[Pre-publication version 11/15/15, to appear in *Linguistic Inquiry*]

The Reduplicative System of Ancient Greek and a New Analysis of Attic Reduplication

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Abstract: The Ancient Greek perfect tense poses an interesting empirical puzzle involving reduplication. While consonant-initial roots display a phonologically regular alternation based on cluster type, vowel-initial roots display two distinct patterns whose distribution is not phonologically predictable. The reduplicative grammar that generates the consonant-initial patterns is directly compatible with the productive vowel-initial pattern, vowel-lengthening. The minority vowel-initial pattern, "Attic Reduplication," both its shape and its distribution, can be explained as a phonotactic repair which operated at a prior stage of the language. This pattern was later reanalyzed, such that Attic Reduplication is retained not as a phonotactic repair but rather through lexical indexation.

Keywords: Attic Reduplication, Ancient Greek, Indo-European, Optimality Theory, Constraint Indexation, Language Change

1. Introduction

The distribution of stem-formation patterns in the Ancient Greek perfect-tense poses an interesting empirical puzzle involving the analysis of reduplication. Consonant-initial roots display a phonologically regular alternation between two patterns, determined by the type of initial cluster; vowel-initial roots also display two distinct patterns, but this variation is not predictable based on phonological properties. While most vowel-initial roots show lengthening of the root-initial vowel, a small set of roots instead displays "Attic Reduplication," *VC*-copying plus lengthening of the root-initial vowel.

The reduplicative grammar necessary to generate the patterns for consonant-initial roots is directly compatible with the more productive vowel-lengthening pattern. Attic Reduplication, both its shape and its distribution, can be explained through careful consideration of diachrony. The pattern arises as the result of laryngeal-related phonotactics in Pre-Greek, which force an alternative reduplication strategy. The pattern itself is constrained by the normal reduplicative grammar and other laryngeal-related repairs, namely "laryngeal vocalization." The loss of the laryngeals forces reanalysis, such that Attic Reduplication is retained in Ancient Greek by more complicated mechanisms, namely constraint indexation.

The account developed in this paper yields three primary results. First, it provides a comprehensive analysis of the synchronic system of perfect-stem formation in Ancient

Greek, integrating the minority pattern – Attic Reduplication – with the productive majority patterns. Secondly, it synthesizes previous, relatively informal proposals regarding the origin of the Attic Reduplication pattern into a full-fledged formal synchronic analysis, located at the Pre-Greek stage. And third, more generally, it addresses the problem of how to deal with residual morphophonological patterns within a language's morphological and phonological grammar. Minority patterns of the sort represented by Attic Reduplication are omnipresent cross-linguistically, yet analysts often overlook their value. This account not only demonstrates that such patterns can reveal significant insights about the larger systems in which they are embedded, but illustrates diachronic pathways by which they arise and the diachronic tools which can be employed to yield a meaningful analysis of this kind.

1.1. Data

In the Ancient Greek perfect-tense, consonant-initial roots display a phonologically regular alternation between two stem-formation patterns, determined by the type of initial cluster. Roots with an initial singleton consonant or an initial *stop-sonorant* cluster show the overtly reduplicative pattern in (1)a: a prefixed copy of the root-initial consonant followed by a fixed vowel [e]. Roots with all other types of initial clusters lack reduplicative copying and show just the prefixed [e], the "non-copying" pattern in (1)b.[1]

(1) Distribution of stems in the perfect: consonant-initial roots

a. **C_1-copying**

Singleton roots: √CV- → Ce-CV-, e.g. √*dɔ̄* 'give'→ perf. *de-dɔ̄-*

Stop-Sonorant roots: √TRV- → Te-TRV-, e.g. √*kri* 'judge' → perf. *ke-kri-*

b. **Non-copying**

Other Cluster roots: √CCV- → e-CCV-, e.g. √*kten* 'kill' → perf. *e-kton-*

Vowel-initial roots likewise show a dichotomy of patterns; however, unlike among the C-initial roots, there is no clear phonological conditioning which regulates the variation – it simply varies by lexeme. Most V-initial roots form their perfect stem by lengthening the root-initial vowel, as in (2)a. However, a small set of roots, illustrated in (2)b, instead displays copying of the root-initial *VC-* sequence while simultaneously lengthening the root-initial vowel, a pattern referred to as Attic Reduplication (AR).

[1] I will use the following notations: " > " indicates a diachronic development; " → " indicates a synchronic Input-Output mapping; " ** " indicates a form which never occurred; " * " indicates a reconstructed form.

(2) Distribution of stems in the perfect: vowel-initial roots[2]

a. **Vowel lengthening**: √VC- → V̄C-

e.g. √*ag* 'lead' → perf. *āg*-, √*onoma* 'name' → perf. *ɔ̄noma*-

b. **Attic Reduplication**: √VC- → VC-V̄C-

e.g. √*ager* 'gather' → perf. *ag-āger*-, √*ol* 'destroy' → perf. *ol-ɔ̄l*-

AR's distribution within the synchronic grammar is seemingly arbitrary; the roots which undergo AR have no discernible phonological characteristics that set them apart from roots which undergo the default pattern.

1.2. Outline

This paper will provide a comprehensive account of the historical development of the Attic Reduplication pattern set within the larger reduplicative system of Greek. In exploring the synchronic reduplicative system of attested Ancient Greek in Section 2, we will find that the grammar that generates the pattern displayed by consonant-initial roots also directly generates the productive vowel-lengthening pattern for vowel-initial roots. This reveals that it is indeed Attic Reduplication which requires further attention.

We will first answer the question of how the Attic Reduplication pattern came into being, in Section 3. Virtually all roots which display AR are reconstructed with an initial laryngeal consonant (e.g., Winter 1950:368-9, Beekes 1969:113-26, *et seq*); e.g., Ancient Greek √*ol* < Proto-Indo-European *√h_3elh_1 (*LIV*[2]:298, Beekes & van Beek 2010:1069-70). With this in mind, I will propose that the historical source of Attic Reduplication (henceforth "Pre-AR") arose at a stage of the language in which the laryngeal consonants were still present ("Pre-Greek"), such that an AR form like Ancient Greek *ol-ɔ̄l*- derives historically from a Pre-AR form *h_3el-e-h_3l-. Pre-AR is a deviation from the normal reduplication pattern, restricted to laryngeal-initial roots, induced by the unique phonetic and phonological properties of the laryngeals. The exact nature of Pre-AR is determined in large part by the interaction of the default reduplicative grammar with another laryngeal-related phonological process known as "laryngeal vocalization." The distribution of default reduplication vs. the Pre-AR pattern in Pre-Greek is schematized in (3).

(3) Default reduplication vs. Pre-AR in Pre-Greek (H = laryngeal consonant):

a. Default reduplication pre-forms: *$\underline{C^iV}$-C^iC^kVC- or *$\underline{C^iV}$-C^iC^k-

b. Attic Reduplication pre-forms: *$\underline{H^iVC^kV}$-H^iC^kVC- or *$\underline{H^iVC^kV}$-H^iC^k-

Having accounted for the origin of Attic Reduplication, in Section 4 we will confront the question of how the pattern could be retained as a minority pattern into attested Ancient Greek and how it was represented by speakers in the synchronic grammar. Subsequent to

[2] For forms involving /a/, I use non-Attic-Ionic forms, such that its lengthened correspondent is [ā]. In the Attic-Ionic dialect group, [ā] has become [ɛ̄] (see, e.g., Sihler 1995:48-52), such that the relationship between short and long vowel is slightly less transparent. It may not be the case that all forms with [ā] are actually attested outside of Attic-Ionic (i.e. in Doric or other [ā] dialects), but all are at least attested in their [ɛ̄] forms in Attic-Ionic. When necessary, I will refer to [ā]-forms as belonging to "Common Greek."

the initial development of Pre-AR, the laryngeals were lost in Greek, and thus the phonotactics driving the pattern were no longer recoverable. In order to retain the pattern, learners formulated a new analysis, whereby copying in these forms is motivated by the operation of a lexically-restricted REALIZE MORPHEME constraint (RM; Kurisu 2001). Additional evidence for the special activity of this constraint comes from a set of exceptions to the generalizations regarding cluster-type–dependent copying in (1), namely the reduplicated presents and their associated perfects. Incorporating lexically-restricted RM into the grammar thus provides a principled way of generating the entire synchronic distribution of reduplicative forms in the Ancient Greek perfect.

2. Reduplication in Ancient Greek

This section presents the analysis of the productive reduplicative system of Ancient Greek.[3] The three productive patterns of perfect-tense stem-formation ((1)a, (1)b, and (2)a) are generated from a single, consistent constraint ranking, without appeal to reduplicative templates, under an analysis where two morphemes, RED and /e/, compete for position at the left edge of the word. The analysis will be framed in terms of Base-Reduplicant Correspondence Theory (McCarthy & Prince 1995), though little of the formal apparatus employed in the analysis is dependent on this.[4] It begins in Section 2.1 by analyzing the two patterns found in the C-initial roots, including a discussion of the underlying morphemic structure of the perfect (Section 2.1.2). Section 2.2 examines the behavior of V-initial roots, showing that the analysis developed for the C-initial roots is compatible with the productive vowel-lengthening pattern. When projected back to the earlier stage of the language in which laryngeal consonants were still present, the grammar developed here, adjusted only slightly and supplemented by an independently motivated phonotactic constraint, will generate the Pre-AR pattern.

2.1. Consonant-initial roots

2.1.1. Data and generalizations

As introduced in (1) above, the perfect of Ancient Greek shows two distinct stem-formation patterns for C-initial roots: C_1-copying and "non-copying," exemplified further in (4) and (5), respectively.[5] The distribution is determined by the composition of the root-initial

[3] For the facts of Ancient Greek reduplication, see, e.g., Schwyzer (1939:646-650). For recent theoretical analyses, see Steriade (1982:195–208, 304–12, 1988:135-136), Fleischhacker (2005), Keydana (2006:83-91), Halle (2008:333-6).

[4] For recent alternative theoretical approaches to reduplication, consult Raimy (2000, 2009), Inkelas & Zoll (2005), Idsardi & Raimy (2008), Frampton (2009), Kiparsky (2010), McCarthy et al. (2012).

[5] The Ancient Greek data in this paper is drawn primarily from the survey of verbal forms conducted by Van de Laar (2000). All generalizations comport with traditional descriptions, for example, Smyth (1920 [1984]), Schwyzer (1939), Sihler (1995).

string. If the root begins in a single consonant or a cluster comprised of *stop-sonorant*, it takes C_1-copying. All other C-initial roots show non-copying.[6]

(4) C_1-copying reduplication

a. **Roots with initial singleton consonants**

Root		Present Tense		Perfect Tense	
dɔ̄-	'give'	δίδωμι	[di-dɔ̄-]	δέδωκα	[de-dɔ̄-]
pemp-	'send'	πέμπω	[pemp-]	πέπεμπται	[pe-pemp-]
lu-	'loosen'	λύω	[lu-]	λέλυκα	[le-lu-]

b. **Roots with initial *stop-sonorant* clusters**

Root		Present Tense		Perfect Tense	
kri(n)-	'decide'	κρίνω	[krī-n-]	κέκριμαι	[ke-kri-]
tla-	'suffer, dare'	τλάω	[tla-]	τέτλᾱκα	[te-tlā-]
pneu-	'breathe'	πνέω	[pne-]	πέπνῡμαι	[pe-pnū-]

(5) Non-copying "reduplication"

a. **Roots with other initial clusters**

Root		Perfect Tense		
kten-	'kill'	ἔκτονα	[e-kton-]	not **[ke-kton-]
pseud-	'lie'	ἔψευσμαι	[e-pseus-]	not **[pe-pseus-]
stel-	'prepare'	ἔσταλκα	[e-stal-]	not **[se-stal-]
smɛ̄k^h-	'wipe'	ἐσμηγμένος	[e-smɛ̄g-]	not **[se-smɛ̄g-]

b. **Roots with initial geminates**

Root		Perfect Tense		
rreu-	'flow'	ἐρρύηκα	[e-rru-]	not **[re-rru-]
sseu-	'hasten'	ἔσσυμαι	[e-ssu-]	not **[se-ssu-]

When reduplication is successfully carried out in forms like those in (4), the string pre-posed to the root takes the shape *CV*. In such cases, *C* is always identical to the root-initial consonant. This can be captured using the constraint ANCHOR-L-BR (McCarthy & Prince 1995:123), which penalizes copying from non-root-initial position. (The function of ANCHOR could equally well be taken up by LOCALITY; Nelson 2003, *et seq.*) In the overtly copying pattern in (4), and indeed also in those cases where copying fails to occur (as in (5)), *V* is always [e], regardless of the identity of the root vowel.

2.1.2. Perfect reduplication: one morpheme or two?

The [e] vowel which precedes the root in the perfect does not co-vary with a segment in the base. *A priori*, cases where a fixed segment occurs in a reduplicative context admit of two analytical options (cf. Alderete et al. 1999): a phonological analysis or a morphological

[6] There is a systematic set of exceptions where roots with other cluster types unexpectedly show C_1-copying. These will be discussed in Section 4.4 below.

analysis. Under the phonological approach, the segment is taken to be copied from the base as part of the reduplicant, but markedness constraints induce phonological reduction (a case of *the emergence of the unmarked*; McCarthy & Prince 1994).[7] As will be shown in Sections 2.1.3 and 2.1.4, such an analysis is unworkable for Ancient Greek, as it would lead to a ranking paradox.

Therefore, I will proceed with the alternative, morphological analysis. Rather than identifying the fixed segment as belonging to the reduplicant proper (i.e. arising via "copying"), we can view it as an independent morpheme, bound to co-occur with the reduplicative morpheme. This situation resembles, for example, that of *schm*-reduplication in English (Alderete et al. 1999:355-7; cf. Nevins & Vaux 2003).[8] Under this approach, a typical reduplicated form like *perfect* κέκριμαι [kekrimai] will be decomposed as in (6).

(6) <u>Morphological decomposition of the perfect</u>

<u>k</u>-	e-	kri	-mai
REDUPLICANT	FIXED SEGMENT AFFIX	ROOT	INFLECTION

With the fixed [e] identified as an independent morpheme, two questions remain to be answered in order to complete an analysis of the C-initial roots: (i) how does the reduplicant come to take the shape of a single consonant in the pattern in (4); and (ii) how do we derive the *C ~ Ø* alternation that distinguishes the C_1-copying pattern in (4) from the non-copying pattern in (5). These two questions are taken up immediately below.

2.1.3. The C_1-copying pattern

Since the non-copying pattern exists, the constraints which motivate having segments in the reduplicant must be violable in Ancient Greek. As will be shown in Sections 2.1.4 and 2.2, violation of these constraints can be forced by higher-ranked phonotactic considerations. When these constraints are not in danger of being violated, the constraints which enforce copying are satisfied. This is the case for the roots with C_1-copying.

REALIZE MORPHEME (RM; Kurisu 2001) is a constraint that can motivate reduplicative copying. RM demands that morphemes which are present in the underlying representation have surface exponents in the phonology. If no reduplicative copying were undertaken, the RM constraint on the reduplicative morpheme – RM(RED) – would incur a violation.

The phonotactics provide a motivation for copying, as well. If the /e/ were to surface without a preceding consonant, a violation of ONSET (Prince & Smolensky 1993/2004) would be incurred, since this would create an onsetless syllable. Onsetless syllables are permitted in Ancient Greek, but disfavored. This can be seen from a number of processes, including vowel contraction, cross-word elision (crasis), and "*nu* movable" (cf. Golston 2014). Therefore, ONSET will specifically militate for the presence of a consonant-final (and also consonant-initial) reduplicant, to accommodate the fixed /e/ morpheme.

[7] Alderete et al. (1999) also entertain an analysis in which the fixed segment is not copied, but epenthetic.

[8] As with *schm*-reduplication and similar cases, it is unclear if these two morphs have distinct functions.

RM(RED) and ONSET thus prefer an overt reduplicant of the shape #(*C*…)*C*- (followed immediately by the fixed *e*), but make no further demands regarding reduplicant shape. McCarthy & Prince (1986/1996, *et seq.*) demonstrate that "reduplicative templates" must take the shape of "genuine units of prosody" (*syllable, foot, prosodic word*). In the Ancient Greek perfect, neither of the two overtly reduplicative patterns take on such a shape: the C_1-copying pattern currently under discussion is a single consonant; the Attic Reduplication pattern is a necessarily heterosyllabic *VC* sequence. Therefore, it seems unsuitable to pursue an analysis of reduplicant shape based on templates of any sort. Furthermore, the fact that such different reduplicant shapes result from roots of different shapes would make such an analysis difficult.

Instead, this section will develop an "a-templatic" analysis (cf. Gafos 1998, Hendricks 1999, among others). A-templatic accounts of minimal reduplication patterns such as these rely on the activity of a "size restrictor" constraint (e.g., Spaelti 1997, Hendricks 1999, Riggle 2006). A size restrictor constraint will in some way penalize the reduplicant for having excessive length (or indeed any length at all). When the size restrictor outranks MAX-BR, the minimal reduplicant shape emerges as optimal.

Following Hendricks (1999), I use an ALIGNMENT constraint (McCarthy & Prince 1993, Prince & Smolensky 1993/2004, *et seq.*) as the size restrictor. Given that the fixed [e] has been identified as a distinct morpheme, it can have an alignment constraint defined for it, as in (7).[9]

(7) ALIGN-/e/-L

> Assign one violation * for every segment that intervenes between the left edge of the prosodic word and the left edge of the fixed segment affix *e*.[10]

When ranked above MAX-BR, this constraint will induce the desired minimization effect, since increasing the length of the reduplicant will necessarily increase the number of violations of this constraint, illustrated in (8).[11]

[9] In this paper, for ease of exposition, I employ gradient alignment constraints. McCarthy (2003) argues that alignment constraints (and indeed all OT constraints) should be defined categorically, not gradiently. However, Yu (2007:38-42) demonstrates that McCarthy's restriction to categorical alignment constraints does not actually avoid the typological over-generation problem it seeks to solve. The facts here are compatible with a categorical analysis, in which the single gradient constraint is separated into two categorical constraints: one alignment constraint defined with reference to an intervening *segment*, and another defined with reference to an intervening *syllable*.

[10] In cases where the underlying /e/ morpheme coalesces with a root-initial vowel, this constraint is evaluated with respect to that coalesced vowel.

[11] To ensure that this constraint does not have the effect of placing the [e] to the left of the reduplicant, we may also need to include an alignment constraint on the reduplicant (ALIGN-RED-L), ranked above it. However, such an ordering would generally be disfavored anyway by higher-ranked ONSET.

(8) Minimizing the reduplicant: √*pemp-* → πέπεμπται [p-e-pemp-] ‘he has (been) sent’

/ RED, e, pemp- /	ALIGN-/e/-L	MAX-BR
a. ☞ p-e-pemp-	*	***
b. pem-e-pemp-	**!*	*

Given that we do see copying in the general case, ALIGN-/e/-L must be ranked below ONSET and/or RM(RED), since failure to copy anything will satisfy ALIGN-/e/-L but violate ONSET and RM(RED).[12]

(9) Ensuring consonant-copying: √*pemp-* → πέπεμπται [p-e-pemp-] ‘he has (been) sent’

/ RED, e, pemp- /	RM(RED)	ONSET	ALIGN-/e/-L
a. ☞ p-e-pemp-			*
b. _-e-pemp-	*!	*!	

ALIGN-/e/-L would also be capable of selecting the minimal C_1 reduplicant for roots with initial clusters. However, in accounting for the non-copying pattern in Section 2.1.4 below, we will see that the ranking of ONSET and/or RM(RED) over ALIGN-/e/-L will in that case prefer extending the reduplicant to include the whole the cluster. To avoid this outcome, we must supplement the ranking with a constraint against consonant clusters: *CLUSTER (*CC). We can view this is an *emergence of the unmarked* effect in reduplication; while consonant clusters are permitted generally, they are prevented from occurring in the reduplicant, even to roots beginning in consonant clusters. Therefore, MAX-IO and DEP-IO dominate *CC, but *CC dominates MAX-BR (see McCarthy & Prince 1994, 1995), shown in (10). This ranking prefers the C_1-copying candidate (11)a to the cluster-copying candidate (11)b and the cluster-simplifying candidate (11)c.

(10) Ranking: MAX-IO, DEP-IO » *CC » MAX-BR

(11) C_1-copying reduplication: √*kri-* → κέκριμαι [k-e-kri-mai] ‘I have (been) judged’

/ RED, e, kri- /	MAX-IO	*CC	ALIGN-/e/-L
a. ☞ k-e-kri-		*	*
b. kr-e-kri-		**!	**
c. k-e-ki-	*!		*

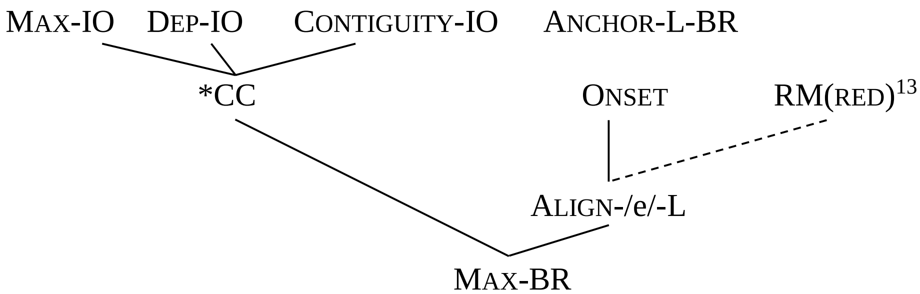
These size-minimizing constraints show why reduplication cannot be larger than a single consonant; however, they do not specify which consonant should be copied into this position. The constraint which will enforce copying of root-C_1, as opposed to, for example, root-C_2 (as in candidate like [r-e-kri-]) has already been mentioned, ANCHOR-L-BR.

[12] It will be shown below in Section 2.2 that ONSET » ALIGN-/e/-L » RM(RED).

(Nothing yet fixes this constraint's relative ranking.) Candidates in which the /e/ is infixed, like [_-k-e-ri-] or [<u>ke</u>-k-e-ri-], would alleviate the root's *CC violation, but these are ruled out if the constraint CONTIGUITY-IO (Kenstowicz 1994, McCarthy & Prince 1995) dominates *CC.

This analysis generates the basic C_1-copying reduplication pattern. The ranking of the constraints employed thus far is summarized in (12).

(12) <u>Ranking Summary</u>



2.1.4. Non-copying to other cluster-initial roots

This C_1-copying pattern is blocked for cluster-initial roots *not* of the shape *stop-sonorant*:

(13) <u>Non-copying perfects (repeated from (5))</u>

a. **Roots with other initial clusters**

Root	Perfect Tense		
kten- 'kill'	ἔκτονα	[<u>e</u>-kton-]	not **[<u>ke</u>-kton-]
pseud- 'lie'	ἔψευσμαι	[<u>e</u>-pseus-]	not **[<u>pe</u>-pseus-]
stel- 'prepare'	ἔσταλκα	[<u>e</u>-stal-]	not **[<u>se</u>-stal-]
smε̄k^h- 'wipe'	ἐσμηγμένος	[<u>e</u>-smε̄g-]	not **[<u>se</u>-smε̄g-]

b. **Roots with initial geminates**

Root	Perfect Tense		
rreu- 'flow'	ἐρρύηκα	[<u>e</u>-rru-]	not **[<u>re</u>-rru-]
sseu- 'hasten'	ἔσσυμαι	[<u>e</u>-ssu-]	not **[<u>se</u>-ssu-]

There are many avenues we might pursue in accounting for these facts (see the end of this sub-section for discussion of a few alternatives). Here I follow Zukoff's (2015a) proposal regarding the motivation for differential treatment of different cluster types in reduplication, namely that there is a dispreference for the surface sequence which would result from C_1-copying to certain types of cluster-initial roots. C_1-copying results in a sequence of repeated consonants separated only by a short vowel. Sequences of repeated consonants are dispreferred cross-linguistically (cf. Walter 2007, Graff & Jaeger 2009, among others). Zukoff shows that the types of clusters which display non-copying in Ancient Greek (and other non-default behaviors in the reduplicative systems of related

[13] We currently have evidence only that one of ONSET or RM(RED) dominates ALIGN-/e/.

languages) are unified by their absence of robust phonetic cues to root-C_1. Put another way, consonant repetitions are dispreferred if one (or both) of the copies appears in a context where robust phonetic cues are lacking. Different combinations of phonetic cues license different sets of consonant repetitions. Avoidance strategies targeting these different sets are borne out in the reduplicative systems of a number of other ancient Indo-European languages, including Sanskrit, Gothic, and Latin. Similar effects are found outside of reduplication in these languages, as well (Zukoff 2015b).

While a fuller exposition of the proposal must be foregone here for reasons of space, the basic facts of Ancient Greek can be captured by positing the anti-repetition constraint in (14), which militates against the repetition of consonants in pre-obstruent position.[14] This comports with the phonetic fact that robust cues such as *steep intensity rise* and *consonant-to-sonorant transitions* are absent in this context (cf. Wright 2004).

(14) $*C_\alpha VC_\alpha$ / _[-son] :

Assign a violation * to any sequence of identical consonants separated by a vowel ($C_\alpha VC_\alpha$) which immediately precedes an obstruent.

This anti-repetition constraint penalizes C_1-copying candidates for roots with initial *consonant-obstruent* clusters, such as (15)b. When ranked above ONSET and RM(RED), this constraint rules out the default pattern in favor of the non-copying candidate (15)a. Besides non-copying, tableau (15) shows two additional ways of avoiding the problematic repetition: copying the entire root-initial cluster (candidate (15)c), and copying root-C_2 (candidate (15)d). Since these are not the preferred solutions to the $*C_\alpha VC_\alpha$ / _[-son] problem, this shows that *CC and ANCHOR-L-BR must outrank ONSET and RM(RED).

(15) Non-copying perfects: √*ktēn-* → ἔκτονα [e-kton-a] 'I have killed'

/RED, e, kton-/	$*C_\alpha VC_\alpha$ /_[-son]	ANCHOR-L-BR	*CC	ONSET	RM(RED)
a. ☞ _-e-kton-			*	*	*
b. k-e-kton-	*!		*		
c. kt-e-kton-			**!		
d. t-e-kton-		*!	*		

[14] The only non-copying cluster type that this constraint will not cover is *s-nasal*; e.g. √*smēkʰ* → perfect ἐσμηγμένος [esmēg-] not **[sesmēg-]. (Roots of the shape *s* + *sonorant* are very infrequent in Ancient Greek due to prior sound change. No other such clusters attest perfects.) To ban this configuration, we will need one additional anti-repetition constraint:

(i) $*S_\alpha VS_\alpha$ / _C: Assign a violation * to any *s-vowel-s* sequence which immediately precedes a consonant.

Notice that this constraint will assign violations also to the *SVST* sequences, which are additionally penalized by the constraint in (14).

In order to select the non-copying candidate (15)a over the C_2-copying candidate, (15)d's ANCHOR-L-BR violation must be fatal. If it were the case that (15)a also suffered from an ANCHOR violation, (15)d would be selected, as it avoids the ONSET and RM(RED) violations. Therefore, it is necessary that a candidate like (15)a does not violate ANCHOR. This informs both the analysis of the fixed [e] and the abstract phonological representation of the non-copying form. If we had pursued a *phonological* fixed segmentism analysis of the [e] vowel, (15)a necessarily would violate ANCHOR, since its leftmost reduplicant segment ([e]) would be in correspondence with a segment not at the left edge of the base (i.e. the root vowel). Therefore, the [e] must indeed be analyzed morphologically.

But the ANCHOR question does remain even under the current morphological analysis, since it is conceivable that an empty reduplicant is still evaluated for ANCHOR-L-BR. Yet, the notion that this candidate violates RM(RED) requires that there is, in a deep sense, *no reduplicant* in the output. Without a reduplicant, there is nothing to instantiate the "R" in the BR-correspondence relation.[15] This implies that BR-faithfulness constraints are *vacuously satisfied* when no reduplicative copying takes place, as the string(s) necessary to establish the correspondence relation is undefined.[16] By this reasoning, (15)a vacuously satisfies ANCHOR-L-BR and is selected as the winner under the ranking shown in (15), schematized in the Hasse diagram in (16).

(16) <u>Ranking:</u> $*C_\alpha VC_\alpha$ / _[son]   ANCHOR-L-BR   *CC

{ONSET, RM(RED)}

ALIGN-/e/-L

The anti-repetition constraint cannot explain the behavior of the geminate-initial roots in (13)b, because geminates are not clusters, *per se*. Instead, the answer here lies in Base-Reduplicant faithfulness. A high-ranking constraint demanding identity for consonant length between base and reduplicant (IDENT[long]-C-BR[17]) would prevent copying a root-initial geminate as a reduplicant singleton. Initial geminates are disallowed, as evidenced by the initial degemination observed for these roots in isolation: e.g., /sseu-/ → [seu-] (*#Cː » IDENT[long]-C-IO). These two factors interact to make any sort of copying impossible for these roots.

[15] Consult McCarthy & Prince (1995) for definition and discussion of Correspondence and the relevant Correspondence constraints.

[16] We could also consider a candidate which is surface-identical to (15)a, but which phonologically *does* have a "reduplicant" in the output, just one which lacks any substantive content. This candidate would satisfy RM(RED), instantiating the BR-correspondence relation. This triggers evaluation of the BR-faithfulness constraints, and thus induces violation of ANCHOR-L-BR. Since ANCHOR » RM(RED), this candidate will always be inferior to the one which leaves the reduplicant phonologically unrealized.

[17] This constraint must be limited to consonant length, because base-reduplicant alternations in vowel length are present in Attic Reduplication forms.

(17) Non-copying perfects: √*sseu-* → ἔσσυμαι [e-ssu-mai] 'I have hastened'

/RED, e, ssu-/	*#C:	IDENT[long]-C-BR	IDENT[long]-C-IO	ONSET	RM(RED)
a. ☞ _-e-ssu-				*	*
b. ss-e-ssu-		*!			
c. s-e-ssu-	*!				
d. s-e-su-			*!		

While I have pursued an analysis of the non-copying pattern based on anti-repetition constraints, there are a number of other approaches to these facts which have previously been proposed. Several of these derive the distinction through differences in syllabification. If *stop-sonorant* clusters formed complex onsets but other clusters were heterosyllabic (Steriade 1982, 1988, Devine & Stephens 1994), we could ascribe the distribution to a ban on copying root-initial consonants which were syllabified as codas. This could be effected within the current analysis by a markedness constraint that penalizes identical consonants within the same syllable (as proposed in Zukoff 2014). However, recent work (Steriade 2015; cf. Saussure 1884) demonstrates that the weight-sensitive phonological processes of Ancient Greek treated all (word-internal) cluster types identically. Assuming that prosodic weight is determined by syllabic constituency, this indicates that all cluster types had equivalent syllabification (see also Hermann 1923).[18] This casts doubt on a syllable-based analysis of the reduplication facts.

Fleischhacker (2005) proposes an analysis of these facts – along with similar cluster-dependent reduplication patterns in Sanskrit, Gothic, and elsewhere – within a theory of similarity-based cluster reduction. Fleischhacker's analysis does not rely on syllabification, so it is not contingent on the answers to these questions of syllabification. Fleischhacker, however, presents no analysis of the behavior of vowel-initial roots, including the Attic Reduplication pattern. While her system may be capable of handling these facts to the same extent as the one proposed here, it is unclear whether it can be extended to capture the "Pre-Attic Reduplication" pattern that will be discussed in Section 3. Her analysis may likewise be insufficient to capture the full range of data in the similar systems of closely related Indo-European languages (cf. Zukoff 2015a). I leave a fuller comparison of the two systems as a direction for further inquiry.

2.2. Vowel-lengthening perfects

The productive pattern for perfect-stem formation for vowel-initial roots is lengthening of the root-initial vowel. Some examples of this pattern are given in (18).

[18] Recent studies of Indo-European syllabification (Byrd 2010, 2015, Cooper 2012, 2014) reach similar conclusions.

(18) Vowel-lengthening perfects (forms from Smyth 1920[1984]:147,Schwyzer 1939:650)

Root	Present Tense	Perfect Tense
onoma- 'name, call'	ὀνομάζω [onoma-]	ὠνόμακα [ɔ̄noma-]
ort^ho- 'set upright'	ὀρθόω [ort^ho-]	ὤρθωκα [ɔ̄rt^ho-]
et^hel- 'wish'	ἐθέλω [et^hel-]	ἠθέληκα [ɛ̄t^hel-]
elpid- 'hope'	ἐλπίζω [elpizd-]	ἤλπικα [ɛ̄lpi-]
aŋgel- 'announce'	ἀγγέλλω [aŋgel-]	ᾱγγελκα [āŋgel-]
ag- 'lead'	ἄγω [ag-]	ᾱγμαι [āg-]

The grammar developed thus far is consistent with V-initial roots forming their perfects through vowel-lengthening. The length derives from the underlying mora contributed by the fixed segment affix /e/. The output long vowel is the result of coalescence of the root-initial vowel with the fixed /e/. This analysis requires that the constraint militating against coalescence, UNIFORMITY-IO (McCarthy & Prince 1995:123), is not highly-ranked. There is independent evidence for this, as Ancient Greek has an extensive process of mora-preserving "vowel contraction" (cf. Smyth 1920 [1984]:20-21, de Haas 1988). To generate vowel coalescence/contraction, we can employ the ranking in (19), which is illustrated in (20). The activity of MAX-μ-IO selects candidate (20)d over (20)c, but there is no evidence for its relative ranking.

(19) Ranking: MAX-IO » ONSET » UNIFORMITY-IO[19]

(20) Vowel contraction: /…Ce-o…/ → […Cō…]

/…Ce₁-o₂…/	MAX-IO	ONSET	UNIFORMITY-IO	MAX-μ-IO
a. …Ce_1-o_2…		*!		
b. …Co_2…	*!			*
c. …$Co_{1,2}$…			*	*!
d. ☞ …$C\bar{o}_{1,2}$…			*	

Vowel-lengthening in the perfect, as well as the vowel-lengthening that occurs in the affixation of the past tense indicative "augment" prefix (cf. Smyth 1920 [1984]:145-146), which is also underlyingly /e/, results in coalescence outputs different than those generally found in vowel contraction. For vowel-lengthening perfects and augmented forms, coalescence of /e/ + /e,o/ generally produces *lax* [ɛ̄,ɔ̄] (orthographic < η, ω >)[20]; yet, in vowel contraction, coalescence produces *tense* [ē,ō] (orthographic < ει, ου >). These distributions are straightforward when viewed from the diachronic perspective, as the

[19] The ranking of MAX-IO over ONSET follows from transitivity relative to *CC (cf. (12) and (16)).

[20] There is some variation on this point, with some vowel-lengthening perfects and augmented forms attesting the contraction outputs [ē,ō].

lengthening pattern arises in a period of Greek prior to the first appearance of the tense long mid vowels.[21]

When the vowel contraction facts are integrated with the evidence from consonant-initial reduplication, we derive the vowel-lengthening forms, subject to one adjustment to the ranking. In the preceding discussion, there was no way to disambiguate ONSET violations from RM(RED) violations. This is because properly-anchored copying always alleviated the ONSET violation that would be incurred by leaving the fixed /e/ without an onset consonant. However, in the case of V-initial roots, properly-anchored copying itself induces a new ONSET violation, since the leftmost copied element will be a vowel in word-initial position. Inspection of the ranking under these circumstances reveals that RM(RED) must in fact be ranked below ALIGN-/e/-L, while ONSET remains relatively highly-ranked.

(21) <u>Vowel-lengthening perfects</u>: √*ag*- → ᾱγμαι [āg-mai] 'I have (been) led'

/RED, e_1, a_2g-/	ANCHOR-L-BR	ONSET	ALIGN-/e/-L	RM (RED)	UNIFORMITY
a. <u>a</u>.-e_1.-a_2g-		**!*	*		
b. ☞ _-$ā_{1,2}$g-		*		*	*
c. <u>ag</u>-$ā_{1,2}$g-		*	*!*		*
d. <u>g</u>-$ā_{1,2}$g-	*!		*		*

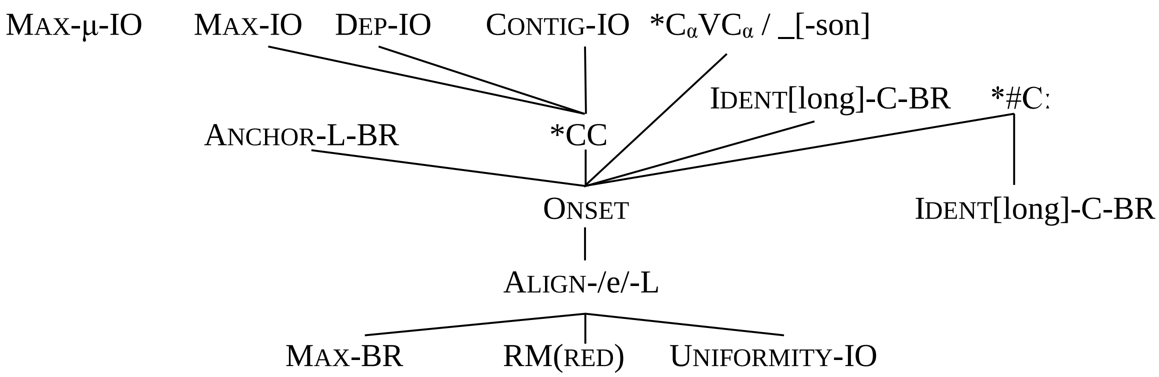
Due to the high-ranking of MAX-IO and MAX-μ-IO (omitted for reasons of space), candidates which delete a vowel, e.g. [g-e_1-g-], or coalesce as a short vowel, e.g. [_-$a_{1,2}$g-], are suboptimal. ONSET eliminates all candidates which display hiatus, here represented by candidate (21)a. Since ANCHOR » ONSET, the word-initial ONSET violation cannot be avoided, as in candidate (21)d. Only two candidates avoid hiatus and improper anchoring: the vowel-lengthening candidate (21)b [_-$ā_{1,2}$g-], and candidate (21)c [<u>ag</u>-$ā_{1,2}$g-], which is the potential output corresponding to the Attic Reduplication pattern. Both candidates receive a single ONSET violation. Candidate (21)b's violation is for the coalesced fixed /e/ + root /a/. Candidate (21)c, on the other hand, repaired that particular ONSET violation by copying both the root-initial vowel and the root-second consonant, which serves as the onset for the coalesced vowel. The two candidates thus have equivalent violation profiles, but from different loci of violation. The choice comes down to the relative ranking of ALIGN-/e/-L and RM(RED). When the resolution of an ONSET violation is not at stake, the system prefers to leave the RED morpheme unrealized than to displace the /e/ from the left edge, selecting the vowel-lengthening candidate (21)b. Nonetheless, that the Attic Reduplication candidate survives this deep into the evaluation will serve as the starting point for an explanation of the Attic Reduplication pattern's survival in the language.

[21] Once the tense vowels become the normal result of contraction, the lax vowels of the perfect must be relegated to irregular morphophonology. This can be represented by a markedness constraint specific to the perfect that bans tense long mid vowels: $*[ē,ō]_{\text{PERF}}$ (cf., e.g., Pater 2009 on constraint indexation). A higher-ranked IDENT constraint would protect *underlying* tense long mid vowels. Therefore $*[ē,ō]_{\text{PERF}}$ would only prohibit [ē,ō] from arising in the course of derivation, such as in perfect-tense vowel-lengthening.

2.3. Interim Summary

This section has developed a grammar that generates the productive distribution of stem-formation patterns in the Ancient Greek perfect tense, both overtly reduplicative – as in the case of C_1-copying – and non-reduplicative – as in the "non-copying" pattern for C-initial roots and the basic vowel-lengthening pattern for V-initial roots. For C-initial roots, C_1-copying is the preferred pattern, applying to roots with an initial singleton consonant or an initial *stop-sonorant* cluster. This pattern is blocked for roots with other types of initial clusters by markedness constraints disfavoring consonant-repetitions in certain environments, namely in pre-obstruent position. It is also blocked for roots with initial geminates by constraints on consonant length. To avoid such violations, copying is eschewed altogether for these roots. The same strategy is ultimately employed for V-initial roots. Since, in such cases, it is impossible to completely alleviate ONSET violations without deletion or improper anchoring, the minimal reduplicant shape, i.e. null, is preferred, despite the violation of RM(RED). The total ranking of the constraints posited in Section 2 is summarized in (22).

(22) <u>Total ranking for Ancient Greek reduplication</u>



The constraint set and ranking thus far motivated leaves Attic Reduplication, the alternative pattern for V-initial roots, completely unexplained. Why should this complicated pattern exist at all, and how could it subsist in a grammar that generates a simpler a pattern? Section 3 will bring to bear insights from historical and comparative linguistics to establish a phonologically-motivated origin for the pattern in a prior stage of the language. Section 4 will track the development from this prior stage into attested Ancient Greek, and propose that the pattern can actually be straightforwardly generated by the introduction of single additional constraint.

3. Attic Reduplication

In investigating the productive reduplicative behavior of vowel-initial roots in the synchronic grammar of attested Ancient Greek, we saw that there is no obvious synchronic motivation for the presence of the Attic Reduplication pattern. Given that it also has a very restricted distribution, the best explanation is that it is a retained archaism. This section shows that the origin of this archaic pattern can be generated directly in the phonology of an earlier stage of the language.

3.1. Attic Reduplication and the laryngeals

Within the synchronic grammar of Ancient Greek, there are no obvious phonological properties which distinguish the V-initial roots that exhibit Attic Reduplication (AR) from the V-initial roots that exhibit vowel-lengthening. However, there is a clear distinction when we consider their etymologies. Virtually all of the roots which display AR can be reconstructed as having an initial laryngeal consonant in Proto-Indo-European (PIE) (see the reconstructions and evidence in *LIV*²).[22] This connection between AR and the laryngeals has long been recognized (Kuryłowicz 1927, Winter 1950:368-9, Beekes 1969:113-26, Suzuki 1994, Sihler 1995:489, Keydana 2006:90-1, 2012:107-8).[23]

(23) <u>Some Attic Reduplication perfects and likely etymologies</u>[24]

Root (Greek < *PIE)		Present Tense		Perfect Tense	
*#*h₁*					
*(en-)eŋk < *h₁nek̂*	'bring'	n/a		ἐνήνοχα	[enε̄nokʰ-]
*eleutʰ < *h₁lewdʰ*	'go, come'	n/a		ἐλήλουθα	[elε̄loutʰ-]
*#*h₂*					
*ager < *h₂ger*	'gather together'	ἀγείρω	[agē̆r-]	ἀγᾱγερμαι	[agāger-]
*ar < *h₂er*	'join, fit together'	ἀραρίσκω	[arar-]	ἄρᾱρα	[arār-]
*#*h₃*					
*od < *h₃ed*	'smell'	ὄζω	[ozd-]	ὄδωδα	[odɔ̄d-]
*or < *h₃er*	'incite'	ὄρνυμι	[or-]	ὄρωρα	[orɔ̄r-]

The laryngeals are a set of consonants reconstructed for PIE based on internal and comparative evidence (Saussure 1879).[25] They are partially attested in the Anatolian languages, but have been lost in all other Indo-European branches. Their exact phonetic characteristics are unknown, but they are generally identified as fricatives with constriction in the rear of the vocal tract. The most commonly recognized phonemic inventory of PIE includes three laryngeals (which will be represented in this paper as h_1, h_2, and h_3, respectively, H collectively), based in large part on the "triple reflex" in Greek. As

[22] Only two of at least 20 AR roots, are definitively not laryngeal-initial, and both are structurally similar (or, in the case of √*or* 'keep watch', identical) to roots which are historically laryngeal initial.
[23] Cowgill (1965:153) takes the opposing view: "It seems also that the Attic Reduplication in Greek perfects must have started from roots which had a prothetic vowel of *nonlaryngeal origin*" (my emphasis).
[24] See Appendix for additional forms.
[25] For an introduction to laryngeal theory, consult, e.g., Byrd (forthcoming), Fortson (2010:62-4,81-3), Mayrhofer (1986:121-145). For further discussion of laryngeal behavior in Greek, cf. Cowgill (1965), Beekes (1969), Rix (1992:68–76), among others.

represented in (24), in each of several environments where we can reconstruct a laryngeal, each of the three different (non-high) vowel qualities are found in Greek.

(24) Laryngeal outcomes in Greek

	Laryngeal Contexts		
	Vocalization *H / {C,#}_C	Coloration *He / #_	Coloration and Lengthening *eH / _{C,#}
h_1	e	e	ɛ̄
h_2	a	a	ā ~ ɛ̄ [26]
h_3	o	o	ɔ̄

We find exactly this triple reflex in the Attic Reduplication forms. Of the approximately 20 vowel-initial roots which have AR perfects, none have an initial high-vowel; all begin in [e,a,o], the outcomes of laryngeals in word-initial position ("vocalization"/"coloration"). The long vowels of the second syllables of the AR forms are limited to [ɛ̄,ā,ɔ̄], the outcomes of tautosyllabic *-eH-* sequences ("coloration and lengthening"). The vowels associated with the AR pattern are thus exactly those vowels associated with laryngeal reflexes. When coupled with comparative etymological evidence for initial laryngeals in these roots, it is safe to assert a connection between Attic Reduplication and laryngeals.

Prior to Proto-Greek (the stage reconstructible based on comparison of the Greek dialects), the laryngeals were lost, leaving only indirect effects such as those listed above. In order to bring the laryngeals to bear on Attic Reduplication, therefore, the origin of the pattern must be localized in a stage of Greek that precedes their loss. Since evidence of this stage comes from internal reconstruction of Common Greek or Proto-Greek, this stage will be identified as "Pre-Greek". I proceed under the conservative assumption that, in the absence of evidence to the contrary, the reduplicative grammar of Pre-Greek is minimally different from the directly observable grammar of Ancient Greek.[27]

3.2. Previous approaches

With the connection between laryngeals and Attic Reduplication established, the null hypothesis would be that the AR pattern was generated by running the laryngeal-initial roots through the basic reduplicative grammar, as we have it still in Ancient Greek. Since the laryngeals were consonantal segments, the default C_1-copying reduplication pattern for consonantal roots would yield a pre-form of the shape $\underline{H}^i$-e-$H^iC^k(VC)$-. For a root √**h₂ger* 'gather together', this would predict the following derivation:

(25) If laryngeal roots reduplicated normally:

a. Pre-Greek input-output mapping: √$*h_2ger$ → perfect $*\underline{h}_2$-e-h_2ger-mai
b. Diachrony: Pre-Greek $*h_2eh_2germai$ > Common Greek $**\bar{a}germai$

[26] In Attic-Ionic, there is a sound change that changes /ā/ to /ɛ̄/. [ā] is attested in other dialects. See fn. 2.
[27] On the behavior of non-laryngeal cluster-initial roots in Pre-Greek, see Section 4.4 below.

The actual form, which does display the AR pattern, is ἀγᾱγερμαι [agāgermai] (Attic-Ionic ἀγήγερμαι [agēgermai]). This form is clearly incompatible with such a derivation.

To fix this problem, most accounts have asserted that roots with initial **HC* clusters exceptionally copied both elements to create a reduplicant of the shape **HCV-* (Winter 1950:368-9, Beekes 1969:113-26, Rix 1992:204-5, Keydana 2006:90-1, 2012:107-8).[28] Once the forms are fixed in such a way, they would derive correctly into Greek:

(26) Copying root-initial *HC*:

a. Pre-Greek IO mapping: √**$h_2$ger* → perfect **$\underline{h_2g}$-e-$h_2$ger-*

b. Diachrony: Pre-Greek **$h_2$ge$h_2$ger-* (> **$\underset{\circ}{h}_2$ge$h_2$ger-*) > Common Greek *agāger-*

However, these accounts rarely consider what the motivation for such exceptional behavior, i.e. copying as $\underline{C_1C_2V}$-C_1C_2V- rather than $\underline{C_1V}$-C_1C_2V-, might have been, and simply announce it as stipulation.

While some have tried to connect this cluster-copying for laryngeals to the behavior of *s-stop*-initial roots (Keydana 2012), it is demonstrably the case that such roots did indeed follow the normal C_1-copying pattern, at least among the reduplicated presents. As was pointed out already by Brugmann (1897-1916:40-1; Byrd 2010:103-4), the exact correspondence between the archaic reduplicated present forms of the PIE root √**steh_2* 'stand' in Ancient Greek ἵστημι [hi-stē-mi] (< Proto-Greek **<u>si</u>-stā-mi*) and Latin *sistō* ([<u>si</u>-st-ō]), neither of which conform to the languages' productive patterns for reduplication, requires that we reconstruct this pattern for Proto-Indo-European, and thus Pre-Greek as well. Under the assumption that reduplication operated in the same way in both present and perfect at the periods in which both were productive, and thus that evidence from the present bears on the behavior of the perfect, we can infer that **ST*-initial roots copied C_1 (i.e. *s*) in Pre-Greek. This leaves **HC*-initial roots as the only type not to follow the *CV* reduplication pattern.

But it is not necessary to stipulate that this one particular root shape should copy in an exceptional way. Appealing to the process of "laryngeal vocalization," and considering the underlying motivation behind it, provides a recourse for deriving the divergent pattern directly through constraint interaction. Once markedness constraints targeting laryngeals are integrated into the reduplicative grammar, the pre-cursor of Attic Reduplication ("Pre-AR") will emerge as the optimal resolution. This resolution yields a pre-form similar to that of the cluster-copying approaches, but with a phonological motivation for the exceptional behavior of laryngeal-initial roots. The proposed distribution of reduplicant shapes in Pre-Greek is shown in (27), slightly modified from (3) above.

[28] Suzuki (1994) also asserts an exceptional copying pattern for laryngeal-initial roots, based on a rule of "laryngeal resyllabification." Under his account, **HC* clusters employed single-consonant copy, but of C_2 rather than C_1, equivalent to what we find in Sanskrit *jāgāra* < **$\underline{g^we}$-h_1g^wor-e*, and also synchronically in Sanskrit *sT*-initial roots. This generates a pre-form in **C_2V-HC_2VC-*, but still requires "analogical" reintroduction of the initial vowel, perhaps through a sort of Base-Derivative faithfulness (though Suzuki does not use exactly those terms).

(27) Default reduplication vs. Pre-AR in Pre-Greek:

a. Default reduplication pre-forms: *$\underline{C^i}$-e-C^iC^kVC- or *$\underline{C^i}$-e-C^iC^k-

b. Attic Reduplication pre-forms: *$\underline{H^iVC^k}$-e-H^iC^kVC- or *$\underline{H^iVC^k}$-e-H^iC^k-

3.3. Vowel prothesis and laryngeal vocalization in Greek

In Ancient Greek, as well as in Armenian and Phrygian, reconstructed Proto-Indo-European word-initial *laryngeal* + *consonant* (*HC*) sequences ultimately surface as the sequence *VC* (see, e.g., Cowgill 1965, Clackson 1994). In Greek, the quality of the vowel corresponds to the quality of the laryngeal (cf. table (24)); for example, Greek ἀνήρ [anɛ̄r] 'man' < PIE *h_2nēr* (cf. Skt *nar*-). This sound change is traditionally referred to as "vowel prothesis," and can be described with the following diachronic correspondence:

(28) Vowel prothesis: PIE *#**H**CV > Ancient Greek #**V**CV (*H > V / #_CV)

Vowel prothesis, however, is really just a special case of the more general process of "laryngeal vocalization," whereby a reconstructed PIE laryngeal consonant displays a vocalic reflex in the daughter language. Laryngeal vocalization in Greek occurred when a laryngeal consonant would have occurred word-medially between consonants in a *-*VCHCV*- sequence.

(29) Examples of laryngeal vocalization in Greek

a. PIE *$h_2$en$\boldsymbol{h_1}$-mos* > Anc. Greek ἄνεμος [anemos] 'breath' (Rix 1992:71)

b. PIE *ǵen$\boldsymbol{h_1}$-tōr* > Anc. Greek γενέτωρ [genetɔ̄r] 'begetter' (Sihler 1995:99)

In terms of diachronic correspondence, the development can be stated as follows:

(30) Laryngeal vocalization: PIE *C**H**C > Ancient Greek C**V**C (*H > V / C_C)

The only difference in conditioning environment between vowel prothesis and traditional laryngeal vocalization is the preceding context: word-boundary in the first case and consonant in the second. The two contexts are unified by the fact that the laryngeal is *not adjacent to a vowel* in either case.

Requiring adjacency to a vowel would be a means of ensuring that the laryngeal consonant has transitional cues. Given that the laryngeals were on their way towards complete loss (likely by way of a gradual lenition process), it is likely that they were relatively difficult to perceive at this stage. Maximizing what phonetic cues they had would have improved the laryngeal's perceptibility, both in terms of perceiving its presence and in terms of perceiving its contrastive place. The constraint demanding that laryngeals be adjacent to vowels, which was active in the grammar of Pre-Greek, is defined in (31):

(31) H//V: Assign one violation * for each laryngeal which is not adjacent to a vowel.

This constraint describes the conditioning environment for laryngeal vocalization, but not the change itself. I will be following the view in which laryngeal vocalization is not seen as direct vocalization of the consonantal segment, but rather as epenthesis of a vowel adjacent to the laryngeal (cf. Mayrhofer 1986:138; Byrd 2010, 2011). The alternative view involving direct laryngeal vocalization is not compatible with the analysis developed in this paper, as it cannot make use of H//V, and requires an optimal output at the Pre-Greek stage which violates ONSET. This means that our previous examples have the historical derivations in (32) (the middle form is the synchronic output of the grammar which contains laryngeal vocalization as an active process).

(32) <u>Derivations of laryngeal vocalization in Greek</u>[29]

a. Pre-Greek IO mapping: */h$_2$nēr/ → *_h$_2$ənēr_
   Diachrony: Pre-Greek *_h$_2$ənēr_ > A. Greek ἀνήρ [anɛ̄r]
b. Pre-Greek IO mapping: */h$_2$enh$_1$-mos/ → *_h$_2$enh$_1$əmos_/*_h$_2$enəh$_1$mos_
   Diachrony: Pre-Greek*_h$_2$enh$_1$əmos_/*_h$_2$enəh$_1$mos_ > A. Greek ἄνεμος [anemos]
c. Pre-Greek IO mapping: */ǵenh$_1$-tōr/ → *_ǵenh$_1$ətōr_/*_ǵenəh$_1$tōr_
   Diachrony: Pre-Greek *_ǵenh$_1$ətōr_/*_ǵenəh$_1$tōr_ > A. Greek γενέτωρ [genetɔ̄r]

The synchronic mappings in Pre-Greek are generated by the ranking in (33). The ranking ONSET » CONTIG is responsible for cluster-internal epenthesis in word-initial position.

(33) <u>Ranking (Pre-Greek)</u>:

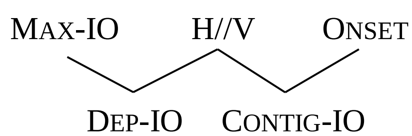


Tableau (34) illustrates how this ranking selects the cluster-internal epenthesis candidate. In this and all subsequent tableaux in this section, the candidates (in the leftmost column) are followed by the form that such a candidate would evolve into in Common Greek. If a candidate would yield the attested outcome, it is accompanied by a "✓"; if it would yield an unattested outcome, it is marked by "**". (">>" means "becomes, possibly via multiple sound changes".) I make the following two assumptions about the diachrony of laryngeals: (i) the synchronic process of laryngeal vocalization does not involve deletion of the laryngeal consonant; (ii) the sound change that eliminates laryngeals occurs after laryngeal vocalization has already run its course, leaving behind the epenthetic vowel as part of the (underlying) phonological representation.

[29] I will not attempt to adjudicate the position of the epenthetic vowel relative to the laryngeal for all cases, as it is likely to vary depending on the specific phonotactics and morphological composition of any given string. However, consistency with the proposed analysis of Pre-AR (Section 3.4) requires cluster-internal (as opposed to cluster-preceding) epenthesis in cases of word-initial *HC clusters.

(34) Laryngeal vocalization: PIE √*h_2*ger*- 'gather' > Ancient Greek ἀγερ- [ager-]

/$h_2$ger-/		H//V	MAX-IO	DEP-IO	ONSET	CONTIG-IO
a. $h_2$ger-	>> **ger-	*!				
b. ger-	>> **ger-		*!			
c. $h_2$er-	>> **ar-		*!			*
d. ☞ h_2əger-	>> ✓ager-			*		*
e. ə$h_2$ger-	>> ✓ager-			*	*!	

3.4. Generating (Pre-)Attic Reduplication in Pre-Greek

When the rankings just motivated for laryngeal vocalization are integrated with the grammar previously developed for reduplication in Ancient Greek, the grammar selects an output that will evolve into the Attic Reduplication pattern. Ultimately, the "Pre-AR" output that the Pre-Greek grammar will produce is [$\underline{h_2}$ə$\underline{g}$-e-$h_2$ger-]. This form copies both members of the root-initial cluster, with an epenthetic vowel inserted between the copied segments in the reduplicant. This divergence from the normal C_1-copying pattern emerges as a repair for two high-ranking laryngeal-related markedness constraints in the system: H//V and an anti-repetition constraint specifically targeting laryngeals.

3.4.1. Motivating the pattern

Prior to the initiation of the Pre-AR pattern (i.e. in Proto-Indo-European and early Pre-Greek), all root-shapes displayed C_1-copying, regardless of cluster type (cf. the discussion in Section 3.2, and evidence from archaisms in Greek in Section 4.4; see also Niepokuj 1997 for a general survey of Indo-European reduplication). This means that laryngeal-initial roots would have had a *CV* reduplicant (i.e. *HV*). This is likely reflected in the Vedic Sanskrit perfect stem [ānaś-] < *$h_{1/2}$*e*-$h_{1/2}$*nok̑*- (for *h_1, see Cowgill 1965:151; for *h_2, see Kümmel 2000:289), which is directly cognate with the Old Irish preterite *–ánaic*. Since neither of these forms are synchronically regular, they are evidence for *HV*- reduplication to **HC* roots in PIE. Applying this pattern to our example root √*h_2*ger*, these grammars select a candidate [$\underline{h_2}$-e-$h_2$ger-], which copies just C_1. Such a form would have derived into Common Greek as ***āger*-, which is clearly not the Attic Reduplication pattern.

What, then, changes such that [$\underline{h_2}$-e-$h_2$ger-] is no longer an acceptable output? The anti-repetition constraint $*C_\alpha VC_\alpha$ / _[-son] proposed in (14) above in order to induce the Ancient Greek non-copying pattern gives us a point of departure. This constraint encoded a dispreference for certain types of repeated consonants in certain contexts. If we posit a constraint of this nature that targets the repetition of laryngeals in the pre-consonantal context, then we have a reason why the default C_1-copying candidate would be disfavored in just this case.

(35) *$H_\alpha VH_\alpha$ / _C

Assign a violation * to any sequence of identical laryngeals separated by a vowel ($H_\alpha VH_\alpha$) which immediately precedes a consonant.

The presence in the grammar of exactly this repetition constraint likely correlates with the factors that led to laryngeal vocalization. Given that laryngeals required epenthesis of an adjacent prop vowel to license their presence, likely as a means of maximizing their phonetic cues, it is reasonable that they would be specially targeted in the repetition context, as well, if indeed repetition avoidance is sensitive to phonetic cues. Conversely, the lack of epenthesis of this sort for other consonants correlates with tolerance of their repetition.

When *$H_\alpha VH_\alpha$ / _C comes to be active in the grammar (i.e. is promoted to a position in the ranking high enough to induce repairs), the default C_1-copying pattern is prevented from surfacing, since the previously optimal C_1-copying form [h_2-e-$h_2$ger-] violates this constraint. The new form which will ultimately be chosen as optimal, [h_2əg-e-$h_2$ger-] (> Common Greek [agāger-]), satisfies *$H_\alpha VH_\alpha$ / _C, as illustrated in (36).

(36) Ruling out C_1-copying reduplication

/RED, e, $h_2$ger- /		*$H_\alpha VH_\alpha$ / _C
a. h_2-e-$h_2$ger-	> **āger-	*!
b. ☞ h_2əg-e-$h_2$ger-	> ✓agāger-	

With the C_1-copy candidate blocked, an alternative copying pattern must take over. The characteristics of this different alternative pattern (i.e. (36)b) are determined by the relative ranking of the remaining constraints, which has in large part already been determined.

3.4.2. The alternative pattern

There are a number of ways in which the *$H_\alpha VH_\alpha$ / _C problem might be avoided. Viable repairs are listed in (37); the Pre-AR form is the *reduplicant-internal epenthesis* candidate (a) [h_2əg-e-$h_2$ger-], which violates DEP-IO (+ CONTIG-BR and ALIGN-/e/-L).

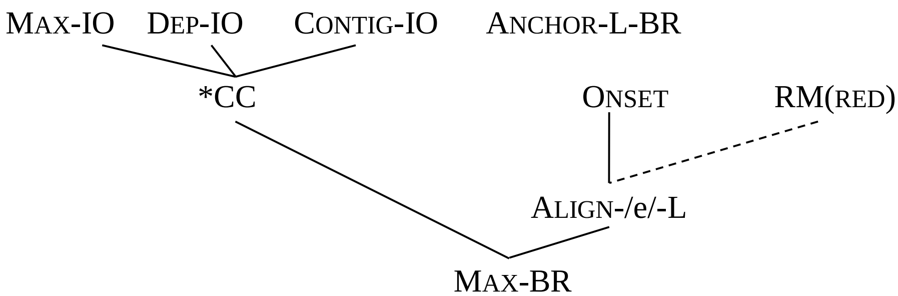
(37) Potential repairs and their associated constraints

	Repair	*Candidate output*	*Constraint(s) violated*
a.	Red-internal epenthesis:	[h_2əg-e-$h_2$ger-]	DEP-IO & CONTIG-BR
b.	Root-internal epenthesis:	[h_2e-h_2əger-]	DEP-IO & CONTIG-IO
c.	Infixation w/ copying:	[h_2e-h_2-e-ger-]	CONTIG-IO
d.	Infixation w/o copying:	[_-h_2-e-ger-]	CONTIG-IO & RM(RED)
e.	Unfilled onset:	[_-e-$h_2$ger-]	ONSET & RM(RED)
f.	Cluster-copying:	[h_2g-e-$h_2$ger-]	H//V
g.	Deletion of root-C_1:	[g-e-ger-]	MAX-IO
h.	Deletion of root-C_2:	[h_2-e-$h_2$er-]	MAX-IO & CONTIG-IO
i.	Improper anchoring:	[g-e-$h_2$ger-]	ANCHOR-L-BR

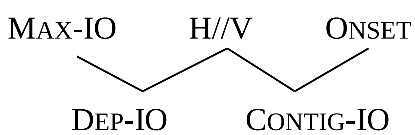
These repairs coincide with operations modulated by the constraints introduced previously in order to account for the basic reduplication pattern and for laryngeal vocalization, respectively. These rankings are repeated below in (38).

(38) Rankings

a. ***Ranking for C_1-copying reduplication*** (Section 2.1.3, ex. (12))

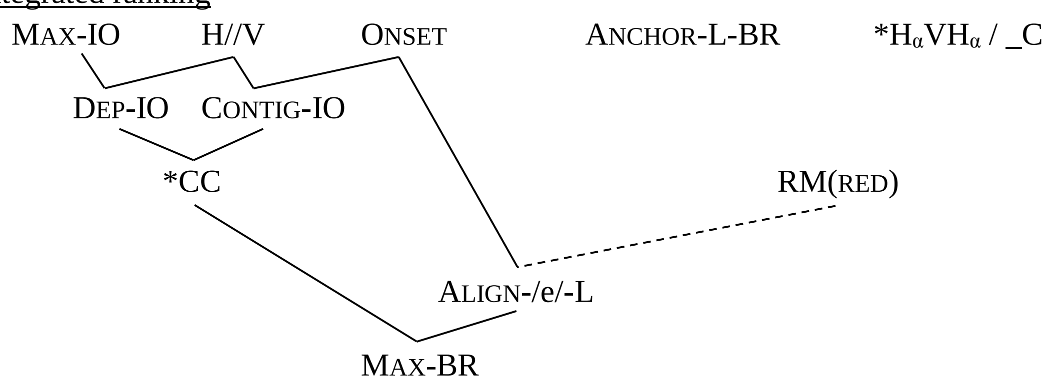


b. ***Ranking for laryngeal vocalization*** (Section 3.3, ex. (33))



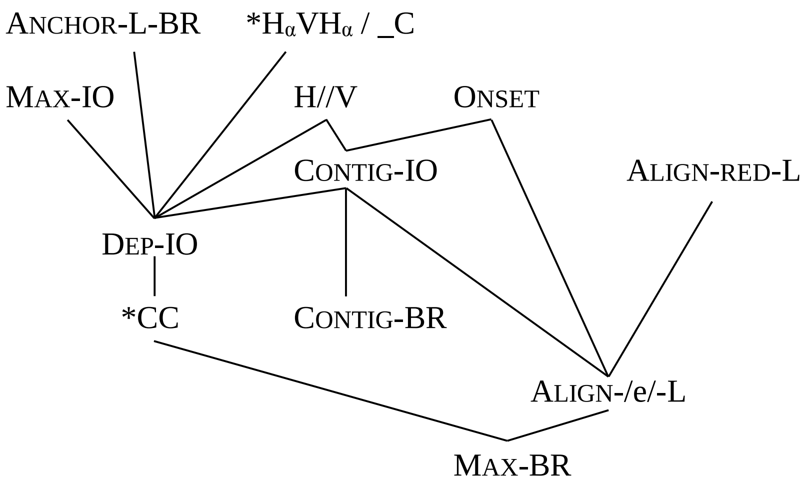
When we compare these rankings, we find that there are no ranking contradictions. The two rankings can therefore be reconciled without changing the results of either process independently. The result of integrating the two rankings without asserting any additional rankings which do not follow from transitivity – other than the addition of undominated $*H_{\alpha}VH_{\alpha}$ / _C – is shown in the Hasse diagram in (39).

(39) Integrated ranking



The critical rankings contained in (39) successfully eliminate a majority of the candidates listed in (37) (assuming the undominated constraints ANCHOR-L-BR and $*H_{\alpha}VH_{\alpha}$ / _C cannot become dominated by otherwise dominated constraints). Among the candidates not eliminated is our presumed Pre-AR candidate (37)a. However, a unique winner cannot be determined with these critical rankings alone. To select the Pre-AR candidate, all that is necessary is to fix CONTIGUITY-IO above DEP-IO, ALIGN-/e/-L, and CONTIGUITY-BR. These additional rankings are shown in the Hasse diagram in (40).[30] Tableau (41) demonstrates that these rankings properly select our desired Pre-AR candidate from among the remaining candidates.

(40) Reconciled total ranking for Pre-AR



(41) The alternative repair: cluster-copying + reduplicant internal epenthesis

/RED, e, $h_2$ger-/		CONTIG-IO	DEP-IO	ALIGN-/e/-L	CONTIG-BR
a. ☞ h_2əg-e-$h_2$ger-	> ✓agāger-		*	***	*
b. h_2-e-h_2əger-	> **āger-	*!	*	*	
c. h_2e-h_2-e-ger-	> **āger-	*!		***	
d. _-h_2-e-ger-	> **ager-	*!		*	

Before moving on, let us consider what this example in particular may be demonstrating about language change. The catalyst for grammatical reorganization (i.e. the creation of the Pre-AR pattern) is the new activity/high-ranking of markedness constraints relating to laryngeals: H//V in laryngeal vocalization; *$H_\alpha VH_\alpha$ / _C in reduplication. These processes are basically *sound changes*, and may, as proposed above, derive from the low-level phonetic changes affecting the laryngeals. When the sound change occurs, i.e. speakers "decide" that they will not violate the new markedness constraint, they are forced to impose rankings among faithfulness constraints which may not have previously interacted. This in some ways may mirror a standard assumption about phonological learning: *markedness* trumps *faithfulness*. Preliminary investigation has indicated that Biased Constraint Demotion (Prince & Tesar 2004) may be able to generate some or all of the additional critical rankings that turn (39) into (40), assuming that alignment constraints are not

[30] RM(RED) is omitted, as there is neither evidence nor need for its ranking.

afforded the bias given to standard markedness constraints. It is probable then that the AR total ranking is to some extent *pre-determined* from a learning perspective. Verifying this fully is left to later work.

Finally, the generalizations captured by the ranking in (40) are summarized in (42). A full summary tableau of the candidates from (37) is shown in (43).

(42) Generalizations and ranking arguments

a.	Laryngeals must be adjacent to a vowel:	H//V is active
b.	H//V violations are repaired by epenthesis:	H//V, MAX-IO » DEP-IO
c.	Consonant-initial roots reduplicate with C_1-copying:	ANCHOR-L-BR is active ONSET » ALIGN-/e/-L » MAX-BR
d.	This is interrupted for laryngeal-initial roots due to a dispreference for laryngeal repetitions:	$*H_\alpha VH_\alpha$ / _C is active
e.	$*H_\alpha VH_\alpha$ / _C violations are avoided by epenthesis + extra copying:	$*H_\alpha VH_\alpha$ / _C, MAX-IO, ANCHOR-L-BR, ONSET » DEP-IO, ALIGN-/e/-L
f.	Reduplicant-internal epenthesis is preferred to root-internal epenthesis:	CONTIG-IO » CONTIG-BR, ALIGN-/e/-L

(43) The alternative repair: cluster-copying + reduplicant internal epenthesis

/RED, e, $h_2$ger-/		$*H_\alpha VH_\alpha$ / _C	ANCHOR-L-BR	MAX-IO	H//V	ONSET	CONTIG-IO	DEP-IO	ALIGN-/e/-L	CONTIG-BR
a. ☞ $\underline{\text{h}_2\text{əg}}$-e-h$_2$ger-	> ✓agāger-							*	***	*
b. $\underline{\text{h}_2}$-e-h$_2$əger-	> **āger-						*!	*	*	
c. $\underline{\text{h}_2\text{e}}$-h$_2$-e-ger-	> **āger-						*!		**	
d. _-h$_2$-e-ger-	> **ager-						*!		*	
e. _-e-h$_2$ger-	> **āger-					*!				
f. $\underline{\text{h}_2\text{g}}$-e-h$_2$ger-	> **gāger-				*!				**	
g. $\underline{\text{g}}$-e-ger-	> **geger-			*!					*	
h. $\underline{\text{h}_2}$-e-h$_2$er-	> **ār-			*!			*		*	
i. $\underline{\text{g}}$-e-h$_2$ger-	> **gāger-		*!						*	
j. $\underline{\text{h}_2}$-e-h$_2$ger-	> **āger-	*!							*	

3.5. Attic Reduplication for **HeC* roots

While the solution proposed above derives the Pre-AR pattern for roots of the shape **HCeC* without problem, there is a complication that arises for **HeC* roots with respect to the operation of ablaut.[31] The expected ablaut grade for the perfect active singular is the "*o*-grade." Therefore, for an **HeC* root like √**$h_1$ed* 'eat' (> Ancient Greek √*ed* 'eat'), the root allomorph which should be entered into the derivation (for the perfect active singular) is /$h_1$od/. Since the normal pattern for reduplication is C_1-copying, the default candidate for this allomorph would be [$\underline{h_1}$-e-$h_1$od-]. In this output, the laryngeal is intervocalic, and thus not in violation of *$H_\alpha VH_\alpha$ / _C or H//V. Therefore, there would be nothing to rule out this candidate, and it should be chosen as the winner. A Pre-Greek form *$\underline{h_1}$-e-$h_1$od-* would yield Ancient Greek ***ɔ̄d-*, which is not the attested perfect stem for this root; instead we have a perfect stem *edɛ̄d-* which shows Attic Reduplication. While the *ɔ̄*-outcome is not attested for this particular root, it is seen in the lexicalized perfect stem ἄνωγα [an-ɔ̄g-a] 'I command',[32] which is typically identified as belonging to the PIE root √**h_2eǵ* 'say' (*LIV*^{2}:256) (the *an* sequence is the preverb *an(a)-* 'up, on, upon'): Pre-Greek **an(a)-*$\underline{h_2}$*-e-*h_2*og-* > Ancient Greek *anɔ̄g-*. Thus, the system developed to account for reduplication in Pre-Greek properly accounts for *o*-grade perfects of Pre-Greek **HeC* roots. This means that the Pre-AR pattern in **HeC* roots cannot come from the *o*-grade.

In order to generate Pre-AR to the **HeC* roots that display it, we must instead start with a formation which takes "zero-grade" ablaut. For √**$h_1$ed*, the best and oldest attested perfect form is the participle ἐδηδώς [edɛ̄d-ɔ̄s]. Since the participle is indeed a zero-grade formation, the input would be: /RED, e, h_1d, wōs/. Plugging in the default C_1-copying candidate, we do encounter our *$H_\alpha VH_\alpha$ / _C violation: [**$\underline{h_1}$-e-h_1d**-wōs]. This leads us down the same road as with the **HCeC* roots, ultimately choosing a candidate [$\underline{h_1 ə d}$-e-h_1d-wōs], which directly yields the attested AR form ἐδηδώς [edɛ̄d-ɔ̄s]. Therefore, while AR should not arise on *e*-grade or *o*-grade formations for **HeC* roots, it should arise in zero-grade formations, which include all categories in the perfect other than the active singular.

This predicts that, for a time, **HeC* roots would have had normal C_1-copying reduplication in *e/o*-grade categories, as is reflected in *anɔ̄g-* (< **an(a)-*$\underline{h_2}$*-e-*h_2*og-*), but Pre-AR reduplication in zero-grade categories, as is reflected in *edɛ̄d-* (< *$\underline{h_1 ə d}$*-e-*h_1*d-*). As ablaut distinctions collapsed, and as the transparency of the relationship between the two reduplicative allomorphs was eroded by the loss of the laryngeals, speakers could have easily generalized one or the other of the stem forms throughout the perfect paradigm.

3.6. Interim conclusions

In this section, we have seen how the phonological properties of the laryngeals, likely deriving from the weakness of their phonetic cues, had major effects on Pre-Greek. In the general case, laryngeals required epenthesis of a prop vowel when not otherwise vowel-adjacent (i.e. laryngeal vocalization). In reduplication, the desire to avoid the local repetition of laryngeals in pre-consonantal position made it impossible for laryngeal-initial

[31] For an introduction to Indo-European ablaut, see, e.g., Mayrhofer 1986, Fortson 2010.
[32] Thank you to an anonymous reviewer for pointing out the relevance of this form.

roots to reduplicate according to the default C_1-copying pattern of the language. This led to the precursor of the Attic Reduplication pattern of attested Ancient Greek. The constraint ranking needed to generate this pattern, which ultimately selects cluster copying and reduplicant-internal epenthesis as the optimal alternative reduplication pattern, is in large part independently motivated by the default C_1-copying reduplication pattern and laryngeal vocalization. The independent activity of these two parts of the grammar may have, in a certain sense, pre-destined this particular resolution of the laryngeal markedness problem. The Pre-AR pattern, generated productively and transparently in Pre-Greek, is maintained in Ancient Greek as Attic Reduplication. In the following section, we will consider how this pattern came to persist into Ancient Greek despite the loss of its original conditioning factors.

4. Attic Reduplication in the synchronic grammar of Ancient Greek

4.1. Compositionality in Greek reduplication

The synchronic analysis of Attic Reduplication presented above hinges crucially on the presence of laryngeals in the phonemic/phonetic inventory. However, the AR forms clearly survive beyond the period at which laryngeals are lost from the inventory (or else we would have no trace of the pattern). If the perfects built to these roots had been productively generated throughout their history, they would have fallen together with the outcomes of other V-initial roots[33] – and thus come to display vowel-lengthening (cf. Section 2.2) – rather than retaining AR. The retention of AR thus requires special explanation.

The simplest account would be that AR forms are retained as non-compositional listed allomorphs to particular roots. However, there is clear evidence for compositionality in reduplication in Greek. The best such evidence comes from the treatment of reconstructed root-initial labiovelar consonants in the unproductive reduplicated present.

While Ancient Greek productively/obligatorily displays reduplication only in the perfect tense, it does show remnants of reduplicative processes in its two other tense-stems: the present and the aorist.[34] In Proto-Indo-European and Pre-Greek, we can reconstruct reduplication of a form virtually identical to that of the perfect (*Ci*- in the present, *Ce*- in the aorist) that was used as an optional derivational process of stem-formation in these two tense categories. By the time of attested Ancient Greek, it appears that new forms could not be generated in this way; but many relics remain (particularly in the present). The unproductiveness of present reduplication gives us a window into the nature of reduplication in the system, vis-à-vis its interaction with sound change.

PIE contained a series of consonants reconstructed as labiovelar stops. These sounds are retained as such in Mycenaean, the earliest attested dialect of Greek.

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[33] Note that there were no (or extremely few) vowel-initial roots in Proto-Indo-European (cf. *LIV*[2]). They come about in Greek (and elsewhere) due primarily to loss of certain consonants in initial position, namely the laryngeals, glides, and *s*. Chronologically, the laryngeals are lost first. Therefore, there is no pre-existing pattern for vowel-initial roots in the perfect.

[34] See Van de Laar (2000) for a catalog of Greek verbal forms; see Giannakis (1992) for a study of the reduplicated presents in Greek

Subsequently, they undergo a series of conditioned partial mergers with the other stop series (see, e.g., Schwyzer 1939:293-296, Rix 1992, Sihler 1995), and have completely merged with the other stops by the period of Common Greek. The laryngeals have already been lost by the Mycenaean period. Therefore, any process relating to the conditioned outcomes of the labiovelars necessarily post-dates any processes affecting the laryngeals.

Of interest here are two particular outcomes of the labiovelars: labiovelars became coronals before a front vowel (/e,i/), but, for the most part, they became labials elsewhere. When a root-initial labiovelar entered into reduplication, the possibility arose that the copied consonant and the root-initial consonant might surface in contexts which would condition different outcomes. Specifically, the reduplicated consonant would be in the palatalizing context even if the root-initial consonant was in the default (i.e. labializing) context. If such a form surfaces in Greek with a dental in the reduplicant but a labial in the root, we would know that the form was "frozen" prior to the application of the labiovelar sound changes. If, on the other hand, the reduplicant consonant matches the outcome in the root, we can surmise that the form was generated compositionally posterior to the application of the sound change. Since we know that reduplication is fully productive in the perfect, perfect forms would all be expected to display the latter behavior (and they do); this question will therefore only be probative when asked about reduplication in the present or the aorist.

The root √$*g^{w}er(h_{3})$ 'eat' gives us exactly the desired test case. This root has a reduplicated present, which takes the form βιβρώσκω [$\underline{\text{b}}$-i-brō-sk-ō], not **διβρώσκω **[$\underline{\text{d}}$-i-brō-sk-ō], which would be the outcome predicted by regular sound change (as if from $*\underline{g^{w}}\text{-}i\text{-}g^{w}r(e)h_{3}\text{-}sk\text{-}\bar{o}$). The fact that such forms do not show the outcomes of regular sound change demonstrates that they were subject to compositional production past the stage at which the labiovelars changed (Schwyzer 1939:649). That is to say, if they had come to be stored non-compositionally, BR-identity would not have protected the copied consonant from undergoing the expected sound change. If the unproductive reduplicated presents were being generated compositionally at this stage, it seems extremely likely that all *perfect* forms – including Attic Reduplication perfects – were being generated compositionally as well, since reduplication was fully productive in the perfect tense well beyond that point. This strongly indicates that AR forms are being generated compositionally past the point at which the laryngeals are lost. This should lead us to eschew the non-compositional analysis, and explore an analysis in which the AR pattern is generated in the phonology. This section develops such an account.

4.2. Attic Reduplication and REALIZE MORPHEME

As discussed in Section 2.2, the productive perfect-stem formation pattern for vowel-initial roots in Ancient Greek is initial-vowel lengthening, e.g. *present* ἀγγέλλω [aŋgell-ō] 'I announce' → Common Greek *perfect* ᾱγγέλκα [āŋgel-ka]. Some roots that originally had laryngeals do indeed follow this pattern, e.g., *present* ἄγω [ag-ō] (< PIE $*h_{2}e\acute{g}\text{-}\bar{o}$) 'I lead' → Common Greek *perfect* ᾱγμαι [āg-mai]. Left un-amended, the grammar we have reconstructed in Section 3 will cease to generate Attic Reduplication forms once laryngeals are lost, and instead will predict that they should display vowel-lengthening perfects. This is illustrated below in tableau (44), which is equivalent to tableau (21) but now showing a root which in reality does display Attic Reduplication: √*ager* (< Pre-Greek √**$h_2$ger*) → ἀγᾱγερ- [agāger-], not **ᾱγερ- [āger-].

(44) The predictions of the synchronic grammar, post laryngeal-loss

/RED, e_1, $a_2$ger-/	ANCHOR-L-BR	ONSET	ALIGN-/e/-L	RM(RED)	UNIFORMITY
a. a.-e_1.-$a_2$ger-		**!*	*		
b. 💣 _-$ā_{1,2}$ger-		*		*	*
c. ☹ ag-$ā_{1,2}$ger-		*	*!*		*
d. g-$ā_{1,2}$ger-	*!		*		*

While still superior to all other possibilities, the AR candidate (44)c loses to the vowel-lengthening candidate (44)b, due to the ranking ALIGN-/e/-L » RM(RED). The system thus prefers maximal left-edge alignment to overt realization of the reduplicative morpheme. What is necessary to generate Attic Reduplication forms is a reversal of this preference, just in the case of roots which actually display AR. This can be accomplished using a lexically-indexed constraint (see Fukuzawa 1999, Itô & Mester 1999, 2001, Kraska-Szelenk 1997, 1999, Pater 2000, 2009) that favors overt realization of the reduplicative morpheme:

(45) REALIZEMORPHEME(RED)$_{\boldsymbol{lex}}$

If a root has the index ***lex***, assign a violation * if there is an underlying RED morpheme which has no phonological content in the output.

When RM(RED)$_{\boldsymbol{lex}}$ is ranked above ALIGN-/e/-L, and all and only the AR roots come with the lexical index ***lex***, we derive the distinction between Attic Reduplication forms and vowel-lengthening forms within the synchronic grammar.[35] In tableau (46), we generate copying to a root indexed with ***lex*:** √ager$_{\boldsymbol{lex}}$ → *perf* [ag-āger-]; in tableau (47), we generate just vowel-lengthening to a root *not* indexed with ***lex*:** √ag → *perf* [_-āger-].

(46) RM(RED)$_{\boldsymbol{lex}}$ **with** lexical indexation selects Attic Reduplication

/RED, e_1, $a^{i}_{2}g^{k}er_{\boxed{lex}}$-/	RM(RED)$_{\boldsymbol{lex}}$	ONSET	ALIGN-/e/-L	RM(RED)
a. _-$ā_{1,2}$ger-	*!	*		*
b. ☞ $a^{i}g^{k}$-$ā^{i}_{1,2}g^{k}$er-		*	**	

[35] The same result could be achieved by lexically indexing the constraint ranking, such that those roots bearing the index ***lex*** were evaluated by a ranking where RM(RED) » ALIGN-/e/-L.

(47) RM(RED)$_{lex}$ **without** lexical indexation selects vowel lengthening

/RED, e$_1$, a$^i{}_2$g^k-/	RM(RED)$_{lex}$	ONSET	ALIGN-/e/-L	RM(RED)
a. ☞ _-ā$_{1,2}$g-	not applicable	*		*
b. a^{i}g^k-ā$^i{}_{1,2}$g^k-		*	*!*	

The crucial difference between the two derivations arises from the relationship between RM(RED)$_{lex}$ and ALIGN-/e/-L. When RM(RED)$_{lex}$ is not activated through the requisite indexation (as in (47)), there is nothing to differentiate the vowel-lengthening candidate (a) from the Attic Reduplication candidate (b) until ALIGN-/e/-L enters the evaluation. Since the AR candidate has extra copying, ALIGN-/e/-L selects vowel-lengthening. When RM(RED)$_{lex}$ *is* activated (as in (46)), ALIGN-/e/-L never gets to exert its force, because RM(RED)$_{lex}$ has already eliminated the vowel-lengthening candidate; this allows ONSET to adjudicate between the various copying candidates, ultimately selecting the Attic Reduplication output.

4.3. Whence lexical indexation?

Adopting the RM(RED)$_{lex}$ approach, we can begin to provide a coherent sketch of the diachronic developments of Attic Reduplication. AR first develops when laryngeal-related phonotactics induce the *cluster-copying + reduplicant-internal epenthesis* pattern for laryngeal-initial roots ("Pre-AR"): √*h$_2$ger → *perfect* *[h$_2$əg-e-h$_2$ger-]. When the laryngeals are lost, the motivation for the pattern (i.e. the application of the laryngeal-related phonotactics) is also lost; i.e. √ager → *perfect* [agāger-] lacks phonotactic motivation. Learners had two options. One option would have been to fail to learn the pattern all together, and instead re-generate the forms using the productive grammar without further modifications. This would mean a diversion to the mapping √ager → *perfect* [āger-], i.e. the vowel-lengthening pattern. This is indeed attested for some roots of laryngeal origin, e.g. √**h$_2$eǵ* 'lead' → *perfect* ᾱγμαι [āg-]. The other option was to attempt to retain the √ager → *perfect* [agāger-] mapping by hook or by crook. To do so required amending the grammar such that it included a new impetus for generating the AR mapping, namely RM(RED)$_{lex}$ coupled with lexical indexation for only those roots which originally, genuinely displayed AR.[36]

When considering why speakers might have chosen option (ii) over option (i), we could speculate about a circumstance like the following. The laryngeals would not have been lost overnight (just as no sound change occurs immediately). At some point while this change is in progress, there would have been some members of the speech community who produced laryngeals, and others who did not. For those who produced the laryngeals, they would have been able to construct the grammar with *H$_\alpha$VH$_\alpha$ / _C and H//V directly motivating AR in the relevant cases. Those without the laryngeals, on the other hand, would

[36] Those roots like √*ag* (< √**h$_2$eǵ*) which had laryngeals but do not surface in Ancient Greek with Attic Reduplication can be described as having failed to receive the lexical index, though for exactly what reason this might have happened it is unclear.

not have been able to generate the forms by means of phonotactics, but nonetheless would have been cognizant of such forms' existence due to contact with laryngeal speakers. (The AR pattern must have been quite striking, considering how divergent it is from the normal reduplication pattern.) The laryngeal-less speakers, in order to accommodate to the laryngeal speakers, would have adduced a new constraint – RM(RED)$_{\textit{\textbf{lex}}}$ – that could allow them to keep producing AR forms despite a lack of phonotactic motivation.

4.4. RM(RED)$_{\textit{\textbf{lex}}}$, reduplicated presents, and their associated perfects

Independent evidence for the activity of RM(RED)$_{\textit{\textbf{lex}}}$ can be found elsewhere in the reduplicative system. This progression from phonological productivity to lexical restriction via RM(RED)$_{\textit{\textbf{lex}}}$ can be seen to repeat itself in the development of the reduplicated presents and the perfects associated with them. As discussed briefly in Section 4.1 above, Ancient Greek possesses a relatively small set of present stems which display reduplication. As illustrated in (48), these forms basically mirror the perfect, differing only in having a fixed [i] rather than [e]. What is noteworthy, however, about the reduplicated presents relative to the perfect is the behavior of roots which begin in non–*stop-sonorant* clusters. As shown in (49), contrary to the productive pattern *for the perfect*, these roots display default C_1-copying rather than non-copying. Even more noteworthy are the perfect forms associated with these roots: these are *perfects* whose root allomorphs begin in non–*stop-sonorant* clusters, yet display default C_1-copying reduplication. That is to say, they contradict the productive pattern even though they are members of the productive category.

(48) Present reduplication (cf. Giannakis 1992)

Root	Present		Perfect	
dɔ̄- 'give'	δίδωμι	[d-i-dɔ̄-mi]	δέδωκα	[d-e-dɔ̄-ka]
t^{h}ɛ̄- 'place'	τίθημι	[t-i-t^{h}ɛ̄-mi]	τέθηκα	[t-e-t^{h}ɛ̄-ka]
p^{h}au- 'show'	πιφαύσκω	[p-i-p^{h}au-sk-ɔ̄]		n/a
teuk^{h}- 'prepare'	τιτύσκομαι	[t-i-tu-sko-mai]	τέτευχα	[t-e-teuk^{h}-a]
klɛ̄- 'call'	κικλήσκω	[k-i-klɛ̄-sk-ɔ̄]	κέκληκα	[k-e-klɛ̄-ka]

(49) Present reduplication to non-*stop-sonorant* clusters

Root	Present		Perfect	
mnɛ̄- 'remind'	μιμνήσκω	[m-i-mnɛ̄-sk-ɔ̄]	μέμνημαι	[m-e-mnɛ̄-mai]
stɛ̄- 'stand'	ἵστημι	[h-i-stɛ̄-mi] (< ****s****istɛ̄mi*)	ἕστηκα	[h-e-stɛ̄-ka] (< ****s****estɛ̄ka*)
pet- 'fall'	πίπτω	[p-i-pt-ɔ̄]	πέπτωκα	[p-e-ptɔ̄-ka]

What results is a striking gap: there are no C_1-copying perfects to roots beginning in *mn*, *st*, *pt*, etc. that do not also have a reduplicated present.[37] (One further exception *kektēmai*, will be discussed below.)[38] This gap requires explanation. RM(RED)***lex*** provides this explanation. If these roots are lexically indexed, which is necessary to generate reduplication in the present, RM(RED)***lex*** *predicts* that copying will also occur in the perfect, despite being dispreferred by the phonotactics.

First let us consider why the presents to these roots still retain the C_1-copying pattern. Since present reduplication is non-productive in Ancient Greek, it is possible to assume that the characteristics of the formation originate in an earlier period of the language, in a way similar to how we accounted for Attic Reduplication. The non-copying pattern rests upon the application of the anti-repetition constraint $*C_\alpha VC_\alpha$ / _[-son] (cf. Section 2.1.4), but we have no direct evidence that this constraint was active in Pre-Greek. (The only anti-repetition constraint whose activity is evident in Pre-Greek is the one targeting laryngeals, $*H_\alpha VH_\alpha$ / _C from (35) above, which was the impetus for Pre-AR.) If $*C_\alpha VC_\alpha$ / _[-son] was indeed not active in Pre-Greek, we predict across-the-board C_1-copying (except to laryngeal-initial roots), as suggested in Section 3.4.1. This generates Pre-Greek *pipt-* from (the zero-grade of) Pre-Greek root √*pet*.

(50) <u>Copying to non-*stop-sonorant* roots in Pre-Greek</u>: √*pet-* → *present* πίπτω [<u>p</u>-i-pt-ō]

/RED, i, pt, ō/	ONSET	DEP-IO	*CC	$*C_\alpha VC_\alpha$ / _[-son]
a. ☞ <u>p</u>-i-pt-ō			*	*
b. <u>pt</u>-i-pt-ō			**!	
c. <u>pet</u>-i-pt-ō		*!	*	
d. _-i-pt-ō	*!		*	

[37] The forms associated with the root √*pet* 'fall' appear to have contaminated forms of phonologically similar, and perhaps etymologically related, roots that have initial *p(e)t-*. Despite not having reduplicated presents of their own, the verbal systems associated with *petannūmi* 'spread out', *petomai* 'fly', and *ptēssō* 'crouch' all attest perfects in *pept…*, alongside more expected perfects in *ept…* in the first two cases (see Van de Laar 2000:246-248, 253, 259-260). An anonymous reviewer also points to a form *pepterugōmai*, from root *pterugizdō* 'flutter with wings', in a fragment of Sappho/Alcaeus.

It appears as though the lexical idiosyncrasy which is proper to the root √*pet* 'fall', due to the presence of reduplicated *piptō* in its verbal system, has come to be transferred to these other roots, such that they build C_1-copying perfects via RM(RED)***lex***. This state of affairs may have a comparandum among Attic Reduplication forms. The root √*or* 'incite' etymologically contains a laryngeal (PIE √**h₃er*), and builds an AR perfect stem *orōr-*. There is a phonologically nearly identical root in Greek √*⁽ʰ⁾or(a)* 'see, watch', which historically did not contain a laryngeal (PIE √**(s)wer* ; see Chantraine 1968:813-815, Beekes & van Beek 2010:1095-1096), yet attests Attic Reduplication forms in *orōr-* (at least dialectally). (Van de Laar 2000:235 associates this form with an entry *oromai* 'keep watch'.) It thus seems likely that the etymologically validated AR associated with √*or* 'incite' has contaminated a similar root, just like √*pet* 'fly' has done to other *pt* roots.

[38] There are perfect forms in *pep^ht^han-* to the root √*p^ht^han-* 'anticipate', but these are not attested until well after the Classical Period (Beekes & van Beek 2010:1568). In Classical and Pre-Classical Greek, this root shows the expected non-copying forms in *ep^ht^han-*.

This solution entails that the non-copying pattern is an innovation induced by the change in sensitivity to the repetition constraints. Prior to the higher ranking of $*C_\alpha VC_\alpha$ / _[-son], the non-copying perfects would have been normal C_1-copying perfects. This is supported by the existence of the perfects in (49). It is possibly also supported by the distribution of perfect forms built to the root √*kta* 'acquire'. This root has two distinct stem-formation patterns in the perfect: the expected non-copying pattern *e-ktɛ̄-*, but also the unexpected copying pattern *k̲-e-ktɛ̄-*. The expected non-copying form has the expected perfect semantics 'have acquired'. The unexpected C_1-copying perfect, however, has unexpected behavior.[39] First, it has present semantics, consistently meaning 'possess'. Second, it serves as the base of derivation for a future stem *ke-ktɛ̄-s-* 'will possess' and other modal forms, which is not typical of perfect stems. These facts indicate that the stem *ke-ktɛ̄-* became paradigmatically isolated at some point in its history. There is no reason why it should have, after becoming isolated, developed reduplication if it had previously shown non-copying. The only explanation is that the isolated stem *retained* C_1-copying reduplication (or at least the phonological string which it resulted in), and the paradigmatically regular stem changed according to the regular grammar to yield a non-copying stem. Therefore, *ke-ktɛ̄-* must be an archaism, attesting to a pre-stage at which *kt* clusters copied C_1 just like *stop-sonorant* clusters, even in the perfect.

The reason why the reduplicated presents never get remodeled, as opposed to the perfects which (except when they are associated with a reduplicated present) do get remodeled, must be due to differences in productivity between the two categories. For the perfect, reduplication is a productive marker of all forms, blocked on the surface in certain cases by phonotactics but always there "underlyingly." In present-tense stem-formation, reduplication is one of many derivational markers, and thus is never obligatory. It is completely unproductive by the time of Ancient Greek. This means that present reduplication, maybe even prior to the change in ranking of the repetition constraints, must in some way be lexically restricted, possibly indexed to RM(RED)***lex***.

Before the anti-repetition constraint $*C_\alpha VC_\alpha$ / _[-son] came to be active in the grammar, the reduplicated present forms could be productively generated as such once the proper morphemes were entered into the underlying representation, as was illustrated in (50) above. However, after $*C_\alpha VC_\alpha$ / _[-son] becomes higher-ranked (above ONSET), the proper underlying form would fail to generate any copying. Armed with the mechanism of RM(RED)***lex***, which they independently had to deduce to account for the Attic Reduplication forms, speakers could avoid losing the reduplication here by assigning these roots to the lexical class of RM(RED)***lex***. If RM(RED)***lex*** dominates the anti-repetition constraint(s) in Ancient Greek, then we can generate copying even to non–*stop-sonorant* cluster-initial roots. The following tableau illustrates how this generates *piptɔ̄* in the synchronic grammar of Ancient Greek.

[39] Thank you to an anonymous reviewer for pointing out these distributional regularities.

(51) Present reduplication in Ancient Greek: √*pet-* → *present* πίπτω [p-i-pt-ɔ̄]

/RED, i, pt$\boxed{lex}$, ɔ̄/	RM(RED)$_{lex}$	DEP-IO	*CC	*$C_\alpha VC_\alpha$ / _[-son]	ONSET
a. ☞ p-i-pt-ɔ̄			*	*	
b. pt-i-pt-ɔ̄			**!		
c. pet-i-pt-ɔ̄		*!	*		
d. _-i-pt-ɔ̄	*!		*		*

What is most tantalizing about this solution is that it immediately provides an answer for the more surprising forms of this type, the unexpectedly copying *perfects* to these same roots. When these roots become indexed to RM(RED)$_{lex}$, RM(RED)$_{lex}$ applies not only in the present, but also in the perfect. Therefore, the aberrant and idiosyncratic copying behavior of the present carries over to the perfect despite there being no category-internal reason for doing so.

(52) RM(RED)$_{lex}$ in present-perfect pairs in Ancient Greek:

√*pt-* → *perfect* πέπτωκα [p-e-ptɔ̄-ka]; cf. *present* πίπτω [p-i-pt-ɔ̄]

/RED, e, ptɔ̄$\boxed{lex}$, ka/	RM(RED)$_{lex}$	*$C_\alpha VC_\alpha$ / _[-son]	ONSET
a. ☞ p-e-ptɔ̄-ka		*	
b. _-e-ptɔ̄-ka	*!		*

The crucial point here is the RM(RED)$_{lex}$ violation in the non-copying candidate (b). This violation supersedes the *$C_\alpha VC_\alpha$ / _[-son] violation of the C_1-copying candidate (a). If the root were not indexed to RM(RED)$_{lex}$, that *$C_\alpha VC_\alpha$ / _[-son] would be fatal, as it is in the general case for roots with non–*stop-sonorant* clusters. But due to RM(RED)$_{lex}$, copying is required, and the C_1-copying candidate emerges. Thus, the grammar obeys the copying requirement at the cost of the phonotactics. This is the same sort of constraint interaction that led to the selection of the Attic Reduplication form in (46) and (47) above.[40]

5. Conclusions

This paper has provided a comprehensive account of the historical development of the Attic Reduplication pattern of Ancient Greek, set within the larger reduplicative system of Greek. It was demonstrated that the synchronic reduplicative system of Ancient Greek simultaneously generates the patterns displayed by consonant-initial roots and the

[40] There may be one more corner of the grammar that displays similar RM(RED)$_{lex}$ effects. Brent Vine (p.c.) has pointed out to me that there is a set of apparently reduplicated nouns built to **HeC* roots which bear striking resemblance to Attic Reduplication verbal forms – in fact, they are built to many of the same roots which display Attic Reduplication in the perfect: e.g. √*ag* < **h₂eǵ* ‘lead’ → ἀγωγή [agɔ̄gɛ̄], √*ed* < **h₁ed* ‘eat’ → ἐδωδή [edɔ̄dɛ̄] (see Vine, 1998). As of yet, I cannot reconstruct the scenario by which these forms would have arisen, but the connection seems relevant.

productive vowel-lengthening pattern for vowel-initial roots. What was not evident from the facts of basic reduplication was how and why the Attic Reduplication pattern co-existed with the vowel-lengthening pattern for vowel-initial roots.

Based on the clear etymological connection between Attic Reduplication and the laryngeals, it was argued that laryngeal-specific phonotactics operative in Pre-Greek spawned the precursor of Attic Reduplication (Pre-AR). Pre-AR was then shown to be consistent with, and maybe even to directly follow from (via principles of phonological learning), the interaction of another laryngeal-specific phonotactic repair (laryngeal vocalization) with the normal reduplicative grammar as still evidenced in attested Ancient Greek.

In an attempt to retain the pattern as faithfully as possible subsequent to the loss of the laryngeals (and thus the loss of the pattern's conditioning factors), speakers innovated a new constraint system based on lexical indexation. This same system can be used to account for a previously unrecognized regularity, namely the unexpectedly-copying cluster-initial perfects associated with reduplicated presents. This demonstrates that both patterns are not simply frozen, archaic forms which have arbitrarily persisted in the language, but rather synchronically generable minority patterns which are subject to the normal demands of the grammar.

This paper illustrates how synchrony and diachrony can be used in tandem to help explain systematic irregularities. By constructing the synchronic grammar of Ancient Greek, we formalized the exceptionality of the Attic Reduplication pattern. By consideration of historical reconstruction, we generated a clear hypothesis about why the irregularity should exist, namely the behavior of laryngeals. This suggested the possibility of integrating other known phonological processes of a similar time depth and scope, namely laryngeal vocalization, into a new synchronic account of the phenomenon at a distinct diachronic stage. In turn, consideration of how the output of this stage interacted with subsequent diachronic change allowed us to connect the exceptional behavior of Attic Reduplication roots to other very different root types with similar exceptional behavior (the reduplicated presents and their exceptionally copying associated perfects), which was hitherto completely without principled explanation.

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Appendix: Attic Reduplication perfects

- *Forms from Van de Laar (2000:59–320); see also Beekes (1969:116–20)*

Root (Greek < *PIE)		Present Stem	Perfect Stem	Pre-Greek Reconstruction of Perfect Stem[41]
#*h_1				
eger <*$h_1$ger	'wake'	egēr-	egrε̄gor-[42]	*h_1əg-e-$h_1$gor-
ela(u) < *$h_1$elh_2	'drive'	ela(u)-	elε̄la-	*h_1əl-e-h_1l-a-
eleut^h < *$h_1$lewd^h	'go, come'	--	elε̄l(o)ut^h-	*h_1əl-e-h_1l(o)ud^h-
(en-)eŋk < *$h_1$nek	'bring'	--	enε̄nok^h-	*h_1ən-e-$h_1$nok^h-
eme < *wemh_1	'vomit'	eme-	emε̄me-	--
ered < *$h_1$reyd	'cause to lean'	ereid-	erε̄reis-	*h_1ər-e-$h_1$rei^d/$_s$-
ereip < *$h_1$reyp	'throw down'	ereip-	erε̄rip-[43]	*h_1ər-e-$h_1$rip-
#*h_2				
ager < *$h_2$ger	'gather together'	agēr-	agāger-	*h_2əg-e-$h_2$ger-
ako(u) < *$h_2$kow(s)	'hear'	akou-	akāko-	*h_2ək-e-$h_2$kow(s)-
ale < *$h_2$elh_1	'grind'	ale	alāle-s-	*h_2əl-e-$h_2$le-s-
ar < *$h_2$er	'join'	arar-	arār-	*h_2ər-e-h_2r-
aro < *$h_2$erh_3	'plow'	aro-	arāro-	*h_2ər-e-h_2r-o-
#*h_3				
od < *$h_3$ed	'smell'	ozd-	odɔ̄d-	*h_3əd-e-h_3d-
ol < *$h_3$elh_1	'destroy'	ol-	olɔ̄l-	*h_3əl-e-h_3l-
om < *$h_3$emh_3	'swear'	om-	omɔ̄mo-	*h_3əm-e-h_3m-o-
op < *$h_3$ek^w	'see'	--	opɔ̄p-	*h_3ək^w-e-h_3k^w-
or < *$h_3$er	'incite'	or-	orɔ̄r(e)-	*h_3ər-e-h_3r(-e)-
or < *(s)wer	'keep watch'	or-o-	orɔ̄r-	--
oreg < *$h_3$reg	'stretch'	oreg-	orɔ̄reg-	*h_3ər-e-$h_3$reg-
orug < *$h_3$ru-g^h	'dig'	orus-	orɔ̄rug-	*h_3ər-e-$h_3$ru-g^h-

[41] Stem-final material may be anachronistic.

[42] The [r] in the reduplicant is secondary. Brent Vine (p.c.) has suggested that it is the result of hyper-corrective *r*-insertion, along the lines of the phenomenon discussed in Vine (2011).

[43] Beside this there is also *ererim-* with short [e] for long [ε̄].