Support for span-conditioned allomorphy and late linearization

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The takeaway:

Data from the multiple exponence of the perfect in Classical Greek provide empirical evidence for:

- inwardly– and outwardly–sensitive span–conditioned allomorphy
- a cyclic Vocabulary Insertion process
- a post–Vocabulary Insertion linearization process
- the extremely late computation of the phonology of reduplicants

1. What is going on in the Classical Greek perfect?

- In most of the active voice paradigm of Classical Greek[1], perfect aspect has reflexes in three places simultaneously within a given inflected verb:
  - a **reduplicative prefix**,
  - a **suffix (κ, /k/)** and/or a special form of the verb root, and
  - a **dedicated set of φ-feature inflections**. For example:

(1) (a) λῡ́ω
lu:-o:[2]
loose(n)/release/destroy-1SG.PRS.ACT.IND
'I release'

[1] The data in this article are drawn from the Greek of the Classical period (~800–300 BCE), in Attica. We're looking at the "synthetic perfect"; that is, the inflected form(s) taken by a verb that expresses perfect meaning. These forms stand in contrast to the periphrastic constructions used with some verbs in the present perfect, and with most verbs in the future perfect active and past middle–passive. Abbreviations: ACT = active voice, AOR = aorist aspect, F = feminine gender, FUT = future tense, IND = indicative mood, INF = infinitive, IPFV = imperfective aspect, M = masculine gender, MP = middle–passive voice, NOM = nominative case, OPT = optative mood, PL = plural number, PRF = perfect aspect, PRS = present tense, PST = past tense, PSTPRF = past perfect, PTCP = participle, RED = reduplicative Vocabulary Item, SG = singular number, SUBJ = subjunctive mood

[2] Data are drawn from Groton (2000) and Smyth (1920). I assume a null present tense suffix in all present tense forms (excluded from examples for ease of exposition).

(b) λέλυκα

le~lu-**k**-**a**

PRF?~release-**PRF**?-1SG.**PRF**.ACT.IND

'I have released'

- I conclude that what might seem to be multiple instantiations of an Aspect head in Classical Greek are in fact signals of three separate heads:
  - The reduplicative prefix instantiates **Aspect[perfect]**
  - The -/k/ suffix is an allomorph of **Voice[active]** outwardly conditioned by the span ⟨Aspect, Tense⟩ and the stem allomorphy that occurs in place of or in addition to -/k/ in some roots is conditioned by the span ⟨Voice, Aspect, Tense⟩ (Section 3); and
  - The allomorphs of **AGR** are inwardly sensitive to the span of ⟨Voice, Aspect, Tense, Mood⟩

- Thus I will gloss perfect forms as follows (repeating 1b here as 2):

(2) λέλυκα

le~lu-**k**-**a**

PRF~release-ACT.**PRF**-1SG.**PRF**.ACT.IND

'I have released'

- The surface order of the relevant elements makes it clear that
  - Hierarchical adjacency, rather than surface order, is conditioning the insertion of Vocabulary Items, and thus
  - Linearization must not occur until after Vocabulary Insertion is complete

- What about **meanings**?
  - There were various uses of the Classical Greek perfect;
  - I adopt Haug's (2004) position that the "abnormal" uses of the perfect (such as the "intensive") are derivable semantically in the same way as the typical uses;
  - I will assume that for a given time period, there is a unitary perfect semantics general enough to allow us to derive all the various readings
  - There is at least no variation in form that corresponds to the different shades of meaning.

2. Reduplication: Linearization and phonological determination

- All perfect forms, regardless of tense, mood, voice, person, or number, show reduplication
- I argue that this reduplication instantiates Aspect in the presence of the feature [perfect]
- Its surface form(s) and position tell us two key things about the morphological order of operations:
    - It surfaces as a prefix but conditions the presence of other morphemes that end up as suffixes

        → the conditioning of those morphemes can't depend on the surface order of the exponents
    - Its surface form is dependent on the output phonology of the left side of the base

        → linearization must occur before the phonological computations take place, and that the reduplicant must have "access" to the base's output phonology

2.1 Aspect is instantiated by reduplication

Table 1: Perfect forms of /paideuo:/ 'I teach'

Present perfect active indicative	**pe**paideuka
Past perfect active indicative	e**pe**paideuke:
Perfect active subjunctive	**pe**paideuko:
Perfect active optative	**pe**paideukoimi
Perfect active imperative	**pe**paideuke
Perfect active infinitive	**pe**paideukenai
Future perfect active infinitive	**pe**paideusein
Present perfect middle/passive indicative	**pe**paideumai
Past perfect middle/passive indicative	e**pe**paideume:n
Future middle/passive indicative	**pe**paideusomai
Perfect middle/passive imperative	**pe**paideuso
Perfect middle/passive infinitive	**pe**paideust^{h}ai
Future perfect middle/passive infinitive	**pe**paideusesthai
Perfect active participle	**pe**paideuko:s
Future perfect active participle	**pe**paideuso:n...
Perfect middle/passive participle	**pe**paideumenos...
Future perfect middle/passive participle	**pe**paideusomenos...

- Reduplication is always present in forms with perfect meaning and it is an indicator only of perfect meaning in those forms: I take it to be the primary signal of the perfect

- The basic patterns of perfect reduplication are predictable from the phonology of the root, as seen in Table 2 (after Smyth 1920, Groton 2000) (see Appendix for full examples).
- Note that part of the reduplicant is always the fixed segment /e/ (and in fact this is sometimes the entirety of the reduplicant)

Table 2: Patterns of perfect reduplication

If the root begins in…	ex.	Reduplicant is…	ex.
A single aspirated stop	t^{h}uo:	Corresponding plain stop + /e/	**te**-t^{h}uka
Stop + liquid or nasal	blepo:	The stop + /e/	**be**-blep^{h}a
"Double" C (e.g. ζ /zd/)	zde:teo:	/e/	**e**-zde:teka
Any other C cluster	sp^{h}allo:	/e/	**e**-sp^{h}alka
/r/ or /^{h}r/	^{h}ripto:	/e/ (and /r/ doubles)	**e**-rrip^{h}a
Any other single C	luo:	That C + /e/	**le**-luka
A vowel	et^{h}elo:	Lengthened form of that vowel[3]	**e:**-t^{h}ele:ka

2.2 Greek perfect reduplication is an affix whose phonology is determined very late

- The challenge of reduplication for piece–based theories like Distributed Morphology: The reduplicant gains its phonological identity in reference to the phonology of the base, rather than being associated with its own phonological piece (see e.g. Haugen 2008; Haugen 2011; Cook 2013)
- In Distributed Morphology terms: Instead of a Vocabulary Item with a phonological string and a context for insertion, we have a context (e.g., the feature [perfect] on Aspect), but no invariant (or simply phonologically conditioned) string to insert.

[3] That is, the reduplicant is a copy of the initial vowel; the two resulting vowels follow language–wide rules of coalescence. Exceptionally, α /a/ "lengthens" to η /e:/ instead of ᾱ /a:/. A small (phonologically unpredictable) set of vowel–initial roots instead display what is known as "Attic" reduplication, copying initial VC as well as lengthening the first vowel in the root. For example, the root /eleut^{h}-/ has the perfect /ele:lout^{h}-/ (where we would expect /e:lelout^{h}-/ otherwise). Zukoff (2017a; b) addresses Attic reduplication at length, concluding that it arose as a case of phonotactic repair in a previous stage of the language, such that at the stage of Greek considered here, indexation of particular lexemes was involved and apparent in the constraints.

- The reduplicant must instead reference the output of any phonological processes that apply to the root.
- I follow Haugen's (2008; 2011) proposal for reduplication in Distributed Morphology
    - Special kind of Vocabulary Item, RED; its phonological output is derived in the phonology via correspondence with a base
    - Morphosyntactic structure built in the narrow syntax and Morphological Structure (Merge, Copy, etc.; Fission, Fusion, etc.)
    - Vocabulary Insertion and linearization take place after these morphological adjustments
    - The surface phonology can be determined via Correspondence Theoretic means in the phonology proper: The Vocabulary Items inserted in the morphosyntax are the inputs to the Optimality Theoretic tableaux.

- In the Greek data, RED surfaces as a prefix whose phonology is dependent on the phonology of the left side of the verb. It must therefore be the case that RED is in place linearly before the phonology undertakes its operations.

    → support for Deal's (2016) contention that the actual phonological instantiation of a reduplicant must be extremely late – after Vocabulary Insertion and linearization

- I assume RED to instantiate the head of a grammatical/outer AspectP. I take there to be a single morphosyntactic feature involved in the expression of perfect aspect, which I will call [perfect].

(3) Vocabulary Items competing for insertion into Aspect (partial)

[perfect] ↔ RED

- This Vocabulary Item will compete for insertion into the Aspect terminal node.
- The perfect contrasts with the aorist in both finite and non–finite verb forms, often realized with the suffix -σ -/s/ (and different suffixes for agreement); and with the imperfective, which has no overt phonological realization. For example:

(4) (a) ἐπαίδευσα

e-paideu-s-a

PST-teach-AOR-1SG.PST.AOR.ACT.IND

'I taught'

(b) ἐπαίδευον

e-paideu-ø-on

PST-teach-IPFV-1SG.PST.IPFV.ACT.IND

'I was teaching'

(c) ἐπεπαίδευκα

e-pe~paideu-k-a

PST-PRF~teach-ACT.PRF-1SG.PRF.ACT.IND

'I had taught'

- We arrive at the following list of Vocabulary Items that compete for insertion into Aspect:

(5) *Vocabulary Items competing for insertion into Aspect*

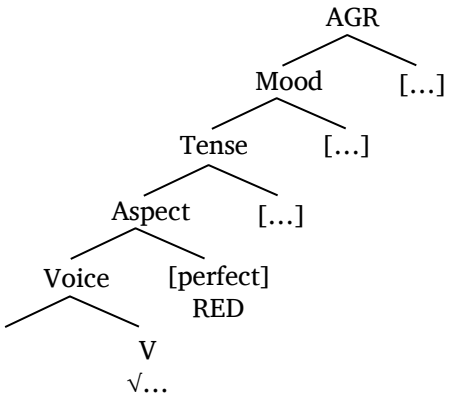
[perfect] ↔ RED

[aorist] ↔ /s/

elsewhere ↔ ø

- At Vocabulary Insertion, RED will win the competition and be inserted in an Aspect terminal node specified for [perfect].

(6) *Preliminary structure with feature and Vocabulary Item for a perfect form*



- Let us lexically specify (Noyer 1992/1997) the RED Vocabulary Item as a prefix:

(7) [perfect] ↔ RED-

- The order of Vocabulary Insertion and the eventual linear order of affixes is not related, as Halle (1997: 135) acknowledges
- Vocabulary Insertion itself presumably proceeds “inside–out” (Bobaljik 2000; Embick 2010), that is, hierarchically up the tree
- If linearization happens at Vocabulary Insertion (Embick & Noyer’s 2001 Late Linearization Hypothesis) or after, and can “read” the information about whether each Vocabulary Item is specified as a prefix or suffix, then the Vocabulary Items can end up in the correct place without any special dislocation mechanism having to be posited.
- The partial linearized form can be seen in (8) (using Embick & Noyer’s 2001 notation for linear precedence and adjacency)

(8) [RED- * [√] * …]

- With the reduplicant linearized as a prefix to the root, it is in a position for its surface form to be correctly determined by the **phonology**.
- Zukoff (2017a,b) provides a detailed Correspondence Theoretic analysis of the set of interacting constraints at play in this phonological calculation; I adopt his basic account.
- He claims that RED and /e/ must be separate “morphemes” in order to ensure the successful interaction of his constraints
- I counter that there is no evidence that RED and /e/ are separate entities in the syntax, morphology, or interpretive component, and that his issue is equally solved if the relevant Vocabulary Item has the phonological reflex RED/e/- (see Appendix B for details).

(9) *Vocabulary Items competing for insertion into Aspect (partial, revised)*

[perfect] ↔ RED/e/-

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3 The suffix -/k/ and stem allomorphy

3.1 Suffixed -/k/ instantiates the [active] Voice head in “first perfects”

- In the active voice, in all tenses, aspects, and moods other than future infinitives and future participles, perfects display a suffix -/k/ or stem allomorphy
- Verb roots ending in vowels, dentals, liquids, and nasals (traditionally “first perfects”) suffix -/k/; those ending in labials and velars (traditionally “second perfects”) instead have a special stem form.

- A prototypical example of a verb with a “first” perfect is λῡ́ω /luo:/, ‘I loose/release/destroy’, as seen in (10).

(10) (a) λῡ́ω
lu:-o:
release-1SG.PRS.ACT.IND
‘I release’

(b) λέλυκα
le~lu-k-a
PRF~release-ACT.PRF-1SG.PRF.ACT.IND
‘I have released’

(c) ἐλελύκη
e-le~lu-k-e:
PST-PRF~release-ACT.PRF-1SG.PSTPRF.ACT.IND
‘I had released’

A typical example of verb with a “second perfect” is βλέπω /blepo:/ ‘I see’:

(11) (a) βλέπω
blep-o:
see-1SG.PRS.ACT.IND
‘I see’

(b) βέβλεφα
be~blep^{h}-a
PRF~see.ACT.PRF-1SG.PRF.ACT.IND
‘I have seen’

(c) ἐβεβλέφη
e-be~blep^{h}-e:
PST-PRF~see.ACT.PRF-1SG.PSTPRF.ACT.IND
‘I had seen’

- Table 4 (after Groton 2000; Smyth 1920) shows the patterns in question, and full examples can be found in Appendix A.

Table 4: Patterns of perfect "suffixation" for regular verbs

	If the root ends in…	ex.	Change is…	ex.
"First perfects"	A vowel	agoreu-o:	Suffix /k/	e:goreu-**k**-a
	A dental (or ζ /zd/)	peit^{h}o:	Drop dental, suffix /k/	pepei-**k**-a
	A liquid or nasal	angello:	Suffix /k/	e:ngel-**k**-a
"Second perfects"	A labial	blepo: tribo:	Labial becomes φ /p^{h}/	beble**p^{h}**-a tetri**p^{h}**-a
	A velar	ago: dio:ko:	Velar becomes χ /k^{h}/	e:**k^{h}**-a dedio:**k^{h}**-a

- It is predictable whether a root will suffix -/k/ or not, based on the final segment in the root.
- Many roots that do not suffix -/k/ undergo predictable root changes (as seen in Table 4), but many other roots undergo unpredictable changes.

- RED/e/- is present across perfect forms; I took it to be the instantiation of Aspect[perfect].
- But…perfect aspect is a necessary but not sufficient condition for the appearance of the -/k/ suffix/stem changes
- Most notably, these right–side changes only occur in the active voice, as seen in (12) (using the same verbs from above as examples):

(12) (a) λέλυκα
le~lu-k-a
PRF~release-ACT.PRF-1SG.PRS.ACT.IND
'I have released'

(b) λέλυμαι
le~lu-mai
PRF~release-1SG.PRS.MP.IND
'I have been released'

(c) βέβλεφα
be~blep^{h}-a
PRF~see.ACT.PRF-1SG.PRF.ACT.IND
‘I have seen’

(d) βέβλεμμαι
be~blem^{4}-mai
PRF~see.MP.PRF-1SG.PRS.MP.IND
‘I have been seen’

- They do not appear in non-perfect aspects:

(13) (a) λῡ́ω
lu:-ø-o:
release-IPFV-1SG.IPFV.ACT.IND
‘I release/am releasing’
(b) ἔλῡσα
e-lu:-s-a
PST-release-AOR-1SG.AOR.ACT.IND
‘I released’
(c) βλέπω
blep-o:
see-1SG.PRS.ACT.IND
‘I see’
(d) ἔβλεψα
e-blep-s-a
PST-see-AOR-1SG.AOR.ACT.IND
‘I saw’

- And they appear across tenses and moods with the exception of future infinitives (14a) and future participles (14b):

[4] This root in fact displays a different kind of change in the middle–passive voice.

(14) (a) λελῡ́σειν

le~lu:-s-ein

PRF~release-FUT-INF.FUT.PRF.ACT

‘to be going to have released’

(b) λελῡ́σων

le~lu:-s-o:n

PRF~release-FUT-PTCP.FUT.PRF.ACT.M.NOM.SG

‘being going to have released’

- The appearance of -/k/ or stem allomorphy is dependent on a **combination** of the featural content of Voice, Aspect, and Tense

- Given that -/k/ appears only in the active voice and appears in a position after the verb root and before mood and agreement endings, we might imagine it is instantiating Voice, Aspect, or Tense
- We can rule out tense distributionally:
  - -/k/ co–occurs with the past tense prefix /e/- (11c)
  - The two verbs that form their future perfect indicatives synthetically show -/k/ + future -/s/, as expected if -/k/ instantiates a head inside Tense.

(15) (a) ἵστημι

histe:-mi

stand-1SG.PRS.ACT.IND

‘I stand’

(b) ἕστηκα

heste:-k-a

PRF~stand.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND

‘I have stood’

(c) ἑστήξω

he~ste:-k-s-o:

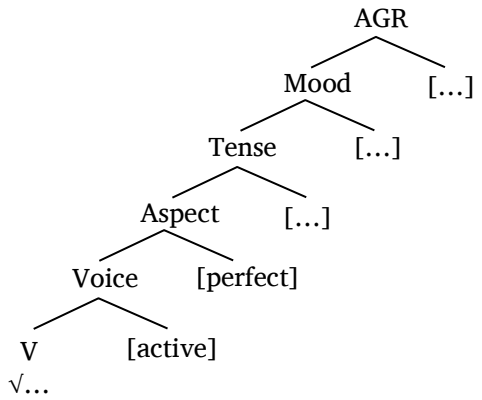
PRF~stand.ACT.PRF-ACT.PRF-FUT-1SG.FUT.ACT.IND

‘I will have stood’

- If -/k/ and stem allomorphy were also direct results of Aspect[perfect], a second exponent would need to be involved that somehow managed to get expressed simultaneously with, and on the other side of the root from, RED/e/- (see Appendix C for an exploration of this alternative)
- A simpler explanation is that these changes are the result of an allomorph of Voice[active] that is conditioned by the presence of [perfect] on Aspect, among other things.

- The structure (without Vocabulary Items) we have so far is as follows:

(16) *Structure with features for a perfect active form*



- -/k/ occurs only in perfect aspect, does not appear in future infinitives or future participles, and does not appear after labials or velars;

  → the appearance of -/k/ in Voice is dependent upon both its outward–looking morphosyntactic environment and its inward–looking phonological environment

- Importantly, the appearance of -/k/ is conditioned by the content not of a single head, but of two heads taken together: Aspect and Tense.
- These data thus provide empirical evidence for the existence of outwardly–sensitive span–conditioned allomorphy, supporting Merchant's (2015) *Span Adjacency Hypothesis*: Allomorphy is conditioned by structurally adjacent spans[5] of terminal nodes, all of whose members are implicated in the conditioning.
- The span in question is ⟨Aspect, Tense⟩, as only certain combinations of features across these two heads permit -/k/ to appear.

[5] After Svenonius's (2012) definition, who was building upon Williams (2003), Abels & Muriungi (2008), and Taraldsen (2010).

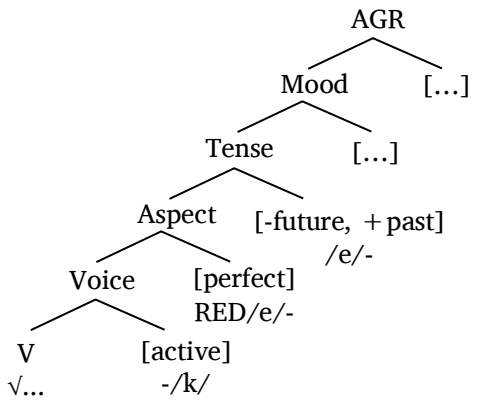
(17) Voice[active]

↔ /-k/ /[-labial, -velar] __ Aspect[perfect] Tense[-finite, -future]

↔ /-k/ /[-labial, -velar] __ Aspect[perfect] Tense[+finite]

↔ -∅ elsewhere

(18) *Structure with features and Vocabulary Items for a past perfect with -/k/*



3.2 Conditioning the stem allomorphy in "second perfects"

- In the cases that meet the morphological criteria for inserting -/k/ but not the phonological ones, stem allomorphy occurs. Merchant (2015) is concerned with similar stem allomorphy in Modern Greek; a similar proposal is applicable here.
- These changes appear in exactly the same morphosyntactic environments that -/k/ does (active voice, perfect aspect, not in future infinitives or future participles).
- Rather than instantiating the Voice head, though, these are roots; their insertion thus depends on a span that includes Voice[active] (⟨Voice, Aspect, Tense⟩). Below are the relevant rules for a sampling of roots:[6]

[6] While many verbs show irregularities in this form, there are recognizable regularities in the stems ending in labials and velars, as noted in Table 4: a number of labial–ending stems change that labial to a [p^h], and a number of velar–ending stems change that labial to a [k^h]. Though I do not address it in detail here, these phonological regularities that apply to only small portion of the lexicon could be captured with Readjustment Rules (e.g., √ [-syllabic, +labial]#→ [p^h] / √blep, √…___ [perfect]; √ [-syllabic, +velar]# → [k^h] / √dio:k, √…___ [perfect]), which are Distributed Morphology's typical way of addressing such sub–regularities; or, from a more strictly phonological approach, with cophonologies, indexed constraints (see Inkelas & Zoll 2007 for a comparison of the two approaches), or floating features for, e.g., Tense and Aspect (for some related work on Modern Greek, see e.g. Markopoulos 2018).

(19) √SEE

↔ /blep^{h}/ / Voice[active] Aspect[perfect] Tense[-finite, -future]

↔ /blep^{h}/ / Voice[active] Aspect[perfect] Tense[+finite]

↔ /blep/ / elsewhere

(20) √PURSUE

↔ /dio:k^{h}/ / (as above)

↔ /dio:k/ / elsewhere

- Some roots ending in liquids and nasals add an /e:/ to the stem as well as taking the -/k/ suffix. For example, μένω /meno:/ 'I lead' becomes μεμένηκα /memene:ka/ 'I have led':

(21) √LEAD ↔ /mene:/ / (as above)

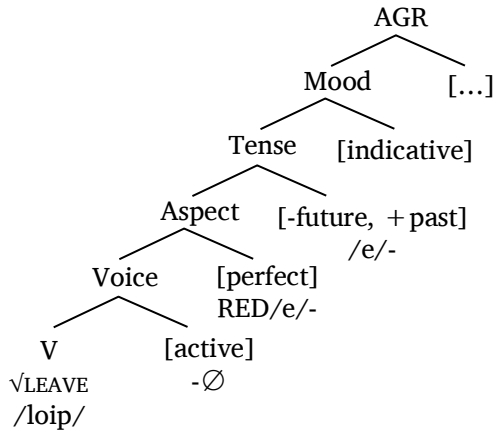
↔ /men/ / elsewhere

- Still other, more irregular, stems show other types of changes; for example, λείπω /leipo:/ 'I leave' becomes λέλοιπα /leloipa/ 'I have left', undergoing stem–internal vowel changes without a stem-final labial consonant change.

(22) √LEAVE ↔ /loip/ / (as above)

↔ /leip/ / elsewhere

(22) *Structure with features and Vocabulary Items for a past perfect without -/k/*



- A span–based analysis allows us to easily account for the active voice perfect data in Greek.

3.4 Implications for linearization

- The Greek perfect provides an interesting testing ground for determining the order of operations for Vocabulary Insertion and linearization. Recall:

(23) *Vocabulary Items competing for insertion into Voice[active]:*

↔ /-k/ /[-labial, -velar] __ Aspect[perfect] Tense[-finite, -future]

↔ /-k/ /[-labial, -velar] __ Aspect[perfect] Tense[+finite]

↔ -∅ elsewhere

- The contexts for insertion of -/k/ over -∅ involve both the phonology of (the right side of) the root and the (hierarchically) adjacent morphosyntax.
- The need for Vocabulary Insertion to be able to "read" the surface–adjacent phonology might lead us to assume a pre–Vocabulary Insertion linearization process
    - Embick (2010) e.g. argues from data with root–conditioned allomorphy that linearization must occur before Vocabulary Insertion, and Arregi & Nevins (2012) and Haugen & Siddiqi (2013) assume that Vocabulary Insertion operates on a linearized syntactic representation

- This would not be a problem for our data if the conditioning span ⟨Aspect, Tense⟩ were linearly adjacent to the Voice head
    - However, Aspect surfaces as a prefix (RED/e/-) and thus would not be linearly adjacent to Voice when Vocabulary Insertion began.
    - Tense[past], too, also surfaces as a prefix (/e/-). An approach under which the winning Vocabulary Items are determined based on surface (post-linearization) order of the morphemes would fail here.

- The choice of Vocabulary Item inserted in Voice[active] thus needs to depend instead on a **hierarchically adjacent** span
- As Merchant (2015: 279–280) notes, linearization (by design) removes the information about the hierarchical structure built by the syntax.
    - Given the data at hand, if linearization were to occur entirely before Vocabulary Insertion, the hierarchical information needed to determine the winning Vocabulary Items for Voice would be unavailable.

- In order to allow for conditioning by both surface–adjacent phonology and hierarchically–adjacent morphosyntactic elements, Vocabulary Insertion must proceed cyclically, and linearization must occur after Vocabulary Insertion is complete.
- After the hierarchical arrangement of the heads is determined by the syntax, Vocabulary Insertion will proceed from the root outwards.

- The choice of Vocabulary Item for the root will in some cases be sensitive to the span of heads ⟨Voice, Aspect, Tense⟩.
- Once the root Vocabulary Item is spelled out, Vocabulary Insertion can proceed for Voice.
    - Since linearization has not yet removed the hierarchical information, Aspect and the rest of the heads in the span are available to condition the allomorphy in the presence of the feature [active].
- When Vocabulary Insertion operates on Voice[active], it can take into account the phonology of the spelled–out Vocabulary Item inserted into the root ("inward sensitivity" to phonological features, as discussed by Embick 2012), as well as the morphosyntax of the hierarchically adjacent heads.

4 Agreement marking and perfect aspect

4.1 Conditioning the agreement suffixes

- Person/number agreement suffixes in Greek resemble each other in large part across tenses and aspects for a given voice and mood.

  Table 5: *General pattern for active and passive suffixes in the indicative*

	Active	Passive
1s	-V	-mai
2s	-s	-V
3s	-V(n)	-tai
1p	-men	-met^{h}a
2p	-te	-st^{h}e
3p	(Various)	-ntai

- Table 6 shows the full agreement suffixes (including "theme vowels") for the present (carrying imperfective semantics), present perfect, past perfect, and future perfect active indicative.

Table 6 *Some agreement suffixes for the active indicative (Groton 2000)*

	PRS IPFV	PRS PRF	PST PRF	FUT PRF
1s	-o:	-a	-e:	-o:
2s	-eis	-as	-e:s	-eis
3s	-ei	-e(n)	-ei(n)	-ei
2d	-eton	-aton	-eton	-eton
3d	-eton	-aton	-ete:n	-eton
1p	-omen	-amen	-emen	-omen
2p	-ete	-ate	-ete	-ete
3p	-ousi(n)	-asi(n)	-esan	-ousi(n)

- Some representative examples from the 2nd person singular paradigms of /lu:o:/ and /blepo:/ (with /histe:mi/ for future perfect, as most verbs form their future perfect forms periphrastically):

(24) (a) λῡ́εις
lu:-eis
release-2SG.PRS.ACT.IND
'You release'

(b) βλέπεις
blep-eis
see-2SG.PRS.ACT.IND
'You see'

(25) (a) λέλυκας
le~lu-k-as
PRF~release-ACT.PRF-2SG.PRF.ACT.IND
'You have released'

(b) βέβλεφας
be~blep^{h}-as
PRF~see.ACT.PRF-2SG.PRF.ACT.IND
'You have seen'

(26) (a) ἐλελύκης

e-le~lu-k-e:s

PST-PRF~release-ACT.PRF-2SG.PSTPRF.ACT.IND

'You had released'

(b) ἐβεβλέφης

e-be~blep^{h}-e:s

PST-PRF~see.ACT.PRF-2SG.PRF.ACT.IND

'You had seen'

(27) ἑστήξεις

he~ste:-k-s-eis

PRF~stand.ACT.PRF-ACT.PRF-FUT-2SG.FUT.ACT.IND

'You will have stood'

- Note that the suffixes in Table 6 in the present and past perfects have their own distinctive vowel pattern.[7]

    - This might be unremarkable if the conditioning head were adjacent to AGR; however, Tense intervenes between Aspect[perfect] and AGR.
    - *Pruning* (Embick 2010: 54) could possibly be at work in the conditioning of the Vocabulary Items in AGR in the present (Tense, when realized by -∅, can be essentially, removed from the tree for the purposes of computing adjacency and Vocabulary Insertion)

    - But observe that the past perfect forms, like the future perfect forms, have an overt tense affix, and yet are conditioned by the presence of perfect aspect.
    - Furthermore, Tense is not the only thing that affects the realization of the agreement suffixes in addition to Aspect: They also vary according to voice and mood.

[7] In some forms, particularly those in the optative mood, the instantiations of Mood and AGR are separate; in other forms, they are fused. In those forms in which two distinct pieces are not recognizable, I assume Fusion (or perhaps rebracketing, Radkevich 2010) takes place after the syntax and before Vocabulary Insertion to create one node out of two hierarchically adjacent ones. The feature(s) present in Mood are still available to condition the insertion of the correct Vocabulary Item into Aspect, and so forth.

Table 7: Some agreement suffixes for perfects (Groton 2000).

	PRS IPFV ACT IND	PRS PRF ACT IND	PRF ACT SUBJ	PRF ACT OPT	PRS PRF MP IND	FUT PRF MP IND
1s	-o:	-a	-o:	-oimi	-mai	-omai
2s	-eis	-as	-e:is	-ois	-sai	-e:i
3s	-ei	-e(n)	-e:i	-oi	-tai	-etai
2d	-eton	-aton	-e:ton	-oiton	-st^{h}on	-est^{h}on
3d	-eton	-aton	-e:ton	-oite:n	-st^{h}on	-est^{h}on
1p	-omen	-amen	-o:men	-oimen	-met^{h}a	-omet^{h}a
2p	-ete	-ate	-e:te	-oite	-st^{h}e	-est^{h}e
3p	-ousi(n)	-asi(n)	-o:usi(n)	-oien	-ntai	-ontai

- As was the case for the Voice[active] allomorphs, the realization of AGR depends again on the *combination* of the features across several heads – namely, Voice, Aspect, Tense, and Mood.

- Our Vocabulary Insertion rules must have spans that are similar to those we saw for -/k/. Some examples are given below:

(28) AGR[1PL]

↔ /-amen/ / Voice[+active] Aspect[perfect] Tense[present] Mood[indicative] __

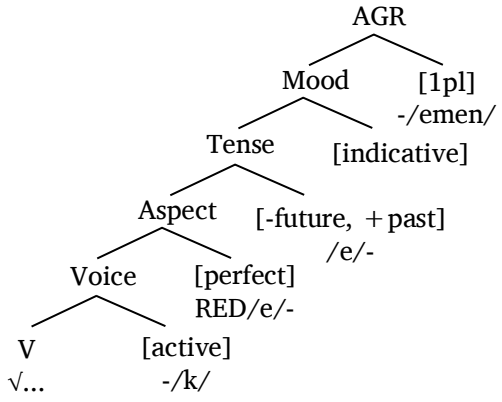
↔ /-met^{h}a/ / Voice[-active] Aspect[perfect] Tense[present] Mood[indicative] __

↔ /-o:men//Voice[+active] Aspect[perfect] Tense[present] Mood[subjunctive] __

…

- In the case of -/k/ we saw outward–sensitive span–conditioned allomorphy; here we have inward–sensitive span–conditioned allomorphy.

(29) *Structure with features and Vocabulary Items for a past perfect 1st person plural*



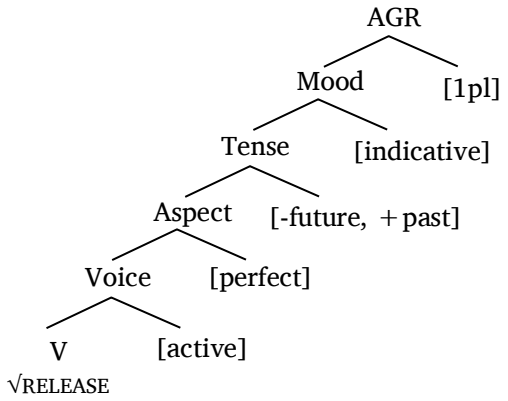
4.2 Implications of AGR for linearization

- As was the case for -/k/, the Greek agreement affixation data evidence the need for a post–Vocabulary Insertion linearization process.
    - The suffixal Vocabulary Items competing for insertion into AGR are conditioned by the presence of Aspect[perfect], and in some cases Tense[past] (instantiated by the prefix /e/-).
    - The conditioning of the instantiations of AGR by these heads again demonstrates the need for linearization to occur after Vocabulary Insertion is complete.

Let's consider a derivation in its entirety…

- First, the feature bundles are selected and form the Numeration, and the structure is built from these bundles via a series of Merge operations (etc.), yielding (30):

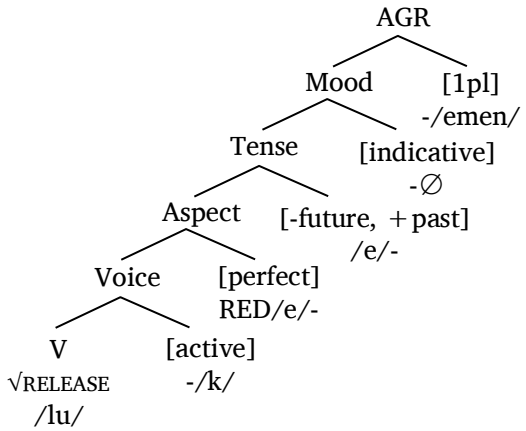
(30) *Structure with features for the first person plural past perfect active indicative of /luo:/ – /elelukemen/ 'we had released'*



- Vocabulary Insertion proceeds from the root outward, with hierarchical information conditioning the choice of several Vocabulary Items (including the form of the root in "second perfects"), resulting in (31)

    - Vocabulary Insertion must proceed cyclically, as e.g. the choice of Vocabulary Item for Voice[active] depends on the root Vocabulary Item.

(31) *Structure with features and Vocabulary Items for the first person plural past perfect active indicative of /luo:/ – /elelukemen/ 'we had released'*



- Only after Vocabulary Insertion is complete does linearization take place, yielding (32)

(32) *Output of linearization on 'we had released'*

[[e * [REDe- * [[lu] * -k]]] * -emen]

- Finally, the linearized string, with the reduplicative morpheme linearly adjacent to the root, undergoes phonological computations.

- Functionally, reduplication copies the first segment of /lu/ and adds /e/, yielding /le/-. The surface string results: [*elelukemen*].

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5 Conclusion

- The particular effects of the feature Aspect[perfect] on the Classical Greek verb allow us to arrive at key insights into the nature of Vocabulary Insertion and linearization.

- The Greek perfect:

    - Reduplication instantiates Aspect[perfect]
    - The -/k/ suffix in active forms other than future participles and future infinitives is an allomorph of Voice[active] conditioned by the span ⟨Aspect, Tense⟩,
    - The stem allomorphy that occurs in the same context is conditioned by the span ⟨Voice, Aspect, Tense⟩ (both cases of outwardly sensitive span–conditioned allomorphy)
    - The allomorphs of AGR are inwardly sensitive to the span ⟨Voice, Aspect, Tense, Mood⟩.

- The data together point to a linearization process that occurs very late, after Vocabulary Insertion is complete (but still before phonological computations are undertaken)

    - Both Voice[active] and AGR are sensitive to spans of hierarchically adjacent nodes, rather than spans of surface–contiguous heads.
    - This is apparent due to the unique combination of prefixes and suffixes that instantiate Voice, Aspect, Mood, Tense, and AGR in Classical Greek

- The Greek perfect data thus:

  (a) support the existence of span–conditioned allomorphy and highlight its importance for our understanding of morphosyntactic conditioning;

  (b) call for an extremely late phonological resolution of reduplicants; and

  (c) point towards the need for a post–Vocabulary Insertion linearization process.

- These data must be taken into account in any claims made about Vocabulary Insertion and linearization.
- Data from other languages would strengthen the conclusions drawn from Greek.

- It remains to be seen whether the ordering called for by the Greek perfect data is universal across languages, or whether there is evidence for parameterization when it comes to the timing of linearization.

- The Greek data should also be borne in mind for the purposes of cross–linguistic comparisons of extended or multiple exponence (as undertaken by, e.g., Caballero & Harris 2012; Harris 2017).
  - While the account here will certainly not apply across the board in instances of extended exponence, the core of the analysis may be fruitfully applied in other cases.

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Appendix: Additional examples

Part 1: Examples of perfect reduplication patterns

An initial single aspirated stop yields the corresponding unaspirated stop, plus ε /e/:

(I) (a) θύω
t^{h}u-o:
sacrifice-1SG.PRS.ACT.IND
‘I sacrifice’

(b) τέθυκα
te~t^{h}u-k-a
PRF~sacrifice-ACT.PRF-1SG.PRF.ACT.IND
‘I have sacrificed’

An initial cluster of a stop plus liquid or nasal yields the stop plus /e/:

(II) (a) βλέπω
blep-o:
see-1SG.PRS.ACT.IND
‘I see’

(b) βέβλεφα
be~blep^{h}-ø-a
PRF~see.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND
‘I have seen’

An initial “double” consonant such as ζ /zd/ yields simply /e/:

(III) (a) ζητέω
zde:te-o:
seek-1SG.PRS.ACT.IND
‘I seek’

(b) ἐζήτεκα
e~zde:te-k-a
PRF~seek-ACT.PRF-1SG.PRF.ACT.IND
‘I have sought’

An initial consonant cluster that is not a stop plus liquid or nasal also yields /e/:

(IV) (a) σφάλλω
sp^{h}all-o:
overthrow-1SG.PRS.ACT.IND
‘I overthrow’

(b) ἔσφαλκα
e-sp^{h}al-k-a
PRF~overthrow.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND
‘I have overthrown’

An initial ρ, whether preaspirated or not (/^{h}r/ or /r/), yields /e/ plus doubled /r/:

(V) (a) ῥίπτω
^{h}ript-o:
throw-1SG.PRS.ACT.IND
‘I throw’

(b) ἔρριφα
e-rrip^{h}-ø-a
PRF~throw.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND
‘I have thrown’

An initial single consonant other than an aspirated stop or ρ yields that consonant plus /e/:

(VI) (a) λῡ́ω
lu:-o:
release-1SG.PRS.ACT.IND
‘I release’

(b) λέλυκα
le~lu-k-a
PRF~release-ACT.PRF-1SG.PRF.ACT.IND
‘I have released’

And an initial vowel yields the lengthened form of that vowel:

(VII) (a) ἐθέλω
et^{h}el-o:
be.willing-1SG.PRES.ACT.IND
‘I am willing (to)’

(b) ἠθέληκα
e:~t^{h}ele:-k-a
PRF~be.willing-ACT.PRF-1SG.PRF.ACT.IND
‘I have been willing (to)’

Part 2: Examples of perfect “suffixation” patterns

Regular roots that end in a vowel suffix -/k/:

(VIII) (a) ἀγορεύω
agoreu-o:
speak.in.the.assembly-1SG.PRS.ACT.IND
‘I speak in the assembly’

(b) ἠγόρευκα
e:~goreu-k-a
PRF~speak.in.the.assembly-ACT.PRF-1SG.PRF.ACT.IND
‘I have spoken in the assembly’

Some slightly less regular roots suffix -/k/ and also show stem changes; for example, ἀκούω /akouo:/ ‘I hear’ (ἀκήκοα /ake:koa/ ‘I have heard’); ζάω /zdao:/ ‘I live’ (ἔζηκα /ezde:ka/ ‘I have lived’); καίω /kaio:/ ‘I kindle/burn’ (κέκαυκα /kekauka/ ‘I have kindled/burned’).

Regular roots that end in a dental drop the dental and suffix -/k/:

(IX) (a) πείθω
peit^{h}-o:
persuade-1SG.PRS.ACT.IND
‘I persuade’

(b) πέπεικα
pe~pei-k-a
PRF~persuade-ACT.PRF-1SG.PRF.ACT.IND
‘I have persuaded’

Also, e.g., θαυμάζω /t^{h}aumazdo:/ ‘I wonder/marvel’ (τεθαύμακα /tet^{h}aumaka/ ‘I have wondered/marveled’); νομίζω /nomizdo:/ ‘I use/practice/believe’ (νενόμικα /nenomika/ ‘I have used/practiced/believed’).

Regular roots that end in a liquid or nasal suffix -/k/:

(X) (a) ἀγγέλλω
aggell-o:
announce-1SG.PRS.ACT.IND
‘I announce’

(b) ἤγγελκα
e:ggel-k-a
PRF~announce.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND
‘I have announced’

Some slightly less regular roots suffix -/k/ and also show stem changes; for example, βάλλω /ballo:/ ‘I throw’ (βέβληκα /beble:ka/ ‘I have thrown’); χαίρω /k^{h}airo:/ ‘I am well/happy’ (κεχάρηκα /kek^{h}are:ka/ ‘I have been well/happy’).

Regular and semi-regular roots that end in a labial do not suffix -/k/. The labial may remain, as in (XI) (where there is also root–internal vowel change), or become φ /p^{h}/ (if it is not already) as in (XII, XIII).

(XI) (a) λείπω

leip-o:

leave-1SG.PRES.ACT.IND

‘I leave’

(b) λέλοιπα

le~loip-ø-a

PRF~leave.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND

‘I have left’

(XII) (a) τρίβω

trib-o:

rub-1SG.PRES.ACT.IND

‘I rub’

(b) τέτριφα

te~trip^{h}-ø-a

PRF~rub.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND

‘I have rubbed’

(XIII) (a) βλέπω

blep-o:

see-1SG.PRES.ACT.IND

‘I see’

(b) βέβλεφα

be~blep^{h}-ø-a

PRF~see.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND

‘I have seen’

Also e.g. πέμπω /pempo:/ ‘I send’ (πέπομφα /pepomp^{h}a/ ‘I have sent’); τρέπω /trepo:/ ‘I turn’ (τέτροφα /tetrop^{h}a/ ‘I have turned’).

Regular roots that end in a velar also do not suffix -/k/; the velar may remain, as in (XIV), or become χ /k^{h}/, as in (XV):

(XIV) (a) φεύγω

p^{h}eug-o:

flee.1SG.PRS.ACT.IND

‘I flee’

(b) πέφευγα

pe~p^{h}eug-Ø-a

PRF~flee.ACT.PRF-ACT.PRF-1s.PRF.ACT.IND

‘I have fled’

(XV) (a) διώκω

dio:k-o:

pursue-1SG.PRS.ACT.IND

‘I pursue’

(b) δεδίωχα

de~dio:k^{h}-Ø-a

PRF~pursue.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND

‘I have pursued’

Also ἄγω /ago:/ ‘I lead’ (ἦχα /e:k^{h}a/ ‘I have led’); διδάσκω /didasko:/ ‘I teach’ (δεδίδαχα /dedidak^{h}a/ ‘I have taught’).

Then, some verbs show other stem changes, either alone or in combination with those discussed above, and either with or without -/k/ suffixed. For example:

(XVI) (a) μένω

men-o:

lead-1SG.PRS.ACT.IND

‘I lead’

(b) μεμένηκα

me~mene:-k-a

PRF~lead.ACT.PRF-ACT.PRF-1SG.PRF.ACT.IND

‘I have led’

Also e.g. ἔχω /ek^{h}o:/ ‘I have’ (ἔσχηκα /esk^{h}e:ka/ ‘I have had’); λανθάνω /lant^{h}ano:/ ‘I escape notice’ (λέληθα /lele:t^{h}a/ ‘I have escaped notice’); πάσχω /pask^{h}o:/ ‘I experience’ (πέπονθα /pepont^{h}a/ ‘I have experienced’).

Appendix B: The Phonological Story

- The realizations of the reduplicant that surface in Greek perfect aspect depend on the form of the first one or two segments of the surface form of the verb, and always include the fixed segment /e/.

Table A: Patterns of perfect reduplication.

If the root begins in…	ex.	Reduplicant is…	ex.
A single aspirated stop	t^{h}uo:	Corresponding plain stop + /e/	**te**-t^{h}uka
Stop + liquid or nasal	blepo:	The stop + /e/	**be**-blep^{h}a
"Double" C (e.g. ζ /zd/)	zde:teo:	/e/	**e**-zde:teka
Any other C cluster	sp^{h}allo:	/e/	**e**-sp^{h}alka
/r/ or /^{h}r/	^{h}ripto:	/e/ (and /r/ doubles)	**e**-rrip^{h}a
Any other single C	luo:	That C + /e/	**le**-luka
A vowel	et^{h}elo:	Lengthened form of that vowel	**e:**-t^{h}ele:ka

- Roots with initial stop–sonorant clusters copy the stop and add /e/; other C–initial roots add /e/; and regular V–initial roots lengthen the V

I. Bases and targets for reduplication

- The morphosyntactic target of perfect reduplication I assume with Haugen (2008) and Travis (2001) (among others) to be the morphosyntactic sister of the reduplicant. But consider the verb in (i):

(i) (a) ἐπικρατέω
epi-krate-o:
upon/over-rule-1SG.PRS.ACT.IND
'I rule over'

(b) ἐπικεκράτηκα
epi-ke~krate:-k-a
upon/over-PRF~rule-PRF-1SG.PRF.ACT.IND
'I have ruled over'

- The perfect of the compound verb is the same as that of the base verb κρατέω /krateo:/ ‘I rule’ (ii) but with /epi/- prefixed to the reduplicated form.

(ii) κεκράτηκα

ke~krate:-k-a

PRF~rule-PRF-1S.PRF.ACT.IND

‘I have ruled’

  - If the morphosyntactic target of reduplication were the root with the prefix already attached, we would expect a perfect form of *ἠπικρατηκα /e:pikrate:ka/.
  - This tells us that either the prefix is merged at the very end of the derivation (which would render mysterious the semantic scope of perfect over the meaning of the compound verb), or there is some kind of dislocation of the prefix in the morphology – after Aspect is fixed hierarchically outside the root but before the phonological computation of RED-.

- Evidence that the target is what we might call the “root” form and not, say, the present stem, comes from the behavior of verbs whose present active indicative form have an infixed nasal.
  - For instance, the verb μανθάνω /mant^{h}ano:/ ‘I learn’ is built on the root μαθ- /mat^{h}/ (Liddell & Scott 1889: 486); its perfect form is μεμάθηκα /memat^{h}e:ka/, not *μεμάνθηκα /memant^{h}e:ka/, as would be expected if the present stem was the target.
- What is the (phonological) base for reduplication? This topic is the subject of Haugen’s (2009) work
  - Most theories of reduplication (including McCarthy and Prince 1993) at least implicitly assume that the entire stem is the base for reduplication, and that no other demarcation of a more limited base is allowed
  - Haugen concludes that what is needed to account for the empirical data (from e.g. Mainland Comox, Urbanczyk 2000) is something like Shaw’s (2005) Constituent Base Hypothesis, which allows both morphological and prosodic constituents to be bases for reduplication.
  - He leaves for future work the task of finding “other cases of delimited bases,” to test the predictions of the Hypothesis.
  - Classical Greek is just such a case, as is made clear in Zukoff’s (2017a; b) Correspondence Theoretic analysis

II. Accounting for the phonological output: Zukoff (2017a; b) and beyond

- The idea we have so far is that the instantiation of an Aspect head bearing the feature [perfect] in Greek is RED; this reduplicative “morpheme” will be the input to the phonology.

- Zukoff (2017a; b) provides a detailed Correspondence Theoretic account (within McCarthy and Prince's 1995 Base–Reduplicant Correspondence Theory) of the set of interacting constraints at play in this phonological calculation.
- His basic account we can adopt fairly straightforwardly; however, the successful interaction of his constraints demands that the phonology actually be accessing *two* morphemes, RED and the fixed segment /e/.
- Two options for dealing with situations in which a fixed segment figures into reduplication:
    - either the segment is a copy of a vowel from the base that has been reduced (a "phonological analysis"),
    - or the segment is a separate morpheme (a "morphological analysis").
- Zukoff shows that a phonological analysis leads to a ranking paradox for the constraints he proposes.[8]
- Zukoff's key constraints involved in Zukoff's (2017b) analysis are as follows:
    - ONSET (Prince & Smolensky 1993/2004): helps motivate the realization of the reduplicative copy (incurs a violation if /e/ surfaces without a preceding C)
    - REDUP(RED) (based on Zuraw 2002): helps motivate the realization of the reduplicative copy (incurs a violation if RED is in the input but the output does not include Base and Reduplicant substrings)
    - MAX-BR (McCarthy & Prince 1995): motivates copying all segments of the base into the reduplicant
    - ANCHOR-L-BR (McCarthy & Prince 1995): ensures the C that appears in the output matches the root–initial consonant
    - ALIGN-/e/-L: A "size restrictor" constraint; outranking MAX-BR helps maintain a minimal reduplicant (incurs a violation for "for every segment that intervenes between the left edge of the exponent of the fixed segment affix /e/ and left edge of the prosodic word" (Zukoff 2017b: 41)). Ensures that the reduplicant does not end up as a full copy of the base
    - *CLUSTER (*CC): advocates against the copying of the whole consonant cluster when outranking Align-/e/-L. This ensures that we end up with just the stop of stop–sonorant clusters copied in the output
    - NO POORLY-CUED REPETITIONS (*PCR) (≈*$C_{\alpha}VC_{\alpha}$/__$C_{[-son]}$): an "antirepetition" constraint; incurs a violation if matching consonants in the structure CVC precede an obstruent. This is to keep consonant copying from occurring in clusters that are not stop–sonorant clusters.

[8] In addition, /e/ shows no signs (that I am aware of) of being a default vowel elsewhere in the language, and does not correspond to the characteristics for cross–linguistic defaults that Alderete, et al. discuss (arising from the place–markedness hierarchy of Prince & Smolensky 1993; Lombardi 1997).

- These constraints operate together on RED to ensure:
  - That the morpheme is realized overtly;
  - That it copies segments of the base but not the entire base;
  - That the segments that get realized are from the left side of the root; and
  - That clusters are treated differently depending on their make–up.
- This brings us to the potential ranking paradox.
  - Given input like *kton-*, which yields __-*e-kton-* rather than *k-e-kton-* (since /kt/ is not a stop-sonorant cluster), the antirepetition constraint *PCR must outrank ONSET and REDUP(RED).
  - Since we do not see *kt-e-kton-*, *PCR must outrank *CC.
  - But why not just copy the second C, yielding *t-e-kton-*? This output does not incur ONSET or REDUP(RED) violations, while __-*e-kton-* does.
  - The fact that __-*e-kton-* wins over *t-e-kton-* indicates that the violation of ANCHOR-L-BR incurred by *t-e-kton-* is fatal.
  - It must be the case that no such violation is incurred with the candidate __-*e-kton-.*
  - On a phonological analysis of the fixed segment /e/ (i.e., if RED and /e/ are part of the same unit), __-*e-kton-* 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)" (Zukoff 2017a: 468).
  - Since this form does *not* incur an ANCHOR violation (again, it must not, since it wins out over the otherwise less marked *t-e-kton-*), it must be the case that the phonology is treating the /e/ in question as a separate piece, able to be operated on by separate constraints.
- Thus, Zukoff argues that RED and /e/ must enter the phonological computations as "separate morphemes". (He doesn't specify what being "separate morphemes" might mean for RED and /e/.)
- Issues:
  - There is no morphosyntactic or semantic evidence that RED and /e/ are separate entities in the syntax, the morphology, or the interpretive component:
    - There is evidence for /e/ in all the forms of reduplication. Although it may change on the surface due to rules of coalescence in the perfects that involve vowel–lengthening (see e.g. Zukoff 2017a, Section 2.2; 2017b, Section 2.2.2), its presence is detectable in copying environments (CeC(C_{son})V...), non–copying environments (eC$C_{\text{-son}}$V), vowel–initial environments (lengthening of V), and Attic Reduplication environments (lengthening of root–internal initial V).

        - Zukoff treats all these forms as containing /e/. The fate of the two "pieces" (the output of the computations on RED and the output of the computations on /e/) is entirely in the hands of the phonology – they are not distinct in the morphology or the syntax.
    - In the data at hand, the realization of the reduplicant appears as a copy of particular segments, plus /e/. This additional segment does not overwrite part of the base, as happens in *schm-* reduplication; it simply exists alongside the (imperfect) copy of the base.
- What's happening?
    - The phonology is targeting RED as separate from /e/, despite their being a single entity in the eyes of the morphology.
    - The phonology needs to be able to treat them as separate pieces, even though they are part of the same unit in terms of morphosyntactic structure and meaning.
    - This can be accomplished if the phonological instantiation of an Aspect node specified for [perfect] has the shape *RED/e/-*
        - The phonology in a Vocabulary Item is essentially a set of instructions for the phonological component to follow. In a case where the instantiation is (for example) /da/, the phonology's instructions are roughly "undertake language–relevant operations (including the application of relevant constraints) on the segments /d/ and /a/, together in that order." The Vocabulary Item RED/e/- would be similarly read by the phonology as "undertake language–relevant operations on RED and /e/, together in that order."
        - Of course, RED is not a unique segment; but, its language–relevant operations could include a second layer of instructions, such as "make a copy of the base and undertake language–relevant operations on the segments of that copy."
    - Treating this Vocabulary Item as made of two phonological elements allows the phonology to treat one morphosyntactic unit as two pieces phonologically.

Appendix C: Alternative Analyses

Alternative I: Two instantiations of Aspect

- Possibility: -/k/ somehow also instantiates Aspect along with RED/e/-, and only in the presence of a (hierarchically lower) active Voice head
    - Since there are two phonological pieces, presumably these would represent two distinct Vocabulary Items, both with the same context for insertion into the Aspect node (namely, [perfect]) – not remediable using the usual tools of Distributed Morphology
    - The Subset Principle cannot decide between these Vocabulary Items (and we wouldn't want it to—both appear in the output)
    - The Vocabulary Item for -/k/ would require the presence of active voice in its context somehow, but it can't simply be an active voice allomorph of the perfect: RED/e/- appears in the active voice as well
- Even given a solution to the first problem, we would end up with two Vocabulary Items that appear on either side of the verb root.
- Schreiner & Stone (2016) face a seemingly similar problem in the mood marking of Cherokee.
    - They argue that the so–called "future" markers *ta-* and *-i* together constitute a single, two–part affix (essentially a circumfix), instantiating the head of a ModalP specified for the feature [Circumstantial].
    - Schreiner & Stone propose that in Cherokee, a language–specific rule of Enrichment (Müller 2007) operates on a Modal head specified for [Circumstantial], doubling the feature
    - This yields a situation in which there are two [Circumstantial] features when Vocabulary Insertion begins.
    - This triggers Fission (Noyer 1992/1997) of the Modal position of exponence, yielding two nodes specified for the same feature.
    - Both Vocabulary Items specified for [Circumstantial] can then be inserted.
- A similar approach could be taken with Classical Greek, with Enrichment doubling the feature [perfect] and Fission dividing the Aspect node
- How the two Vocabulary Items end up on either side of the verb root? (Schreiner & Stone do not make a detailed proposal)
    - Assuming linearization happens late (as in Embick & Noyer's 2001 proposal), and the Vocabulary Items are lexically specified as prefixes or suffixes (Noyer 1992/1997), linearization would be responsible for establishing the linear order between Aspect and the root
    - Order of Vocabulary Insertion of the two affixes is presumably random, but linearization could also establish the ordering of the two halves of Aspect with respect to each other, based on their respective affixal statuses

    - But to arrive at the surface order, another operation would have to be in play to relocate the reduplicative prefix to a position before the root, for instance, Embick & Noyer's (2001) *Local Dislocation*.
- While this solution is arguably workable for the Classical Greek situation, it presents a number of disadvantages to the Voice–based analysis. It requires:
    - a dedicated (and perhaps overly powerful) mechanism, Enrichment, which is not otherwise widely justified;
    - application of Fission in a non-canonical environment; and
    - a further mechanism to get the affixes in the correct linear order.

Alternative II: Stem listing

- What if we attribute both the stem allomorphy and affixation of -/k/ to stem listing, in the spirit of e.g. Bermúdez-Otero (2013) and Haugen (2016)?[9]
- The [perfect] feature would be instantiated directly only once (by RED/e/-), but the changes on the right side would not involve a separate Vocabulary Item
- Instead, roots would undergo what amounts to contextual allomorphy in the context of the features [perfect], [active], etc.
- Benefits:
    - Does not require a dedicated mechanism like Enrichment, and eliminates the need to undertake Fission in an unexpected environment
    - Avoids Local Dislocation, since there is no second "half" of the Fissioned Aspect head to be relocated
- But a completely[10] stem–listing approach falls short:
    - The -/k/ suffix as well as the stem allomorphy would be the result of stem listing, relegating the frequent appearance of -/k/ in perfects to the status of accidental homophony.
    - This obscures the fact that -/k/ appears across so many forms, and that its appearance vs. the presence of stem allomorphy is phonologically predictable.
- The Voice–based analysis allows us to account for these regularities while avoiding the pitfalls of the Enrichment–based approach.

[9] Thanks to an anonymous reviewer for this suggestion.

[10] As an anonymous reviewer rightly points out, the analysis I pursue could be seen as containing elements of stem listing – the instances of conditioned allomorphy resulting in the Vocabulary Items in (22) and (23), for example, could be analyzed equally well as listed stems. The analysis I reject is one in which all stems are listed.

Alternative III: Rebracketing/Fusion

- Christopoulos & Petrosino (2017) suggest an analysis for Modern Greek root allomorphy that employs rebracketing (Radkevich 2010, similar in function to Fusion) to join two contiguous nodes – here, Voice and Aspect – to allow for realization by a single Vocabulary Item
- In the Classical Greek perfect, however, we do not see fusion between Voice and Aspect
    - In the passive, for instance, we see forms like /le-lu-met^{h}a/ – perfect reduplication, root, and then fusion of Voice, Mood, and AGR
    - In the active, fusion is frequently present between Mood and AGR.
    - Neither of these facts affects the conditioning of the Vocabulary Items for Aspect (or Voice) that I call for
- Given that we are dealing with many forms that show separate exponents for Tense, Aspect, Mood, and Voice (by assumption that -/k/ is Voice), I do not pursue an overall Fusion (or rebracketing) approach here.
- An analysis of the middle or passive voice systems would require more Fusion in some forms; for instance, the aorist aspect does not appear with a separate exponent outside the active voice. I leave this pursuit for future work.