An Alignment-Based Approach to Arabic Verbal Templates

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1 Introduction

1.1 An ordering puzzle

- In (Classical/Modern Standard) Arabic, there is a verbal morpheme /t/ (the "Reflexive"), highlighted in red in Table 1, which recurs across multiple morphological "Forms" (morphosyntactic categories).
  - It usually surfaces as a *prefix*, as in Forms V, VI, X (Table 1b).
  - But in one case, Form VIII, it surfaces as an *infix* (Table 1a).

Position	Form	Proposed morphosyntax	Example form	Translation
a. *Infixal*	VIII	Reflexive	***kt**ataba*	'write, be registered'
	V	Reflexive of the Causative	***t**akattaba*	(*constructed form*)
b. *Prefixal*	VI	Reflexive of the Applicative	***t**akaataba*	'write to each other'
	X	Causative of the Reflexive	***st**aktaba*	'write, make write'

Table 1: Forms with Reflexive /t/ (perfective active), exemplified with $\sqrt{}$*ktb* 'write'

- Most previous accounts of this distribution (e.g. McCarthy 1979, 1981, Tucker 2010) have relied on some sort of stipulation to explain Form VIII's divergent behavior.

⋆ I have recently proposed a morphosyntactic explanation for this distribution (Zukoff 2017a, 2021, to appear):

(1) **Morphosyntactic generalization about Reflexive /t/**
  a. When Reflexive co-occurs with (and scopes over/c-commands) another *v*-domain morpheme, its exponent is *prefixal* (Table 1b).
  b. When Reflexive is the only *v*-domain morpheme, its exponent is *infixal* (Table 1a).

- In order to make use of this generalization, we need a theory of word-internal linearization that is both
  (i) Responsive to changes in morphosyntactic structure, and
  (ii) Sensitive to phonological properties.

⋆ In Zukoff (to appear) (see also Zukoff 2017a,b, 2021, in press), I develop such a framework based on Generalized Alignment (McCarthy & Prince 1993), which I call the "**Mirror Alignment Principle**":

(2) **The Mirror Alignment Principle (MAP)**
  a. If a terminal node α *asymmetrically c-commands* a terminal node β, then the alignment constraint referencing α *dominates* the alignment constraint referencing β.
  b. SHORTHAND: **If α c-commands β → ALIGN-α ≫ ALIGN-β**

→ In §3.1 below, I will lay out in detail how this approach can solve the Reflexive ordering puzzle.

1.2 Zooming out

⋆ The use of the MAP as a general approach for morpheme ordering opens up a new(-ish) line of analysis for the morphophonology of the Arabic verbal system, based on a more articulated appeal to alignment constraints than has previously been attempted.

- Alignment has played a role in a number of recent analyses of Arabic templatic morphology (e.g. Ussishkin 2003, Tucker 2010, Wallace 2013) set within Optimality Theory (OT; Prince & Smolensky [1993] 2004) / Generalized Template Theory (GTT; McCarthy & Prince 1995).[1]
- However, the driving forces in most GTT analyses (Ussishkin 2000, 2003, Tucker 2010, 2011, Kastner 2016, *a.o.*) have been *prosodic* markedness constraints.

→ In this talk, I will show that deploying a more extensive alignment-based system, grounded morphosyntactically via the MAP, can derive the morphophonological properties of the Arabic verbal system without prosodic constraints.
  - ○ Like all GTT accounts, much of the remaining ground will be covered by basic faithfulness and markedness constraints (though here specifically linear markedness not prosodic markedness).
  - ○ The main additional component is a single lexically-indexed markedness constraint which will drive the irregular CV-sequencing behavior of certain affixes.

⋆ This analysis thus supports McCarthy's (1993) contention that the Arabic verbal system is *not* an instance of prosodic morphology.
  - ○ Additionally, this analysis aligns with much recent work (Tucker 2010, 2011, Wallace 2013, Kastner 2016, 2019, Kusmer 2019, *a.o.*) in viewing Arabic's root-and-pattern morphological system as garden-variety morpheme concatenation that is subject to unusual complications in the phonology and/or at the morphosyntax-phonology interface.

1.3 Roadmap

- After previewing the data in §2, the talk will be structured as follows:

  §3 Flesh out the analysis of the Reflexive ordering alternation using the MAP (Zukoff to appear)

  §4 Introduce the lexically-indexed phonotactic constraint $*\text{AFX}_i$/_C to account for a pattern of unexpected alignment violations in certain Forms

  §5 Lay out novel phonological generalizations about the distribution of vowels in the "vocalic melodies", and show that INTEGRITY constraints (McCarthy & Prince 1995) can restrictively explain this distribution

  §6 Slightly revise the Generalized Alignment schema to allow constraints that align morphemes simultaneously to both edges of the word, in order to account for various properties of the right edge of the verb word that mirror the left edge

  §7 Summarize the results and point towards a number of remaining questions

  §A **Appendix:** Explore how the morphological operation *amalgamation* (Harizanov & Gribanova 2019) can resolve a problem with the alignment rankings vis-à-vis the MAP

∗ In addition to the works cited throughout the paper, I have drawn on the data and descriptions from various grammars of Classical and Modern Standard Arabic, including Wright (1896), Fischer (2002), Watson (2002), and Ryding (2005).

[1] I will be taking GTT-based analyses as my main points of comparison. See, e.g., Faust (2015) for a recent, updated version of McCarthy's (1979) early CV-template-based analysis, applied to similar facts in other Semitic languages.

2 Data Preview

- I make the following, largely traditional assumptions about the morphological composition of Arabic verbs:

(3) **Morphological composition**

a. Roots consist of a string of underlying consonants (usually 3).
My analysis works transparently for 3-consonant roots; more will need to be said for 2- and 4-consonant roots.

b. The "vocalic melodies" expone Aspect and Voice, and consist of a string of 1–3 underlying vowels.
I treat them as portmanteaux, but contextual allomorphy may be possible as well.

c. The additional phonological content present in derived "Forms" expones *v*-domain morphemes: CAUSATIVE, APPLICATIVE, REFLEXIVE, MIDDLE (vel sim.).
Their precise morphosemantic character is not crucial for the phonology, but their structural positions are.

d. Subject agreement affixes are outermost: suffixal in the perfective, simultaneously prefixal and suffixal (→ circumfixal) in the imperfective.
I won't have anything to say about their actual exponence.

- The phonological shapes of the nine productive verb "Forms", in the four aspect/voice categories, are given in Table 2.

Form	Pf. Act. /a/	Pf. Pass /ui/	Impf. Act. /???/	Impf. Pass. /ua/
I	**katab-a**	**kutib-a**	**y-aktub-u**	**y-uktab-u**
II	**kat$_c$tab-a**	**kut$_c$tib-a**	**y-ukat$_c$tib-u**	**y-ukat$_c$tab-u**
III	**kaa$_v$tab-a**	**kuu$_v$tib-a**	**y-ukaa$_v$tib-u**	**y-ukaa$_v$tab-u**
IV	**ʔaktab-a**	**ʔuktib-a**	**y-u(ʔa)ktib-u**	**y-u(ʔa)ktab-u**
V	**takat$_c$tab-a**	**tukut$_c$tib-a**	**y-atakat$_c$tab-u**	**y-utakat$_c$tab-u**
VI	**takaa$_v$tab-a**	**tukuu$_v$tib-a**	**y-atakaa$_v$tab-u**	**y-utakaa$_v$tab-u**
VII	**nkatab-a**	**nkutib-a**	**y-ankatib-u**	**y-unkatab-u**
VIII	**ktatab-a**	**ktutib-a**	**y-aktatib-u**	**y-uktatab-u**
X	**staktab-a**	**stuktib-a**	**y-astaktib-u**	**y-ustaktab-u**

Table 2: Arabic verbal system (3SG.M of root √ktb 'write'; adapted from McCarthy 1981:385)

∗ In the imperfective of Form IV, the /ʔ/ and the following vowel are absent on the surface. It is not clear whether this is due to a deletion process or morphological non-exponence.

- My morphological analysis of the various *v*-domain morphemes is given in Table 3.

Syntactic Heads		Morphs		Forms
Applicative		/μ_v/		III, VI
Reflexive		/t/		V, VI, VIII, X
Middle		/n/		VII
v		/Ø/		I, IV, VII, X
Causative	i.	/μ_c/	(sister to Root)	II, V
	ii.	/ʔ/	(sister to *v*)	IV
	iii.	/s/	(sister to Refl)	X

Table 3: Morphemes involved in verbal Forms

∗ The precise morphosemantic characterization of the *v*-domain morphemes is not crucial.

3 Alignment constraints and the Mirror Alignment Principle

- The first problem I'll tackle is the relative order of exponents towards the left edges of the various Forms.
  → I will do this using *alignment* constraints (McCarthy & Prince 1993, Prince & Smolensky [1993] 2004, Hyde 2012).
- The main way I diverge from previous alignment-based accounts (e.g. Ussishkin 2003, Tucker 2010):
  ◦ The ranking of alignment constraints is not fixed across derivations.
  → Rather, it is *directly and dynamically tied to the morphosyntactic structure* of individual derivations by means of the "**Mirror Alignment Principle**" (Zukoff to appear).

3.1 The Reflexive

- Reflexive /t/ recurs across multiple Forms, but appears in different positions, as shown in Table 4:

Position	Form	Proposed morphosyntax	Perfective	Imperfective
a. *Infixal*	VIII	Reflexive	***kt**utiba*	*yu**kt**atabu*
	V	Reflexive of the Causative	***tuk**uttiba*	*yu**tak**attabu*
b. *Prefixal*	VI	Reflexive of the Applicative	***tuk**uutiba*	*yu**tak**aatabu*
	X	Causative of the Reflexive	***stuk**tiba*	*yu**stak**tabu*

Table 4: Forms with Reflexive /t/ (passive)

- Recent accounts (Ussishkin 2003, Tucker 2010) have used alignment constraints like the ones in (4–5) to help derive the ordering alternation.

(4) **Align-Root-L:** Assign one violation * for each segment which intervenes in the output between the left edge of the exponent of Root and the left edge of the word.

(5) **Align-Refl-L:** Assign one violation * for each segment which intervenes in the output between the left edge of the exponent of Reflexive and the left edge of the word.

→ However, an alignment-based analysis of the Reflexive requires an apparent ranking paradox (6), demonstrated in (7).

(6) **Ranking paradox**

a. Infixal Form (VIII): Align-Root-L ≫ Align-Reflexive-L
b. Prefixal Forms (V,VI,X): Align-Reflexive-L ≫ Align-Root-L

(7) **Alignment-based derivation of the Reflexive alternation** (/t/ ⇔ Refl)

i. Infixal order: Form VIII Reflexive ***kt**utiba* [= (6a)]

/**t**$_{\text{REFL}}$, **k**tb, ui$_{\text{AV}}$, a$_{\text{AGR}}$/		Align-Root-L	Align-Refl-L
a.	**tuk**tiba	*!*	
b. ☞	**kt**utiba		*

ii. Prefixal order: Form V Reflexive of Causative ***tuk**uttiba* [= (6b)]

/**t**$_{\text{REFL}}$, $\mu_{C\ \text{CAUS}}$, **k**tb, ui$_{\text{AV}}$, a$_{\text{AGR}}$/		Align-Refl-L	Align-Root-L
a. ☞	**tuk**u$t_c$tiba		**
b.	**kt**u$t_c$tiba	*!	

∗ A candidate ****tk**ataba* would be ruled out for independent reasons (*Afx$_i$/_C; see §4 below). Hence the non-minimal violations of Align-Root-L in these tableaux.

- Tucker (2010) circumvented this by indexing Form VIII to a special alignment constraint, *basically*:

(8) **Tucker's ranking:** ALIGN-REFL$_{\text{VIII}}$-L ≫ ALIGN-ROOT-L ≫ ALIGN-REFL-L

  ∗ Similarly, McCarthy (1979, 1981) posits a special metathesis rule for Form VIII.

- This successfully avoids the problem, but does not provide explanatory power.

→ I propose a new solution based on a novel morphosyntactic generalization (9):

(9) **Morphosyntactic generalization about Reflexive /t/**

  a. When Reflexive co-occurs with (and scopes over/c-commands) another *v*-domain morpheme (e.g. Causative or Applicative; cf. Tables 2 and 3), its exponent is *prefixal.*

  b. When Reflexive is the only *v*-domain morpheme, its exponent is *infixal.*

- This can help account for the difference if we adopt the Mirror Alignment Principle (MAP) approach to linearization (Zukoff to appear), defined in (10):

(10) **The Mirror Alignment Principle**

  a. If a terminal node α *asymmetrically c-commands* a terminal node β, then the alignment constraint referencing α *dominates* the alignment constraint referencing β.[2]

  b. SHORTHAND: **If α c-commands β → ALIGN-α ≫ ALIGN-β**

- Compare the morphosyntactic structures of Form V (11a), the reflexive of the causative, and Form VIII (11b), the simple reflexive:

Form V (11a):

Refl ***asymmetrically*** *c-commands* Root, b/c it adjoins to the complex Root+Caus head.

  ↪ The MAP therefore generates the ranking ALIGN-REFL-L ≫ ALIGN-ROOT-L (12b).

  ◦ This ranking produces a prefixal position for /t/ (7.ii).

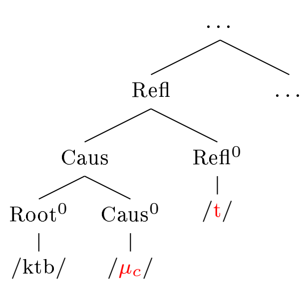
Form VIII (11b):

Refl and Root ***symmetrically*** *c-command* one another, b/c Refl is the first head to adjoin to Root.

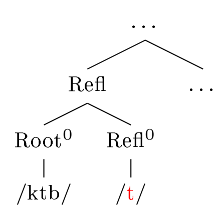
  ↪ The MAP thus asserts no ranking between ALIGN-REFL-L and ALIGN-ROOT-L (12a), meaning that **other factors** will have to determine their relative ranking.

(11) **Morphosyntactic structures with Reflexive** (after head movement)

  a. Form V ***tukut$_c$tiba***



  b. Form VIII ***ktutiba***



(12) **MAP-governed rankings with Reflexive**

  a. Form VIII (infixal order): ALIGN-ROOT-L, ALIGN-REFLEXIVE-L

  b. Form V (prefixal order): ALIGN-REFLEXIVE-L ≫ ALIGN-ROOT-L

[2] The operative definition of c-command here must apply to the lowest segments of heads, and exclude the non-domination condition. (Thank you to Gereon Müller for bringing this to my attention.)

> **Quick recap:**
> - ∘ The MAP generates prefixal order for cases like Form V, VI, and X.
> - ∘ The MAP fails to generate any order for cases like Form VIII.
> - → We need to identify other factors that can determine the alignment ranking in such cases.

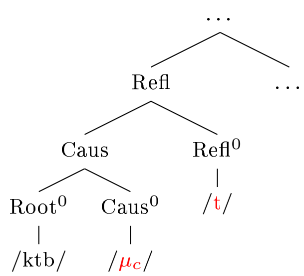
- We can build out this last piece of the puzzle by noticing one additional ordering generalization (13):

(13) **Root-alignment generalization:** The (left edge of the) Root always surfaces further to the left than the first head it adjoins to.

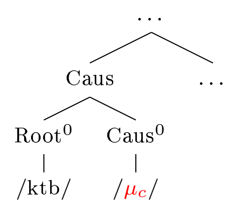
- This generalization holds not only for Form VIII ***kt**utiba* (11b), but also for other combinations of heads:
  - ∘ Root and Causative in Form V *tukut*$_c$*tiba* (14a) (= (11a)) and Form II ***kut***$_c$*tiba* (14b).
  - ∘ Root and Applicative in Form VI *tukuu*$_v$*tiba* (15a) and Form III ***kuu***$_v$*tiba* (15b).

(14) **Morphosyntactic structures with Causative**

a. Form V *tukut*$_c$*tiba*

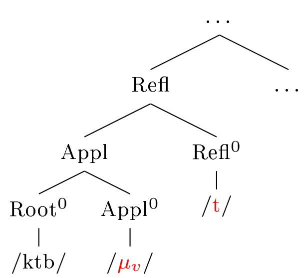


b. Form II ***kut***$_c$*tiba*

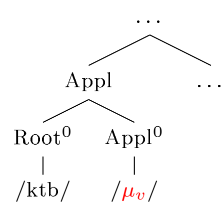


(15) **Morphosyntactic structures with Applicative**

a. Form VI *tukuu*$_v$*tiba*



b. Form III ***kuu***$_v$*tiba*



- These are exactly the cases where the MAP does not establish a ranking, because the two heads stand in symmetric c-command (i.e. no asymmetric c-command).

→ We can understand this generalization by positing that the grammar is capable of applying *additional conditions* on the ranking of alignment constraints *just in case the MAP fails to prescribe a ranking*:

(16) **Default Ranking Principle (DRP) for Arabic:** When the MAP does not prescribe a ranking between ALIGN-ROOT-L and another alignment constraint, rank ALIGN-ROOT-L higher.

∗ DRP's bear some resemblance to the concept of a "Master Ranking" in cophonology theory (Inkelas & Zoll 2007, Sande, Jenks, & Inkelas 2020) — a language-wide default ranking that can be superseded by morpheme-specific rankings.

- For the infixal Reflexive in Form VIII ***kt**utiba* (11b), the DRP in (16) resolves the indeterminacy in favor of ALIGN-ROOT-L. This yields the ranking in (17a).

(17) **MAP-governed rankings supplemented by Arabic's DRP** (cf. (12))
  a. Form VIII (infixal order): ALIGN-ROOT-L ≫ ALIGN-REFLEXIVE-L
  b. Form V (prefixal order): ALIGN-REFLEXIVE-L ≫ ALIGN-ROOT-L

⋆ These two distinct rankings are the paradoxical rankings from (6) above which generate the contrasting prefixal vs. infixal behavior of Reflexive (Table 4).

- Unlike in Tucker's (2010) constraint indexation approach, we have found an explanation for the apparent paradox: the dynamic interaction of the MAP and Arabic's DRP as mediated by morphosyntactic structure.

3.2 Summary of structures and MAP rankings

- Using these same principles, we can analyze the full Form system with the structures/rankings in Table 5.

Form	Perf. Act.	Syntactic structure	Alignment Ranking
I	*kataba*	[*v* [Root]]	ALIGN-ROOT-L (≫ ALIGN-*v*-L)
II	*ka**t**$_c$taba*	[Caus [Root]]	ALIGN-ROOT-L ≫ ALIGN-CAUS-L
III	*ka**a**$_v$taba*	[Appl [Root]]	ALIGN-ROOT-L ≫ ALIGN-APPL-L
IV	***ʔ**aktaba*	[Caus [*v* [Root]]]	ALIGN-CAUS-L ≫ ALIGN-ROOT-L (≫ ALIGN-*v*-L)
V	***t**aka**t**$_c$taba*	[Refl [Caus [Root]]]	ALIGN-REFL-L ≫ ALIGN-ROOT-L ≫ ALIGN-CAUS-L
VI	***t**aka**a**$_v$taba*	[Refl [Appl [Root]]]	ALIGN-REFL-L ≫ ALIGN-ROOT-L ≫ ALIGN-APPL-L
VII	***n**kataba*	[Mid [*v* [Root]]]	ALIGN-MID-L ≫ ALIGN-ROOT-L (≫ ALIGN-*v*-L)
VIII	*k**t**ataba*	[Refl [Root]]	ALIGN-ROOT-L ≫ ALIGN-REFL-L
X	***st**aktaba*	[Caus [Refl [*v* [Root]]]]	ALIGN-CAUS-L ≫ ALIGN-REFL-L ≫ ALIGN-ROOT-L

Table 5: Morphosyntactic structure and alignment analysis of verbal Forms

∗ Note that, for a consistent analysis, we need to posit the presence of a null *v* head in several Forms. See Zukoff (2017a, to appear) for evidence of this null *v* from the two types of basic causatives (Form II vs. Form IV).

⋆ In all Forms, we require the ranking ALIGN-ROOT-L ≫ ALIGN-AV-L.
  ◦ This does not follow from the MAP in any obvious way; in fact, we'd probably expect the opposite.
  ◦ See the Appendix (§A) for a way to derive a structure that can generate the desired ranking using *amalgamation* (Harizanov & Gribanova 2019).
  ◦ Until then, I simply take the ranking for granted.

4 Explaining the left edge: a lexically-indexed phonotactic constraint

- The alignment-based ordering analysis developed thus far makes an incorrect prediction about the sequences at the left edge of certain Forms.
- One such Form is Form V, shown in (18), now with an extra candidate (18a) where the Root-initial [k] comes immediately after Reflexive /t/:

(18) **Form V perfective passive** ***tukut$_c$tiba*** (alignment only) (cf. (7b))

/t$_{REFL}$, $\mu_{C\ CAUS}$, ktb, ui$_{AV}$, a$_{AGR}$/	ALIGN-REFL-L	ALIGN-ROOT-L	ALIGN-AV-L
a. 💣 **tku**t$_c$tiba		*	**
b. ☹ **tuku**t$_c$tiba		**!	*
c. **ktu**t$_c$tiba	*!		*

→ If alignment were the only thing in play, we'd predict (18a), since it better satisfies ALIGN-ROOT-L than desired (18b). [(18b) also splits AV /u/, incurring a violation of INTEGRITY (see §5) not shared by (18a).]

- Three (sets of) morphemes have this same property of disrupting alignment to have a following vowel:

(19) **Morphemes requiring a following vowel**

a. Reflexive /t/ [Form V,VI,X]
b. Causative /ʔ/ [Form IV]
c. Imperfective agreement affixes (at least the left-edge morphs): /y,t,ʔ,n/.

- In McCarthy (1979, 1981) and other templatic approaches, these are all morphemes/Forms which have to be associated to a template beginning in CV.

⋆ Rather than building this into the representations, we can implement the generalization using a *lexically-indexed markedness constraint* (following Pater 2000, 2009, Flack 2007, *a.o.*):

(20) ***AFX$_i$/_C:** Assign a violation * if a morpheme(/segment) with the index *i* precedes a consonant in the output. { *Alternatively*: AFX$_i$ | *CC or AFX$_i$ | *C]$_\sigma$ or *C$_i$C }

→ As long as the morphemes in (19) are indexed to *AFX$_i$/_C,[3] and *AFX$_i$/_C outranks the alignment constraints, we derive the desired outputs for these cases, as demonstrated for Form V in (21).
 ▹ Exponents indexed to *AFX$_i$/_C are underlined in candidate outputs.

(21) **Form V perfective passive** ***tukutₑtiba*** (alignment plus *AFX$_i$/_C)

/**t**$_{i\ \text{REFL}}$, $\mu_{c\ \text{CAUS}}$, **ktb**, **ui**$_{\text{AV}}$, a$_{\text{AGR}}$/	*AFX$_i$/_C	ALIGN-REFL-L	ALIGN-ROOT-L	ALIGN-AV-L
a. <u>t</u>kut$_c$tiba	*!		*	**
b. ☞ <u>t</u>ukut$_c$tiba			**	*
c. k<u>t</u>ut$_c$tiba		*!		*

4.1 *AFX$_i$/_C and the *v*-domain morphemes

- The other *v*-domain morpheme indexed to *AFX$_i$/_C is the Causative /ʔ/ found in Form IV. The constraint interaction works exactly the same as before, as shown in (22).

(22) **Form IV perfective passive** ***ʔuktiba*** (*AFX$_i$/_C active for /ʔ/)

/**ʔ**$_{i\ \text{CAUS}}$, **ktb**, **ui**$_{\text{AV}}$, a$_{\text{AGR}}$/	*AFX$_i$/_C	ALIGN-CAUS-L	ALIGN-ROOT-L	ALIGN-AV-L
a. <u>ʔ</u>kutiba	*!		*	**
b. ☞ <u>ʔ</u>uktiba			**	*
c. k<u>ʔ</u>utiba		*!		**

- In Forms without affixes indexed to *AFX$_i$/_C — e.g. Form VII with Middle /n/ (23) — alignment can be maximally satisfied, allowing for clusters to surface at the left edge:

(23) **Form VII perfective active** ***nkataba*** (*AFX$_i$/_C not active)

/**n**$_{\text{MID}}$, **ktb**, **a**$_{\text{AV}}$, a$_{\text{AGR}}$/	*AFX$_i$/_C	ALIGN-MID-L	ALIGN-ROOT-L	ALIGN-AV-L
a. ☞ nkataba	n/a		*	**
b. naktaba			**!	*
c. knataba		*!		**

[3] This constraint is indexed to the /ʔ/ exponent of CAUSATIVE, but not the /μ_c/ or /s/ exponents of CAUSATIVE. This indicates that the index is attached not to the "morpheme" (in the DM sense), but to the morph/exponent.

- Initial clustering is also found in Form VIII (reflexive). In this case, both alignment and *Afx$_i$/_C advocate for Reflexive /t/ to surface in pre-vocalic position (24a).

(24) **Form VIII perfective passive** *ktutiba* (*Afx$_i$/_C active for /t/, but superfluous)

/t$_{i\ \text{REFL}}$, ktb, ui$_{\text{AV}}$, a$_{\text{AGR}}$/	*Afx$_i$/_C	Align-Root-L	Align-Refl-L	Align-AV-L
a. ☞ ktutiba			*	**
b. kuttiba	*!		**	*
c. tkutiba	*!	*		**

∗ I represent a strict ranking between Align-Refl-L and Align-AV-L. This is not necessary for the candidates considered, but it would be if we considered an additional candidate *[kututiba], with an extra [u]. This ranking does not follow from the MAP or the DRP. A solution is still wanting.

4.2 *Afx$_i$/_C and imperfective agreement

- As can be seen in Table 6 below, in the imperfective, a vowel always intervenes between the left-edge agreement morph and the next consonant (whether it belongs to the Root or to a *v*-domain morpheme).

Form	Pf. Act. /a/	Pf. Pass /ui/	Impf. Act. /???/	Impf. Pass. /ua/
I	**katab-a**	**kutib-a**	**y-aktub-u**	**y-uktab-u**
II	**kat$_c$tab-a**	**kut$_c$tib-a**	**y-ukat$_c$tib-u**	**y-ukat$_c$tab-u**
III	**kaa$_v$tab-a**	**kuu$_v$tib-a**	**y-ukaa$_v$tib-u**	**y-ukaa$_v$tab-u**
IV	**ʔaktab-a**	**ʔuktib-a**	**y-u(ʔa)ktib-u**	**y-u(ʔa)ktab-u**
V	**takat$_c$tab-a**	**tukut$_c$tib-a**	**y-atakat$_c$tab-u**	**y-utakat$_c$tab-u**
VI	**takaa$_v$tab-a**	**tukuu$_v$tib-a**	**y-atakaa$_v$tab-u**	**y-utakaa$_v$tab-u**
VII	**nkatab-a**	**nkutib-a**	**y-ankatib-u**	**y-unkatab-u**
VIII	**ktatab-a**	**ktutib-a**	**y-aktatib-u**	**y-uktatab-u**
X	**staktab-a**	**stuktib-a**	**y-astaktib-u**	**y-ustaktab-u**

Table 6: Arabic verbal system (repeated from Table 2 above)

- This vowel varies by voice (and by Form, in the active), but not by person.
  - i.e., the [ya]'s and [yu]'s of the 3rd person singular are matched by [ta]/[tu], [ʔa]/[ʔu], and [na]/[nu].
- This strongly suggests that these vowels are *not* part of the agreement morpheme (cf. McCarthy 1981), but rather part of the AV morpheme (Brame 1970:70, Yip 1988:569).

→ Therefore, just as with the *v*-domain morphemes, we can derive the requirement of a second-position vowel by indexing the imperfective agreement morphs to *Afx$_i$/_C.

- For illustration, consider the Form I imperfective passive *yuktabu* (25), which follows from the same interaction that derived the more complex Forms above.

(25) **Form I imperfective passive** *yuktabu* (*Afx$_i$/_C active for /y/)

/ktb, ua$_{\text{AV}}$, y$_i$(-)u$_{\text{AGR}}$/	*Afx$_i$/_C	Align-Agr-L	Align-Root-L	Align-AV-L
a. ykutabu	*!		*	**
b. ☞ yuktabu			**	*
c. kyutabu		*!		**

5 Explaining the vocalic melodies: Integrity and *CCC

- The interaction between alignment and *Afx_i/_C explains the behavior at the left edge of all the forms.

⋆ The largest remaining piece of the puzzle is the position and number of the vowels of the AV vocalic melody in the various Forms.

→ My jumping off point is the (somewhat novel) generalizations in (26), confirmed by Table 7. [See McCarthy (1981:400), Yip (1988:565) for similar observations.]

(26) **Phonological conditions on vowel splitting**

a. No Form has multiple instances of multiple AV vowels (only one vowel splits).

b. Assuming the sonority scale $a \succ u \succ i$, whenever additional vowels are required in order to create well-formed structures, the most sonorous vowel splits.

Form	Pf. Act. /a/	Pf. Pass /ui/	Impf. Act. /???/	Impf. Pass. /ua/
I	**katab-a**	**kutib-a**	**y-aktub-u**	**y-uktab-u**
II	**kat$_c$tab-a**	**kut$_c$tib-a**	**y-ukat$_c$tib-u**	**y-ukat$_c$tab-u**
III	**kaa$_v$tab-a**	**kuu$_v$tib-a**	**y-ukaa$_v$tib-u**	**y-ukaa$_v$tab-u**
IV	**ʔaktab-a**	**ʔuktib-a**	**y-u(ʔa)ktib-u**	**y-u(ʔa)ktab-u**
V	**takat$_c$tab-a**	**tukut$_c$tib-a**	**y-atakat$_c$tab-u**	**y-utakat$_c$tab-u**
VI	**takaa$_v$tab-a**	**tukuu$_v$tib-a**	**y-atakaa$_v$tab-u**	**y-utakaa$_v$tab-u**
VII	**nkatab-a**	**nkutib-a**	**y-ankatib-u**	**y-unkatab-u**
VIII	**ktatab-a**	**ktutib-a**	**y-aktatib-u**	**y-uktatab-u**
X	**staktab-a**	**stuktib-a**	**y-astaktib-u**	**y-ustaktab-u**

Table 7: Arabic verbal system (repeated from Table 2 above)

- These generalizations clearly hold in the Perfective Active, Perfective Passive, and Imperfective Passive, where the same combination of vowels in the same order appears across the different Forms.
- They hold also in the Imperfective Active, even though the set of vowels differs by Form.

∗ Note that this cannot be recast in directional terms (Yip 1988):
- In the Perfective Passive (/ui/) and Forms VII, VIII, X in the Imperfective Active (/ai/), the *lefthand* vowel splits.
- But in the Imperfective Passive (/ua/), the *rigthand* vowel splits.

→ This is problematic for directional autosegmental association accounts:
- In order to maintain *left-to-right* association, McCarthy (1981:401) had to stipulate a prior rule that associates /i/ to the right edge first.

⋆ We can use this phonological conditioning to generate the range of surface patterns from compact UR's.

- I implement this with the faithfulness constraint Integrity (McCarthy & Prince 1995), relativized to individual vowel qualities, ranked (inversely) according to their sonority value (27).

(27) **Definition and ranking of Integrity (sub-)constraints**

a. *Definition* of Integrity[x]-IO: For each input segment of type x, assign one violation * for each pair of corresponding segments in the output.

b. *Ranking*: Integrity[i]-IO ≫ Integrity[u]-IO ≫ Integrity[a]-IO

- This approach yields three desiderata:

(28) **Splitting desiderata**

a. It correctly selects *which* vowel splits when splitting occurs.
b. It correctly predicts that only one underlying vowel is ever split in a given form.
c. It predicts that splitting will be minimal (since more splitting incurs more violations), subject to the needs of higher-ranked constraints.

- The primary drivers of INTEGRITY violation are $*\text{AFX}_i/\_\text{C}$ and *CCC (29), modulated by alignment.

(29) ***CCC:** Assign a violation * for each three-consonant sequence in the output.

⋆ One Form where splitting occurs is the Form X imperfective active *yastaktibu*, where there are *two* instances of [a] in the output.

5.1 Relative order via alignment

- The order of consonantal morphemes is determined purely by alignment ranking (cf. Table 5), as in (30):

(30) **Ordering via alignment**

ALIGN-AGR-L	≫	ALIGN-CAUS-L	≫	ALIGN-REFL-L	≫	ALIGN-ROOT-L
y	>	s	>	t	>	k

- As long as INTEGRITY ranks *below* these alignment constraints, splitting AV vowels will always be better than reordering the consonantal morphemes as a repair for $*\text{AFX}_i/\_\text{C}$.
  → A candidate like **syaktitbu* (31c), which satisfies $*\text{AFX}_i/\_\text{C}$ by swapping the order of the exponents, excessively violates high-ranked alignment constraints (here, ALIGN-AGR-L and ALIGN-REFL-L).
  ∗ *Italicized* vowels in the output are split vowels, incurring INTEGRITY violations.

(31) **Form X imperfective active** *yastaktibu*: ordering via alignment

/s_{CAUS}, $t_{i\ \text{REFL}}$, ktb, ai_{AV}, y_i(-)u_{AGR}/	$*\text{AFX}_i/\_\text{C}$	ALIGN-AGR-L	INTEGRITY[a]
a. ystkatibu	*!*		
b. ☞ y*a*st*a*ktibu			*
c. syaktitbu		*!	

5.2 Splitting driven by $*\text{AFX}_i/\_\text{C}$ and *CCC

⋆ Holding the ordering of the consonantal morphemes constant, we can now see the full interaction between $*\text{AFX}_i/\_\text{C}$, *CCC, and INTEGRITY. This is demonstrated in (32) below.

- Perfect alignment (32a) produces a long string of consonants at the beginning of the word, violating both $*\text{AFX}_i/\_\text{C}$ and *CCC.

(32) **Form X Imperfective Active** *yastaktibu*: motivating splitting

/s_{CAUS}, $t_{i\ \text{REFL}}$, ktb, ai_{AV}, y_i(-)u_{AGR}/	$*\text{AFX}_i/\_\text{C}$	*CCC	INTEGRITY[a]
a. ystkatibu	*!*	*!*	
b. ysatkitbu	*!*		
c. yastiktbu		*!	
d. ☞ yastaktibu			*

- There is no way to fully repair both markedness problems by simply moving around the AV vowels (i.e. without splitting). Candidates (32b) and (32c) can each solve one problem, but no candidate can solve both:

1. Place the two AV vowels after every second consonant from the left (32b).
   - This satisfies *CCC, but doesn't alleviate the $*\text{AFX}_i/\_\text{C}$ violations.[4]

   ↪ Therefore, $*\text{AFX}_i/\_\text{C} \gg$ INTEGRITY.
2. Place the two AV vowels after the two exponents indexed to $*\text{AFX}_i/\_\text{C}$ (32c).
   - This satisfies $*\text{AFX}_i/\_\text{C}$, but creates a *CCC-violating cluster towards the right.

   ↪ Therefore, *CCC ≫ INTEGRITY.

→ Only by splitting one of the vowels (32d) can both markedness constraints be satisfied simultaneously.

5.3 Splitting governed by INTEGRITY

⋆ Once splitting is motivated by $*\text{AFX}_i/\_\text{C}$ and *CCC, INTEGRITY does the rest, as shown in (33).

- INTEG[i] ≫ INTEG[a] ensures that underlying /a/ is split (33b) rather than underlying /i/ (33a).
- The ranking of the INTEGRITY constraints over other markedness constraints, e.g. NOCODA or *CC, ensures that additional splitting does not occur: (33b) ≻ (33c,d).[5]

(33) **Form X Imperfective Active** *yastaktibu*: governing splitting

/s_{CAUS}, $t_{i\ \text{REFL}}$, ktb, ai_{AV}, y_i(-)u_{AGR}/	INTEGRITY[i]	INTEGRITY[a]	NOCODA/*CC
a. yastiktibu	*!		**
b. ☞ yastaktibu		*	**
c. yastakatibu		**!*	*
d. yasatakatibu		**!****	

∗ (33d) would actually be ruled out by alignment, because the extra [a] (the second one) intervenes between the left word-edge and the left edge of several left-oriented morphemes.

∘ (33c), though, does have the same alignment profile as (33b), because the extra vowel surfaces inside the root, after all the left edges.

[4] Note that there are consonant-initial agreement suffixes, which would trigger a *CCC violation at the right edge of the stem.

[5] I have defined INTEGRITY to assign violations to all pairs of corresponding output segments, so the number of violations will increase exponentially as splitting increases. This has no effect on the evaluation as long as we are operating with constraint ranking rather than weighting.

6 Explaining the right edge: *both-edge* alignment

- The last issue that I'll tackle is the relative positions of exponents towards the *right* edge of the stem.

- Nothing about the current analysis distinguishes, e.g., the two candidates outputs for a Form X imperfective active in (34):

(34) **Form X imperfective active**

a. *yastak**ti**bu* (stem-final **CV**C)

b. **yastak**it**bu* (stem-final **VC**C)

- In both forms, left-alignment of all the morphemes is maximized (subject to markedness and Integrity), and there are the same number of codas and consonant clusters.

- The answer seems to lie in the longstanding generalization that all verbal stems (i.e. the material preceding the agreement suffixes) must *end in a VC sequence* (McCarthy 1979, McCarthy & Prince 1990, *a.o.*).
  - ⋆ If something actively enforces this generalization, it will prefer *yastak**ti**bu* (34a) over **yastak**it**bu* (34b).

→ The current alignment-based analysis presents a new explanation.

Other possible explanations

- We could simply hardwire this into the analysis with some expanded version of the constraint Final-C (cf. McCarthy & Prince 1990, McCarthy 1993, 2005a, Kiparsky 2003, Farwaneh 2009, *a.o.*).
  - ◦ But this would not provide much explanatory value without further contextualization.
- We could alternatively appeal to paradigm uniformity using McCarthy's (2005b) "Optimal Paradigms" (OP) approach, which he shows can derive similar facts through paradigmatic overapplication.
  - ◦ Since there are consonant-initial verbal agreement suffixes, and three-consonant clusters are not allowed (*CCC), some inflected forms will not tolerate a VCC-final stem.
  - ◦ These instead require a VC-final stem, and this is transferred through OP-correspondence (perhaps Linearity, or something relating to syllable weight) to the rest of the paradigm, resulting in consistently VC-final stems.

6.1 Alignment and the right edge

- Consider the following two facts:
  (i) The stem-final VC sequence is always composed of the last AV vowel followed by the last Root C.
  (ii) Based on the behavior of the left edge of the stem: Align-Root ≫ Align-AV.

→ If these alignment constraints *also regulate the right edge*, then alignment derives the distribution.
  - ◦ Furthermore, the right-side agreement morph always *follows* this VC sequence, just like the left-side agreement morph always *precedes* the Root and the AV morpheme at the left edge (cf., e.g., (25)).

⋆ A right-oriented version of the alignment ranking that is independently needed for the left edge (35) generates the correct order in full (for agreement suffixes of any shape), as shown in (36) below.

(35) **Ranking** (to be refined): Align-Agr-R ≫ Align-Root-R ≫ Align-AV-R

(36) **Form X imperfective active** *yastaktibu*: explaining the right edge

/s$_{CAUS}$, t$_{i\ REFL}$, ktb, ai$_{AV}$, y$_i$(-)u$_{AGR}$/	ALIGN-AGR-R	ALIGN-ROOT-R	ALIGN-AV-R	INTEG
a. ☞ yastaktibu		*	**	*
b. yastakitbu		*	***!	*
c. yastiktubu		*	***!**	*
d. yastiktub	*!		****	

- ○ Because ALIGN-AGR-R is highest ranked, agreement must be rightmost, ruling out (36d), which solves the markedness problems without splitting by moving the Agr /u/ inside the Root.
  - ▪ This means there must be a violation of ALIGN-ROOT-R, and ensures the word-final sequence [bu].
- ○ Beyond that, the only constraint that cares which segment comes next is ALIGN-AV-R.
  - ▪ This ensures that the rightmost AV vowel comes next (36a).
- ⋆ Having the Root-medial /t/ surface next (36b) confers no benefit, nor does splitting the agreement affix and having it come next (36c); in fact, both worsen AV-alignment.

- As long as ALIGN-AV-R dominates the INTEGRITY constraints, this approach also explains why agreement suffixes don't split even when they provide the most sonorous (and thus most splittable) vowel:
  → **Doing so would worsen AV-alignment**.
- We can see this in the Form V perfective passive 3SG.MASC, w/ AV morph /ui/ and agreement morph /a/.
  ▹ All candidates in (37) have the same CV shape, differing only in which vowel splits.

- The ranking INTEG[i] ≫ INTEG[u] ≫ INTEG[a] prefers splitting the agreement morph /a/ (37a).
  - ○ But, this displaces the AV-final /i/ further left than the other splitting options, incurring extra ALIGN-AV-R violations.

→ To ensure that the AV-final /i/ is as far right as possible, the AV-initial /u/ gets split instead (37b).
  - ○ Still, (37b) ≻ (37c) because it splits the more sonorous vowel without any consequences for alignment.

(37) **Form V perfective passive** *tukuttiba*

/t$_{i\ REFL}$, $\mu_{c\ CAUS}$, ktb, ui$_{AV}$, a$_{AGR}$/	ALIGN-AV-R	INTEG[i]	INTEG[u]	INTEG[a]
a. tukit$_c$taba	***!**			*
b. ☞ tukut$_c$tiba	**		*	
c. tukit$_c$tiba	**	*!		

6.2 *Both-edge* alignment

- We now see that we need **both** *left*-alignment and *right*-alignment for:

(38) a. The Root
b. The AV morpheme
c. The (imperfective) agreement morphemes

- ○ This may have been obvious on its face for the imperfective agreement markers, which can (superficially, at least) be categorized as circumfixes.[6]

⋆ I implement this by enriching Generalized Alignment (McCarthy & Prince 1993, Hyde 2012) as follows:

→ **Alignment constraints can select *both edge* ("E") as their direction of alignment**.

[6] Perfective agreement is aligned only to the right. Therefore, the direction of alignment must differ for the different agreement categories. Conceptually, we might relate this to the idea that the lexical index for *AFX$_i$/_C must apply to morphs not morphemes (see fn. 3). More thought about how this fits into the alignment system broadly is required.

- Adopting this approach, the alignment constraint for, e.g., the AV morpheme would be defined as in (39):

(39) **Align-AV-E:** Assign one violation * for:
  a. each segment which intervenes in the output between the *left* edge of the exponent of the AV morpheme and the *left* edge of the word, **and**
  b. each segment which intervenes in the output between the *right* edge of the exponent of the AV morpheme and the *right* edge of the word.

  ∗ This to some extent recapitulates Yip's (1988) notion of "Edge-In Association", which was motivated by the same facts.

- One other place where we can see the effects of E-alignment is the perfective active AV morpheme /a/.

→ If we assume a unisegmental UR /a/ (rather than OCP-violating /aa/), we can view E-alignment as the driver of splitting in Form I, where one vowel would suffice for phonotactics (40).

(40) **Form I perfective active** 3sg.masc *kataba*

/ktb, a_{AV}, a_{AGR}/	Align-AV-E	Integ[a]
a. katb-a	4! (*|***)	
b. ktab-a	4! (**|**)	
c. ☞ katab-a	3 (*|**)	*

▷ For E-alignment constraints, violations for the left edge are indicated to the left of the " | ", violations for the right edge to its right.

- This holds equally well for consonant-initial agreement suffixes, e.g. the perfective 3pl.fem /-na/ (41).

(41) **Form I perfective active** 3pl.fem *katabna*

/ktb, a_{AV}, na_{AGR}/	*CCC	Align-Root-E	Align-AV-E	Integ[a]
a. katb-na	*!	2 (|**)	5 (*|****)	
b. ktab-na		2 (|**)	5! (**|***)	
c. ☞ katab-na		2 (|**)	4 (*|***)	*
d. katba-na		3! (|***)	3 (*|**)	*

  ∗ There is an outstanding problem regarding a candidate like *[kat-n-ab-a], where the Root and the AV morph intrude into the multisegmental agreement suffix.
  ○ This is probably solvable by introducing a high-ranked Contiguity-Afx constraint. However, this will require further scrutiny about the representation of the imperfective agreement markers, which are definitionally discontiguous.

7 Conclusion

- The analysis presented here is able to derive the full range of productive, canonical phonological forms of the Arabic verbal system, including the imperfective, which has often been omitted from previous analyses.
- It consists mainly of four types of constraints:

(42) **Constraint summary**
  a. Alignment constraints: ranked according to the MAP, some aligned to both edges
  b. One lexically-indexed linear phonotactic constraint: *Afx_i/_C
  c. One general linear phonotactic constraint: *CCC
  d. One faithfulness constraint (family): Integrity, relativized by vowel quality

- This analysis does not require recourse to CV templates. Nor does it require recourse to prosodic constraints, which have, in many previous analyses, imposed opaque prosodic requirements on stems.

→ This analysis thus fleshes out the insights of McCarthy (1993) that prosody is not a driver of the phonology of the Arabic verbal system.

Loose ends for future work

1. Conditions on mora association for the Form II/V CAUS /μ_c/ and the Form III/VI APPL /μ_v/
2. Unproductive verbal Forms (IX, XI–XV)
3. Non-canonical root shapes
   - Two-consonant roots
   - Roots with defective consonants
   - Four-consonant roots (which seem to have different morphological restrictions)
4. Imperfective agreement morphs vis-à-vis Vocabulary Insertion and underlying representation
5. The nominal system, which McCarthy (1993) (following McCarthy & Prince 1990) argues *does* admit to a prosodic morphology analysis
6. Other Semitic languages (do they work the same way, or do they require a different sort of analysis)

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A Amalgamation and the relationship between Root & Aspect/Voice

- There is one place where naive assumptions about asymmetric c-command vis-à-vis the MAP are not met:
  → The interaction between **Root and Aspect/Voice** (i.e. the vocalic melodies).

- We would expect Aspect and Voice to asymmetrically c-command Root given their higher position on the clausal spine. However, an alignment-based ordering analysis requires the reverse ranking:

(43) **Ranking:** ALIGN-ROOT-L ≫ ALIGN-AV-L (instead of expected ALIGN-AV-L ≫ ALIGN-ROOT-L)

⋆ In this section, I will first motivate this ranking, then propose solution based on *amalgamation* (Harizanov & Gribanova 2019) that can derive it in a way that is consistent with the MAP.

A.1 Alignment ranking

- Tableau (44) shows the basic interaction from a Form I (basic form) perfective passive.
  → Assuming that alignment is all that is in play, we would need the ranking ALIGN-ROOT-L ≫ ALIGN-AV-L.

(44) **Form I perfective passive *kutiba***

/ktb, ui_{AV}, a_{AGR}/	ALIGN-ROOT-L	ALIGN-AV-L
a. ☞ kutiba		*
b. uktiba	*!	

- Tableau (45) shows an additional case, the Form VII ("middle") perfective active, where the output is clearly not otherwise phonotactically optimizing.
  → This ensures that it is alignment which is driving the derivation, not markedness considerations.

(45) **Form VII perfective active *nkataba***

/n_{MID}, ktb, a_{AV}, a_{AGR}/	ALIGN-MID-L	ALIGN-ROOT-L	ALIGN-AV-L
a. ☞ nkataba		*	**
b. naktaba		**!	*
c. knataba	*!		**
d. ankataba	*!	**	

⋆ **Question:** Why does ALIGN-ROOT-L outrank ALIGN-AV-L?

A.2 Towards a solution: the Default Ranking Principle and portmanteau exponence

⋆ The Default Ranking Principle in (16) (repeated in (46)) will produce an unexpectedly-high ranking of ALIGN-ROOT-L *in the absence of asymmetric c-command*.

(46) **DRP for Arabic:** When the MAP does not prescribe a ranking between ALIGN-ROOT-L and another alignment constraint, rank ALIGN-ROOT-L higher.

→ If we can derive a structure where **Aspect and Voice no longer asymmetrically c-command Root**, we can use (46) to generate the necessary ranking.

- Now, recall that I have assumed that Aspect and Voice are *always* exponed together as a portmanteau morpheme in the language, as can be seen in Table 8.

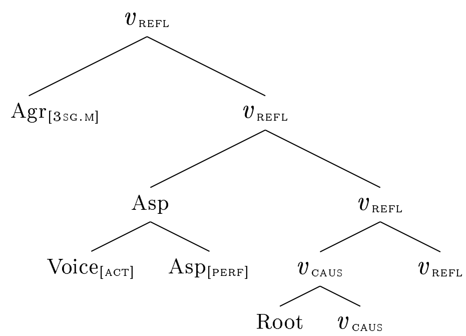
Form	Pf. Act. /a/	Pf. Pass /ui/	Impf. Act. /???/	Impf. Pass. /ua/
I	katab-a	kutib-a	y-aktub-u	y-uktab-u
II	$kat_c tab$-a	$kut_c tib$-a	y-$ukat_c tib$-u	y-$ukat_c tab$-u
III	$kaa_v tab$-a	$kuu_v tib$-a	y-$ukaa_v tib$-u	y-$ukaa_v tab$-u
IV	ʔaktab-a	ʔuktib-a	y-u(ʔa)ktib-u	y-u(ʔa)ktab-u
V	$takat_c tab$-a	$tukut_c tib$-a	y-$atakat_c tab$-u	y-$utakat_c tab$-u
VI	$takaa_v tab$-a	$tukuu_v tib$-a	y-$atakaa_v tab$-u	y-$utakaa_v tab$-u
VII	nkatab-a	nkutib-a	y-ankatib-u	y-unkatab-u
VIII	ktatab-a	ktutib-a	y-aktatib-u	y-uktatab-u
X	staktab-a	stuktib-a	y-astaktib-u	y-ustaktab-u

Table 8: Arabic verbal system (repeated from Table 2 above)

- Systematic facts like these ought to be captured through the application of syntactic and/or morphological processes of the language, rather than through accidents of Vocabulary Insertion.
  → i.e., there should be something special about the structural relationship between Aspect and Voice.

- I propose that the final structure of the complex head is that in (47), where the lowest segments of Aspect and Voice are displaced from the root of the head by a segment of Asp.[7]
  → For this section, I will explicitly be assuming that the "*v*-domain morphemes" are flavors of *v*.

(47) **Proposed morphological structure of the verb word** (Form V perfective active $t a k a t_c t a b a$)



⋆ This structure can be derived with Harizanov & Gribanova's (2019) post-syntactic *amalgamation* operation.
  - Its "counter-cyclic" appearance is derived by an odd, but permissible, configuration of feature values of the morphological feature driving amalgamation.
  - ∗ One might be able to derive this (or an equivalent) structure by positing that Voice moves to Aspect prior to roll-up head movement, as long as roll-up head movement operates over the higher segment of Asp.

⇒ This structure will generate the desired ranking ALIGN-ROOT-L ≫ ALIGN-AV-L because the lowest segments of Aspect and Voice no longer c-command Root.
  - This bleeds the MAP and allows the DRP to rank ALIGN-ROOT-L higher.

A.3 Amalgamation (an overview)

- Harizanov & Gribanova (2019) propose "almagamation" as the morphological process by which heads generated by the syntax are combined to form morphological words (complex head-adjunction structures).
  - In their view, amalgamation is the post-syntactic counterpart of *bona fide* head movement, which takes place in the syntax and exhibits the same behavior/restrictions as Internal Merge.

- Amalgamation adjoins one head to a structurally local head. Adjunction is driven by a binary morphological feature [M] (which can be un(der)specified), present on individual heads:

(48) **Amalgamation and [M]**
  a. Heads specified for [M:−] undergo *lowering* (Embick & Noyer 2001).
  b. Heads specified for [M:+] undergo *raising* (the mirror-image of lowering).
  c. Heads unspecified for this feature ([M:]) don't undergo raising or lowering, but they can still host it for other local heads.

- Amalgamation proceeds cyclically from the lowest head upwards, and the head which the mover adjoins to is the one that projects (just as in traditional head movement).

⋆ When multiple heads with specified values for [M] are present in the same domain, amalgamation (typically) leads to "roll-up head movement", which lands on whichever head is unspecified.

[7] Wallace (2013:4) assumes a similar structure.

A.4 Amalgamation and Aspect/Voice

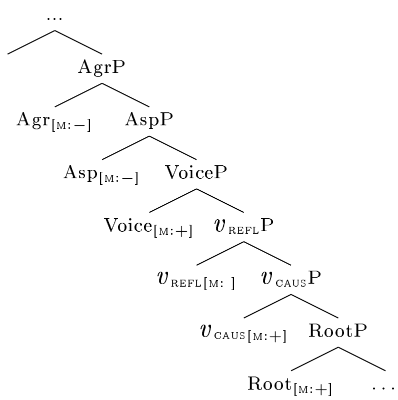
- We can derive the “counter-cyclic” structure in (47) by intermingling *different values of* [M] among the heads comprising the verbal domain, as follows:

(49) **M values in the Arabic verb** (from lowest to highest)

a. Root ⇒ [M:+]
b. All *v* heads ⇒ [M:+], *except*
c. The highest *v* head ⇒ [M:] (derived by impoverishment; §A.5.2)
d. Voice ⇒ [M:+] ← ***this is the crucial part***
e. Aspect ⇒ [M:−]
f. Agr ⇒ [M:−]

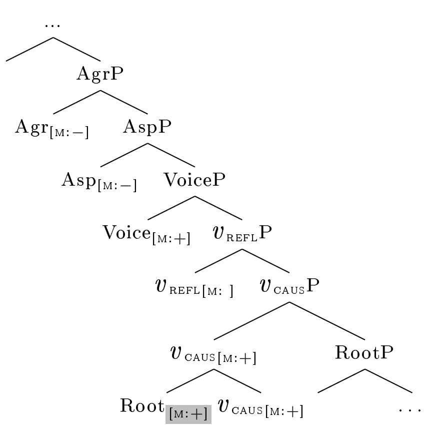
⋆ The trees in (50–55) track the cyclic application of amalgamation applied to the underlying syntactic structure of a perfective active Form V form (reflexive of the causative) (50) *takat*$_c$*taba*.

(50) **Syntactic structure underlying Form V**

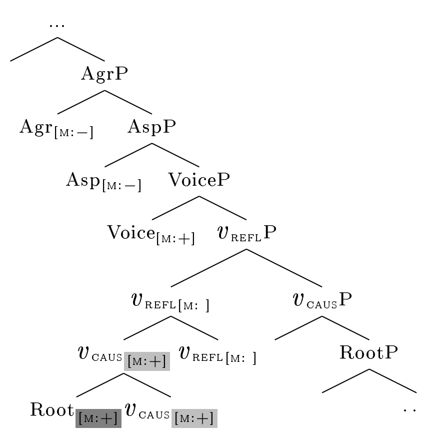


- Since Root and all non-highest *v* heads (here, Caus) are specified for [M:+]:
  (i) First, Root raises to adjoin to Caus (51).
  (ii) Then, Caus (which is now itself a complex head) raises to adjoin to Refl (52).

(51) **First amalgamation step: Root raises to Caus**



(52) **Second amalgamation step: Caus raises to Refl**



∗ Features which are discharged by the current step of amalgamation are notated with light gray; features which have been discharged by an earlier step of amalgamation are notated with dark gray.

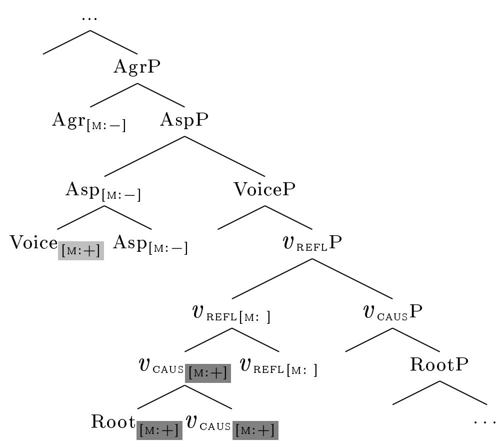
- Since the highest *v* head (here, Refl) is unspecified for [M:], it does not undergo movement.

- The derivation proceeds upwards to the next highest head, Voice.
  → Since it is specified for [M:+], it raises to Asp (53).

⋆ But because Refl did not undergo amalgamation, this raising step applies *only to the Voice head*.
  - i.e., *it leaves the complex Refl head behind* (for now).

- This yields the structure in (53), where there are now two separate complex heads within the verbal domain.

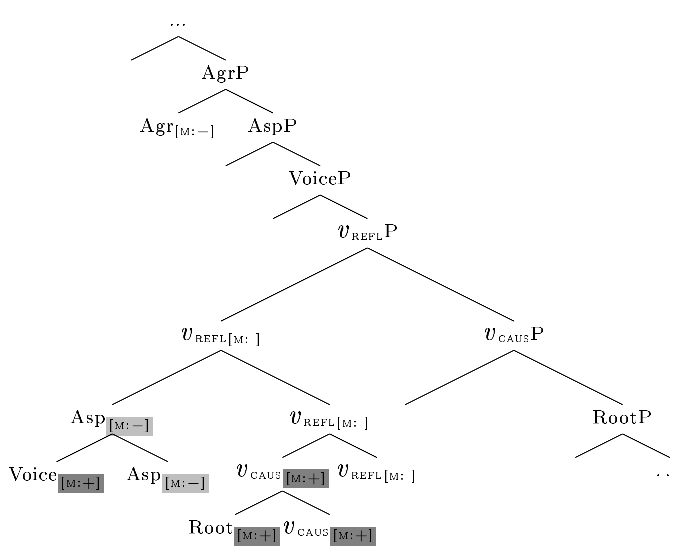
(53) **Third amalgamation step: Voice raises to Asp**



- While we might expect this to result in two separate morphological words, the presence of the [M:−] values on the higher heads counters this expectation:
  → As long as Asp is specified for [M:−], this will trigger *lowering* of the complex Asp head down to the complex Refl head (54).

  ∗ Harizanov & Gribanova (2019:488) explicitly state that this configuration is sufficiently local to permit amalgamation to proceed unabated.

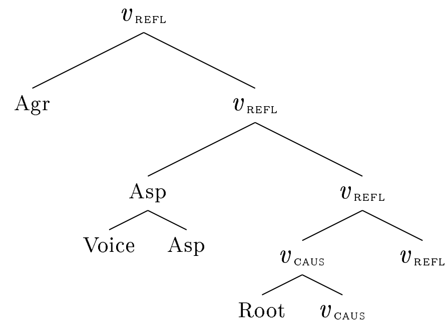
(54) **Fourth amalgamation step: Asp *lowers* to Refl**



⋆ This lowering results in two distinct complex heads being joined into one single complex head, but one that does not look like "roll-up head movement".

- Lastly, the [M:−] value on Agr leads to one more lowering step, completing the morphological word, shown in its final form in (55) (= (47)).

(55) **Complete morphological word**



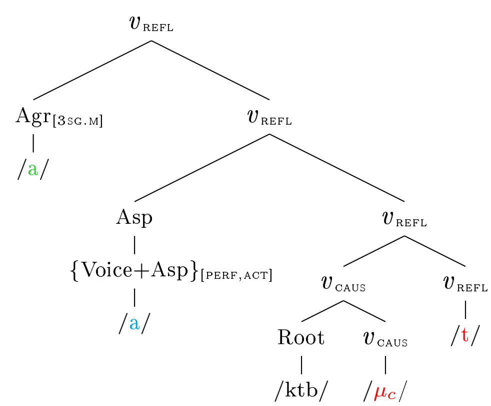
A.5 Morphological odds and ends

A.5.1 Aspect/Voice and Vocabulary Insertion: Fusion or contextual allomorphy

- In (56), I show that the structure derived by amalgamation can appropriately feed Vocabulary Insertion if we adopt either *fusion* (56a) or *contextual allomorphy* (56b) for Aspect/Voice:

(56) **Vocabulary Insertion** (Form V perfective active $takat_c taba$)

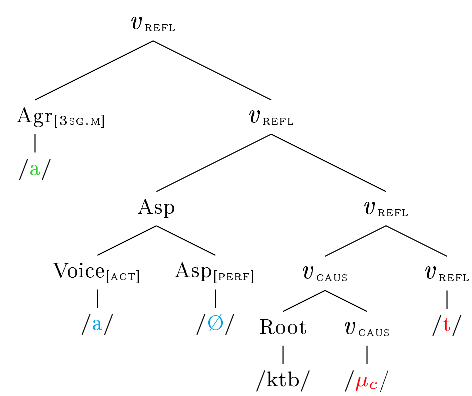
a. Fusion of Aspect & Voice



Vocabulary Items		
[PERF,ACT]	⇔	**/a/**
[IMPF,ACT]	⇔	/???/
[PERF,PASS]	⇔	/ui/
[IMPF,PASS]	⇔	/ua/

∗ VI's are maximally specific, and can be simplified.

b. Contextual allomorphy



Vocabulary Items				
[ACT]	⇔	**/a/**	/	**_PERF**
[ACT]	⇔	/???/	/	_IMPF
[PASS]	⇔	/ui/	/	_PERF
[PASS]	⇔	/ua/	/	_IMPF
[PERF/IMPF]	⇔	/∅/		

→ Fusion (Halle & Marantz 1993) directly captures the consistent portmanteau exponence of Aspect and Voice (assuming insertion into terminal nodes via the subset principle; Halle & Marantz 1993, Halle 1997).
  - But fusion must leave the intermediate segment of Asp intact (or else c-command would be reinstated), ruling out operations like *M-Merger* (Matushansky 2006) or *Coalescence* (Hsu 2021).

→ The same result can be obtained by assuming that either Aspect or Voice consistently has vocabulary entries conditioned by the other's feature, and the other consistently has a null exponent.
  - But Aspect and Voice's portmanteau exponence would be epiphenomenal, since it follows only from the structure of the vocabulary entries.

A.5.2 The distribution of M features and Impoverishment

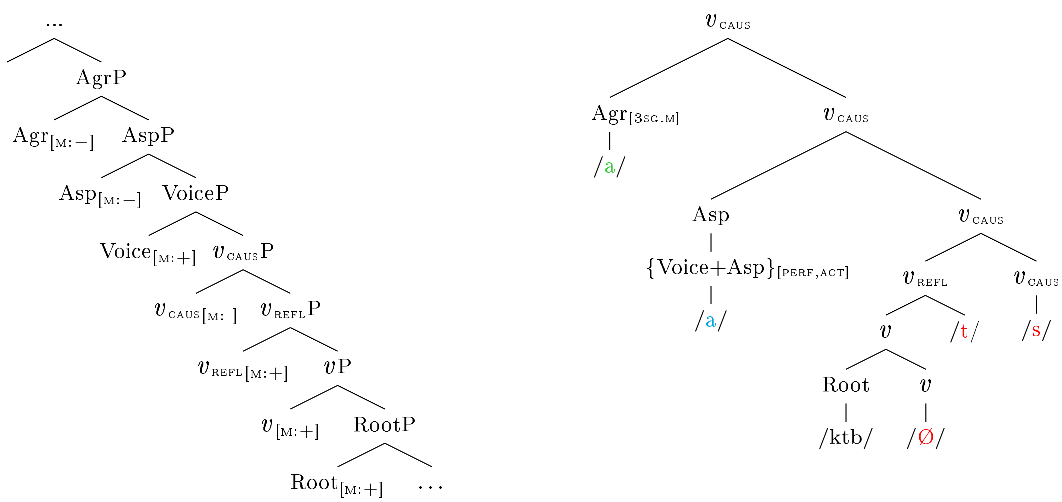
- As mentioned above, the distribution of M features seems to be in part grammatically-controlled:
  → In all Forms, the highest v head needs to be unspecified [M:], while all other v heads need to be [M:+].

- For example, based on the behavior of Form X, we know that:
  (i) Refl can't always be unspecified [M:], and
  (ii) Caus can't always be specified as [M:+]

- In Form X (57), the structural order of these two are reversed, and it is now crucial that Refl be specified as [M:+] and that Caus be unspecified [M:], the opposite of Form V.

(57) **Form X (causative of reflexive) perfective active** ***staktaba*** (cf. Table 5)

a. Underlying syntactic structure ⇒ b. Amalgamated head



- The predictability of this distribution can be generated as follows:
  (i) All v morphemes are specified as [M:+] in the lexicon.
  (ii) They lose that specification via *impoverishment* (Bonet 1991, Noyer 1992; et seq.) when they are selected by Voice:

(58) **[M]-impoverishment rule:** [M:+] → [M:] /_Voice

- This impoverishment rule must *precede* amalgamation.

A.6 Local summary

- In order to generate the necessary ranking ALIGN-ROOT-L ≫ ALIGN-AV-L, I have proposed a complex-head structure where Aspect and Voice do not c-command Root.
  - This prevents the MAP from generating any ranking (namely, the reverse ranking), which allows the Default Ranking Principle to rank ALIGN-ROOT-L higher.
- I derived the structure via amalgamation. It's counter-cyclic appearance is due to the sequencing of M feature-values: **[M:+]** → **[M:]** → **[M:+]** → **[M:−]**
  - This creates two separate complex heads before joining them together.
- This structure is (to some extent) independently motivated by the consistent portmanteau exponence of Aspect and Voice, under the view that morphological generalizations should be captured by morphological processes rather than accidents of vocabulary entries.