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Deriving Arabic verbal "templates" without templates

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Abstract. Much of the recent OT-based literature on Arabic root-and-pattern morphology has identified prosodic constraints as a main driver of the language's verbal "templates". I argue instead that the system is governed by *non-prosodic* (morpho)phonological constraints (in the spirit of McCarthy 1993). Following much recent work, this approach views Arabic's root-and-pattern system as garden-variety morpheme concatenation that is subject to unusual complications in the phonology and/or at the (morpho)syntax-phonology interface. This paper outlines an integrated analysis of the morphophonological properties of the Arabic verbal system without CV templates or prosodic constraints.

Keywords. Arabic; root-and-pattern morphology; non-concatenative; alignment

1. Introduction. Arabic's root-and-pattern verbal morphology has long been described in terms of Consonant/Vowel (CV) "templates", which were analytically reified in McCarthy (1979, 1981) and subsequent work (see, e.g., Faust 2015). Within the Optimality Theory (Prince & Smolensky [1993] 2004) literature, however, most researchers have pursued Generalized Template Theory (McCarthy & Prince 1995) analyses, whereby templatic effects are derived from independent principles. Many of these analyses have been based on the interaction between affixation and *prosody* (Ussishkin 2000, 2003, Tucker 2010, 2011, Kastner 2016, *a.o.*).

I argue instead that the Arabic verbal system is rather governed by the interaction between affixation and *non-prosodic* (morpho)phonological constraints, in the spirit of McCarthy (1993). Following much recent work (Tucker 2010, 2011, Wallace 2013, Kastner 2016, 2019, Kusmer 2019, *a.o.*), this approach views Arabic's root-and-pattern system as garden-variety morpheme concatenation that is subject to unusual complications in the phonology and/or at the morphosyntax-phonology interface. In this paper, I outline an integrated analysis of the morphophonological properties of the Arabic verbal system, based on the types of constraints previewed in (1), that does not rely on CV templates or prosodic constraints.

(1) **Constraint types**

a. Alignment constraints whose ranking follows dynamically from the morphosyntactic structure via the "Mirror Alignment Principle" (Zukoff to appear) [§3]
b. A lexically-indexed phonotactic constraint: $*\text{AFX}_i/\_\text{C}$ [§4]
c. INTEGRITY constraints (McCarthy & Prince 1995) regulating vowel splitting, subdivided by vowel quality [§5]
d. A general phonotactic constraint against three-consonant clusters: *CCC [§5]
e. Alignment constraints that simultaneously align to both edges of the word [§6]

2. Data preview. I make the following, largely traditional assumptions about the morphological composition of Arabic verbs: Roots consist of a string of underlying consonants (canonically 3); the "vocalic melodies" expone Aspect and Voice, and consist of a string of 1–3 underlying vowels; and the additional phonological content present in derived "Forms" expones *v*-

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domain morphemes (see Table 2). Subject agreement affixes are outermost: suffixal in the perfective, simultaneously prefixal and suffixal (thus circumfixal) in the imperfective.[1]

The phonological shapes of the nine productive verb "Forms", in the four aspect/voice categories, are given in Table 1. The exponents of the *v*-domain morphemes are underlined. My morphological analysis of the various *v*-domain morphemes is given in Table 2.[2] (The precise morphosemantic characterization of the *v*-domain morphemes is not crucial.)

Form	**Pf. Act.** /a/	**Pf. Pass** /ui/	**Impf. Act.** (?)	**Impf. Pass.** /ua/
I	katab-a	kutib-a	y-aktub-u	y-uktab-u
II	ka$\underline{t}_c$tab-a	ku$\underline{t}_c$tib-a	y-uka$\underline{t}_c$tib-u	y-uka$\underline{t}_c$tab-u
III	ka$\underline{a}_v$tab-a	ku$\underline{u}_v$tib-a	y-uka$\underline{a}_v$tib-u	y-uka$\underline{a}_v$tab-u
IV	$\underline{ʔ}$aktab-a	$\underline{ʔ}$uktib-a	y-u($\underline{ʔ}$a)ktib-u	y-u($\underline{ʔ}$a)ktab-u
V	$\underline{t}$aka$\underline{t}_c$tab-a	$\underline{t}$uku$\underline{t}_c$tib-a	y-a$\underline{t}$aka$\underline{t}_c$tab-u	y-u$\underline{t}$aka$\underline{t}_c$tab-u
VI	$\underline{t}$aka$\underline{a}_v$tab-a	$\underline{t}$uku$\underline{u}_v$tib-a	y-a$\underline{t}$aka$\underline{a}_v$tab-u	y-u$\underline{t}$aka$\underline{a}_v$tab-u
VII	$\underline{n}$katab-a	$\underline{n}$kutib-a	y-a$\underline{n}$katib-u	y-u$\underline{n}$katab-u
VIII	k$\underline{t}$atab-a	k$\underline{t}$utib-a	y-ak$\underline{t}$atib-u	y-uk$\underline{t}$atab-u
X	$\underline{st}$aktab-a	$\underline{st}$uktib-a	y-a$\underline{st}$aktib-u	y-u$\underline{st}$aktab-u

Table 1. Arabic verbal system (3SG.M of root √ktb 'write'; adapted from McCarthy 1981; 385)

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

Table 2. Morphemes involved in verbal Forms

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 accounts (e.g. Ussishkin 2003, Tucker 2010) is that the ranking of alignment constraints is not fixed across derivations, but rather *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 3 below. Recent accounts (Ussishkin 2003, Tucker 2010) have

[1] In addition to the works cited throughout the paper, I have drawn on data and description from various grammars of Classical and Modern Standard Arabic, including Wright (1896), Fischer (2002), Watson (2002), and Ryding (2005).
[2] 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.

used alignment constraints like the ones in (2–3) to help derive the ordering alternation. However, an alignment-based analysis of the Reflexive requires an apparent ranking paradox (4), demonstrated in (5).

Position	**Form**	**Proposed morphosyntax**	**Example form**	**Translation**
a. *Infixal*	VIII	Reflexive	***kt̲**ataba*	'write, be registered'
	V	Reflexive of the Causative	***t̲ak**attaba*	(*constructed form*)
b. *Prefixal*	VI	Reflexive of the Applicative	***t̲ak**aataba*	'write to each other'
	X	Causative of the Reflexive	*s**t̲ak**taba*	'write, make write'

Table 3. Forms with Reflexive /t/ (perfective active)

(2) **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.

(3) **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.

(4) **Ranking paradox**

a. Infixal Form (VIII): ALIGN-ROOT-L $\gg$ ALIGN-REFLEXIVE-L

b. Prefixal Forms (V,VI,X): ALIGN-REFLEXIVE-L $\gg$ ALIGN-ROOT-L

(5) **Alignment-based derivation of the Reflexive alternation** (/t/ ⇔ REFL)[3]

i. Infixal order: Form VIII Reflexive *kt̲ataba* [= (4a)]

/t_{REFL}, ktb, a_{AV}, a_{AGR}/		ALIGN-ROOT-L	ALIGN-REFL-L
a.	**t̲ak**taba	*!*	
b. ☞	**kt̲**ataba		*

ii. Prefixal order: Form V Reflexive of Causative *t̲akattaba* [= (4b)]

/t_{REFL}, $\mu_{C\ \text{CAUS}}$, ktb, a_{AV}, a_{AGR}/		ALIGN-REFL-L	ALIGN-ROOT-L
a. ☞	**t̲ak**at$_c$taba		**
b.	**kt̲**at$_c$taba	*!	

Tucker (2010) circumvented this by indexing Form VIII to a special alignment constraint (*basically*: ALIGN-REFL$_{\text{VIII}}$-L $\gg$ ALIGN-ROOT-L $\gg$ ALIGN-REFL-L). Similarly, McCarthy (1979, 1981) posits a special methathesis rule for Form VIII. This successfully avoids the problem, but does not provide explanatory power. I propose a new solution based on a novel syntactic generalization (6). This can help account for the difference if we adopt the Mirror Alignment Principle (MAP) approach to linearization (Zukoff to appear), defined in (7).

(6) **Syntactic 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. (1–2)), its exponent is *prefixal*.

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

[3] A candidate **t̲kataba* would be ruled out for independent reasons (see below).

(7) **The Mirror Alignment Principle**

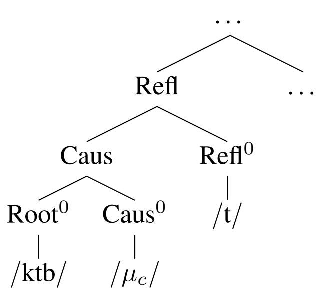
a. If a terminal node α *asymmetrically c-commands* a terminal node β, then the alignment constraint referencing α *dominates* the alignment constraint referencing β.[4]

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

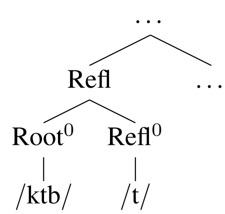
Compare the morphosyntactic structures of Form V (8a), the reflexive of the causative, and Form VIII (8b), the simple reflexive. In Form V, Refl *asymmetrically c-commands* Root, because it adjoins to the complex head containing Root and Caus. The MAP therefore generates the ranking ALIGN-REFL-L ≫ ALIGN-ROOT-L (9b), which produces a prefixal position for /t/ (5.ii). On the other hand, in Form VIII, Refl and Root *symmetrically c-command* one another, because Refl is the first head to adjoin to Root. The MAP thus asserts no ranking between ALIGN-REFL-L and ALIGN-ROOT-L, meaning that other factors will have to determine their relative ranking.

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

a. Form V *ṯakat$_c$taba*



b. Form VIII *kṯataba*



(9) **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

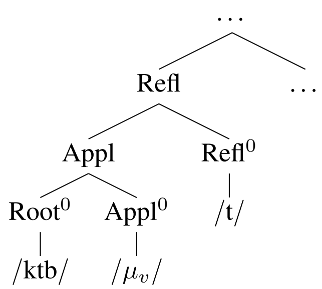
While we have now identified a distinction in the alignment behavior between the two types of structures, the MAP itself doesn't directly explain why Reflexive /t/ is infixal in Form VIII. However, we can now observe one further generalization (10). This generalization holds not only for Form VIII ***kṯ**ataba* (8b), but also for other combinations of heads (cf. Table 4 below). It holds of the relationship between Root and Causative in Form V *ta**ka**ṯ$_c$taba* (8a) and Form II ***ka**ṯ$_c$taba*. And it also holds of the parallel relationship between Root and Applicative in Form VI *ta**ka**a̱$_v$taba* (11a) and Form III ***ka**a̱$_v$taba* (11b).

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

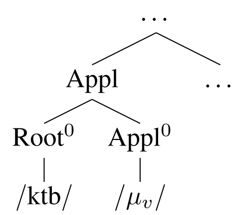
[4] The operative definition of c-command here must apply to the lowest segments of heads, and exclude the non-domination condition. (Thank you to Gereon Müller for bringing this to my attention.)

(11) **Syntactic structures with Applicative**

a. Form VI *takaa*$_v$*taba*



b. Form III *kaa*$_v$*taba*



We can understand the generalization in (10) in terms of alignment: in each of the relevant cases, the constraint ALIGN-ROOT-L outranks the left-oriented alignment constraint of the *v*-domain morpheme. Crucially, these are exactly the cases where the MAP does not establish a ranking, because the two heads stand in symmetric c-command. This suggests that there is a governing principle within the alignment system of Arabic that favors the high ranking of ALIGN-ROOT-L. I capture this with the "Default Ranking Statement" (DRS) in (12). For the infixal Reflexive in Form VIII ***kṯ****ataba* (8b), the DRS in (12) resolves the indeterminacy in favor of ALIGN-ROOT-L. This yields the ranking in (13a).

(12) **Default Ranking Statement for Arabic:** When the MAP provides no ranking statement, ALIGN-ROOT-L is higher-ranked by default.

(13) **MAP-governed rankings supplemented by Arabic's DRS** (cf. (9))

a. Form VIII (infixal order): ALIGN-ROOT-L $\gg$ ALIGN-REFLEXIVE-L

b. Form V (prefixal order): ALIGN-REFLEXIVE-L $\gg$ ALIGN-ROOT-L

These two distinct rankings are the paradoxical rankings from (4) above which generate the contrasting prefixal vs. infixal behavior of Reflexive (Table 3). 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 DRS 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 and rankings in Table 4.

Form	Perf. Act.	Syntactic structure	Alignment Ranking
I	*kataba*	[*v* [Root]]	ALIGN-ROOT-L ($\gg$ ALIGN-*v*-L)
II	*ka**t̲***$_c$*taba*	[Caus [Root]]	ALIGN-ROOT-L $\gg$ ALIGN-CAUS-L
III	*ka**a̲***$_v$*taba*	[Appl [Root]]	ALIGN-ROOT-L $\gg$ ALIGN-APPL-L
IV	***ʔ̲****aktaba*	[Caus [*v* [Root]]]	ALIGN-CAUS-L $\gg$ ALIGN-ROOT-L ($\gg$ ALIGN-*v*-L)
V	***t̲****aka**t̲***$_c$*taba*	[Refl [Caus [Root]]]	ALIGN-REFL-L $\gg$ ALIGN-ROOT-L $\gg$ ALIGN-CAUS-L
VI	***t̲****aka**a̲***$_v$*taba*	[Refl [Appl [Root]]]	ALIGN-REFL-L $\gg$ ALIGN-ROOT-L $\gg$ ALIGN-APPL-L
VII	***n̲****kataba*	[Mid [*v* [Root]]]	ALIGN-MID-L $\gg$ ALIGN-ROOT-L ($\gg$ ALIGN-*v*-L)
VIII	*k**t̲****ataba*	[Refl [Root]]	ALIGN-ROOT-L $\gg$ ALIGN-REFL-L
X	***s̲t̲****aktaba*	[Caus [Refl [*v* [Root]]]]	ALIGN-CAUS-L $\gg$ ALIGN-REFL-L $\gg$ ALIGN-ROOT-L

Table 4. Morphosyntactic structure and alignment analysis of verbal Forms

3.3. ROOT AND ASPECT/VOICE. There is one place where naive assumptions about asymmetric c-command vis-`a-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 that ALIGN-AV be dominated by ALIGN-ROOT. Tableau (14) shows the interaction from a Form I (basic form) perfective passive. Tableau (15) 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, rather than markedness considerations.

(14) **Form I Perfective Passive** *kutiba*

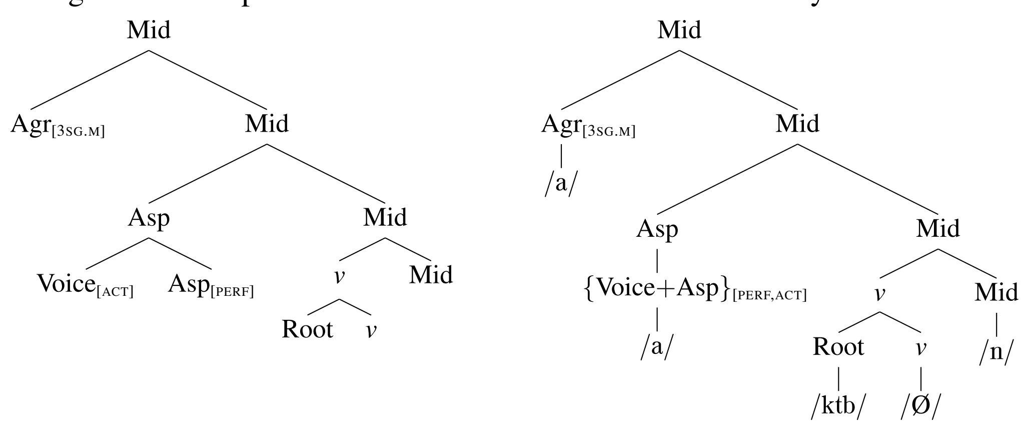
/ktb, ui$_{AV}$, a$_{AGR}$/	ALIGN-ROOT-L	ALIGN-AV-L
a. ☞ **ku**tiba		*
b. **uk**tiba	*!	

(15) **Form VII Perfective Active** *nkataba*

/n$_{MID}$, ktb, a$_{AV}$, a$_{AGR}$/	ALIGN-MID-L	ALIGN-ROOT-L	ALIGN-AV-L
a. ☞ n**ka**taba		*	**
b. n**ak**taba		**!	*
c. **kna**taba	*!		**
d. **a**n**k**ataba	*!	**	

The consistent portmanteau exponence of Aspect and Voice points to a solution in the post-syntax. In Zukoff (to appear), I propose the structure in (16), which is derived through amalgamation (Harizanov & Gribanova 2019), followed by fusion (or perhaps contextual allomorphy). Wallace (2013; 4) assumes an equivalent structure.

(16) **Assumed morphological structure of the verb word** (Form VII perf. active *nkataba*)
a. Amalgamated complex head   b. Fusion and Vocabulary Insertion



This structure generates the desired ranking. Because Aspect and Voice are displaced from the root of the complex head, they do not stand in any c-command relation with Root, and the MAP does not assert a ranking. This allows the DRS in (12) to generate the ranking ALIGN-ROOT-L ≫ ALIGN-AV-L. This interaction, and the resulting ranking, holds across all Forms. Nevertheless, conflict with higher-ranked constraints can generate outputs where (the left edge of) the AV morpheme surfaces further to the left than the Root.

4. A lexically-indexed phonotactic constraint. Much of the original rationale for CV templates was the unpredictability of the CV-strings towards the left-edge of the various Forms. Embedded within the system proposed here, this unpredictability can be reduced to a single parameter (17), and its interaction with the other relevant constraints: some (consonantal) affixes must be immediately followed by a vowel (i.e. can't precede a consonant).

(17) ***AFX$_i$/_C:** Assign a violation * if a morpheme with the index *i* precedes a consonant in the output.

$$\left\{ \textit{Alternatively}: \begin{array}{c} \text{AFX}_i \\ | \\ \text{*CC} \end{array} \text{ or } \begin{array}{c} \text{AFX}_i \\ | \\ \text{*C]}_\sigma \end{array} \right\}$$

This is essentially a constraint against these morphemes surfacing in coda position. However, since initial clusters are only resolved post-lexically (no repair when following a vowel phrase-internally; epenthesis of [i] when following a consonant phrase-internally; epenthesis of [ʔi] phrase-initially), this formulation circumvents syllabification problems. Regardless of the constraint's precise formulation, it is a lexically-indexed markedness constraint (following Pater 2009, *a.o.*), indexed to (i) Reflexive /t/, (ii) Causative /ʔ/, and (iii) the imperfective agreement affixes (or at least the morphs that show up at the left edge: /y,t,ʔ,n/).[5]

This derives the *absence* of clusters in certain forms where alignment would otherwise predict them. Consider the Form IV (causative) perfective passive *ʔuktiba*. As shown in (18), if only alignment were in play (assuming the analysis in Table 4 above), we would incorrectly generate a left-edge cluster *[ʔ̲kutiba] (18i.a). Adding in *AFX$_i$/_C eliminates the clustering candidate and generates the desired result (18ii.b). This reverses the order of Root and AV relative to their preferred alignment, as a repair for *AFX$_i$/_C. In Forms without affixes indexed to *AFX$_i$/_C — e.g. Form VII (19) — alignment will be maximally satisfied, allowing for clusters to surface at the left edge.

(18) **Form IV Perfective Passive** *ʔuktiba*

i. The derivation with only alignment constraints

/ʔ$_{\text{CAUS}}$, ktb, ui$_{\text{AV}}$, a$_{\text{AGR}}$/	ALIGN-CAUS-L	ALIGN-ROOT-L	ALIGN-AV-L
a. 💣 ʔ̲kutiba		*	**
b. ☹ ʔ̲uktiba		**!	*
c. kʔ̲utiba	*!		**

ii. The derivation with alignment plus *AFX$_i$/_C

/ʔ$_{i\ \text{CAUS}}$, ktb, ui$_{\text{AV}}$, a$_{\text{AGR}}$/	*AFX$_i$/_C	ALN-CAUS-L	ALN-RT-L	ALN-AV-L
a. ʔ̲kutiba	*!		*	**
b. ☞ ʔ̲uktiba			**	*
c. kʔ̲utiba		*!		**

(19) **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. ☞ n̲kataba			*	**
b. n̲aktaba	n/a		**!	*
c. kn̲ataba		*!		**

[5] 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.

4.1. *AFX$_i$/_C AND IMPERFECTIVE AGREEMENT. As can be seen in Table 5 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). 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 (as partially implied by templatic analyses like 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.

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 5. Arabic verbal system (repeated from Table 1)

For illustration, consider the Form I imperfective passive *yuktabu* (20). For now, assume that the agreement morphemes have left-oriented alignment constraints. (This will be revised below, in order to account for the behavior at the right edge.) The same interaction derives the more complex Forms in the same fashion.

(20) **Form I Imperfective Passive** *yuktabu* (*AFX$_i$/_C active for /y/)

/ktb, ua$_{AV}$, y$_i$(-)u$_{AGR}$/	*AFX$_i$/_C	ALIGN-AGR-L	ALIGN-ROOT-L	ALIGN-AV-L
a. ykutabu	*!		*	**
b. ☞ yuktabu			**	*
c. kyutabu		*!		**

4.2. *AFX$_i$/_C AND THE REFLEXIVE. 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 (21a).[6] Nevertheless, we know Reflexive /t/ is indexed to *AFX$_i$/_C because of its behavior in Forms V & VI. In Form V (22), alignment dictates that Reflexive /t/ be leftmost, followed by the Root. This should generate a cluster (22a), but the AV vowel surfaces in second position instead (22b). This follows only if Reflexive /t/ is indexed to *AFX$_i$/_C.

[6] 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 DRS. A solution is still wanting.

(21) **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. ☞ k$\underline{t}$utiba			*	**
b. ku$\underline{t}$tiba	*!		**	*
c. $\underline{t}$kutiba	*!	*		**

(22) **Form V Perfective Passive** *tukuttiba* (*AFX$_i$/_C active for /t/)

/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-CAUS-L	ALIGN-AV-L
a. $\underline{t}$ku$t_c$tiba	*!		*	***	**
b. ☞ $\underline{t}$uku$t_c$tiba			**	****	*
c. $\underline{t}$u$k_c$kutiba			***!	**	*
d. ku$t_c\underline{t}$utiba		*!**		**	*

A candidate *$\underline{t}$ukt$_c$tiba* would satisfy *AFX$_i$/_C and do better on alignment than (22b) — it would have one fewer violation of ALIGN-CAUS-L. This candidate is ruled out by phonotactics: either *CCC (see below) or a constraint forbidding geminates adjacent to consonants, both of which are surface true constraints in the language.

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 (23), confirmed by Table 6. (See McCarthy 1981; 400, Yip 1988; 565 for similar observations.)

Form	**Pf. Act.** /a/	**Pf. Pass** /ui/	**Impf. Act.** (?)	**Impf. Pass.** /ua/
I	katab-a	kutib-a	y-aktub-u	y-uktab-u
II	ka$t\underline{_c}$tab-a	ku$t\underline{_c}$tib-a	y-uka$t\underline{_c}$tib-u	y-uka$t\underline{_c}$tab-u
III	ka$a\underline{_v}$tab-a	ku$u\underline{_v}$tib-a	y-uka$a\underline{_v}$tib-u	y-uka$a\underline{_v}$tab-u
IV	$\underline{ʔ}$aktab-a	$\underline{ʔ}$uktib-a	y-u($\underline{ʔ}$a)ktib-u	y-u($\underline{ʔ}$a)ktab-u
V	$\underline{t}$aka$t\underline{_c}$tab-a	$\underline{t}$uku$t\underline{_c}$tib-a	y-a$\underline{t}$aka$t\underline{_c}$tab-u	y-u$\underline{t}$aka$t\underline{_c}$tab-u
VI	$\underline{t}$aka$a\underline{_v}$tab-a	$\underline{t}$uku$u\underline{_v}$tib-a	y-a$\underline{t}$aka$a\underline{_v}$tab-u	y-u$\underline{t}$aka$a\underline{_v}$tab-u
VII	$\underline{n}$katab-a	$\underline{n}$kutib-a	y-a$\underline{n}$katib-u	y-u$\underline{n}$katab-u
VIII	k$\underline{t}$atab-a	k$\underline{t}$utib-a	y-ak$\underline{t}$atib-u	y-uk$\underline{t}$atab-u
X	$\underline{st}$aktab-a	$\underline{st}$uktib-a	y-a$\underline{st}$aktib-u	y-u$\underline{st}$aktab-u

Table 6. Arabic verbal system (repeated from Table 1)

(23) **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.

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, and 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 (24). This approach yields three desiderata: (i) it correctly selects *which* vowel splits when splitting occurs; (ii) it correctly predicts that only one underlying vowel is ever split in a given form; and (iii) 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 *AFX$_i$/_C and *CCC (25), modulated by alignment.

(24) **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

(25) ***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. The order of the consonantal morphemes is determined purely by alignment ranking (cf. Table 4), as in (26). As long as INTEGRITY is ranked below these alignment constraints, it will always be preferable to split the AV vowels rather than reorder the consonantal morphemes as a repair for *AFX$_i$/_C. That is, a candidate like **syaktitbu*, which satisfies *AFX$_i$/_C by swapping the order of the exponents, would excessively violate high-ranked alignment constraints (here, ALIGN-AGR-L and ALIGN-REFL-L).

(26) **Ordering via alignment**

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

Holding the ordering of the consonantal morphemes constant, we can now see the interaction between *AFX$_i$/_C, *CCC, and INTEGRITY. Segments that are underlined in the output are exponents of morphemes indexed to *AFX$_i$/_C. Bolded vowels in the output are split vowels, incurring INTEGRITY violations.

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

/s$_{CAUS}$, t$_{i\ REFL}$, ktb, ai$_{AV}$, y$_i$(-)u$_{AGR}$/	*AFX$_i$/_C	*CCC	INTEGRITY[a]
a. ystkatibu	*!*	*!*	
b. ysatkitbu	*!*		
c. yastiktbu		*!	
d. ☞ y**a**st**a**ktibu			*

Perfectly adhering to alignment (27a) produces a long string of consonants at the beginning of the word, causing violations of both *AFX$_i$/_C and *CCC. The fact that this output is not selected shows that the alignment constraints must be dominated by (at least one of) these two markedness constraints. Shifting the AV vowels leftward can improve these problems, but it can't fix them completely. Placing the two vowels after every second consonant (27b) yields a *CCC-obeying output,[7] but doesn't alleviate the *AFX$_i$/_C violations. This confirms the ranking *AFX$_i$/_C ≫ INTEGRITY. As mentioned above, fixing the *AFX$_i$/_C violations by swapping the consonantal exponents (**syaktitbu*) will worsen alignment. This confirms that the alignment constraints outrank INTEGRITY as well. Shifting all of the underlying vowels over towards the left without splitting (27c) can alleviate the *AFX$_i$/_C violations, but it creates a three-consonant cluster towards the right, fatally violating *CCC. This confirms the ranking *CCC ≫ INTEGRITY. Only by splitting the vowels (27d) can both markedness constraints be satisfied simultaneously.

Once splitting is motivated by *AFX$_i$/_C and *CCC, INTEGRITY does the rest, as shown in (28) below. The ranking INTEGRITY[i] ≫ INTEGRITY[a] ensures that the underlying /a/ is split (28b) rather than the underlying /i/ (28a). The ranking of the INTEGRITY constraints over other markedness constraints, e.g. NOCODA or *CC, ensures that additional splitting does not occur: (28b) ≻ (28c,d). (Note that (28d) would actually be ruled out by alignment, because the extra [a] intervenes between the left word-edge and the left edge of left-oriented morphemes.)

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

/s$_{CAUS}$, t$_{i\ REFL}$, ktb, ai$_{AV}$, y$_i$(-)u$_{AGR}$/	INTEGRITY[i]	INTEGRITY[a]	NOCODA/*CC
a. yast**i**kt**i**bu	*!		**
b. ☞ y**a**st**a**ktibu		*	**
c. y**a**st**a**k**a**tibu		**!	*
d. y**a**s**a**t**a**k**a**tibu		**!*	

6. Explaining the right edge: *both-edge* alignment. The last major piece of the puzzle is to account for the relative positions of consonants and vowels towards the *right* edge of the stem. Consider again the Form X imperfective active *yastaktibu*. Nothing about the current analysis distinguishes actual *yastak**ti**bu* from alternative **yastak**it**bu*. In both forms, left-alignment of all the morphemes is maximized, subject to its interaction with markedness and INTEGRITY, and both forms have 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* over **yastak**it**bu*.

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.

Regardless, the current alignment-based analysis presents a new explanation. First, we know that ALIGN-ROOT ≫ ALIGN-AV based on the behavior of the left edge of the stem.

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

Second, we know that the stem-final VC sequence is always composed of the last AV vowel followed by the last Root consonant. 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., (20)). Thus, a right-oriented version of the alignment ranking needed for the left edge (29) generates the correct order in full. Considering just the right-edge alignment of these morphemes, the tableau in (30) shows how we derive a VC-final stem, followed by agreement of any shape. (Split vowels are bolded.)

(29) **Ranking** (to be refined): ALIGN-AGR-R $\gg$ ALIGN-ROOT-R $\gg$ ALIGN-AV-R

(30) **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. ☞ y**a**st**a**kti$_{AV}$b$_{RT}$u$_{AGR}$		*	**	*
b. y**a**st**a**ki$_{AV}$tb$_{RT}$u$_{AGR}$		*	***!	*
c. yasti$_{AV}$kt**u**b$_{RT}$**u**$_{AGR}$		*	***!**	*
d. yasti$_{AV}$ktu$_{AGR}$b$_{RT}$	*!		****	

Given that agreement must be rightmost (ruling out (30d)), there must be one violation of ALIGN-ROOT-R. This ensures the word-final sequence [bu]. Beyond that, the only constraint which cares about which segment comes next is ALIGN-AV-R, the next highest-ranked constraint. This ensures that the rightmost AV vowel will come next (30a). Having the Root-medial /t/ surface next (30b) confers no benefit, nor does splitting the agreement affix and having it come next (30c).

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*. Consider the Form V perfective passive 3SG.MASC, with AV morph /ui/ and agreement morph /a/. The ranking INTEG[i] $\gg$ INTEG[u] $\gg$ INTEG[a] prefers splitting the agreement morph /a/ (31a), but this displaces the AV-final /i/ further left, 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 (31b).

(31) **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$_c$t**a**b**a**	***!**			*
b. ☞ t**u**k**u**t$_c$tiba	**		*	
c. tuk**i**t$_c$t**i**ba	**	*!		

We now see that we need both left-alignment and right-alignment for the Root, the AV morpheme, and the (imperfective) agreement morphemes. This may have been obvious on its face for the imperfective agreement markers, which can (relatively straightforwardly) be categorized as circumfixes.[8] I propose that we implement this by enriching Generalized Alignment (McCarthy & Prince 1993; cf. Hyde 2012) to allow for alignment constraints that can select

[8] 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. 5). More thought about how this fits into the alignment system broadly is required.

both edge (abbreviated “E”) as their direction of alignment. Adopting this approach, the alignment constraint for, e.g., the AV morpheme would be defined as in (32). This largely recapitulates Yip’s (1988) notion of “Edge-In Association”, which was motivated by the same facts.

(32) **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.

One other place where we can see the effects of E-alignment is in the behavior of the perfective active AV morpheme /a/. If we assume that it is indeed underlyingly unisegmental /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 (33). This holds equally well for consonant-initial agreement suffixes, e.g. the perfective 3PL.FEM /-na/ (34).[9]

(33) **Form I Perfective Active** 3SG.MASC *kataba*

<table>
<tr><th>/ktb, a_{AV}, a_{AGR}/</th><th>ALIGN-AV-E</th><th>INTEG[a]</th></tr>
<tr><td>a. katb-a</td><td>4! (*|***)</td><td></td></tr>
<tr><td>b. ktab-a</td><td>4! (**|**)</td><td></td></tr>
<tr><td>c. ☞ katab-a</td><td>3 (*|**)</td><td>*</td></tr>
</table>

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

(34) **Form I Perfective Active** 3PL.FEM *katabna*

<table>
<tr><th>/ktb, a_{AV}, na_{AGR}/</th><th>*CCC</th><th>ALIGN-ROOT-E</th><th>ALIGN-AV-E</th><th>INTEG[a]</th></tr>
<tr><td>a. katb-na</td><td>*!</td><td>2 (|**)</td><td>5 (*|****)</td><td></td></tr>
<tr><td>b. ktab-na</td><td></td><td>2 (|**)</td><td>5! (**|***)</td><td></td></tr>
<tr><td>c. ☞ katab-na</td><td></td><td>2 (|**)</td><td>4 (*|***)</td><td>*</td></tr>
<tr><td>d. katba-na</td><td></td><td>3! (|***)</td><td>3 (*|**)</td><td>*</td></tr>
</table>

7. Conclusion. The analysis presented here is able to derive the full range of productive 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:

(35) **Constraint summary**
- a. Alignment constraints: ranked according to the MAP, some aligned to both edges
- b. One lexically-indexed phonotactic constraint: *AFX_i/_C
- c. One general phonotactic constraints: *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.

[9] There is an outstanding problem regarding a candidate like *[k**a**t-n-**a**b-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.

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