically affect word-initial *#*čC* (> PA *#*čCC*) and thus entail the loss of **h₁* / *#_V* in PA.

⁴⁷ On (45a), see Melchert (1994:163), and on (45b), see Kloekhorst (2008:468–469). See Byrd (2015:100–102) on the non-deletion of PIE **h₁* / *n_C*.

⁴⁸ The verbal stem in (46c) is directly attested only in the imperative at KBo 3.40+ rev. 13, 14, 15 (for its identification, see Watkins *apud* Melchert 1983:14 n. 30), but is also clearly the base of the verbal noun *tiyamar/n-* (Eichner 1974:57). The verbal stem has exact equations in the Nuclear Indo-European (NIE) languages (Vedic *dyāti*, Old Avestan (*ni*.)*diiāṭam*, Ancient Greek *dēō*), all of which are derived by *LIV*²: 102 from a **-ye/o-*-present PIE **dh₁-ye/o-*.

fail to undergo the broader, Hittite-internal assibilation of coronal stops before [+high, +front] segments (i.e., *i*, *y*) — which accounts, for example, for the difference between the 3SG.NPST.ACT endings Hitt. *–z(i)* and CLuw. *–(t)ti*, Palaic *–(t)ti* — can be explained only under the assumption that **h₁* was still present when the environment for assibilation was subsequently extended in this way.⁴⁹

Still more evidence for situating the loss of **h₁* within the individual Anatolian languages is provided by the development of **h₁* in intervocalic position — specifically, between Pre-Hittite **e* and **a* (< PIE **o*, **a*; conditioned **e*). The Hittite reflex of **h₁* in this context is the glide *y* — in all likelihood, an epenthetic consonant inserted to fill the vowel hiatus left by the loss of **h₁* — as can be observed in (47a–b).⁵⁰ What is relevant here is that the outcome of **h₁* differs from that of PIE/PA **y* in the same context, which was lost with resulting contraction of **e* and **a* to Hitt. *a*, as in (47c–d).⁵¹ The fact that these two sound changes do not interact has direct implications for their relative chronology: if **h₁*-loss (and **y*-insertion) had preceded intervocalic **y*-loss and vowel contraction, one would expect that both **eh₁o* and **eyo* would yield Hitt. *a* (i.e. a diachronic feeding interaction), which is demonstrably not the case, as (47) shows.

- (47) Hittite outcomes of PIE **eh₁o* vs. **eyo*
- | | | | | | |
|----|---------------------------------|---|-----------------------|------------------------|---------------------------------|
| a. | PIE <i>*méh₁-on-</i> | > | Hitt. <i>meyan-</i> | ‘course (of the year)’ | (not ^x <i>mān-</i>) |
| b. | PIE <i>*tyéh₁-or</i> | > | Hitt. <i>zēya</i> | ‘gets cooked’ | (not ^x <i>zā</i>) |
| c. | PIE <i>*wos-éyo-nti</i> | > | Hitt. <i>waššanzi</i> | ‘they clothe’ | |
| d. | PIE <i>*louk-éyo-nti</i> | > | Hitt. <i>lukkanzi</i> | ‘they set fire to’ | |

To correctly derive the differing outcomes in (47a–b) and (47c–d), it is necessary instead to assume that **h₁*-loss occurred only after **y*-loss and vowel contraction, at which stage the regular synchronic repair for *e* and *a* in hiatus was glide insertion (rather than contraction). This relative chronology is significant, since there is general agreement that the loss of intervocalic **y* is a post-PA change, occurring in Hittite but not in Luwian (Melchert 1994:130, 260). In other words, intervocalic **y*-loss — and the vowel contractions that result from it — are changes dateable to the prehistory of Hittite. It follows, then, that the loss of intervocalic **h₁* — which must post-date these changes — is also an inner-Hittite change.

5.3.2 Interpretation

There is thus convergent evidence from three separate phonological processes that **h₁* was preserved in certain environments into the individual Anatolian languages. Specifically, we have presented evidence of late **h₁*-retention in three distinct contexts: **C_V* for assibilation; **C_C* for nasal-sibilant assimilation; and **V_V* for vowel contraction/glide insertion. It is true that word-initial pre-vocalic position (*#_V*), the environment of interest to the question at hand, is not among these. Nevertheless, our understanding of the typology of positional licensing of consonantal contrasts (cf. Steriade 1999) strongly suggests that we would

⁴⁹ While non-assibilation in (46d) is arguably due to analogy with the strong stem (3SG *dāi* ‘places’ < PIE/PA **d^(h)óh₁y-ei*; cf. n. 21 above), such an explanation is hardly plausible for (46c) (*pace* Covini 2018:36 n. 44). Even if Jasanoff (2003:105–107) is correct that Hitt. *tiye/a-* ‘bind’ and its exact NIE cognates (see n. 48 above) ultimately reflect the weak stem of a prehistoric ablauting *i*-present (rather than simply a **-ye/o-* present per *LIV*²: 102), it is far more likely that this stem existed as such in PIE (i.e., **dh₁yé/o-* ‘bind’) than (i) that it was innovated separately in both the ancestor of the non-Anatolian IE languages and Anatolian and (ii) that the strong stem survived just long enough in Hittite to spread its unassibilated stop to the weak stem before itself being leveled out of the paradigm (contrary to the general tendency in the language for the third plural to serve as the basis for analogy, moreover).

⁵⁰ See Rieken (2001) on (47a) and Kloekhorst (2008:1033–1034) on (47b). As mentioned, it is likely that the glide is a historically epenthetic hiatus-filling consonant that arose upon the loss of **h₁*. This glide is not consistently represented orthographically, but is indeed present in the only Old Script attestations of (47a–b): <*mi-e-ya-ni*> (KUB 4.72 rev. 2); <*ze-e-ya*> (KBo 17.36 ii 11).

⁵¹ See Eichner (1969) on (47c) and Watkins (1971:68–69) on (47d); per Melchert (1994:150–152), the geminate *–šš-* in (47c) is analogical after intransitive *wešš-* ‘wear’. The development of PIE **eyo* > Hitt. *a* is disputed by Kloekhorst (2008:532, 542, 657), principally on the basis of *pitteyant-* ‘fugitive’, which he takes to reflect PIE **pth₁-ey-ent-* (via Pre-Hittite **-ey-ant-*). However, the form is clearly a lexicalized participle, and thus better derived from **pteh₁y-ont-* (following Melchert 2015).

be justified in inferring its retention there as well. Specifically, pre-vocalic positions are normally better than pre-consonantal ones for the maintenance of consonantal contrasts (both the contrasts between distinct consonants, and the contrast between consonants and their absence), because the minimal constriction and high amplitude of the following vowel supports more — and more robust — acoustic cues which are relevant for the accurate perception of such contrasts.⁵² Since there is evidence that **h₁* was retained in at least one pre-consonantal context (between a nasal and a sibilant),⁵³ it is highly likely on phonetic grounds that **h₁* was retained in word-initial pre-vocalic position as well.

We therefore take the forms in (45–47) as evidence that word-initial **h₁* was still present in Pre-Hittite; this necessarily entails that word-initial **h₁* was also still present in PA. It is thus also plausible to assume that historically **h₁*-initial roots became (underlyingly) vowel-initial roots only after the language-specific changes affecting reduplication in Hittite and Luwian (specifically, the demotion of *PCR). After the loss of **h₁* within these languages, the relevant roots were subject to reduplication in accordance with the new synchronic grammar, which yielded the innovative VC-VCX- pattern.


6 Synchronic Analysis of Proto-Anatolian

Having established the reconstruction of the reduplicative patterns of PA in Section 5, we now proceed to their analysis, which can be handled quite quickly. The logic of the system can be summarized as follows: reduplicate with C₁V- (ALIGN-ROOT-L ≫ CONTIGUITY-BR, MAX-BR; as demonstrated by (50) below, with MAX-BR omitted for space), unless doing so would yield a *PCR violation, in which case, reduplicate the full cluster STV- (ANCHOR-L-BR, *PCR ≫ ALIGN-ROOT-L; as demonstrated by (49) below).

The most notable difference between this system and those of Hittite and Luwian is the high-ranked *PCR constraint. This constraint blocks the default C₁-copying candidate (49b) for STVX- bases. Under the ranking ANCHOR-L-BR ≫ ALIGN-ROOT-L, mis-anchoring as in (49c) is worse than copying the entire cluster, so (49a) is selected as optimal. When C₁-copying would not lead to a *PCR violation, as in (50) for TRVX- bases, the ranking ALIGN-ROOT-L ≫ CONTIGUITY-BR allows for the C₁-copying pattern to win out, selecting candidate (50b).

(48) **PA Ranking:** ANCHOR-L-BR, *PCR ≫ ALIGN-ROOT-L ≫ CONTIGUITY-BR, MAX-BR

(49) PA **STVX-* → **STV-STVX-* (PA **stu-* → **stu-stu-* > Hitt. *išdušdu-*, CLuw. *dušdu-*)

/RED, STVX-/	ANCHOR-L-BR	*PCR	ALIGN-ROOT-L	CONTIG-BR
a.  <u>STV-STVX-</u> (<i>stu-stu-</i>)			***	
b. <u>SV-STVX-</u> (<i>su-stu-</i>)		*!	**	*
c. <u>TV-STVX-</u> (<i>tu-stu-</i>)	*!		**	

⁵² Consult Wright (2004) for a concise overview of acoustic cues. (On phonetics generally, see Ladefoged and Maddieson 1996, Ladefoged 2001.) For the role of cues and contrast in phonology, see (among many others) Flemming (1995/2002), Steriade (1999), and the contributions in Hayes et al. (2004).

⁵³ More precisely, there is evidence that the contrast between **h₁* and other consonants and/or Ø was retained in this context.

(50) PA **TRVX-* → **TV-TRVX-* (e.g. PA **brV-* → **bV-brV-* > Luw. *pa-pra-*)

/RED, TRVX-/	ANCHOR-L-BR	*PCR	ALIGN-ROOT-L	CONTIG-BR
a. <u>TRV</u> -TRVX- (<i>pra-pra-</i>)			***!	
b. <u>TV</u> -TRVX- (<i>pa-pra-</i>)			**	*
c. <u>RV</u> -TRVX- (<i>ra-pra-</i>)	*!		**	

7 Constraint Re-ranking and the Demise of *PCR in Anatolian

The attested Anatolian languages show different reduplicative patterns — and thus independent constraint re-ranking — with respect to Proto-Anatolian. Generating the set of changes that characterize the attested languages (as summarized in (43) above) requires the separate re-ranking of just three constraints — *PCR, ALIGN-ROOT-L, and CONTIGUITY-BR — in Hittite and Luwian, as outlined in (51).

(51) Constraint rankings in Anatolian

PA	*PCR	≫	ALIGN-ROOT-L	≫	CONTIG-BR
Luwian	ALIGN-ROOT-L	≫	CONTIG-BR	≫	*PCR
Hittite	CONTIG-BR	≫	ALIGN-ROOT-L	≫	*PCR

The set of diachronic developments can mainly be characterized by two changes in rankings. First, Hittite shows a reversal of CONTIG-BR and ALIGN-ROOT-L; this is responsible for generating cluster-copying as the default pattern for *all* cluster-initial roots — i.e., the development of the TRV-TRVX- pattern alongside the inherited STV-STVX- pattern. Second, *PCR is demoted to the bottom of the ranking in Hittite and in Luwian, rendering it inactive in both languages' grammars; this is what allowed for the emergence of the VC-VCX- pattern. This second piece raises an important question: *why* does *PCR cease to be operative between Proto-Anatolian and the Anatolian daughter languages?

The development of the VC-VCX- pattern for (synchronically) vowel-initial roots (< **h₁eC-*) demonstrates the demotion of *PCR in the Hittite and Luwian grammars, but (we argue) it is an effect rather than a cause of these changes in ranking. We propose that the demotion of *PCR can be attributed to the nature of the learning input and the learning process following the Hittite- and Luwian-internal phonological changes affecting the TRVX- and STVX- bases in reduplication that were discussed already in Sections 5.1 and 5.2 in relation to the reconstruction of PA. After the post-PA loss of (pre-vocalic word-initial) **h₁*, which was motivated in Section 5.3, the innovative grammar arrived that learners arrived at because of the new learning conditions would have productively generated the VC-VCX- reduplication pattern for newly vowel-initial roots.

The remainder of this section details the proposed stages of development and changes that take Proto-Anatolian into Hittite and Luwian, respectively. To properly derive the various changes in ranking — specifically, those relating to *PCR — we propose a slight revision to the Recursive Constraint Demotion learning algorithm (see Section 7.2 below), termed here *Maximally Informative Recursive Constraint Demotion* (MIRCD), which provides a principled means for demoting *PCR even in the absence of direct evidence for its violation.

7.1 The Relative Chronology of Constraint Re-Rankings into Hittite

The crucial innovation for the development of Hittite was the change in TRVX– bases from the inherited C₁-copying pattern (PA *TV-TRVX–) to full cluster-copying reduplication (Hittite TRV-TRVX–). In terms of the ranking of the constraints, the adoption of this pattern amounts to the promotion of CONTIGUITY-BR over ALIGN-ROOT-L. This change is represented in the transition between the stage in (52) below and the stage in (53) below. (The **X** symbol indicates a diachronically prior stage’s winner that now loses under the new constraint ranking.)

(52) Proto-Anatolian

/RED, prai-/	ALIGN-ROOT-L	CONTIG-BR
a. <u>pri</u> -prai-	***!	
b. ☞ <u>pi</u> -prai-	**	*

⇓ Re-rank ALIGN-ROOT-L & CONTIG-BR ⇓

(53) Pre-Hittite I

/RED, prai-/	CONTIG-BR	ALIGN-ROOT-L
a. ☞ <u>pri</u> -prai-		***
b. X <u>pi</u> -prai-	*!	**

Is there any rationale for this change? Despite its prevalence within Indo-European, the C₁-copying pattern is cross-linguistically rare, with direct parallels (perhaps only) in Klamath (Barker 1964; see Steriade 1988, Fleischhacker 2005, Zukoff 2017a: Ch. 6) and possibly (in a much more restricted fashion) some dialects of Gbe/Ewe (Capo 1989, Ameka 1991).⁵⁴ This apparent typological asymmetry might reflect a bias towards contiguous copying — i.e., a bias towards the high ranking of CONTIGUITY-BR. From a learning perspective, one might view it through the lens of a general learning bias in favor of Output-Output faithfulness constraints (McCarthy 1998, Hayes 2004:188), as Base-Reduplicant correspondence could well be subsumed under the broader category of Output-Output correspondence.⁵⁵

Whatever its motivation, the change from TV-TRVX– to TRV-TRVX– — i.e., the change from the PA grammar in (52)/(54) to the Pre-Hittite grammar in (53)/(55) — had significant implications for speakers’ analysis of the pattern for STVX– bases, although not for the surface properties of the pattern itself. At the stage in (55) (“Pre-Hittite I”), the losing C₁-copying candidate (b) violates both CONTIGUITY-BR and *PCR. But unlike *PCR, CONTIGUITY-BR is independently necessary to account for TRV-TRVX– reduplication. In the absence of unambiguous evidence for the activity of *PCR, Hittite learners converged on a simpler analysis: the STV-STVX– pattern was reanalyzed as being driven by CONTIGUITY-BR, while *PCR — with no forms requiring its activity — was demoted to the bottom of the grammar, resulting in the stage in (56) (“Pre-Hittite II”). It is crucial that this process results in the total demotion of *PCR, all the way below ALIGN-ROOT-L, in order to derive the behavior of VCX– bases at the following stage.⁵⁶

⁵⁴ It should be noted, however, that having the combination of conditions under which this pattern could be observed is itself cross-linguistically rare.

⁵⁵ See Zukoff (2017a:109–110) for brief consideration of some potential alternative explanations.

⁵⁶ On the nature of this ranking change, see the discussion in Section 7.2 below.

(54) Proto-Anatolian

/RED, stu-/	*PCR	ALIGN-ROOT-L	CONTIG-BR
a. stu-stu-		***	
b. su-stu-	*!	**	*

⇓ Re-rank ALIGN-ROOT-L & CONTIG-BR (cf. (52) > (53)) ⇓

(55) Pre-Hittite I

/RED, stu-/	*PCR	CONTIG-BR	ALIGN-ROOT-L
a. stu-stu-			***
b. su-stu-	*!(?)	*!(?)	**

⇓ Demote *PCR ⇓

(56) Pre-Hittite II

/RED, stu-/	CONTIG-BR	ALIGN-ROOT-L	*PCR
a. $(i)\text{stu-stu-}$		***	
b. su-stu-	*!	**	*

Provided that the innovations in (55) and (56) chronologically *precede* the loss of $*h_1$ (a plausible assumption based on the discussion in Section 5.3 above), the new grammar generates $\underline{VC-VCX-}$ reduplication straightforwardly, as shown in (58). Note again that *PCR must be demoted not just below CONTIG-BR but also below ALIGN-ROOT-L in order to generate the $\underline{VC-VCX-}$ pattern.

(57) PIE/Proto-Anatolian

/RED, h_1Vrgh- /	*PCR	ALIGN-ROOT-L	CONTIG-BR
a. h_1V-h_1Vrgh-		**	
b. h_1Vr-h_1Vrgh-		***!	

⇓ ... ⇓

(58) Pre-Hittite III (= Hittite)

/RED, ark-/	CONTIG-BR	ALIGN-ROOT-L	*PCR
a. ar-ark-		**	*
b. ark-ark-		***!	
c. ak-ark-	*!	**	

Prior to the changes between Proto-Anatolian and “Pre-Hittite III”, $*h_1VC-$ roots would have reduplicated like ordinary $CVX-$ roots, as shown in (57). (A PIE/PA form like $*h_1V-h_1Vrgh-$ would have yielded something like Hittite $^x\text{ark-}$, which is clearly not the attested form.) However, after (i) the constraint re-ranking motivated by the changes for cluster-initial bases and (ii) the loss of $*h_1$, these newly vowel-initial roots in Hittite are correctly predicted to show $\underline{VC-VCX-}$ reduplication, i.e. (58). A summary of the proposed changes from Proto-Anatolian to Hittite and their relative chronology is given in (59).

(59) Hittite relative chronology

Stage	Ranking
(I) Proto-Anatolian	*PCR \gg ALIGN-ROOT-L \gg CONTIG-BR
	<ul style="list-style-type: none"> • <i>TRVX– roots: C₁-copying pattern changes to cluster-copying pattern</i> • <i>Indeterminacy about ranking of *PCR vis-à-vis STVX– roots</i>
(II) Pre-Hittite I	*PCR ?? CONTIG-BR \gg ALIGN-ROOT-L
	<ul style="list-style-type: none"> • <i>*PCR is unnecessary to account for STVX– roots, so it is demoted</i>
(III) Pre-Hittite II	CONTIG-BR \gg ALIGN-ROOT-L \gg *PCR
	<ul style="list-style-type: none"> • <i>*h₁ deletes /#_V</i> • <i>Newly vowel-initial roots fed into grammar, generate <u>VC-VCX–</u> pattern</i>
(IV) Pre-Hittite III / Hittite	CONTIG-BR \gg ALIGN-ROOT-L \gg *PCR

7.2 Maximally Informative Recursive Constraint Demotion (MIRCD)

To generate the full set of changes posited between Proto-Anatolian and Hittite, it is necessary for *PCR to go from the top-ranked constraint (among the three under discussion) in PA to the bottom-ranked constraint in Hittite, despite there being a period during which *PCR remained a surface true constraint (at least within the domain of reduplication). Notably, this scenario would seem to constitute a counter-example to the “subset principle” (cf. Prince and Tesar 2004 and references therein).

The subset principle states that, when learners are choosing between multiple possible grammars consistent with the positive evidence, they ought to select the grammar that is most restrictive (i.e., allows the fewest possible unseen forms), because doing otherwise has the potential to overgenerate relative to the target language and make it impossible to later arrive at the more restrictive target language. In phonology, this reduces mainly to a preference for the higher ranking of markedness constraints than faithfulness constraints, as implemented in, for example, Biased Constraint Demotion (BCD; Prince and Tesar 2004) and Low Faithfulness Constraint Demotion (LFCD; Hayes 2004). It is standardly assumed that it is a desideratum of a phonological learning procedure for it to capture the subset principle. Capturing the subset principle is thus taken as one of the key arguments in favor of BCD and LFCD over simple Recursive Constraint Demotion (RCD; Tesar 1995, Tesar and Smolensky 1998, 2000).

However, if the current question regarding the diachronic development of *PCR within Anatolian has been correctly framed here, then it constitutes a case in which learners have failed to learn the subset language, as a superset language emerges in a diachronically subsequent stage. That is to say, despite having no positive evidence that *PCR was violable in their language, (Pre-)Hittite learners acquired a grammar that tolerated the emergence of a pattern (viz., the VC-VCX– pattern) that violated *PCR, rather than the more restrictive grammar (appropriate to a prior stage) that would have outlawed forms of this type. Therefore, resolute adherence to the subset principle would in fact *not* be consistent with the empirically available data. What is needed, rather, is a learning procedure that — under the right circumstances — is capable of learning a grammar other than the most restrictive one. Accordingly, we propose below a modification to the RCD algorithm (which can be made consistent with BCD as well) that is capable of accounting for the *PCR problem in Anatolian without completely undermining the restrictiveness of the approach.

The logic of the argument presented here is that *PCR *lost its explanatory power* in the development of Hittite with the advent of the *TRV-TRVX-* pattern, and that this lack of explanatory power is ultimately responsible for its complete demotion. As alluded to above, this type of logic is not consistent with most established procedures for phonological learning. With no evidence for the violation of *PCR, RCD — which is concerned only with whether or not a constraint prefers a losing candidate (henceforth, *loser*) to the winning candidate (henceforth, *winner*) — would install this constraint in the top stratum of the ranking, not the bottom one. This holds all the more for BCD and LFCD, where the fact that *PCR is a markedness constraint would further bias it towards high ranking.⁵⁷ Nor will this work in standard error-driven weighted constraint learning models like the Gradual Learning Algorithm (GLA; Boersma 1997, Magri 2012), because weight accrued by erroneously picking a **SV-STVX-* output will be assigned to both *PCR and CONTIGUITY-BR.⁵⁸ While we will entertain an alternative solution in Section 7.6 below based on inherent bias for Base-Reduplicant faithfulness constraints (in the mode of BCD), we believe that the most successful solution is the following.

We propose here that a slight adjustment to the Recursive Constraint Demotion algorithm can capture the logic of the problem and properly derive the ranking issues. What is needed is a procedure that prefers to install constraints with greater explanatory power. Namely, rather than RCD installing *all* constraints that prefer no losers (or even only winners) among the current *Winner~Loser* pairs which have not yet received a **W** from an installed constraint (the “support”), RCD installs only the constraint or constraints which prefer *the most* winners.⁵⁹ Such a system can be described as aiming to explain observed *Winner~Loser* pairs using the fewest constraints possible.⁶⁰

The standard formulation of the RCD algorithm collects all constraints that prefer no losers among the current support — i.e., those constraints which have only **W**'s and/or **e**'s in their column — and installs them (recursively) in the highest stratum.⁶¹ The way that Becker (2009:164) formalizes the algorithm, which is reproduced in (60) below, is very slightly different, but in an interesting way (though this divergence is made without comment, as far as we can tell). Rather than selecting all the constraints that prefer no losers, this formulation selects only those constraints which prefer at least one winner and no losers (60a). For the *PCR ranking problem in Pre-Hittite currently under discussion, either version would result in *PCR being placed in the top stratum, because it prefers no losers and one winner (see (62) below).⁶² Since the goal is to generate a ranking where *PCR is at the bottom, this approach is not going to be sufficient.

The relative difference between the Becker approach and the standard approach hints at a solution to the problem. Our proposal — which we term Maximally Informative Recursive Constraint Demotion (MIRCD), formalized in (61) below — is that only the *maximally informative* winner-preferring constraints are installed in the highest stratum. We formalize this by introducing a new category into the RCD algorithm, the *maximally-informative-winners* (61b). This selects from among the winner-preferring constraints (or indeed the non-loser-preferring constraints) the one or more constraints which prefer the most winners. These constraints are maximally informative in the sense that their installation will explain the greatest

⁵⁷ Note, however, that, under the cue-based version of *PCR that is developed and advocated for by Zukoff (2017a: Ch. 6), it is less clear that *PCR should be thought of as a normal markedness constraint.

⁵⁸ There is some indication that, using the GLA, assigning *PCR a sufficiently lower initial weight than all the other constraints involved could generate the result, but we can see no reason for making such an assumption.

⁵⁹ Consult Prince (2002) on the comparative tableau format and the use of **W**, **L**, and **e**.

⁶⁰ Hayes's (2004) “Favour Autonomy” preference in LFCD — which prefers the installation of constraints that account for the most data that no other remaining constraints could also account for — is a principle of much the same sort, although applying with a somewhat different priority and scope than what is needed for the present case. Hayes's “Favour Activeness” preference — which favors the installation of constraints whose column contains at least one **W** but no **L**'s (given the current support) to constraints whose column has only **e**'s — also bears some similarity.

⁶¹ See Tesar (1995) for the original formulation of and argument for RCD. See also Hayes (2004:169 ex. 2) for a description of the algorithm in plainer English.

⁶² However, only Becker's version would be able to account for the Pre-Luwian situation without adjustment; see Section 7.5 below.

(60) RCD Algorithm (Becker 2009:164)

Given a Support S ,

Given a set of constraints in S , *not-yet-ranked constraints*,

$H :=$ a new constraint hierarchy.

While S is not empty, repeat:

- a. *current-stratum* := all the constraints in *not-yet-ranked constraints* that have at least one W and no L's in their column in S
- b. If *current-stratum* $\neq \emptyset$,
 - i. remove winner-loser pairs that are assigned a W by any constraint in *current-stratum*.
 - ii. put *current-stratum* as the next stratum in H , and
 - iii. remove *current-stratum* from *not-yet-ranked constraints*

Put *not-yet-ranked constraints* as the next stratum in H .

Return H .

number of data points, i.e. *Winner~Loser* pairs. It is then the *maximally-informative-winners* which are the set of constraints that get installed (61c), rather than the entire “*current-stratum*” as in the standard algorithm.

(61) Maximally Informative Recursive Constraint Demotion (MIRCD)

Given a Support S ,

Given a set of constraints in S , *not-yet-ranked constraints*,

$H :=$ a new constraint hierarchy.

While S is not empty, repeat:

- a. *current-stratum* := all the constraints in *not-yet-ranked constraints* that have (at least one W and) no L's in their column in S
- b. ***maximally-informative-winners* := all the constraints in *current-stratum* for which no other constraint in *current-stratum* has more W's in their column in S**
- c. If *maximally-informative-winners* $\neq \emptyset$,
 - i. remove winner-loser pairs that are assigned a W by any constraint in *maximally-informative-winners*.
 - ii. put *maximally-informative-winners* as the next stratum in H , and
 - iii. remove *maximally-informative-winners* from *current stratum*
 - iv. return *current stratum* to *not-yet-ranked constraints*

Put *not-yet-ranked constraints* as the next stratum in H .

Return H .

This proposed change will only be compatible with Biased Constraint Demotion if the “biased” part of BCD — viz., the preferential installation of Markedness constraints before Faithfulness constraints — takes the *maximally-informative-winners* as its input, not if the *maximally-informative-winners* are chosen from among the markedness-biased set of constraints in the *current-stratum*. This is because *PCR is a markedness constraint while CONTIGUITY-BR is a faithfulness constraint,⁶³ yet in the present case it is necessary that some aspect of the system prefer CONTIGUITY-BR over *PCR. Therefore, the preference

⁶³ Although see the discussion in Section 7.6 below regarding these assumptions.

for markedness over faithfulness must be located after the step in (61b), not the step in (61a). Nevertheless, this shows that the adoption of MIRCD is not wholly incompatible with the mechanisms that advocate for the subset grammar, only that it overrides this mechanism in one particular case — namely, when multiple winner-preferring constraints differ in their explanatory power. Further consideration of exactly how this impacts views of the subset principle in phonological learning and what other empirical facts bear on this question is an important direction for future research.

7.3 From Proto-Anatolian to Hittite

With the MIRCD algorithm in place, it is now possible to demonstrate how this proposal actually derives the proper result for *PCR in Pre-Hittite. The violation profile in (62) shows two candidate comparisons for the two cluster-initial base types at the stage following the change from C₁-copying to cluster-copying in TRVX- bases — i.e., “Pre-Hittite I” from Section 7.1 above. The comparisons are (i) between the winning cluster-copying candidate and the losing C₁-copying candidate, and (ii) between the winning cluster-copying candidate and the losing “over-copying” candidate.

It will be helpful to consider the relationship between ALIGN-ROOT-L (abbreviated ALIGN) and MAX-BR (abbreviated MAX), so these derivations will assume that the base has additional copyable material after the first base vowel — i.e., specifically CCVCV- rather than just CCVX-. The “over-copying” candidate is the one that has copied the second syllable, and thus incurs extra violations of ALIGN-ROOT-L relative to the winning cluster-copying candidate. In addition to ALIGN-ROOT-L and MAX-BR, the violation profile in (62) and the tableaux that follow include the violation profile of these *Winner~Loser* pairs with respect to *PCR and CONTIGUITY-BR (abbreviated CONTIG).

(62) MIRCD for Pre-Hittite I: Initial Support

	*PCR	CONTIG	ALIGN	MAX
i. TRVCV- → TRV-TRVCV- > TV-TRVCV-	e	W	L	W
ii. TRVCV- → TRV-TRVCV- > TRVCV-TRVCV-	e	e	W	L
i. STVCV- → STV-STVCV- > SV-STVCV-	W	W	L	W
ii. STVCV- → STV-STVCV- > STVCV-STVCV-	e	e	W	L

With traditional RCD, both *PCR and CONTIG would be installed in the first stratum, as both of them prefer no losers, and indeed both prefer at least one winner (i.e., their columns have only **W**'s and **e**'s). This is not what we want, since this ranking would not be consistent with the *VR-VRT-* pattern. However, if we employ the MIRCD update, which installs only the *maximally-informative-winners*, we achieve a different result, namely, the one we are looking for. While *PCR has one **W** in its column, CONTIG has two. This means that only CONTIG belongs to the *maximally-informative-winners* set, and it alone gets installed. This is shown in (63).

(63) MIRCD (round 1) for Pre-Hittite I: Install *maximally-informative-winners*, i.e. CONTIG

	CONTIG	*PCR	ALIGN	MAX
i. TRVCV- → TRV-TRVCV- > TV-TRVCV-	W	e	L	W
ii. TRVCV- → TRV-TRVCV- > TRVCV-TRVCV-	e	e	W	L
i. STVCV- → STV-STVCV- > SV-STVCV-	W	W	L	W
ii. STVCV- → STV-STVCV- > STVCV-STVCV-	e	e	W	L

The gray rows in (63) indicate the *Winner~Loser* pairs which are removed from the support by the installation of CONTIG. Crucially, the single *Winner~Loser* pair which provides *PCR with its **W** (STV-STVCV- \succ SV-STVCV-) is among those removed from the support. This means that, in subsequent iterations of the algorithm, *PCR will *never* get installed in a stratum above another constraint, since it will never again be a constraint that actively prefers a winner — even though, of course, it prefers no losers. Put another way, installing CONTIG first has entirely robbed *PCR of its *informativity*: all remaining *Winner~Loser* pairs in the support fare equally well on *PCR.

Among the remaining *Winner~Loser* pairs, ALIGN is now a winner-preferring constraint. Since it is in fact the only winner-preferring constraint, it is identified as a member of the *maximally-informative-winners* set, and gets installed, as shown in (64) below. Installing ALIGN takes care of the remaining support, and thus MIRCD completes without having installed *PCR (or MAX) in an upper stratum. *PCR is ranked at the very bottom of the grammar, which is precisely the desired result; the ranking in (64) is exactly the one required in order to generate the VR-VRT- pattern at the subsequent stages.

(64) MIRCD (round 2) for Pre-Hittite I: Install *maximally-informative-winners*, i.e. ALIGN

	CONTIG	ALIGN	*PCR	MAX
i. TRVCV- \rightarrow TRV-TRVCV- \succ TV-TRVCV-	W	L	e	W
ii. TRVCV- \rightarrow TRV-TRVCV- \succ TRVCV-TRVCV-	e	W	e	L
i. STVCV- \rightarrow STV-STVCV- \succ SV-STVCV-	W	L	W	W
ii. STVCV- \rightarrow STV-STVCV- \succ STVCV-STVCV-	e	W	e	L

To summarize, the MIRCD update of RCD has a property that we call “informativity-based constraint bounding.” If a constraint \mathbb{C}_1 is informative (i.e., winner-preferring) about some non-zero set of *Winner~Loser* pairs, and another constraint \mathbb{C}_2 is informative about a proper *superset* of those *Winner~Loser* pairs (i.e., all the *Winner~Loser* pairs about which \mathbb{C}_1 is informative, and one or more additional *Winner~Loser* pairs), \mathbb{C}_1 will always be installed in the very lowest stratum of the ranking. This is because the preference for installing *maximally-informative-winners* will always install \mathbb{C}_2 first, which will remove all **W**’s from \mathbb{C}_1 ’s support.⁶⁴

7.4 (M)RCD in Proto-Anatolian

When the situation of informativity-based constraint bounding is not present in the support, MIRCD appears to be functionally equivalent to standard RCD. We briefly illustrate this point using the case of Proto-Anatolian. At this stage, where TRVX- bases show \mathbb{C}_1 -copying but STVX- bases show cluster-copying, *PCR and CONTIGUITY-BR do not have the same scope, as can be seen in (65). CONTIGUITY-BR is now not a uniquely winner-preferring constraint, because it is violated by the winning \mathbb{C}_1 -copying candidate for TRVX- bases. This lets *PCR, with its one **W** and no **L**’s, be installed on the first round, since there is no other winner-preferrer with more **W**’s (in fact, there are no other uniquely winner-preferring constraints in the initial support). This is reflected in (66). Lastly, ALIGN takes care of the remaining support. MIRCD thus completes — as shown in (67) — properly yielding the necessary PA constraint ranking which was established in Section 6.

⁶⁴ It might be the case that \mathbb{C}_1 could avoid this fate if there were another constraint \mathbb{C}_3 which (i) is a uniquely winner-preferring constraint, (ii) has **W**’s in all *Winner~Loser* pairs for which \mathbb{C}_2 has a **W** but \mathbb{C}_1 does not, and (iii) has a greater overall number of **W**’s than \mathbb{C}_2 . Such a \mathbb{C}_3 would be installed before \mathbb{C}_2 and remove the support which differentiates \mathbb{C}_2 from \mathbb{C}_1 . Whether this or other formal properties of the proposal advanced here have any significant ramifications we leave as a question for future inquiry.

(65) MIRCD for Proto-Anatolian: Initial Support

	*PCR	CONTIG	ALIGN	MAX
i. TRVCV- → TV-TRVCV- > TRV-TRVCV-	e	L	W	L
ii. TRVCV- → TV-TRVCV- > TRVCV-TRVCV-	e	L	W	L
i. STVCV- → STV-STVCV- > SV-STVCV-	W	W	L	W
ii. STVCV- → STV-STVCV- > STVCV-STVCV-	e	e	W	L

(66) MIRCD (round 1) for Proto-Anatolian: Install *maximally-informative-winners*, i.e. *PCR

	*PCR	CONTIG	ALIGN	MAX
i. TRVCV- → TV-TRVCV- > TRV-TRVCV-	e	L	W	L
ii. TRVCV- → TV-TRVCV- > TRVCV-TRVCV-	e	L	W	L
i. STVCV- → STV-STVCV- > SV-STVCV-	W	W	L	W
ii. STVCV- → STV-STVCV- > STVCV-STVCV-	e	e	W	L

(67) MIRCD (round 2) for Proto-Anatolian: Install *maximally-informative-winners*, i.e. ALIGN

	*PCR	ALIGN	CONTIG	MAX
i. TRVCV- → TV-TRVCV- > TRV-TRVCV-	e	W	L	L
ii. TRVCV- → TV-TRVCV- > TRVCV-TRVCV-	e	W	L	L
i. STVCV- → STV-STVCV- > SV-STVCV-	W	L	W	W
ii. STVCV- → STV-STVCV- > STVCV-STVCV-	e	W	e	L

Notice that the invocation of *maximally-informative-winners* was never required for this data, as at each step of the process there was only ever one constraint that was uniquely winner-preferring. In at least cases of this sort, then, MIRCD and RCD are completely equivalent.

7.5 From Proto-Anatolian to Luwian

In the development from Proto-Anatolian into Hittite, the crucial means of demoting *PCR to the bottom of the grammar was getting the independently necessary high ranking of CONTIGUITY-BR to depress the ranking of *PCR via MIRCD. In other words, *PCR's status as a winner-preferring constraint was eliminated when the support that was explained by CONTIGUITY-BR was removed after CONTIGUITY-BR's installation. Similarly, in Luwian, the total demotion of *PCR can be explained in terms of the removal of support for *PCR; however, rather than being removed in the process of MIRCD, it is (at least in part) removed from the language via sound change.

As argued in Section 5.1 above, (Pre-)Luwian lost the synchronic contrast between roots of the shape /STVX/ and /TVX/ due to the operation of a categorical rule of /s/-deletion in inherited **#ST* clusters. Insofar as any remnants of the earlier treatment of **/STVX/* roots/bases remain in the language, they are treated as frozen archaisms, and perhaps not even analyzed synchronically as reduplicated. As a consequence, when (Pre-)Luwian learners were constructing their reduplicative grammar with respect to cluster-initial bases, the only data that they could have taken into account was the data for TRVX- bases, which still show C₁-copying.⁶⁵

⁶⁵ They would of course also be considering the behavior of CVX- bases, but these give no additional information beyond TRVX- bases: the only relevant *Winner~Loser* pair is the one which demonstrates the preference for not copying post-nuclear segments, a preference equally observable from TRVX- bases.

The initial support for (MI)RCD would therefore be equivalent to that of Proto-Anatolian (65) *but without any Winner~Loser pairs for STVX- bases*. This situation is reflected in (68) by the grayed out rows. Here it is now important whether basic RCD selects all non-loser-preferring constraints (the standard formulation) or just all winner-preferring constraints (Becker 2009's formulation). If we assume that it selects only those constraints that actively prefer winners, then nothing further needs to be said; it will uniquely select ALIGN for installation in the top stratum. High-ranked ALIGN explains the entirety of the support; so, under this approach, *PCR and the other constraints get installed in the bottom stratum, as shown in (69).

(68) MIRCD for Pre-Luwian: Initial Support

	*PCR	CONTIG	ALIGN	MAX
i. TRVCV- → TV-TRVCV- > TRV-TRVCV-	e	L	W	L
ii. TRVCV- → TV-TRVCV- > TRVCV-TRVCV-	e	L	W	L
i. STVCV- → STV-STVCV- > SV-STVCV-	W	W	L	W
ii. STVCV- → STV-STVCV- > STVCV-STVCV-	e	e	W	L

(69) MIRCD (round 1) for Pre-Luwian: Install ALIGN

	ALIGN	*PCR	CONTIG	MAX
i. TRVCV- → TV-TRVCV- > TRV-TRVCV-	W	e	L	L
ii. TRVCV- → TV-TRVCV- > TRVCV-TRVCV-	W	e	L	L

However, under the standard formulation of RCD, which installs all constraints which have no L's among the current support, ALIGN and *PCR would be treated equally on the first run. This would result in *PCR being installed in the top stratum, crucially ranked above CONTIG. This ranking is the opposite of the one required for Luwian (see Section 4), and cannot generate the *VR-VRT-* pattern. The apparent facts of (Pre-)Luwian are therefore *inconsistent* with the standard formulation of RCD, and so require some update to the algorithm that prefers the installation of winner-preferrers over constraints that have only e's. Becker's (2009) approach is one such solution; MIRCD is another. MIRCD is here equivalent to Becker's version of RCD, because they both have a mechanism for selecting a constraint with W's (or W's and e's) over a constraint with just e's. Insofar as MIRCD can be viewed as a ramped up version of Becker's RCD, Luwian therefore also provides evidence in favor of adjusting RCD in the direction of MIRCD.⁶⁶

MIRCD is thus consistent with the development of Luwian argued for above. A summary of the proposed changes from PA to Luwian and their relative chronology is given in (70).

⁶⁶ Note that the relative ranking of CONTIG and *PCR is under-determined based purely on applying either Becker's RCD or MIRCD to the data from TRVX- bases. In order to claim that anything more significant than chance was responsible for fixing the ranking as CONTIG ≫ *PCR, something further would need to be said.

(70) Luwian relative chronology

Stage	Ranking
(I) Proto-Anatolian	*PCR ≫ ALIGN-ROOT-L ≫ CONTIG-BR
	<ul style="list-style-type: none"> • Emergence of rule deleting *s in *#ST • Deletion rule becomes categorical, eliminating evidence for /s/ • */STVX/ roots are restructured as /TVX/
(II) Pre-Luwian I	*PCR ?? ALIGN-ROOT-L ≫ CONTIG-BR
	<ul style="list-style-type: none"> • No synchronic contrast in cluster-initial roots, thus no evidence for *PCR • *PCR is demoted to the bottom of the grammar
(III) Pre-Luwian II	ALIGN-ROOT-L ≫ CONTIG-BR ≫ *PCR
	<ul style="list-style-type: none"> • *h₁ deletes /#_V • Newly vowel-initial roots fed into grammar, generate <u>VC-VCX-</u> pattern
(IV) Pre-Luwian III / Luwian	ALIGN-ROOT-L ≫ CONTIG-BR ≫ *PCR

7.6 MIRCD or a Bias for BR-Faithfulness?

There is one way in which the demotion of *PCR might be generable without a change to the RCD algorithm *per se*, namely, by appealing to Biased Constraint Demotion, or some other learning procedure that can incorporate ranking bias by constraint type. As mentioned earlier, it is frequently assumed (McCarthy 1998, Hayes 2004) that learners have a bias towards the high ranking of Output-Output faithfulness constraints, over not only Input-Output faithfulness constraints, but also over markedness constraints. The two constraints whose relative ranking is at stake in the development from Proto-Anatolian to Hittite and Luwian, respectively, are *PCR and CONTIGUITY-BR. If CONTIGUITY-BR — and Base-Reduplicant faithfulness constraints generally — are to be classified as Output-Output faithfulness constraints for the purposes of learning biases, and *PCR is to be classified as a markedness constraint, then a learning procedure which implements the bias for Output-Output faithfulness constraints will install CONTIGUITY-BR before *PCR when they explain the same set of data. This is the ranking we are trying to derive in both cases. Therefore, if these assumptions hold, it would seem that we might not need to revise our learning procedures, and that this might not really represent a counter-example to the subset principle. However, there is (to our knowledge) little to no work on the question of whether Base-Reduplicant faithfulness constraints should truly be afforded the Output-Output faithfulness bias.

One possible reason to doubt this approach is the behavior of MAX-BR. MAX-BR plays no role in any of the Indo-European reduplicative systems (see Zukoff 2017a), and indeed is wantonly violated in all languages with partial reduplication patterns. If there were an underlying bias towards the high ranking of BR-faithfulness constraints, and MAX-BR is properly characterized as a member of that set, then one should perhaps expect partial reduplication (or at least the sort of minimal partial reduplication evident in Indo-European; see also Hendricks 1999 on other sorts of minimal reduplication patterns) to be much less frequent than it actually is.

Note, finally, that even if BCD is adopted, the Luwian facts still require Becker's version of the constraint selection step, i.e., preferentially selecting active winner-preferrers. If not, then *PCR would

incorrectly be selected in the first run. Given that the difference between the Becker update and MIRCD is fairly small, MIRCD may still be a reasonable proposal even if a ranking bias for BR-faithfulness constraints is justified.

7.7 Further Support for the Late Demotion of *PCR (in Hittite)

The diachronic account developed in the preceding sections argues that *PCR was demoted to the bottom of the rankings independently in Hittite and Luwian. Additional support for this notion comes from the existence of several consonant-initial *PCR-violating reduplicative forms that most likely have arisen within the internal (pre-)history of Hittite. These are given in (71) below.

- (71) Consonant-initial *PCR-violating forms in Hittite
 a. *titha* [títχa] ‘thunders’ (3SG.NPST.MID)
 b. *lilhuwai* [lílχ^wai] ‘pours’ (3SG.NPST.MID) (simplex *lah(h)u-* ‘pour’)

In the case of (71a), the base-initial cluster [tχ] that, when preceded by C_1V -copying, incurs a *PCR violation is demonstrably not reconstructible to PIE or likely even PA, since $*h_2$ was regularly lost in that environment: PIE $*Th_2V > PA *TV$, as evidenced by (e.g.) Hitt. *paltana-* ‘shoulder’ $< *p[th_2-eno-$.⁶⁷ As argued by Oettinger (1979:514) and Dempsey (2015:304–306), (71a) Hitt. *titha* is cognate with the Vedic Sanskrit root *tanⁱ-* ‘thunder’, both deriving from the PIE root $*(s)tenh_2-$. The Hittite form can thus be derived via the developments in (72).

- (72) Historical derivation of Hitt. *titha* ‘thunders’
 PIE/PA $*t\text{-}t\tilde{h}_2\text{-}o > \text{Pre-Hitt. } *i\acute{t}\alpha\chi\alpha > \text{Hitt. } titha$ [títχa]

This derivation explains the synchronically anomalous stem-final cluster $-th-$, which arises only after the PA stage at which $*h_2$ -deletion applied in the sequence $*Th_2V$. At that time, $*h_2$ was separated from the preceding stop by the syllabic nasal, which subsequently vocalized within Pre-Hittite (i.e., $*\eta > *a$).⁶⁸ Finally, the resulting vowel was subject to syncope, yielding the attested $-th-$ cluster.

The important question posed by this derivation is why syncope was allowed to create a new *PCR-violating sequence [títχ]: if *PCR had been active — as it was in PA (cf. Section 6 above) — when the new $*a$ -vowel was targeted by syncope, why was syncope not blocked by this highly ranked constraint? The proposed chronology of constraint re-ranking outlined in Section 7 above offers a simple solution to this question: *PCR did not block syncope because it had already been demoted within the internal development of Hittite.⁶⁹ At an early prehistoric stage (i.e., Pre-Hittite I; see (59) above) following the inner-Hittite vocalization of syllabic nasals, syncope may have been blocked by *PCR; but when *PCR was eventually demoted (Pre-Hittite II in (59) above), the blocking effect ceased to exist, and syncope occurred.⁷⁰

A similar set of developments may have led to the emergence of (71b) Hitt. *lilhuwai-* ($< \text{PIE } *leh_3\text{-}w-$). Reduplicative forms of (at least) the shape $*LV\text{-}LT-$ ($L = \text{liquid}$) are systematically unattested in the Indo-European languages (cf. Sandell 2014).⁷¹ For instance, there is no $*lel\acute{g}-$ (to the root of Latin *lēgō*, Tocharian

⁶⁷ See Melchert (1994:68–69), who tentatively situates this deletion in PA. If — as seems likely — the PIE 2PL.MID ending is properly reconstructed as $*-d^h h_2we-$ (see Lundquist and Yates 2018: §4.2.7), the deletion of $*h_2$ in both CLuw. $-d\acute{d}uwar(i)$ and Hitt. $-ttuma(ri)$ would all but confirm that $*h_2$ -loss in this environment had already occurred in PA.

⁶⁸ See Melchert (2012:181–182, to appear a) on the development of the syllabic nasals in Hittite and their post-PA vocalization.

⁶⁹ An alternative possibility (suggested by Ryan Sandell, personal communication) is that the application of syncope itself in Pre-Hittite opacified *PCR at this stage and contributed to its ultimate demotion. This possibility merits further investigation in conjunction with a broader study of the conditions for syncope in Hittite.

⁷⁰ It is possible, too, that nasal vocalization occurred only after Pre-Hittite I, in which case deletion may have applied immediately after vocalization.

⁷¹ Possible exceptions to this generalization are Old English dialectal forms like *leort-* $< *le\text{-}lt-$ (Jasanoff 2007); see Zukoff (2017a: Ch. 4).

B *lyāka*, etc.) although there are several morphological contexts (e.g., perfect weak stems) where this configuration theoretically could have arisen.⁷² If this gap is non-accidental and driven by (a version of) *PCR at the PIE level (cf. Zukoff 2017a: Ch. 6 & 7), then [lilχ^w-] could only have emerged within Hittite after the demotion of *PCR.⁷³ We suggest, then, that this form is the result of the same inner-Hittite syncope process that yielded Hitt. *tith-*. Potentially relevant here also is the hapax spelling <*li-la-ḫu-i*> (KUB 21.47 ii 13) — the oldest attested form of the verb (OH or MH/MS; cf. *CHD L-N*: 57) — which could directly reflect a pre-syncope stage (i.e., [lilayχ^wi]). If so, it would even support the possibility that the demotion of *PCR occurred within the historical period of Hittite.⁷⁴

In sum, the Hittite historically reduplicated stems *tith-* and *lilh-* may provide independent support for the chronology of constraint re-ranking proposed in Section 7: *PCR was active in PA, but was separately demoted in the post-PA (pre)history of Luwian and Hittite, allowing for the creation of new *PCR-violating sequences in the latter.

8 Conclusion

The reduplicative patterns of the Anatolian languages differ from those reconstructible for Proto-Anatolian. This is indicative of *grammar change*. Like the other ancient Indo-European languages, PA reduplication shows effects of *PCR (see Zukoff 2017a). Yet by the period of attested Hittite and Luwian, *PCR has been demoted to the bottom of the grammar, as shown especially by the innovative *VC-VCX-* reduplicative pattern. We have argued that these developments can be accounted for with the following diachronic scenario.

First, independent phonological changes in both Hittite and Luwian affected the reduplication of cluster-initial roots: the development of across-the-board cluster-copying in Hittite; the deletion of *s in word-initial *ST clusters in Luwian. These changes produced ambiguities in the learning data with respect to *PCR. By adopting a version of Recursive Constraint Demotion that favors installation of maximally informative winner-preferring constraints over less informative winner-preferring constraints — which we have termed Maximally Informative Recursive Constraint Demotion (MIRCD) — this ambiguity leads directly to the demotion of *PCR to the bottom of the rankings in both languages. Second, the *VC-VCX-* reduplicative pattern emerged independently in each language after the post-PA loss of pre-vocalic word-initial *h₁, when newly vowel-initial roots were input into the innovative synchronic grammar for the first time. This innovation was made possible (and indeed perhaps necessary) by MIRCD’s total demotion of *PCR.

8.1 Anatolian and the Reconstruction of PIE Reduplication

Having reconstructed and analyzed the reduplication patterns of PA in Sections 5–6 above, we are now in a position to assess the implications of the Anatolian evidence for the reconstruction of the reduplicative system of PIE. Since we have focused here on reduplicant shape, our analysis bears primarily on the question

⁷² See Jasanoff (2012) for discussion, with a different conclusion.

⁷³ As shown by Melchert (2011:130), the etymologically related [i]-reduplicated stem CLuw. *li-lūwa-* is a Luwian-internal creation to the (laryngeal-metathesized) base *lūwa-* ‘pour’ (< PIE *luh₃- ← *lh₃u-C-), and thus provides no evidence for an inherited reduplicated [i]-present with zero-grade of the root (as argued by Dempsey 2015:294).

⁷⁴ We assume here that by the attested, post-syncope stage of Hittite, *tith-* and *lilh-* are not synchronically generated reduplicated forms but rather have been reanalyzed as non-derived stems. For *tith-*, the absence of an independently occurring base recommends this analysis. This situation is less clear for *lilh-*, which is attested beside simplex *lah(h)u-*. But the abundance of nominal derivatives to the (historically) reduplicated stem (*lelḫu(wa)rtima-* ‘outpourings (?)’, ^{DUG}*lelḫūndai-* ‘(type of vessel)’, etc.; see *CHD L-N*: 60) suggests that it had an independent existence. Alternatively, see Zukoff (2017a:120–121) for a possible way to synchronically generate *lilh-*.

of whether PIE made a distinction in reduplication between TRVX– vs. STVX– bases, and thus, in turn, on whether an active *PCR constraint can be reconstructed for PIE as in PA.

Concerning the potential distinction in PIE reduplication between these two base types, two main views are represented in Indo-Europeanist literature. The more traditional view reconstructs for PIE the distribution found in Gothic and, according to the proposal advanced here, in Proto-Anatolian as well: C₁-copying for TRVX– roots (TV-TRVX–) but cluster-copying for STVX– roots (STV-STVX–). Such an asymmetric distribution is indicative of *PCR effects, and would provide evidence for reconstructing a relatively high-ranking *PCR constraint in PIE.

The alternative view — found (e.g.) in Byrd (2015:119–121) and argued especially by Zukoff (2017a: Ch. 7) — is that PIE had across-the-board C₁-copying in reduplication. That is to say, *PCR was not sufficiently high-ranked in PIE proper as to divert STVX– bases away from the default C₁-copying pattern. Thus, under this view, both TRVX– and STVX– roots (and indeed all types of root-initial clusters) exhibited C₁-copying, i.e., TV-TRVX– and SV-STVX–, respectively. Despite the newly established agreement between the Gothic and PA reduplicative patterns, we endorse this view here.

The strongest evidence in favor of this reconstruction comes from archaisms in Greek and Latin (Brugmann and Delbrück 1897–1916:40–41), and their agreement with Iranian (Byrd 2015:120), which all point to SV-STVX–. Specifically, there is exact correspondence between the archaic reduplicated present forms of the PIE root **steh*₂– ‘stand’ in Ancient Greek ἵστανμι [hí-stē-mi] (< Proto-Greek **si-stā-mi*) and Latin *sistō* ([si-st-ō]), despite neither belonging to the productive pattern of the language, which is reflected (e.g.) in the (non-copying) Greek perfect ἔσταλκα [é-stal-k-a] ‘I have prepared’ and the (infixing) Latin *stetī* [s-te-t-ī] ‘I stood’. Avestan and Old Persian appear to match the archaic treatment shown by Greek and Latin: Avestan *hi-štaiti*, *vi-šā-star^o*, Old Persian *a-hi-štata* (Byrd 2015:120). The fact that the Latin and Greek forms agree with the Iranian forms can only be explained if that pattern obtained in the last common ancestor of those three branches, namely, PIE.⁷⁵

Possible further support for reconstructing across-the-board C₁-copying in PIE comes from Anatolian, where there is attested at least one verbal form that — like Greek ἵστανμι and Latin *sistō* — may historically reflect this reduplicative pattern (i.e. C₁-copying for STVX– bases) and thus bear witness to the earlier PIE grammar. This potential archaism is the Hittite root *šip(p)and–* ‘libate’. Melchert (2016a) has argued that this root should be analyzed as deriving from an earlier reduplicated formation **se-spónd–*, which then underwent deletion of root-C₁ (possibly with compensatory lengthening) to **sěpónd–*. This deletion process — which is perhaps equivalent to what is observed in the *CēC* reduplicative patterns attested in Sanskrit and Germanic (see Zukoff 2017a: Ch. 5) — is plausibly viewed as an effect of *PCR, since the sequence repaired by deletion is exactly one which would incur a *PCR violation. If this analysis is correct, it implies that Anatolian inherited the SV-STVX– C₁-copying pattern from PIE, and that the reduplicated form ancestral to Hitt. *šip(p)and–* underwent a *PCR-driven deletion process prior to PA’s adoption of the STV-STVX– cluster-copying pattern. While the evidence is perhaps too limited to assert much more about the transitional stage between PIE and PA, it is possible that the process which shaped *šip(p)and–* was some of the first evidence that Anatolian learners received for the activity of *PCR, which was later generalized in a different way to create the PA cluster-copying pattern.

Yet the reconstruction of the SV-STVX– C₁-copying pattern for PIE ultimately does not depend on Hitt. *šip(p)and–*. When C₁-copying is compared to the traditional cluster-copying reconstruction, the primary appeal of the latter is that it offers a way to understand the productive STVX– treatments of Ancient Greek (V-STVX–), Sanskrit (TV-STVX–), and Latin (S-TV-TVX–) in terms of ordinary (if not regular) mechanisms of sound change: these patterns could be seen as different kinds of reductions (often referred to as

⁷⁵ One additional piece of evidence in favor of reconstructing C₁-copying to PIE comes from Celtic. The sole STVX– root attested with reduplication in Old Irish also exhibits C₁-copying: *√scenn* → *se-scann–* (Thurneysen 1946 [1980]:424/§687; Byrd 2015:120).

“dissimilation”) from the original type. However, the precise means by which these reductions are meant to have happened are rarely (if ever) made explicit, and none of them are matched by independently observed types of dissimilation in those languages. This problem is obviated under the approach to diachronic change in reduplication pursued in this article, which has shown that the changes observed within Anatolian can be explained primarily in terms of grammatical reorganization. Significantly, this approach does not deny that ordinary sound change plays a role in the emergence of new reduplicative patterns; on the contrary, we have argued — above all, in our analysis of the diachrony of Luwian reduplication in Section 7.5 — that sound change is instrumental in shaping the learning conditions that give rise to systemic morphophonological change, and that when these learning conditions are properly understood, the direction of the change can be predicted (at least after the fact).

When the diachrony of PIE reduplication is similarly approached in terms of grammatical reorganization, it becomes clear that the various changes attested in the ancient IE languages can be characterized in a unified way: each change results from the promotion of *PCR. In PIE, *PCR would have been ranked *below* all the constraints whose violation would have resulted in some pattern other than C₁-copying. The change in pattern is the result of the re-ranking of *PCR *above* (at least) one such constraint. The reason why the different languages develop different patterns for STVX- roots is because they each “choose” different constraints to promote *PCR above — for instance, the Proto-Anatolian (and Gothic) system arises by re-ranking *PCR above ALIGN-ROOT-L.⁷⁶ In a certain sense, then, the changes in overt reduplication patterns indeed all arise from the same underlying change: an emergent, increased sensitivity to the repetition avoidance constraint. Assuming that *PCR was independently promoted in the various languages — rather than retained as an active constraint from PIE — is logically consistent with the fact that the languages differ both in which repair is enacted and in exactly which repetition sequences are targeted by *PCR (Zukoff 2017a: Ch. 7).

8.2 Synchrony, Diachrony, and Phonological Change

In this article, we have examined the reduplicative systems of the Anatolian languages from both synchronic and diachronic perspectives, which are crucially integrated in our analysis of the observed differences between Hittite and Luwian reduplication. Our explanation of these differences is founded, first, on synchronic theoretical analyses of the reduplicative systems of Hittite, Luwian, and their reconstructed ancestor, Proto-Anatolian. The phonological grammars of these diachronically distinct stages were then compared, such that the differences between the stages could be characterized not just phenomenologically (as is typical in traditional historical linguistic approaches), but in terms of the systemic differences in constraint rankings and/or underlying representations that comprise the individual grammars. This mode of comparison allowed us to bring to bear considerations of (morpho)phonological learning for explanatory effect, deriving one stage from the next through the language learning process and alterations to the learning data resulting from sound change.

What might be overlooked within this larger picture is how the theoretical analysis of PA reduplication developed in Section 6 also contributed to one purely empirical finding of this study: the loss of **h*₁ in at least some environments was a post-PA development. The assumption that the wholesale loss of **h*₁ was dateable to PA itself had not been seriously questioned since Melchert (1994:65) cautiously situated it at this stage. A re-examination of the evidence for this assumption (in Section 5.3) was prompted by a prediction of our analysis — namely, that the *VR-VRTX-* pattern associated with certain vowel-initial roots in Hittite and Luwian should not exist under the constraint ranking necessary to generate the other PA reduplication patterns (i.e., *CV-CVX-*, *TV-TRVX-*, *STV-STVX-*). This prediction was ultimately borne out: we adduced evidence from three separate phonological developments in support of the hypothesis that the loss of word-

⁷⁶ See Zukoff (2017a: Ch. 7) for detailed analysis of these minimal re-rankings.

initial pre-vocalic **h₁* — and thus the creation of the vowel-initial roots on which the *VR-VRTX-* pattern is based — occurred only after the break-up of PA. None of the evidence treated was in fact novel, but the theoretical analysis provided a context in which its historical implications could be more easily recognized.

More broadly, then, this article adds to the substantial body of evidence that synchronic analysis of the phonological grammar has a crucial role to play in the study of historical phonology. Not only can it serve as a complement to traditional comparative-historical methods in the identification of sound change, but when integrated with a theory of (morpho)phonological learning it can offer insight into, and potentially even explanation of the direction of, systemic (morpho)phonological change.

References

- Alderete, John, Jill Beckman, Laura Benua, Amalia Gnanadesikan, John McCarthy, and Suzanne Urbanczyk. 1999. Reduplication with Fixed Segmentism. *Linguistic Inquiry* 30(3).327–364.
- Ameke, Felix Kofi. 1991. Ewe: Its Grammatical Constructions and Illocutionary Devices. PhD Dissertation, Australian National University Canberra.
- Barker, M. A. R. 1964. *Klamath Grammar*. Berkeley: University of California Press.
- Becker, Michael. 2009. Phonological Trends in the Lexicon: The Role of Constraints. Phd dissertation, University of Massachusetts, Amherst.
- Bermúdez-Otero, Ricardo. 2015. Amphichronic explanation and the life cycle of a phonological process. In Patrick Honeybone and Joseph C. Salmons (eds.), *The Oxford Handbook of Historical Phonology*, 374–399. Oxford / New York: Oxford University Press.
- Boersma, Paul. 1997. How We Learn Variation, Optionality, and Probability. In *Proceedings of the Institute of Phonetic Sciences of the University of Amsterdam* 21, 43–58. ROA 221.
- Brugmann, Karl, and Berthold Delbrück. 1897–1916. *Grundriss Der Vergleichenden Grammatik Der Indogermanischen Sprachen*. Strassburg: K.J. Trübner.
- Byrd, Andrew Miles. 2015. *The Indo-European Syllable*. Leiden: Brill.
- Capo, Hounkpati Bamikpo Christophe. 1989. *Précis Phonologique Du Gbe: Une Perspective Comparative*. Labo Gbe.
- Covini, Andrea. 2018. On the Origin of Hitt. *ašāš-/ašēš^{hhi}* ‘seat, settle’. In David M. Goldstein, Stephanie W. Jamison and Brent Vine (eds.), *Proceedings of the 28th Annual UCLA Indo-European Conference*. Bremen: Hempen.
- Cser, András. 2009. The History of Perfective Reduplication and Stem-Initial Patterns in Latin. *Acta Antiqua Academiae Scientiarum Hungaricae* 49(2).107–115.
- DeLisi, Jessica L. 2015. Epenthesis and prosodic structure in Armenian: A diachronic account. Ph.D. diss., University of California, Los Angeles.
- Dempsey, Timothy Richard. 2015. Verbal Reduplication in Anatolian. Phd dissertation, UCLA.
- Eichner, Heiner. 1969. Hethitisch *uešš-/uaššīia-* ‘(Gewänder) tragen; anziehen; bekleiden’. *Münchener Studien zur Sprachwissenschaft* 27.5–44.
- . 1974. Indogermanische Chronik 20b — II. Anatolisch. *Die Sprache* 20.183–86.
- Fleischhacker, Heidi Anne. 2005. Similarity in Phonology: Evidence from Reduplication and Loan Adaptation. Phd dissertation, UCLA.
- Flemming, Edward. 1995/2002. *Auditory Representations in Phonology*. New York: Routledge.
- Friedrich, Johannes, Annelies Kammenhuber, and Inge Hoffmann. 1975–. *Hethitisches Wörterbuch*, 2 edn. Heidelberg: Winter.
- Güterbock, Hans G., Harry A. Hoffner, and Theo van den Hout (eds.). 1989–. *The Hittite Dictionary of the Oriental Institute of Chicago*. Chicago: The Oriental Institute of the University of Chicago.

- Hall, Nancy. 2006. Cross-linguistic patterns of vowel intrusion. *Phonology* 23(3).387–429.
- . 2011. Vowel Epenthesis. In Marc Van Oostendorp, Colin J. Ewen, Elizabeth Hume and Keren Rice (eds.), *The Blackwell Companion to Phonology*, 1576–1596. Oxford / Malden, MA: Wiley-Blackwell.
- Harris, James. 1970. A Note on Spanish Plural Formation. *Language* 46.928–30.
- Hayes, Bruce. 2004. Phonological Acquisition in Optimality Theory: The Early Stages. In René Kager, Joe Pater and Wim Zonneveld (eds.), *Constraints in Phonological Acquisition*, 158–203. Cambridge: Cambridge University Press.
- Hayes, Bruce, Robert Kirchner, and Donca Steriade (eds.). 2004. *Phonetically Based Phonology*. Cambridge: Cambridge University Press.
- Hendricks, Sean Q. 1999. Reduplication without Template Constraints: A Study in Bare-Consonant Reduplication. Phd dissertation, University of Arizona.
- Hoffner, Harry A., Jr., and H. Craig Melchert. 2008. *A Grammar of the Hittite Language (Part I: Reference Grammar)*. Winona Lake, Indiana: Eisenbrauns.
- Jasanoff, Jay H. 2003. *Hittite and the Indo-European Verb*. Oxford: Oxford University.
- . 2007. From Reduplication to Ablaut: The Class VII Strong Verbs of Northwest Germanic. *Historische Sprachforschung* 120(1).241–284.
- . 2010. Lycian *sttati* ‘stands’. In Jörg Klinger, Elisabeth Rieken and Christian Rüter (eds.), *Investigationes Anatolicae. Gedenkschrift für Erich Neu*, 143–151. Harrassowitz.
- . 2012. Long-Vowel Preterites in Indo-European. In H. Craig Melchert (ed.), *The Indo-European Verb. Proceedings of the Conference of the Society for Indo-European Studies, Los Angeles 13-15 September 2010*, 127–135. Wiesbaden: Reichert.
- . to appear. The Prehistory of the IE perfect: A contribution to the theory of the *h₂e*-conjugation. In *1100 Jahre Entzifferung des Hethitischen: Morphosyntaktische Kategorien in Sprachgeschichte und Forschung. Proceedings of the Arbeitstagung of the Indogermanische Gesellschaft, Marburg, 21. bis 23. September 2015*.
- Kavitskaya, Darya. 2001. Hittite Vowel Epenthesis and the Sonority Hierarchy. *Diachronica* 18(2).267–299.
- Keydana, Götz. 2006. Die Indogermanische Perfektreduktion. *Folia Linguistica Historica* 27(1–2).61–116.
- . 2012. Evidence for Non-Linear Phonological Structure in Indo-European: The Case of Fricative Clusters. In Benedicte Nielsen Whitehead, Thomas Olander and Birgit Anette Olsen (eds.), *The Sound of Indo-European: Phonetics, Phonemics, and Morphophonemics*, 99–117. Denmark: Museum Tusulanum Press.
- Kimball, Sara. 1998. On the Origin of Hittite Verbs of the Type *tēhhi, dāi*. In Jay H. Jasanoff, H. Craig Melchert and Lisi Oliver (eds.), *Mír Curad: Studies in Honor of Calvert Watkins*, 335–344. Innsbruck: Institut für Sprachwissenschaft der Universität Innsbruck.
- . 1999. *Hittite Historical Phonology*. Innsbruck: Institut für Sprachwissenschaft der Universität Innsbruck.
- Kloekhorst, Alwin. 2004. The Preservation of **h₁* in Hieroglyphic Luwian: Two Separate *a*-Signs. *Historische Sprachforschung* 117(1).26–49.
- . 2006. Initial Laryngeals in Anatolian. *Historische Sprachforschung* 119.77–108.
- . 2008. *Etymological Dictionary of the Hittite Inherited Lexicon*. Leiden; Boston: Brill.
- . 2014. *Accent in Hittite: A Study in Plene Spelling, Consonant Gradation, Clitics, and Metrics*. Wiesbaden: Harrassowitz.
- Ladefoged, Peter. 2001. *Vowels and Consonants: An Introduction to the Sounds of Languages*. Malden, MA: Blackwell.
- Ladefoged, Peter, and Ian Maddieson. 1996. *The Sounds of the World's Languages*. Oxford/Cambridge, MA: Blackwell.

- Lundquist, Jesse, and Anthony D. Yates. 2018. The Morphology of Proto-Indo-European. In Jared S. Klein and Brian D. Joseph (eds.), *The Handbook of Comparative and Historical Indo-European Linguistics*. Berlin / New York: de Gruyter.
- Magri, Giorgio. 2012. Convergence of Error-Driven Ranking Algorithms. *Phonology* 29(2).213–269.
- Mateus, Maria Helena, and Ernesto d’Andrade. 2000. *The Phonology of Portuguese*. Oxford / New York: Oxford University Press.
- McCarthy, John J. 1980. The Role of the Evaluation Metric in the Acquisition of Phonology. In John J. McCarthy and Carl L. Baker (eds.), *The Logical Problem of Language Acquisition*, 218–248. Cambridge, MA: M.I.T. Press.
- . 1998. Morpheme Structure Constraints and Paradigm Occultation. In M. Catherine Gruber, Derrick Higgins, Kenneth Olsen and Tamra Wysocki (eds.), *Proceedings from the Annual Meeting of the Chicago Linguistic Society 32, Part II: The Panels*, 123–150. Chicago: Chicago Linguistic Society.
- McCarthy, John J., and Alan Prince. 1993. Generalized Alignment. In Geert Booij and Jaap van Marle (eds.), *Yearbook of Morphology 1993*, 79–153. Kluwer.
- . 1995. Faithfulness and Reduplicative Identity. In Jill Beckman, Suzanne Urbanczyk and Laura Walsh Dickey (eds.), *Papers in Optimality Theory*, no. 18 in University of Massachusetts Occasional Papers in Linguistics, 249–384. Amherst, MA: Graduate Linguistics Student Association. URL http://works.bepress.com/john_j_mccarthy/44.
- . 1999. Faithfulness and Identity in Prosodic Morphology. In René Kager, Harry van der Hulst and Wim Zonneveld (eds.), *The Prosody-Morphology Interface*, 218–309. Cambridge: Cambridge University Press. URL http://works.bepress.com/john_j_mccarthy/77.
- Melchert, H. Craig. 1983. A ‘New’ PIE *Men Suffix. *Die Sprache* 29(1).1–26.
- . 1984. *Studies in Hittite Historical Phonology*. Göttingen: Vandenhöck & Ruprecht.
- . 1993. *Cuneiform Luvian Lexicon*. Chapel Hill, NC: H.C. Melchert.
- . 1994. *Anatolian Historical Phonology*. Amsterdam/Atlanta: Rodopi.
- . 2010. The Spelling of Initial /A-/ in Hieroglyphic Luwian. In Itamar Singer (ed.), *ipamati kistamati pari tumatimis: Luwian and Hittite Studies Presented to J. David Hawkins on the Occasion of his 70th Birthday*, 147–58. Tel Aviv: Emery and Claire Yass Publications in Archaeology.
- . 2011. The PIE Verb for ‘to Pour’ and Medial *h₃ in Anatolian. In Stephanie W. Jamison, H. Craig Melchert and Brent Vine (eds.), *Proceedings of the 22nd Annual UCLA Indo-European Conference*, 127–132. Bremen: Hempen.
- . 2012. Hittite *hi*-Verbs of the Type *-āC₁i*, *-aC₁C₁anzi*. *Indogermanische Forschungen* 117.173–186.
- . 2014. “Narten formations” versus “Narten roots”. *Indogermanische Forschungen* 119.251–258.
- . 2015. More on Ablaut Patterns in the *hi*-Conjugation. Paper presented at the Harvard GSAS Workshop, Cambridge, MA, 20 April 2015.
- . 2016a. Initial *sp- in Hittite and *šip(p)and-* ‘to libate’. *Journal of Language Relationship* 14(3).187–195.
- . 2016b. New Luvian Verb Etymologies. In Henning Marquardt, Silvio Reichmuth and José Virgilio García Trabazo (eds.), *Anatolica et Indogermanica: Studia linguistica in honorem Johannis Tischler septuagenarii dedicata*, 203–212. Innsbruck: Institut für Sprachen und Literaturen der Universität Innsbruck.
- . to appear a. Hittite Historical Phonology after 100 Years (and after 20 years). In R. Kim and P. Čech (eds.), *Hrozný and Hittite: The First 100 Years. Prague, 11–14 November 2015*. (Ms. available at: <http://linguistics.ucla.edu/people/Melchert/melchertprague2015.pdf>).
- . to appear b. Hittite *ti(ta)nu-*, *titti-*, and Lycian *stta-*. *Studia Indogermanica Lodziensia*.
- Niepokuj, Mary. 1997. *The Development of Verbal Reduplication in Indo-European*. No. 24 in Journal of Indo-European Studies, Monograph Series. Washington, D.C.: Institute for the Study of Man.
- Oettinger, Norbert. 1979. *Die Stammbildung Des Hethitischen Verbuns*. Nürnberg: Hans Carl.

- Parker, Steve. 2002. Quantifying the Sonority Hierarchy. Phd dissertation, University of Massachusetts, Amherst.
- . 2008. Sound Level Protrusions as Physical Correlates of Sonority. *Journal of Phonetics* 36(1).55–90.
- Pozza, Marianna. 2011. *La Grafia delle Occlusive Intervocaliche in Ittito: Verso una Riformulazione della Lex Sturtevant*. Il Calamo.
- . 2012. Reflections on Some Problematic Cases for Sturtevant’s Law. *Indogermanische Forschungen* 117.257–282.
- Prince, Alan. 2002. Arguing Optimality. In Angela C. Carpenter, Andries W. Coetzee and Paul de Lacy (eds.), *Papers in Optimality Theory II*, vol. 1, 269–304. Amherst, MA: Graduate Linguistics Student Association. ROA 562.
- Prince, Alan, and Paul Smolensky. 1993/2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden, MA: Blackwell Publishing.
- Prince, Alan, and Bruce Tesar. 2004. Learning Phonotactic Distributions. In René Kager, Joe Pater and Wim Zonneveld (eds.), *Constraints in Phonological Acquisition*, 245–291. Cambridge: Cambridge University Press.
- Puhvel, Jaan. 2011. *Hittite Etymological Dictionary, Vol. 8: Words beginning with PA*. Berlin / New York: de Gruyter.
- Rieken, Elisabeth. 2001. Hethitisch *witti meyani* und das urindogermanische Wort für “Monat”. *Historische Sprachforschung* 114(1).73–79.
- . 2010. Das Zeichen <sa> Im Hieroglyphen-Luwischen. In Aygül Süel (ed.), *Acts of the VIIIth International Congress of Hittitology*, vol. 2, 651–660. Ankara: Anit.
- Rix, Helmut, Martin Kümmel, Thomas Zehnder, Reiner Lipp, and Brigitte Schirmer. 2001. *Lexikon Der Indogermanischen Verben: Die Wurzeln Und Ihre Primärstambildungen*, 2 edn. Wiesbaden: Ludwig Reichert.
- Sandell, Ryan. 2014. The Phonological Origins of Indo-European Long-vowel (“Narten”) Presents. Paper presented at the 26th Annual UCLA Indo-European Conference, Los Angeles, 24–25 October 2014 (Handout available at: <https://www.academia.edu/8858713>).
- Simon, Zsolt. 2010. Das Problem der phonetischen Interpretation der anlautenden scriptio plene im Keilschriftluwischen. In Leonid Kogan (ed.), *Language in the Ancient Near East: Proceedings of the 53e Rencontre Assyriologique Internationale*, 249–265. Winona Lake, IN: Eisenbrauns.
- . 2013. Once Again on the Hieroglyphic Luwian Sign *19 <á>. *Indogermanische Forschungen* 118.1–22.
- Spaelti, Philip. 1997. Dimensions of Variation in Multi-Pattern Reduplication. Phd dissertation, University of California, Santa Cruz.
- Steriade, Donca. 1988. Reduplication and Syllable Transfer in Sanskrit and Elsewhere. *Phonology* 5(1).73–155.
- . 1999. Alternatives to the Syllabic Interpretation of Consonantal Phonotactics. In O. Fujimura, B.D. Joseph and B. Palek (eds.), *Proceedings of Linguistics and Phonetics 1998*, 205–245. Prague: Karolinum Press.
- Sturtevant, Edgar H. 1932. The Development of Stops in Hittite. *Journal of the American Oriental Society* 52.1–12.
- Tesar, Bruce. 1995. Computational Optimality Theory. Phd dissertation, University of Colorado, Boulder.
- Tesar, Bruce, and Paul Smolensky. 1998. Learnability in Optimality Theory. *Linguistic Inquiry* 29(2).229–268.
- . 2000. *Learnability in Optimality Theory*. Cambridge, MA: MIT Press.
- Thurneysen, Rudolf. 1946 [1980]. *A Grammar of Old Irish*. Dublin: Dublin Institute for Advanced Studies.
- Čop, Bojan. 1970. Eine luwische orthographisch–phonetische Regel. *Indogermanische Forschungen* 85–96.

- Watkins, Calvert. 1971. Hittite and Indo-European Studies: The Denominative Statives in *-ē-. *Transactions of the Philological Society* 70(1).51–93.
- Weeden, Mark. 2011. Spelling, Phonology and Etymology in Hittite Historical Linguistics. *Bulletin of the School of Oriental and African Studies* 74(1).59–76.
- Wright, Richard. 2004. A Review of Perceptual Cues and Cue Robustness. In Bruce Hayes, Robert Kirchner and Donca Steriade (eds.), *Phonetically Based Phonology*, 34–57. Cambridge: Cambridge University Press.
- Yakubovich, Ilya. 2010. *Sociolinguistics of the Luvian Language*. Leiden / Boston: Brill.
- Yates, Anthony D. 2014. Acrostatic Neuter *-s-Stems and Sonority-driven Epenthesis in Proto-Anatolian. Paper presented at the 33rd Annual East Coast Indo-European Conference, Blacksburg, VA, 6–8 June 2014 (Handout available at: <http://www.adyates.com/research/>).
- . 2016a. Hittite Stressed Vowel Lengthening and the Phonology-Orthography Interface. In David M. Goldstein, Stephanie W. Jamison and Brent Vine (eds.), *Proceedings of the 27th Annual UCLA Indo-European Conference*, 235–257. Bremen: Hempen.
- . 2016b. Left But Not Leftmost? Interactions between Epenthesis and Ictus Assignment in Anatolian. In Stephanie W. Jamison, H. Craig Melchert and Brent Vine (eds.), *Proceedings of the 26th Annual UCLA Indo-European Conference*, 161–178. Bremen: Hempen.
- . 2017. Lexical Accent and Its Diachrony: Studies in Hittite and Cupeño Prosody. Ph.D. diss., UCLA.
- Yun, Suyeon. 2016. A Theory of Consonant Cluster Perception and Vowel Epenthesis. Ph.D. diss., MIT.
- Zukoff, Sam. 2017a. Indo-European Reduplication: Synchrony, Diachrony, and Theory. Ph.D. diss., MIT (available at: <http://web.mit.edu/szukoff/www/pdfs/Zukoff2017Dissertation.pdf>).
- . 2017b. The Reduplicative System of Ancient Greek and a New Analysis of Attic Reduplication. *Linguistic Inquiry* 48(3).459–497.