The Mirror Alignment Principle: Morpheme Ordering at the Morphosyntax-Phonology Interface

Sam Zukoff, Leipzig University
(samzukoff@gmail.com)

Manuscript, August 24, 2020

Abstract

As codified by Baker's (1985) "Mirror Principle", the linear order of morphemes within a morphologically complex word generally correlates with hierarchical syntactic structure (see also Muysken 1981). Broadly speaking, *morphological derivations must directly reflect syntactic derivations.* While Baker uses morphological ordering as a means of demonstrating the inseparability of syntax and morphology, he does not explore in great detail the question of the formal means by which compliance with the Mirror Principle is enacted in the grammar, tacitly assuming a cyclic morphological concatenation-based system.

This paper develops a new framework for morpheme ordering that derives the Mirror Principle while avoiding some of the shortcomings of cyclic morphological concatenation. The core of the proposal is an algorithm that applies at the morphology-phonology interface, called the *Mirror Alignment Principle* (MAP). The MAP is an algorithm that takes the hierarchical structure of morphosyntactic terminals (in the form of asymmetric c-command relations) generated by the syntax — and potentially operated on by the morphology — and dynamically translates it into a ranking of Alignment constraints (McCarthy & Prince 1993a, Prince & Smolensky [1993] 2004) in CON in the phonological component. All possible morpheme orders (and phonological modifications thereof) are generated by GEN, and the optimal surface order is selected by EVAL. Even though morpheme order in this system is computed in the phonology, the driving force behind this order resides in the syntax/morphology. This link between grammatical components generates Mirror Principle-compliant surface morpheme orders.

This paper explores two case studies of classical morpheme ordering problems, demonstrating how the MAP is consistent with each case and provides new insights into various aspects of these problems. First, it will show how the MAP is consistent with the complex interaction between Mirror Principle-satisfaction and the so-called "CARP template" in the Bantu languages (Hyman 2003). Second, it will show that the MAP framework can explain ordering alternations within Arabic's nonconcatenative verbal system. This will demonstrate that Mirror Principle-behavior can indeed be identified even in nonconcatenative morphology. Lastly, the paper situates the MAP proposal within the broader debates surrounding the phonology-morphology interface, with special attention to the MAP's ramifications for the theory and typology of infixation.

Keywords: Mirror Principle • Alignment • Morpheme ordering • Bantu CARP template • Arabic nonconcatenative morphology • Asymmetric compositionality • Infixation

1 Introduction

Even before Baker's (1985) influential proposal of the "Mirror Principle", it was widely recognized that the linear order of morphemes within a morphologically complex word generally correlates with hierarchical syntactic structure (see also Muysken 1981; cf. Baker 1988).* In morphologically complex words, morphemes

* This paper has been in the works for a very long time. It has benefited immensely from input by too many people to count. I will here list as many as I can remember right now, but certainly there are more that deserve my thanks. Thank you to Adam Albright, Nico Baier, Mark Baker, Ryan Bennett, Kenyon Branan, Heidi Harley, Larry Hyman, Itamar Kastner, Michael Kenstowicz, Gereon Müller, Neil Myler, David Pesetsky, Ezer Rasin, Norvin Richards, Nik Rolle, Kevin Ryan, Ryan Sandell, Donca Steriade, Jochen Trommer, Matt Tucker, Martin Walkow, Tony Yates, Michelle Yuan, Eva Zimmermann, the members of Leipzig Phonology Reading Group, the members of IMoLT, the audience at NELS 47, and audiences at MIT and Berkeley. The many mistakes and bad ideas that remain are entirely my fault.

which represent the exponents of morphosyntactic terminals that are *lower* in the syntactic structure (or, in Baker's terms, apply earlier in the syntactic derivation) generally surface *closer* to the root than those morphemes which are exponents of higher morphosyntactic terminals. In broad terms:

(1) **The Mirror Principle** (Baker 1985:375)
Morphological derivations must directly reflect syntactic derivations (and vice versa).

While Baker uses morphological ordering as a means of demonstrating the inseparability of syntax and morphology, he does not explore in great detail the question of the formal means by which compliance with the Mirror Principle is enacted in the grammar.

Baker assumes that the Mirror Principle follows from a cyclic morphological concatenation operation which joins (the exponents of) morphosyntactic terminals which are adjacent (i.e. sisters) in the syntactic structure (1985:377–378). Embick (2007) attempts to formalize this sort of concatenation operation by proposing a framework related to Kayne's (1994) "Linear Correspondence Axiom" for syntactic linearization (see also Julien 2002). However, as recognized in Embick (2015), while this approach may be able to limit the set of possible morpheme orders to those which obey the Mirror Principle, it underdetermines the choice between multiple possible Mirror Principle-obeying orders.[1] Some language-specific property (or set of properties) must be brought to bear in order to resolve this indeterminacy. Furthermore, identifying morphological concatenation as the formal mechanism behind morpheme ordering immediately excludes nonconcatenative morphological processes — especially things like Semitic "root-and-pattern" morphology — from the phenomena which can be directly assessed through the lens of the Mirror Principle (Baker 1985:400–403; cf. LeTourneau 1997).

This paper develops a new framework for morpheme ordering that derives the Mirror Principle while avoiding some of the shortcomings of a morphological concatenation-based system. The core of the proposal is an algorithm that applies at the morphology-phonology interface, called the *Mirror Alignment Principle* (MAP). The MAP is an algorithm that takes the hierarchical structure of morphosyntactic terminals generated by the syntax (and potentially operated on by the morphology) and translates it into a ranking of alignment constraints (McCarthy & Prince 1993a, Prince & Smolensky [1993] 2004) in CON in the phonological component. All possible morpheme orders (and phonological modifications thereof) are generated by GEN, and the optimal surface order is selected by EVAL.

This proposal assumes a modular, feed-forward grammatical architecture with the characteristics schematized in Figure 1 below (cf. Embick 2015). The syntax generates a hierarchical structure of morphosyntactic terminals (following basically Chomsky's 1995, *et seq.* Minimalist Program). This hierarchical structure serves as input to a discrete morphological component (as in Distributed Morphology (DM); Halle & Marantz 1993) which has the ability to perform its own operations on hierarchical structure (see, e.g., Embick & Noyer 2001, Arregi & Nevins 2012, Harizanov & Gribanova 2019). Vocabulary Insertion endows the morphosyntactic terminals with phonological content at the end of the morphological component.[2] These vocabulary entries serve as the input to an Optimality Theoretic (OT; Prince & Smolensky [1993] 2004) phonological grammar, which generates surface forms through constraint evaluation.

The part of this grammatical architecture which is responsible for determining the linear order of morphemes is the "*ranking of alignment constraints*" produced by the morphological component. This ranking is determined by the Mirror Alignment Principle (defined below), which converts c-command relations into ranking relations. Even though morpheme order in this system is computed in the phonology, the driving force behind this order resides in the syntax/morphology. This link between grammatical components generates Mirror Principle-compliant surface morpheme orders.

This paper is structured as follows. Section 2 lays out the formal details of the proposal. It defines and exemplifies the Mirror Alignment Principle, and shows how the use of alignment constraints can restrictively generate morpheme order when dynamically connected to the syntax. Sections 3 and 4 explore two case

[1] See Kusmer (2019) for an alternative adaptation of the Linear Correspondence Axiom which may not suffer from the same issues.

[2] In Figure 1, I present Vocabulary Insertion within the morphological component for the sake of clarity and consistency with standard DM approaches. However, note that the current proposal crucially assumes that linear order is completely absent until the phonological component. Therefore, any aspects of Vocabulary Insertion which are truly dependent on linear information (at least, linear order across a morpheme juncture) must be derived in the phonology. Full exploration of the relationship between Vocabulary Insertion and the MAP approach will be taken up in future work.

Syntactic Component

syntactic operations: MERGE, MOVE, *etc.*

⇓

hierarchical structure of morphosyntactic terminals

⇓

Morphological Component

morphological operations: IMPOVERISHMENT, LOWERING, *etc.*

⇓

vocabulary insertion

⇓

linearly unordered set of morphemes & **ranking of alignment constraints**

⇓

Phonological Component

Optimality Theoretic grammar: GEN, CON, EVAL

⇓

surface representations with linearly ordered morphemes

Figure 1: The modular architecture

studies of classical morpheme ordering problems, demonstrating how the MAP is consistent with both cases and provides new insights into various aspects of these problems.

Section 3 explores Mirror Principle effects, and Mirror Principle violations, in the Bantu languages. Mirror-image orderings of Causative and Reciprocal in Chichewa directly follow from the formulation of the Mirror Alignment Principle. However, these sorts of mirror-image orderings are embedded within a more complicated system, termed by Hyman (2003) the "CARP template". In this system, some morpheme pairs have "asymmetrically compositional" (Hyman 2003) ordering properties, and other pairs have fixed orders regardless of semantic scope (Ryan 2010). Both types, either in part or in whole, violate the Mirror Principle. Nonetheless, the Mirror Principle must remain in force in order to properly generate certain aspects of asymmetric compositionality. I will show that the Mirror Alignment Principle successfully captures the distribution of order-interpretation pairs in the basic cases of both asymmetric compositionality and fixed order, and is consistent with various approaches to the CARP template (and templatic morphology generally), situated at different time-points in the grammatical derivation.

Section 4 shows how the MAP framework can begin to make headway on a longstanding problem in theoretical linguistics, the Semitic system of nonconcatenative morphology. I focus on two specific puzzles in Arabic having to do with the relative order of the root and certain affixes, one involving the Reflexive morpheme /t/ and one involving the two basic types of Causative constructions. The exponents of Reflexive and Causative appear as prefixes in some morphosyntactic categories but as infixes in others. In previous frameworks based on concatenation and/or prosodic templates (cf. McCarthy 1979, 1981), these and other ordering alternations had to be stipulated or denied entirely. Yet, in the MAP framework, these alternations find a unified explanation in terms of stateable syntactic differences, in the form of a novel empirical generalization linking syntactic structure with linear order: *these morphemes appear as infixes when they are the first head to combine with the root, but they appear as prefixes when they attach higher*. The section concludes with a preliminary alignment-based analysis of the broader root-and-pattern system, showing that the Mirror Principle is indeed relevant more broadly in nonconcatenative morphological systems.

Section 5 explores additional empirical predictions and theoretical consequences of the MAP proposal, including its relevance for understanding infixation and the way phonological information interacts with morphological processes. The section concludes with a summary of the main contributions of the paper and a discussion of how the general proposal could be extended to account for ordering of constituents above the word level.

2 The Mirror Alignment Principle

In developing the theory of Generalized Alignment, McCarthy & Prince (1993a) argue for the existence of alignment constraints, a species of constraint which demands that specified edges of phonological and/or morphological constituents coincide in the output representation. As recognized in McCarthy & Prince's original proposal, and implemented in various ways thereafter (cf. Anderson 1996, Potter 1996, Hargus & Tuttle 1997, Trommer 2001, Yu 2007, *a.o.*), one possible application of the theory of Generalized Alignment is in the determination of morpheme order.[3]

The proposal outlined in this section takes Generalized Alignment as its starting point, but seeks to significantly constrain its power by placing principled restrictions on the ways alignment constraints can operate in the phonology. Namely, the relative ranking of alignment constraints is not free, contrary to the normal conception of free ranking of constraints in OT. Instead, their ranking is fixed (for any given derivation), transmitted from the morphological component by means of the Mirror Alignment Principle. This section defines the Mirror Alignment Principle, and illustrates how it can constrain the operation of Generalized Alignment in a way that derives the Mirror Principle (Baker 1985).

2.1 Generalized Alignment

McCarthy & Prince (1993a:80) define Generalized Alignment as follows:

(2) **Generalized Alignment** [GA]

"Align (Cat[egory]1, Edge1, Cat[egory]2, Edge2) $=_{\text{def}}$

$\forall$ Cat1 $\exists$ Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide.

Where

Cat1, Cat2 $\in$ P[rosodic]Cat $\cup$ G[rammatical]Cat

Edge1, Edge2 $\in$ Right, Left

...A GA requirement demands that a designated edge of each prosodic or morphological constituent of type Cat1 coincide with a designated edge of some other prosodic or morphological constituent Cat2."

Alignment constraints that align morphological categories to prosodic categories are constraints on the morphology-phonology interface. Since morpheme ordering is about determining the linear relationship between morphemes in the phonological representation, these constraints can be used to enforce morpheme order. In this paper, I focus specifically on alignment constraints that relate morphological categories to an edge of the prosodic word (much as in Trommer 2001). All claims about alignment are thus restricted to the activity of this type of alignment constraint. Further research is needed in order to determine whether other types of alignment constraints are also necessary, and whether there are any principled restrictions on their operation in the grammar.

When a single alignment constraint is active in a phonological derivation, it will appear as though its effect is simply to place the edge of the relevant morphological category at the edge of a particular prosodic category (or as near to it as possible, subject to higher-ranking phonological considerations). However, a different picture of alignment constraints emerges when we examine how they can interact with one another. Consider the following schematic example.

[3] McCarthy (2003), Yu (2003, 2007), Paster (2006, 2009), and Ryan (2010), among others, have argued that an unconstrained use of alignment constraints makes various undesirable predictions, which they claim are avoided by the alternative frameworks they advocate for. Some of these ills may be alleviated by the present proposal, which expressly limits and contextualizes the use of alignment constraints.

Suppose that there is a word that contains a Root plus three affixal morphemes: X, Y, and Z. The underlying representation for this word is (by hypothesis) an *unordered* set of the four morphemes /Root, X, Y, Z/ (cf. McCarthy & Prince 1993a; see also Wolf 2008:80). Each morpheme is referenced by an alignment constraint. (For the time being, I omit discussion of the alignment of the Root. This is an important issue to which I will return below.) As mentioned above, I assume that each morpheme is referenced by a single, word-edge–oriented alignment constraint. In this example, all three constraints are defined with reference to the *right* edge of the (prosodic) word, as shown in (3):[4]

(3) **Alignment constraints for the input /Root, X, Y, Z/**

a. ALIGN(X, R; PWD, R) [ALIGN-X-R]
Assign one violation mark for each segment intervening between the right edge of morpheme X and the right edge of the prosodic word.

b. ALIGN(Y, R; PWD, R) [ALIGN-Y-R]
Assign one violation mark for each segment intervening between the right edge of morpheme Y and the right edge of the prosodic word.

c. ALIGN(Z, R; PWD, R) [ALIGN-Z-R]
Assign one violation mark for each segment intervening between the right edge of morpheme Z and the right edge of the prosodic word.

Each alignment constraint will be maximally satisfied when the morpheme it references is absolute rightmost within the word. However, in any candidate output, only one morpheme can successfully attain this position (assuming no coalescence).[5] This means that satisfaction of one of these alignment constraints entails increased violation of the others. These constraints, therefore, will be in *direct competition* for a particular position in the output (here, word-final position).

The following table shows the violation profiles for each possible combination of the three morphemes X, Y, and Z. (I consider here only candidates where each of these morphemes follows the Root.) Violations are assigned here by treating each morpheme as if it were a single segment.

(4) **Violation profiles**

/Root, X, Y, Z/		ALIGN-X-R	ALIGN-Y-R	ALIGN-Z-R
a.	Root-X-Y-Z	**	*	
b.	Root-Y-X-Z	*	**	
c.	Root-X-Z-Y	**		*
d.	Root-Z-X-Y	*		**
e.	Root-Y-Z-X		**	*
f.	Root-Z-Y-X		*	**

Each candidate order has a total of three alignment violations (the morpheme second from the right incurs one alignment violation; the morpheme third from the right incurs two), but distributed across the different constraints. The six possible ranking permutations of the three alignment constraints each correspond to the selection of one of the six candidate orders.

2.2 The Mirror Alignment Principle Algorithm

Optimality Theory generally assumes that, in the absence of evidence to the contrary, any set of constraints is freely rankable. Under such an assumption, we would expect that all of these rankings would be permissible, and we would have no prior expectation as to which of the six candidate orders the language should display. In other words, for the set of languages that allow morphemes X, Y, and Z to co-occur, the factorial typology predicts languages of all six sorts.

However, it has long been recognized that the order in which morphemes appear within a word generally reflects the relative positions that their corresponding morphosyntactic terminals occupy in the hierarchical morphosyntactic structure (Muysken 1981, Baker 1985, 1988; cf. Rice 2000, Stiebels 2003, *a.o.*, on a semantic

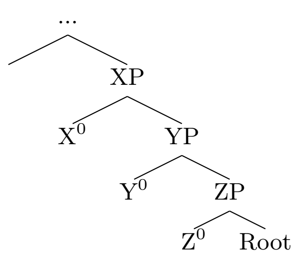
[4] It will be shown below that gradient evaluation of alignment constraints is crucial for the proposal.
[5] If a morpheme fails to have a surface exponent, any alignment constraint referencing it will be vacuously satisfied.

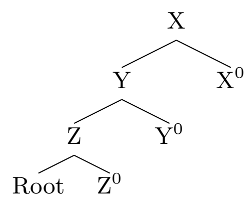
interpretation). Specifically, a morpheme that expones a terminal that appears higher in the syntactic structure will be *more external* in the word than a morpheme that expones a lower terminal.[6] As discussed above, Baker (1985) termed this generalization the "Mirror Principle". Given the Mirror Principle, we *do* have prior expectations about the relative order of morphemes in complex words.

Taking our schematic example, let's assume that we independently (through principles of syntax) have reason to believe that the morphemes X, Y, and Z stand in the hierarchical syntactic relation shown in (5):[7]

(5) **Syntax of /Root, X, Y, Z/**

a. Base-generated structure → b. Complex head





Given this structure, the Mirror Principle dictates that Z surface closest to the Root, Y surface next closest, and X surface farthest away. This is candidate order (4f) [Root-Z-Y-X]. The ranking of the three alignment constraints in (3) which will generate candidate order (4f) is the one in (6):

(6) **Generating the Mirror Principle order**

i. *Ranking*: Align-X-R ≫ Align-Y-R ≫ Align-Z-R

ii. *Tableau*:

/Root, X, Y, Z/		Align-X-R	Align-Y-R	Align-Z-R
a.	Root-X-Y-Z	*!*	*	
b.	Root-Y-X-Z	*!	**	
c.	Root-X-Z-Y	*!*		*
d.	Root-Z-X-Y	*!		**
e.	Root-Y-Z-X		**!	*
f. ☞	Root-Z-Y-X		*	**

What is important here is the relationship between the hierarchical structure in (5) and the ranking in (6). The highest terminal in the syntactic tree is X; the highest-ranked constraint in the constraint ranking is Align-X. The next highest terminal in the syntactic tree is Y; the next highest-ranked constraint is Align-Y. The lowest terminal in the syntactic tree is Z; the lowest-ranked constraint is Align-Z. This illustrates how mapping hierarchical syntactic relations onto ranking relations among alignment constraints generates a Mirror Principle-compliant order of morphemes.

If we characterize hierarchical relations using c-command, this mapping can be defined as in (7). Evidence from Arabic presented in Section 4 will demonstrate that the MAP must calculated over a (post-)syntactic structure that includes the results of head movement, i.e., structures like (5b) rather than (5a).[8]

(7) **The Mirror Alignment Principle (The 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 $\beta \rightarrow$ Align-$\alpha \gg$ Align-β

[6] Throughout this paper, I will aim to use the term "morpheme" to refer to the phonological exponent(s) of a morphosyntactic terminal node.

[7] I will use the superscript 0 to indicate the lowest segment of a head. This is the element which will be relevant for the determination of the MAP.

[8] Under this assumption, the definition of c-command I employ here will have to be relaxed so as not to exclude cases where a higher segment of the c-command*ing* terminal node dominates the c-command*ed* terminal node. (Thanks to Gereon Müller for pointing this out to me.) This adjustment would not be necessary if the MAP were calculated over the base-generated syntactic structure. Note also that by terminal node I mean the lowest segment of the terminal node.

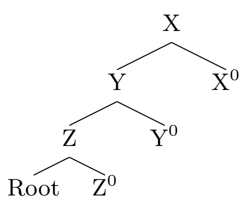
Through the lens of the MAP, there are two different ways in which a surface structure can be viewed as complying with the Mirror Principle. When Align-α and Align-β reference the same edge, applying the MAP-determined ranking will result in α being closer to the desired edge than β, i.e., the competition will be resolved in favor of α. From the reverse perspective, this results in β being closer to the Root than α is; this is the canonical characterization of Mirror Principle-compliance. If, on the other hand, the alignment constraints reference opposite edges, then both alignment conditions can be satisfied simultaneously. Such would be the case when, descriptively speaking, one morpheme is a prefix and the other is a suffix, e.g. Align-α-Left but Align-β-Right.[9] Since the two conditions do not interact, Mirror Principle satisfaction is essentially vacuous.

Note also that the tableau in (6) demonstrates why alignment constraints must be defined gradiently in this system, rather than categorically (*contra* McCarthy 2003). If they were defined categorically (something like *"Assign one violation mark if Y/Z is not at the right edge of the prosodic word"*), Align-Y-R and Align-Z-R would not be able to differentiate between the candidates which displace Y and Z from the right edge; i.e., the Mirror Principle-violating candidate (6e) would be indistinguishable from the Mirror Principle-obeying and desired candidate (6f). Under categorical definitions, both candidates would incur single violations of both constraints, because, in both candidates, neither Y nor Z is at the right edge. The two candidates would thus have identical violation profiles, and the MAP would not be able to choose between them. This would invalidate the MAP's ability to generate the Mirror Principle. Therefore, in order to adopt the MAP as a framework for morpheme ordering, alignment constraints must be defined gradiently.

2.3 Alignment Ranking in the Absence of Asymmetric C-Command

The Mirror Alignment Principle establishes the ranking of alignment constraints whose terminals stand in asymmetric c-command relations. But what happens when two terminals do not stand in an asymmetric c-command relation? Consider again the schematic complex head structure from (5b), repeated in (8). In complex heads, the lowest two terminals stand in *symmetric* c-command, not *asymmetric* c-command.

(8) **Complex head structure of /Root, X, Y, Z/**



Since X^0 asymmetrically c-commands Y^0, Z^0, and Root, the MAP asserts that Align-X must outrank all the other terminals' alignment constraints. Similarly, since Y^0 asymmetrically c-commands both Z^0 and Root, Align-Y must dominate Align-Z and Align-Root. However, since Z^0 and Root stand in *symmetric c-command*, the MAP does not establish a ranking between Align-Z and Align-Root. The MAP thus generates the alignment ranking in (9.i). The tableau in (9.ii) shows what results from this ranking if we now take into account candidates where Root is displaced from the left-edge. (For this example, I assume a right-oriented alignment constraint for Root, such that Root is competing for rightward positioning with the affixes.)

(9) **Ranking indeterminacy at the bottom of a complex head**

i. *Ranking*: Align-X-R ≫ Align-Y-R ≫ Align-Z-R, Align-Root-R

ii. *Tableau*:

/Root, X, Y, Z/	Align-X-R	Align-Y-R	Align-Z-R	Align-Rt-R
a. ☞ Root-Z-Y-X		*	**	***
b. ☞ Z-Root-Y-X		*	***	**
c. Root-Y-Z-X		**!	*	***
d. Root-Z-X-Y	*!		**	***

[9] In the MAP approach to morpheme ordering, the notions of "prefix" and "suffix" correlate (imperfectly) with the properties of left-alignment and right-alignment, respectively.

The top-ranking of ALIGN-X-R rules out any candidate output like (9d) where X is not the rightmost morpheme. ALIGN-Y-R is next highest ranked; so, among all remaining candidate orders (i.e. those with X at the right edge), this eliminates any which does not have Y immediately preceding X, here represented by (9c). But, because of the ranking indeterminacy brought about by the symmetric c-command at the bottom of the complex head, the MAP alone cannot adjudicate between the remaining candidate orders (9a) and (9b), which display the two possible orderings of Root and Z at the left edge. As far as the MAP is concerned, both orders are equally harmonic. Therefore, other factor(s) must be responsible for resolving this indeterminacy.

One possible factor that could be involved in resolving this sort of indeterminacy is what I will refer to as "Default Ranking Statements". These are (language-specific?) ranking principles which take effect when the MAP yields underdetermined rankings.[10] In Section 4, I will show that by assuming a single Default Ranking Statement — a preference for the high-ranking of the Root's alignment constraint — we can capture a coherent set of otherwise arbitrary ordering alternations in Arabic. Default Ranking Statements might also be implicated in the analysis of the "CARP template" in Bantu, which will be examined in Section 3.

2.4 Local summary

This section has demonstrated that the Mirror Principle can be implemented in a framework that handles morpheme ordering in the phonological component using alignment constraints, as long as there is a connection which links hierarchical morphosyntactic structure to the ranking of those alignment constraints. This causal link between hierarchical structure and alignment ranking is an algorithm here termed the Mirror Alignment Principle (MAP). The MAP limits the overgeneration problem typically associated with a Generalized Alignment approach to morpheme ordering, because it eliminates (in the general case) the possibility of free ranking of alignment constraints, in contradistinction to (most) other phonological constraints.

While the phonology does ultimately determine the surface order of morphemes, this determination is non-arbitrary; syntactic structure is responsible for providing this information to the phonology. Therefore, in this proposal, we can view the syntax/morphology as making the *decision* about morpheme ordering, and phonology as simply being responsible for the *implementation* of this decision. Since the final determination of order is made in the phonology, this implementation may be imperfect from the perspective of the syntax/morphology, as other phonological constraints may interact with the MAP-determined alignment constraints in a way that obscures the underlying structures.

This framework, though developed independently, bears significant resemblance to a proposal by Potter (1996), whereby morpheme order is determined in the phonology through the interaction of competing alignment constraints whose relative ranking is non-arbitrarily determined in relation to the syntax. For Potter, the non-arbitrary link is "Hierarchy Correspondence":

(10) **Hierarchy Correspondence** (Potter 1996:297)
"With respect to inflection, the dominance relationships within the syntactic functional hierarchy mirror the dominance relationships within the alignment constraint hierarchy at PF."

The main point of difference between the two approaches, though relatively small, is the following. Potter rejects the notion that morphologically complex words are built up through head movement/adjunction; instead, morphosyntactic feature values are present lexically and simply "checked" in the course of the derivation. As such, the "functional hierarchy" need not necessarily reflect the syntactic derivation, *per se*; this relationship is somewhat more indirect than in the MAP approach. In the following sections, using evidence primarily from verbal derivational morphemes, rather than the purely inflectional morphemes examined by Potter, I will show that the Mirror Principle — whether implemented by the MAP or by some other means — must truly be tracking syntactic derivation rather than some abstract functional hierarchy, since contrastive semantic/syntactic derivations result in contrasting ordering facts.[11]

[10] This notion bears a passing similarity to the concept of the "Master Ranking" in cophonology theory (cf. Inkelas & Zoll 2007).

[11] One other difference is that Potter uses opposite-edge alignment constraints, where the affix is the first argument of the constraint and the Root is the second argument, to derive the basically parametric difference between ordering in Apache and SiSwati. This is not something that is needed for the data examined in this paper, and thus is something which would be ideally eliminated from the theory on the grounds of parsimony, but this is an empirical question.

3 Mirror-Image Morpheme Orders and the CARP Template in Bantu

The Bantu languages represent a banner case of Mirror Principle behavior. Many Bantu languages display mirror-image orderings between the same verbal derivational morphemes ("verbal extensions"), where the ordering alternations correlate directly with a reversal in semantic scope (Baker 1985, Hyman 2003, *a.o*). I demonstrate in Section 3.1, using data from Chichewa, that these types of alternations can be derived straightforwardly using the MAP approach to morpheme ordering and linearization.

While these sorts of Mirror Principle-obeying mirror-image orderings are common in the Bantu languages, they represent just one piece of a more complex picture. In Bantu, the drive for Mirror Principle satisfaction sometimes stands in conflict with the so-called "CARP template" (Hyman 2003, Good 2005), a default preference for certain verbal derivational morphemes to appear in a particular order, namely, CAUSATIVE-APPLICATIVE-RECIPROCAL-PASSIVE (C-A-R-P). This conflict manifests itself in different ways across different languages and in different corners of the grammar within individual languages. In Sections 3.2 and 3.3, I focus on one particular type of Mirror Principle-CARP template interaction, "asymmetric compositionality" (Hyman 2003:250; cf. Ryan 2010), as instantiated in Chichewa.

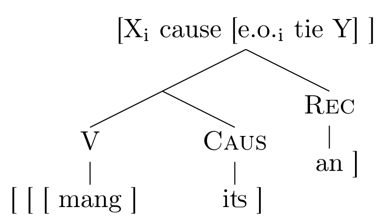
It is not the goal of this section to provide a definitive explanation of the CARP template, or morphological templates generally. Rather, I simply aim to show that the Mirror Alignment Principle approach to morpheme ordering is capable of capturing the contingent compliance vs. violation of the Mirror Principle as instantiated by this well-known case of templatic morphology. Furthermore, I will show that the MAP is flexible enough to allow for explanations of templatic morphology at various stages of the grammatical derivation, i.e., in the syntax, in the morphology, or in the phonology — all of which have been proposed in the literature.

3.1 Mirror-Image Morpheme Orders in Chichewa

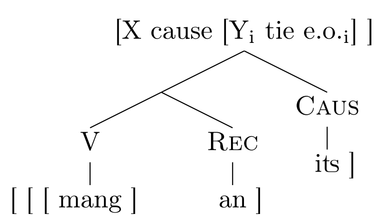
Baker (1985) demonstrates that, in certain Bantu languages, given two meaningful elements in verbal derivation, such as Causative and Reciprocal, a reversal in semantic interpretation correlates with a reversal in the linear order of the morphemes that expone those meanings. This generalization can be seen with the following contrast from Chichewa:

(11) **Orders of Causative and Reciprocal in Chichewa** (Hyman 2003:247)

a. Reciprocalized Causative: *mang-its-an-* 'cause each other to tie'



b. Causativized Reciprocal: *mang-an-its-* 'cause to tie each other'



When the Reciprocal meaning scopes over that of the Causative (11a), the Reciprocal morpheme *-an-* is more external in the linear order than the Causative morpheme *-its-*. On the other hand, when the Causative meaning scopes over the Reciprocal meaning (11b), that order is reversed and Causative *-its-* is most external.

While Hyman (2003) is cautious not to assert that these hierarchical structures are truly the syntactic structures associated with these derivations, I propose that we should indeed interpret them as such; these structures are the complex heads resulting from head movement. When the Mirror Alignment Principle algorithm receives these two distinct structures, it generates two distinct rankings, as shown in (12). These verbal derivational morphemes are suffixal in Chichewa (and the other Bantu languages), so they have right-oriented alignment constraints.

(12) **Mirror Alignment Principle rankings for the structures in (11)**

a. Reciprocalized Causative (11a):
Rec c-commands Caus → ALIGN-REC-R ≫ ALIGN-CAUS-R

b. Causativized Reciprocal (11b):
Caus c-commands Rec → ALIGN-CAUS-R ≫ ALIGN-REC-R

When these rankings are submitted to CON and run through EVAL in the phonological component, they will generate mirror-image orders, as demonstrated in (13) and (14). As mentioned earlier, in the input, the morphemes are unordered; therefore, the order in which they are listed graphically is purely arbitrary. Each morpheme is notated with the morphosyntactic category it is exponing.

(13) **Reciprocalized Causative** *mang-its-an-* (11a)

/mang$_{\text{ROOT}}$, its$_{\text{CAUS}}$, an$_{\text{REC}}$/	ALIGN-REC-R	ALIGN-CAUS-R
a. ☞ mang-its-an-		** (an)
b. mang-an-its-	*!* (its)	
c. its-mang-an-		**, *!*** (an, mang)
d. an-mang-its-	*!*, **** (its, mang)	

(14) **Causativized Reciprocal** *mang-an-its-* (11b)

/mang$_{\text{ROOT}}$, its$_{\text{CAUS}}$, an$_{\text{REC}}$/	ALIGN-CAUS-R	ALIGN-REC-R
a. mang-its-an-	*!* (an)	
b. ☞ mang-an-its-		** (its)
c. its-mang-an-	*!*, **** (an, mang)	
d. an-mang-its-		**, *!*** (its, mang)

In the derivation of the Reciprocalized Causative in (13), the highest ranked constraint is ALIGN-REC-R. This constraint eliminates all candidate orders which do not place the right edge of the Reciprocal morpheme (the [n] of *an*) at the right edge of the word, i.e. candidates (b) and (d).[12] The next highest ranked constraint is ALIGN-CAUS-R. This constraint selects from among the remaining candidate orders the one where the right edge of the Causative morpheme (the [ts] of *its*) is as far to the right as possible, i.e. interior to the Reciprocal morpheme but no farther — candidate (a) over candidate (c). When the MAP produces the opposite ranking for the Causativized Reciprocal in (14), the candidate set and violation profiles are identical, but the constraint ranking instead selects candidate (b).

This demonstrates again that alignment constraints can place morphemes in the correct order in the phonological component *without* the application of declarative concatenation operations at any point within the grammar, as in the standard approaches represented by, for example, Baker (1985, 1988) and Embick (2007, 2015). All that is required is that hierarchical relations in the syntax/morphology are transmitted to the phonology as a set of pairwise ordered rankings of alignment constraints, via the MAP.

3.2 The CARP Template and Asymmetric Compositionality

While a number of Bantu languages do indeed display behaviors like those introduced above for Chichewa, the full picture is a great deal more complicated. Hyman (2003:247–248) outlines several ways in which the Bantu languages violate the Mirror Principle in order to satisfy the CARP template; that is to say, instances

[12] Note that these verb forms require "final vowel" suffixes, so the rightmost CARP element will never be absolute word-final. This is further evidence that the alignment constraints must be evaluated gradiently.

in which the languages linearize Causative (C), Applicative (A), Reciprocal (R), and Passive (P) in that order even when it contradicts the order expected by the Mirror Principle.

First and most basically, some Bantu languages obey the CARP template at all costs. For example, Chimwiini (Hyman 2003:258) and Kinyarwanda (Banerjee 2019), and perhaps Luganda (McPherson & Paster 2009), show no mirror-image orders with CARP elements. Insofar as they allow semantic scopal reversals like those discussed above for the Causative and Reciprocal in Chichewa, the distinct syntactic structures underlying the distinct scopal interpretations are invariably mapped to the same CARP-obeying linear order.

Second, among those languages that do show mirror-image ordering behavior, mirror-image orders are generally only permitted with certain pairs of suffixes, rather than as a whole throughout the system. For example, while Chichewa allows mirror-image orderings between Causative and Reciprocal, it *does not* allow mirror-image orders between Causative and Applicative or Applicative and Reciprocal (Hyman 2003). In both of those cases, both scopal interpretations are mapped invariably to the CARP-obeying linear order.

Thirdly and most interestingly, there is an interpretive asymmetry within this system, which Hyman (2003:250) terms "asymmetric compositionality". In languages which do permit mirror-image orderings, the CARP-obeying order permits *both scopal interpretations* while the CARP-violating order permits only the one correlated with the surface order via the Mirror Principle (Hyman 2003:248, Good 2005:30–41). Put another way, in Bantu, CARP-*obeying* orders are (in most if not all cases) semantically ambiguous, while CARP-*violating* orders are never semantically ambiguous. The Causative and Reciprocal in Chichewa display this type of asymmetric compositionality.

The asymmetric compositionality illustrated by Chichewa's Causative and Reciprocal is summarized in Table 1. In the discussion below, a semantic interpretation which is "CARP-violating" is one where an element farther to the right in the CARP acronym semantically scopes below an element farther to the left in the acronym. (Under the assumption that syntax and semantics are essentially isomorphic in this regard, semantic CARP-violation is equivalent to syntactic CARP-violation.) A "✓" indicates an order-interpretation (O-I) pair which is licit in Chichewa; a "✗" indicates an O-I pair which is illicit in Chichewa.

Table 1: Asymmetric compositionality with Chichewa's Causative and Reciprocal

	Surface Morpheme Order	
	CARP-obeying	CARP-violating
Semantic Interpretation	Root-Caus-Rec *mang-its-an*	Root-Rec-Caus *mang-an-its*
CARP-obeying [[[Root] Caus] Rec]	a. ✓ (**MP-obeying**)	b. ✗ (MP-violating)
CARP-violating [[[Root] Rec] Caus]	c. ✓ (MP-violating)	d. ✓ (**MP-obeying**)

From this table, we can draw two generalizations about the nature of asymmetric compositionality:

- First, O-I pairs that **obey the Mirror Principle** are licit, whether order and interpretation are both CARP-obeying (Table 1a) or both CARP-violating (Table 1d). Thus, any verbal form can be interpreted as having the outer affix take semantic scope over the inner affix.
- Second, O-I pairs where the **linear order is CARP-obeying** are licit, whether semantically CARP-obeying (Table 1a) or semantically CARP-violating (Table 1c). Linearly CARP-obeying orders are thus semantically ambiguous.

Taken together, this shows that there are two conditions which license an O-I pair in such cases: (i) Mirror Principle satisfaction, or (ii) linear CARP satisfaction. The only illicit O-I pair is Table 1b, the one which satisfies neither of these conditions: it is not Mirror Principle-obeying, nor is it linearly CARP-obeying.

The way to distinguish a language like Chimwiini (which permits no mirror-image orders) from a language like Chichewa (which does permit certain mirror-image orders), is whether or not Mirror Principle satisfaction is a sufficient condition for licensing an O-I pair. If this is not sufficient, an O-I pair like Table 1d will not be licensed, and the system will map to a Chimwiini-type language, where only CARP-obeying orders are allowed. The same can be said of different CARP combinations within a language like Chichewa which allows certain mirror-image orderings but not others. That is, in Chichewa, the Mirror Principle is able to license the CARP-violating order with Causative and Reciprocal, but it is not sufficient to license the CARP-violating order with Causative and Applicative.

Our explanation (or explanations) of CARP effects thus must be able to handle several different kinds of situations. We must be able to derive languages that fully obey CARP. We must be able to derive languages with limited Mirror Principle-driven violation of CARP. And we must be able to derive asymmetric compositionality for CARP-violating orders, which stand beside linearly fixed, semantically ambiguous CARP-obeying orders in the same language.

3.3 CARP and the MAP

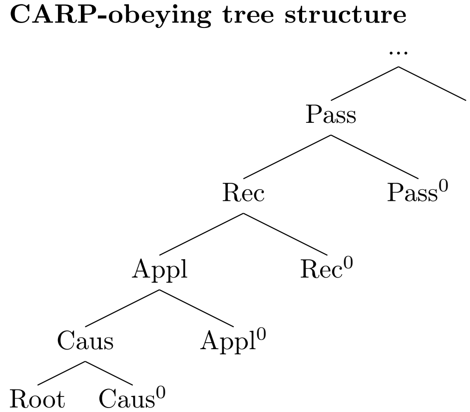
Since CARP effects involve in some way all aspects of the grammar — semantics, syntax, morphology, and phonology — one could reasonably seek to locate the explanation of the CARP template in any component(s) of the grammar. In the remainder of this section, I entertain several different types of explanations for the CARP template and its interaction with the Mirror Principle, and show how the MAP approach is able to generate Mirror Principle-compliance and asymmetric compositionality in concert with any of these types of explanations.

3.3.1 CARP in the Syntax: Syntactic Selection

There have recently been attempts to explain certain aspects of the CARP template by appealing to selectional restrictions on the syntactic heads involved in CARP. (See also Myler 2015 for a syntactic selectional approach to similar templatic phenomena in Quechua.) For example, Banerjee (2019) shows that independently identifiable syntactic and semantic properties of CARP elements and other heads in the verbal domain may be able to account for the full-scale adherence to the CARP template observed in Kinyarwanda. According to Banerjee, semantically CARP-violating structures can only be realized through periphrasis. This implies that Kinyarwanda does not actually show asymmetric compositionality, suggesting that Kinyarwanda's CARP system may be substantially different than that of Chichewa and other languages that allow some degree of CARP violation.

In any event, if this sort of syntactic approach is an appropriate analysis of CARP, for Kinyarwanda or more generally, then the MAP would have no problem generating the correct morpheme order. If the syntax is limited to hierarchical structures where elements further to the right in the CARP acronym necessarily c-command elements further to the left (schematized in (15)),[13] and they all have right-oriented alignment constraints, then the MAP will automatically generate the rankings necessary to derive CARP (shown in (16)).[14]

(15) **CARP-obeying tree structure**



[13] Note that Banerjee‘s (2019) syntactic analysis of Kinyarwanda is significantly more sophisticated than this tree suggests. The tree is meant for expositional purposes only.

[14] The fact that the Root is always to the left of all CARP suffixes, whether there is one CARP suffix or multiple ones, suggests that the Root has a left-alignment constraint in Bantu.

(16) **MAP-determined rankings for (15)**

a. Pass^0 c-commands $\text{Rec}^0 \rightarrow$ ALIGN-PASS-R $\gg$ ALIGN-REC-R
b. Rec^0 c-commands $\text{Appl}^0 \rightarrow$ ALIGN-REC-R $\gg$ ALIGN-APPL-R
c. Appl^0 c-commands $\text{Caus}^0 \rightarrow$ ALIGN-APPL-R $\gg$ ALIGN-CAUS-R
$\Rightarrow$ ALIGN-PASS-R $\gg$ ALIGN-REC-R $\gg$ ALIGN-APPL-R $\gg$ ALIGN-CAUS-R

This schematization reiterates that, whenever the syntax furnishes a hierarchically CARP-obeying structure, the MAP will faithfully realize the CARP order. However, the existence of asymmetric compositionality tells us very clearly that there are some linearly CARP-obeying forms whose underlying syntactic structure does not conform to the hierarchy in (15). Additionally, consider the following piece of syntactic evidence adduced by Hyman (2003:260): in Chichewa, there are extraction asymmetries between the arguments of semantically ambiguous verb forms whose exponents are linearly CARP-obeying.

As mentioned earlier, in Chichewa, Causative and Applicative always surface in that order (linearly CARP-obeying). When this order corresponds to an Applicativized Causative interpretation (C < A), and gets passivized, only the Applicative argument can be promoted to subject, as shown in (17). On the other hand, when this order corresponds to a Causativized Applicative interpretation (C > A), and gets passivized, only the Causee can be promoted to subject, as shown in (18).

(17) **Applicativized Causatives in Chichewa** (Hyman 2003:260, ex. 22)
(Caus *-its*, Appl *-il*, Pass *-idw*, 'cry' *líl*, 'children' *aná*, 'stick' *ndodo*)

a. Mchómbó a-ná-líl-**its-il**-a [$_{\text{CAUSEE}}$ aná] [$_{\text{APPL}}$ ndodo]
'Mchombo made the children cry with a stick'
b. [$_{\text{APPL}}$ ndodo] i-ná-líl-**its-il**-idw-á [$_{\text{CAUSEE}}$ aná]
'a stick was used to make the children cry'
c. ?*[$_{\text{CAUSEE}}$ aná] a-ná-líl-**its-il**-idw-á [$_{\text{APPL}}$ ndodo]
'the children were made to cry with a stick'

(18) **Causativized Applicatives in Chichewa** (Hyman 2003:260, ex. 23)
('cultivate' *lím*, 'hoes' *makásu*)

a. Mchómbó a-ná-lím-**its-il**-a [$_{\text{CAUSEE}}$ aná] [$_{\text{APPL}}$ makásu]
'Mchombo made the children cultivate with hoes'
b. [$_{\text{CAUSEE}}$ aná] á-ná-lím-**its-il**-idw-á [$_{\text{APPL}}$ makásu]
'the children were made to cultivate with hoes'
c. ?*[$_{\text{APPL}}$ makásu] a-ná-lím-**its-il**-idw-á [$_{\text{CAUSEE}}$ aná]
'hoes were used to make the children cultivate'

These facts indicate that only the argument that is syntactically highest is available for movement to subject. This requires that the arguments, and, correspondingly, the heads that introduce them, be merged in different syntactic orders for the two different scopal interpretations. Thus, there must be distinct syntactic structures underlying the ambiguous surface form of the verb word.

Another suggestive piece of evidence that CARP-obeying orders can derive from "CARP-violating" syntactic structures comes from idioms (Hyman & Mchombo 1992, Hyman 2003, Henderson 2019). For example, in Chichewa, the root *uk-* 'wake up' plus the applicative suffix *-il* combine to create the idiomatic meaning 'rebel against'. This idiomatic meaning is preserved under causativization, even though the applicative is (necessarily) no longer adjacent to the root, due to the CARP requirement. Under the standard assumption that syntactic locality is required in order to generate idiomatic meaning (see Marantz 1997, Arad 2003), the root and the applicative must still be adjacent in the syntax despite their non-adjacency in the linear output.[15]

[15] Donca Steriade (personal communication) raises the following concern regarding this example: if we were to instead ascribe to *uk-* a translation 'rise up', it is less clear that the suffixed derivatives truly have an idiomatic meaning at all. If this is correct, then it is less clear that this example constitutes evidence in favor of an underlying CARP-violating structure.

(19) **Lexicalized applicative + causative in Chichewa** (Hyman 2003:264, ex. 32; from Hyman & Mchombo 1992)

a. *uk-* ‘wake up’
b. *uk-il-* ‘rebel against’
c. **uk-il-its-* ‘cause to rebel against’
d. *uk-its-il-* ‘cause to rebel against’

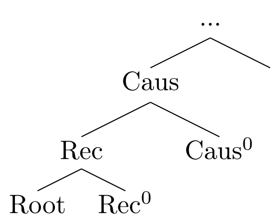
Therefore, in Chichewa at least, the explanation for CARP (either in part or in full) must lie somewhere in the imperfect mapping between syntactic structure and the surface order of morphemes, i.e., *after* the narrow syntax.[16]

3.3.2 CARP in the Morphology: Post-Syntactic Operations

We now know that the syntax is capable of outputting a hierarchical structure that, if fed into the MAP, would yield a CARP-violating order. We also know, because of asymmetric compositionality, that this structure can nonetheless be mapped onto a CARP-obeying order as well. The next possible explanation that needs to be considered is one where the hierarchical structure can be reshaped by the morphological component, such that the MAP can operate transparently on that mutated structure to generate a CARP-obeying order. This is possible if we follow Distributed Morphology (Halle & Marantz 1993) and allow morphological operations to apply to syntactic structure prior to submission to the phonological component (e.g. Embick & Noyer 2001, Arregi & Nevins 2012; cf. Trommer 2001).

Consider the syntactic structure of a Chichewa Causativized Reciprocal (20). This syntactic structure can be realized either as the CARP-obeying, Mirror Principle-violating form *mang-its*$_{\text{CAUS}}$-*an*$_{\text{REC}}$- (11a), or the CARP-violating, Mirror Principle-obeying form *mang-an*$_{\text{REC}}$-*its*$_{\text{CAUS}}$- (11b). If the MAP applies to this structure and nothing else intercedes, the phonology will output the Mirror Principle-obeying form (11b). If we want to have the MAP apply transparently to the output of the morphological component, we therefore will need some morphological operation to take place in order to generate the CARP-obeying order (11a).

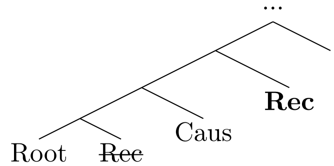
(20) **Syntactic structure of a Causativized Reciprocal**



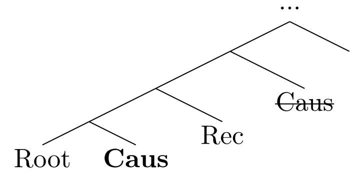
From the point of view of the MAP, the simplest solution will be one which transforms the tree in (20) into one which is fully syntactically CARP-obeying; that is to say, one where Rec asymmetrically c-commands Caus. Theoretically, this could be effectuated by moving one of the heads — either raising the Rec head above the Caus head (21a), or lowering the Caus head below the Rec head (21b) — or by directly reversing the order of the two heads (22).[17]

(21) **Movement operation** (∼ raising/lowering)

a.



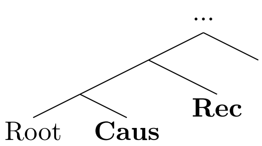
b.



[16] Assuming the “Y-model” of the grammar (Chomsky 1986 et seq.), where the narrow syntax feeds separate PF and LF derivations, this rules out a (purely) semantic explanation of linear CARP effects.

[17] The exploration of morphological operations here is primarily for expository purposes. It is not meant to be a serious analysis. A more substantive morphological analysis based on Harizanov & Gribanova‘s (2019) “amalgamation” operation, which may be applicable to this case as well (vis-à-vis the tree in (24b) below), will be carried out in Section 4 for Arabic with respect to Aspect and Voice.

(22) **Reversal operation** (∼ dislocation)



We could view these operations as being motivated by morphological markedness constraints (cf. Arregi & Nevins 2012) relating to c-command relations. For the specific pair at hand, this would be the markedness constraint in (23):

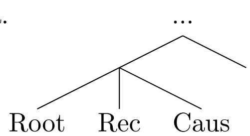
(23) **Morphological markedness constraint**
*CAUS > REC: Causative may not asymmetrically c-command Rec.

Under this approach, CARP is the result of a set of such c-command–based morphological markedness constraints involving the CARP elements. Whichever constraints are active in a given Bantu language will (obligatorily or optionally; see below) trigger the morphological operation that transforms syntactically CARP-violating orders into (post-)syntactically CARP-obeying orders. The resulting orders feed the MAP, and generate the linear CARP order transparently.

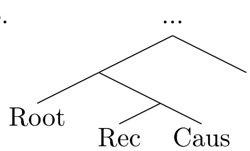
Alternatively, if an operation could remove all asymmetric c-command relations between CARP elements, resulting in some flat structure resembling the trees in (24), this would nullify the MAP's influence on order.

(24) **Flattening operation** (∼ fusion)

a.



b.



Without guidance from the MAP, the grammar would require a Default Ranking Statement (DRS) of the sort to be motivated for Arabic in Section 4 below. This would be where the CARP template lives. The DRS for the CARP template would be the ranking shown in (25). Note that this ranking is the same as the ranking the MAP generates for syntactically CARP-obeying structures (see (16) above).

(25) **Default Ranking Statement for Bantu**
ALIGN-PASS-R ≫ ALIGN-REC-R ≫ ALIGN-APPL-R ≫ ALIGN-CAUS-R

Further research into the typology of morphological operations is required in order to judge which if any of these operations is most appropriate to posit here. But each of these operations, potentially paired with morphological markedness constraints like that in (23) and/or the DRS in (25), is sufficient to generate asymmetric compositionality, if we assume that it applies *optionally*. That is to say, when the operation *applies* to a syntactically CARP-violating structure, it will generate the CARP-obeying, Mirror Principle-violating order; when the operation *fails to apply* to a syntactically CARP-violating structure, it will generate the CARP-violating, Mirror Principle-obeying order. In languages or constructions which only tolerate the CARP-obeying order, the operation is *obligatory*. This shows that the MAP is consistent with an approach to CARP, and perhaps templatic morphology more generally, located in the morphological component of the grammar.

3.3.3 CARP in the Phonology: Bigram Morphotactic Constraints

Lastly, let us consider how the MAP could interact with an approach to CARP located in the phonology.[18] If syntactically CARP-violating structures proceed through the morphological derivation unaltered, the MAP will unequivocally advocate for the linearly CARP-violating order in the phonological component. However, recall that MAP-governed alignment constraints can interact with, and indeed be outranked and thus overridden by, other constraints in the phonological component. Therefore, if we can formulate phonological

[18] One could also locate this sort of analysis in an autonomous, constraint-based morpho(phono)logical component of the sort (apparently) envisioned by Trommer (2001), Hyman (2003), and Ryan (2010).

constraints that advocate for the CARP order, we still may be able to generate the desired ordering facts. To this end, I will explore Ryan‘s (2010) “bigram morphotactic constraints” as a means of integrating CARP and the MAP in the phonology.[19]

Ryan (2010) demonstrates that an effective means of capturing (seemingly) arbitrary ordering properties of the sort instantiated by the CARP template is through the use of bigram morphotactic constraints. These are constraints that prefer immediate precedence relations between particular morpheme pairs. For example, (one aspect of) the requirement that Applicative follow Causative in the CARP template would be effectuated by a constraint Caus-Appl (Ryan 2010:778), which assigns violations for every instance of Causative which is not immediately followed by Applicative.

Ryan identifies four ordering scenarios which can arise based on the interaction between bigram constraints and a constraint advocating for the Mirror Principle (for which he uses Rice’s 2000 semantics-based Scope constraint). These are enumerated in Table 2. (“≫” indicates strict ranking domination; “∼” indicates variable ranking.)

Table 2: Ryan’s ordering typology (Ryan 2010:761, Table 1)

	Scenario	**Ranking**	**Output(s) for /[[[Root]X]Y]/**	**Output(s) for /[[[Root]Y]X]/**
i.	Compositional	Scope ≫ X-Y ∼ Y-X	Root-X-Y	Root-Y-X
ii.	Fixed (a)	X-Y ≫ Scope ∼ Y-X	Root-X-Y	Root-X-Y
	Fixed (b)	Y-X ≫ Scope ∼ X-Y	Root-Y-X	Root-Y-X
iii.	Asymmetric (a)	X-Y ∼ Scope ≫ Y-X	Root-X-Y	Root-X-Y, Root-Y-X
	Asymmetric (b)	Y-X ∼ Scope ≫ X-Y	Root-X-Y, Root-Y-X	Root-Y-X
iv.	Free	X-Y ∼ Y-X ≫ Scope	Root-X-Y, Root-Y-X	Root-X-Y, Root-Y-X

Chichewa’s Causative and Reciprocal reflects a type (iii) asymmetric ordering scenario (see below). Elsewhere in Chichewa, Causative and Applicative, and Applicative and Reciprocal, always surface in the CARP order (Hyman 2003). This means that they each represent a type (ii) fixed ordering scenario. In the MAP framework, the function of Scope is handled by the MAP-driven ranking of alignment constraints (henceforth sometimes shorthanded as “MAP Ranking”). Replacing Scope with the MAP-driven alignment ranking within Ryan’s ranking schema, and substituting the specific morphemes involved in Chichewa, we arrive at the following rankings for the constraints determining the relative order of Causative, Applicative, and Reciprocal:

(26) **Chichewa bigram + MAP rankings**

a. Asymmetric: Caus-Rec ∼ [MAP Ranking] ≫ Rec-Caus
b. Fixed: Caus-Appl ≫ [MAP Ranking] ∼ Appl-Caus
c. Fixed: Appl-Rec ≫ [MAP Ranking] ∼ Rec-Appl

The phonological derivations of the fixed ordering cases are straightforward. The dominant bigram constraint — Caus-Appl and Appl-Rec, respectively — is decisive in the evaluation, masking any effects of the MAP. This is illustrated in (27) for Causative and Applicative.

(27) **Fixed ordering of Causative and Applicative (consistent CARP order)**

i. Applicativized Causative *mang-its-il-* (Mirror Principle-obeying):
MAP ranking: Align-Appl-R ≫ Align-Caus-R

[[[Root]Caus]Appl] /$mang_{ROOT}$, its_{CAUS}, il_{APPL}/		MAP Ranking		
	Caus-Appl	Align-Appl-R	Align-Caus-R	Appl-Caus
a. ☞ mang-its-il-			** (il)	*
b. mang-il-its-	*!	** (its)		

[19] The approach outlined here bears some similarities to Hyman‘s (2003) analysis, where a set of violable pairwise “Mirror” constraints compete with a unitary “Template” constraint that prefers the CARP order. However, since the MAP generates Mirror Principle effects indirectly through the transmission of syntactic structure into the phonology, the MAP will not be compatible with Hyman’s approach as currently constituted.

ii. Causativized Applicative *mang-its-il-* (Mirror Principle-violating):
MAP ranking: ALIGN-CAUS-R ≫ ALIGN-APPL-R

[[[Root]Appl]Caus] /$mang_{ROOT}$, its_{CAUS}, il_{APPL}/	CAUS-APPL	MAP Ranking: ALIGN-CAUS-R	MAP Ranking: ALIGN-APPL-R	APPL-CAUS
a. ☞ mang-its-il-		** (il)		*
b. mang-il-its-	*!		** (its)	

Unlike the fixed ordering scenarios, the asymmetric ordering scenario represented by Causative and Reciprocal allows us to see how the MAP-based alignment constraints operate within the bigram morphotactic constraint approach to CARP. The crucial point is the *variable* ranking between the dominant bigram constraint and the MAP Ranking, or, more precisely, between the dominant bigram constraint and the dominant alignment constraint in the MAP-driven alignment ranking.[20]

Table 3 — which mirrors the asymmetric compositionality structure from Table 1 above — summarizes the ranking interactions which are possible between the dominant bigram constraint and the dynamic MAP rankings, given the variable ranking inherent to asymmetric ordering scenarios. There are two free variables under consideration. The first is the syntactic structure submitted to the MAP Ranking: when Rec scopes over Caus, ALIGN-REC-R will dominate ALIGN-CAUS-R (Table 3a,b); but when Caus scopes over Rec, ALIGN-CAUS-R will dominate ALIGN-REC-R (Table 3c,d). The second free variable is the relative ranking of the dominant bigram morphotactic constraint — CAUS-REC — and the alignment constraint which is dominant in the MAP Ranking: either CAUS-REC will be higher ranked (Table 3a,c) or the dominant alignment constraint will be higher ranked (Table 3b,d).

Table 3: Deriving asymmetric compositionality with Chichewa's Causative and Reciprocal

Syntactic Structure ↪ *MAP Ranking*	**Ranking Variability**: *Bigram dominant* CAUS-REC ≫ MAP	**Ranking Variability**: *MAP dominant* MAP ≫ CAUS-REC
[[[Root] Caus] Rec] ALIGN-REC-R ≫ ALIGN-CAUS-R	**Root-Caus-Rec** a. CAUS-REC ≫ ALIGN-REC-R	**Root-Caus-Rec** b. ALIGN-REC-R ≫ CAUS-REC
[[[Root] Rec] Caus] ALIGN-CAUS-R ≫ ALIGN-REC-R	**Root-Caus-Rec** c. CAUS-REC ≫ ALIGN-CAUS-R	**Root-Rec-Caus** d. ALIGN-CAUS-R ≫ CAUS-REC

When the syntactic input is a Reciprocalized Causative (*[[[Root]Caus]Rec]*; Table 3a,c), the MAP and the dominant bigram constraint pull in the same direction: both favor linearizing Reciprocal as far to the right as possible. Therefore, the variable ranking will have no effect — the CARP-obeying order *Root-Caus-Rec* will always be selected.

However, if the syntactic input is instead a Causativized Reciprocal (*[[[Root]Rec]Caus]*; Table 3b,d), the MAP and the dominant bigram constraint come into conflict: the MAP favors the order *Root-Rec-Caus* (because the MAP transmits the ranking ALIGN-CAUS-R ≫ ALIGN-REC-R), but the bigram constraint (CAUS-REC) favors the order *Root-Caus-Rec*. Therefore, with just this particular input, variability in the ranking will have a crucial effect.

When the derivation chooses the ranking where the bigram constraint is higher ranked (Table 3b), the candidate order *Root-Caus-Rec* is selected (28a). On the other hand, just in case the reverse ranking is chosen, where the MAP's dominant alignment constraint is higher ranked (Table 3d), the opposite candidate order *Root-Rec-Caus* is selected (29b). As indicated by the shading in Table 3, this is the *only* combination of factors (CARP-violating syntactic input plus selection of dominant MAP constraint for higher ranking) which can result in a CARP-violating linear order. This captures precisely the generalizations made earlier in respect to Table 1.

[20] For these cases, it would be functionally equivalent to demote the dominant bigram constraint below the subordinate MAP-based alignment constraint.

(28) **Causativized Reciprocal: bigram ≫ MAP yields CARP-*obeying* order**

[[[Root]Rec]Caus] /$\text{mang}_{\text{ROOT}}$, its_{CAUS}, an_{REC}/	*Bigram* Caus-Rec	*MAP 1* Align-Caus-R	*MAP 2* Align-Rec-R
a. ☞ mang-its-an-		** (an)	
b. mang-an-its-	*!		** (its)

(29) **Causativized Reciprocal: MAP ≫ bigram yields CARP-*violating* order**

[[[Root]Rec]Caus] /$\text{mang}_{\text{ROOT}}$, its_{CAUS}, an_{REC}/	*MAP 1* Align-Caus-R	*Bigram* Caus-Rec	*MAP 2* Align-Rec-R
a. mang-its-an-	*!* (an)		
b. ☞ mang-an-its-		*	** (its)

This demonstrates that combining Ryan's (2010) bigram morphotactic constraints with the MAP *in the phonology* is capable of deriving Hyman's (2003) "asymmetric compositionality", and indeed Ryan's full ordering typology.[21]

3.4 Local Conclusions

In this section, I have shown that the use of the MAP-driven ranking of alignment constraints can straightforwardly and restrictively capture the basic cases of Mirror Principle-compliant mirror-image orderings in the Bantu languages. Furthermore, I have shown that the MAP framework is consistent with various approaches to asymmetric compositionality and the CARP template. Notably, it is flexible enough to integrate with approaches to templatic morphology located in different modules of the grammar, i.e., syntactic, morphological, or phonological.

Before moving on, consider again that, in these analyses, the relative ranking of alignment constraints differs across different syntactic derivations; this is, in fact, the very nature of the proposal. This is somewhat unusual from the perspective of Optimality Theory, in which the constraint ranking is generally taken to be internally consistent within a language. But note that these are not purely phonological constraints; they crucially depend on morphosyntactic information, both with respect to their definitions and (by the MAP hypothesis) their rankings. This suggests that there may be principled ways in which the rankings of constraints that directly reference the morphosyntax can vary within a language. This would contrast with purely phonological constraints: since they are not sensitive to morphosyntactic structure, there should be no way in which their rankings would vary within a language and we should observe internal consistency — though one could adduce similarities in the operation of lexically-indexed constraints (e.g. Pater 2009) or cophonology theory (cf. Inkelas & Zoll 2007) in the explanation of lexically- or morphologically-specific phonology.

4 Arabic Nonconcatenative Morphology and the Mirror Alignment Principle

In Arabic, like many other Semitic languages, morphological derivation frequently does not consist of sequential affixation to a fixed base of derivation.[22] Rather, these languages exhibit a nonconcatenative "root-and-pattern" morphological system, where morphemes may be interspersed within other morphemes, and the addition of new morphemes often significantly alters the segmental order and/or larger prosodic organization of the word relative to its corresponding less derived morphological form.[23] The Semitic root-and-pattern

[21] This analysis is largely sufficient to account also for the combination of *three* CARP suffixes, e.g. Causative and Applicative and Reciprocal (Hyman 2003:272–275; cf. Ryan 2010), though not completely so. Space precludes full investigation here; for preliminary discussion of these cases, see Zukoff (2017).

[22] For the purposes of this paper, "Arabic" refers to the varieties Classical Arabic and Modern Standard Arabic. They do not appear to differ significantly on any of the points under discussion, and I will thus draw on scholarship of both varieties interchangeably.

[23] Consult McCarthy (1979, 1981) for an overview of the system and an early generative phonological analysis.

system has posed a persistent challenge to analysis at a number of levels.[24] One such challenge has been how to understand this sort of nonconcatenative system in light of the Mirror Principle. Because Baker conceived of word formation as a process of cyclic morphological concatenation (Baker 1985:378ff.), there was no clear way to reason about thoroughly nonconcatenative morphological processes/systems with respect to the Mirror Principle in his framework (Baker 1985:400–403, LeTourneau 1997).

In this section, I develop a Mirror Alignment Principle analysis of several ordering alternations in Arabic. I show that these ordering alternations are driven by differences in syntactic structure, based on a novel generalization tying the contrast between infixal and prefixal ordering to the relative structural height at which the morpheme adjoins to the root. By inspecting the alignment rankings that generate the ordering differences, rather than inspecting the surface forms *per se*, we will find that Arabic's root-and-pattern morphology does in fact show exactly the sorts of Mirror Principle effects discussed by Baker (1985), as instantiated by mirror-image ordering properties between Causative, Reflexive, and Root. Therefore, adopting the MAP's alignment-based approach to morpheme ordering and the (morpho)syntax-phonology interface newly brings nonconcatenative morphology under the umbrella of the Mirror Principle.

This section also addresses the nature and behavior of the "vocalic melodies" of the Arabic verbal system, which I analyze as portmanteau morphemes that simultaneously expone Aspect and Voice. This special morphological status, and its consequent phonological ramifications via the MAP, help explain a number of otherwise unexpected ordering properties of the system as a whole. With all this in hand, I provide an overview of the phonological analysis which ties the system together. The takeaway from this analysis, in line with much of the recent literature (for example, the research program of "Generalized Nonlinear Affixation"; Bermúdez-Otero 2012, Bye & Svenonius 2012, Zimmermann 2017), is that nonconcatenative morphology is not fundamentally different from concatenative morphology from the perspective of the syntax and the morphology; rather, nonconcatenative systems like Arabic result from idionsyncracies of the phonology and underlying representations interacting with the normal operation of the (morpho)syntax-phonology interface.

4.1 A MAP-Based Analysis of the Reflexive

Arabic verbs are built around a consonantal root, usually consisting of three consonants.[25] For example, the root meaning 'write' is underlyingly /ktb/. The Arabic verbal system is divided into "Forms", built to these consonantal roots. Forms are morphosyntactic categories associated with a particular phonological shape (traditionally described in terms of a CV "template") and a range of morphosemantics (albeit often highly idiomatized). Within this system, Reflexive /t/ recurs across multiple Forms, sometimes as an *"infix"* (Table 4a), sometimes as a *"prefix"* (Table 4b).[26]

This distribution cannot be due to phonotactics, as the alternative affixation pattern could yield phonotactically legal structures for all categories. Form VIII could have had a phonotactically legal prefixal structure, such as _*ṯaktaba_ or _*ṯakataba_. And Form V, for example, could have had a phonotactically legal infixal structure, such as _*kaṯattaba_ or _*(ʔi)kṯattaba_. Something beyond phonotactics must be involved in determining this distribution.

A number of recent accounts (Tucker 2010, 2011; cf. Ussishkin 2003) have used alignment constraints to help derive the ordering alternation. However, an alignment-based analysis of the Reflexive requires an apparent ranking paradox, as shown in (30). That these paradoxical rankings properly derive the distribution is confirmed in (31). (I return below in Section 4.5 to some of the phonological exigencies responsible for

[24] The following is a partial list of works which have sought to analyze the phonological properties — in concert with the morphosyntactic properties, in a few cases — of Semitic nonconcatenative morphology: McCarthy (1979, 1981), Golston 1996, Gafos (1998, 2018), Ussishkin (2000a,b, 2003, 2005), Bat-El (2003, 2011), Tucker (2010, 2011), Wallace (2013), Kastner (2016, 2019, 2020), Kusmer (2019).

[25] Verbal roots may alternatively contain either two or four consonants. Descriptively, two-consonant roots largely behave as if they were three-consonants roots where the final two consonants are identical. Four-consonant roots seem like they may have certain distinct morphological properties. See, e.g., McCarthy (1979) for extensive discussion of these issues. I will limit my discussion here to canonical three-consonant roots. Also note that the identification of the verbal root as containing only consonants is not universal; Gafos (2018), e.g., argues that certain roots underlyingly contain vowels.

[26] I follow much of the literaute — both descriptive (e.g. Fischer 2002:98) and theoretical (e.g. McCarthy 1981:389) — in identifying this morpheme as Reflexive. However, as pointed out to me by Itamar Kastner, it is not completely clear if this is the right designation, as this morpheme does not consistently produce argument structure alternations typical of reflexives. All that is important for the current argumentation is that the /t/ morpheme that shows up in multiple Forms is the exponent of the same morphosyntactic terminal (whatever that happens to be) and is in the hierarchical relations with Root that I claim it to be.

Table 4: Forms with Reflexive /t/ (to example root $\sqrt{}$*ktb* 'write'; data from McCarthy 1981:384)

Position		Form	Proposed morphosyntax	Example form	Translation
a.	*Infixal*	VIII	Reflexive	*(ʔi)**k***$\boxed{t}$*ataba*	'write, be registered'
		V	Reflexive of the Causative	$\boxed{t}$*a**k**attaba*	(*constructed form*)[27]
b.	*Prefixal*	VI	Reflexive of the Applicative	$\boxed{t}$*a**k**aataba*	'write to each other'
		X	Causative of the Reflexive	*(ʔi)s*$\boxed{t}$*a**k**taba*	'write, make write'

the non-minimal differences between the prefixal and infixal candidates — namely, the position and number of vowels. For now, focus solely on the relative order of the Reflexive [t] and the Root-initial [k].) In the candidate outputs, the Reflexive morpheme [t] is bolded and underlined, and the leftmost segment of the Root [k] is bolded. Epenthetic segments (*ʔi*), which would be present in phrase-initial position only, must be treated as being outside the domain of alignment (if present at this stage of evaluation at all).

(30) **Ranking paradox**

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

(31) **Alignment-based derivation of the Reflexive alternation**

(/t/ ⇔ Refl, /μ_c/ ⇔ Caus, /a/ ⇔ Perf.Act, /a/ ⇔ 3sg.Masc)

i. Infixal order: Form VIII Reflexive *(ʔi)ktataba* [= (30a)]

/t, ktb, a, a/	Align-Root-L	Align-Refl-L
a. $\underline{\textbf{t}}$a**k**taba	*!*	
b. ☞ *(ʔi)***k**$\underline{\textbf{t}}$ataba		*

ii. Prefixal order: Form V Reflexive of Causative *takattaba* [= (30b)]

/t, μ_c, ktb, a, a/	Align-Refl-L	Align-Root-L
a. ☞ $\underline{\textbf{t}}$a**k**at$_c$taba		**
b. *(ʔi)***k**$\underline{\textbf{t}}$at$_c$taba	*!	

Tucker (2010, 2011) circumvented this ranking paradox by indexing Form VIII to a special alignment constraint (basically: Align-Refl$_{\text{VIII}}$-L ≫ Align-Root-L ≫ Align-Refl-L). This successfully avoids the problem, but does not provide explanatory power. However, armed with the MAP (repeated in (32)), there is a previously unnoticed syntactic generalization about this (morpho)phonological distribution of the Reflexive /t/, spelled out in (33), that can help deliver an explanation.

(32) **The Mirror Alignment Principle** (repeated from (7) above)

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

(33) **Syntactic generalization about Reflexive /t/**

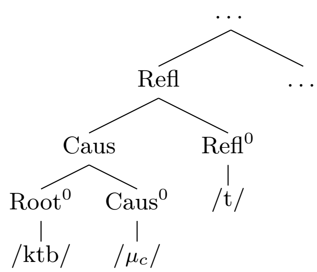
a. When Reflexive co-occurs with (and scopes over/c-commands) another verbal derivational morpheme, e.g. Causative or Applicative (cf. Tables 7 and 8 below), its exponent is *prefixal*.[28]
b. When Reflexive is the only verbal derivational morpheme, its exponent is *infixal*.

We can illustrate this difference by comparing the syntactic structures of Form V (the reflexive of the causative) and Form VIII (the simple reflexive), as shown in (34).

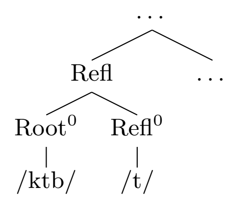
[27] The root $\sqrt{}$*ktb* happens not to attest a Form V form, so *takattaba* is not an actual word (McCarthy 1981:385fn.). A real Form V that rather transparently exemplifies the proposed semantics is *taħassana* 'improve, get better', from the root $\sqrt{}$*ħsn* 'good' (Form I: *ħasuna* 'be good') (Ryding 2005:457, 530, 533).
[28] More must be said about Form X, the Causative of the Reflexive; see Section 4.3 below.

(34) **Syntactic structures with Reflexive**

a. Form V *takat*$_c$*taba*



b. Form VIII *(ʔi)ktataba*



Consider what the MAP has to say about the alignment rankings that would be associated with these respective structures. In Form V (34a), Refl *asymmetrically c-commands* Root, since it adjoins to the complex head already containing both Root and Caus. Therefore, the MAP generates the ranking Align-Refl-L ≫ Align-Root-L. This is the ranking required to derive the prefixal behavior of /t/, as in (31.ii).

In Form VIII (34b), on the other hand, Refl and Root stand in *symmetric c-command*, because Refl is the first head to adjoin with Root. Since the MAP only establishes rankings based on asymmetric c-command, the ranking between Align-Refl-L and Align-Root-L is underdetermined. (Importantly, this is also the case for the relative ranking of Align-Root-L and Align-Caus-L for Form V (34a).) These results are summarized in (35), where “ , ” indicates non-ranking.

(35) **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

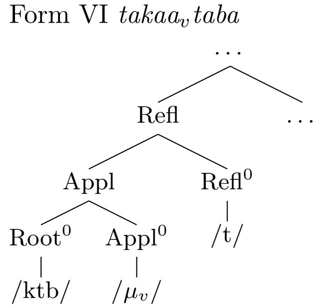
While we have now identified a distinction between the two types of structures’ alignment behavior, the MAP itself will not explain the fact that the Reflexive /t/ surfaces as an infix in Form VIII. However, we can observe one further generalization that will lead us closer to an explanation:

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

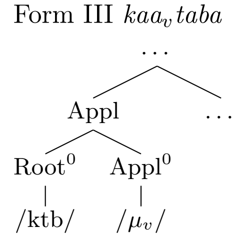
As mentioned above, this is the case not only for the relative positioning of Root and Reflexive in Form VIII *(ʔi)**kt̲**ataba* (34b), but also for the relative positioning of Root and Causative in Form V *ta**kat̲**$_c$taba* (34a). This generalization holds also of the relative positioning of Root and Applicative in Form VI *ta**kaa̲**$_v$taba* and Form III ***ka**a̲$_v$taba*, whose structures are provided in (37) below, and of Root and Causative in Form II (see Section 4.2).

(37) **Syntactic structures with Applicative**

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



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



We can understand the generalization in (36) in terms of alignment. In each of the relevant cases, the constraint Align-Root-L outranks the left-oriented alignment constraint of the verbal derivational morpheme. Note crucially that 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" in (38):

(38) **Default Ranking Statement for Arabic**
When the MAP provides no ranking statement (i.e. when two heads are not in asymmetric c-command), Align-Root-L is higher-ranked by default.

This Default Ranking Statement (DRS) may be conceptualized in one of (at least) two ways. First, it could be a ranking principle that resides in the same component as the MAP, which applies in series after the MAP to fix any rankings which remain indeterminate. Under this conception, the DRS would be a property of the (morpho)sytnax-phonology interface governing the mapping between the morphosyntactic structure and the constraint ranking of the phonological component (the exact same type of property as the MAP itself).

Alternatively, it could be conceived of as a property of the phonological component, whereby the high ranking of Align-Root-L is part of the "default" ranking in the language, and this ranking is overridden just in case the MAP transmits a crucial ranking that contradicts the default. This conception of the DRS is similar to the "Master Ranking" in cophonology theory (Inkelas & Zoll 2007). In Inkelas & Zoll's view, the Master Ranking is the partial ranking of constraints which is consistent across a language's full set of morphologically-indexed cophonologies. In more recent work, Sande & Jenks (2018:41–42) and Sande, Jenks, & Inkelas (2020) take the Master Ranking to be a language-wide default, which may be overridden by, or (through cumulative constraint weighting) integrated with, contrasting morpheme-specific constraint rankings. This latter sort of interaction would be consistent with the view of the Default Ranking Statement as a property of the phonological component.

I leave it to future work to further consider the nature of such DRSs and their implementation in the grammar. For present purposes, it suffices to conclude that language-specific properties,[29] such as Arabic's default preference for left-alignment of the Root, can be brought to bear to resolve ranking indeterminacy left over after the operation of the MAP.[30]

We can now return finally to the case of the infixal Reflexive in Form VIII *(ʔi)**kṯ**ataba* (34b). The DRS in (38) applies to resolve the indeterminacy in favor of Align-Root-L. This now yields the ranking in (39a). The two distinct rankings in (39) are the paradoxical rankings from (30) above which are necessary to generate the contrasting prefixal vs. infixal behavior of the Reflexive detailed in Table 4 above. 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 the syntactic structure.

(39) **MAP-governed rankings supplemented by Arabic's DRS** (cf. (35))
a. Form VIII (infixal order): Align-Root-L $\gg$ Align-Reflexive-L
b. Form V (prefixal order): Align-Reflexive-L $\gg$ Align-Root-L

4.2 A MAP-Based Analysis of Causative

It is not only the Reflexive forms in Arabic that demonstrate this consistent interaction between the MAP and the DRS in (38). So too do the forms involving Causative. Arabic has two basic types of morphological causatives (cf. Wright 1896:31–36, Ryding 2005:491, 515, *a.o.*): Form II, which is marked by an infixal consonantal mora (/μ_c/), as in *ka**t**$_c$taba*; and Form IV, which is marked by a prefixal /ʔ/, as in ***ʔ**aktaba*.

The analysis of the Reflexive in the previous subsection gives us a roadmap for understanding this infix vs. prefix alternation. An infixal morpheme should be the first head to attach to the Root, such that the DRS can institute the higher ranking of Align-Root-L in the absence of a MAP-determined ranking. A prefixal morpheme should be a higher head, such that it asymmetrically c-commands Root, and the MAP can rank its alignment constraint above Align-Root-L. If we reverse engineer the syntax in this way, we

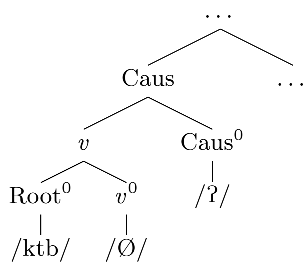
[29] It may also be fruitful to consider to what extent the relevant properties may be universal, along the lines of the alignment relations discussed in Trommer (2001).

[30] Kusmer (2019) proposes that a DRS such as this can be replaced by a constraint that prefers heads to follow their complements ("HeadFinality"). His analysis as currently constituted predicts that all such cases of ranking indeterminacy cross-linguistically will be resolved in favor of the head following the complement. This is an empirical question that requires further investigation. If it is found that there is no such universality in head direction, then the directional flexibility inherent to alignment constraints will be necessary.

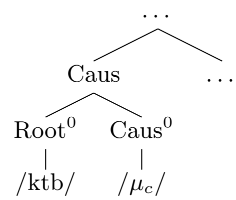
come up with the structures in (40). Note that we must posit a null *v* head in Form IV (40a) in order to create the necessary structures.

(40) **Syntactic structures with Causative**

a. Form IV *ʔaktaba*



b. Form II $kat_c taba$



The phonological analysis based on the MAP thus predicts distinct syntactic structures for the two types of causatives. Does this supposed difference in syntactic structure correlate with other observable differences between the two Forms? The answer is *yes*: we can observe a difference in the semantics of the two categories.

Both Forms can contribute causative or factitive semantics (Wright 1896:31–36). (Both also make denominals, frequently with a causative or factitive type of meaning.) Most instances of Form IV have a canonically causative or factitive interpretation (ibid.:34). On the other hand, the instances of Form II have a substantially wider range of interpretations relating to causation, or, more generally, transitivity; some of these include (in Wright's parlance) intensive, extensive, iterative/frequentative, declarative, and estimative (ibid.:31–32). The root $\sqrt{}$*ʕlm* 'know' provides a minimal pair that illustrates this distinction clearly (ibid.:34): it has a Form II causative *ʕa*$\underline{\boldsymbol{l}}_c$*lama* which means 'teach', and it also has a Form IV causative $\underline{\boldsymbol{ʔ}}$*aʕlama*, which means 'inform' (≈ 'make someone know').[31]

In this light, consider the precise nature of the syntactic difference posited in (40). In Form IV, the Causative head selects a *v*P; whereas, in Form II, the Causative head directly selects the Root. Cross-linguistically, root-selecting heads allow more idiomatic semantics than non–root-selecting heads (Marantz 1997, Arad 2003). This is exactly what we observe in the semantics of these two Forms. The one which selects for Root (Form II) has a wide range of semantics, but the one which selects for *v*P has more consistent semantics.

We therefore have exactly the sort of correlation between ordering, syntactic structure, and semantics that we would expect in the MAP framework. Because the MAP generates morpheme order using a feed-forward modular architecture, syntactic differences should lead to ordering differences at PF the same way they lead to interpretative differences at LF. Furthermore, this section demonstrates that the MAP allows us to use phonological patterning to make falsifiable hypotheses about syntactic structure (and thus indirectly about semantics), exactly as the Mirror Principle envisions.

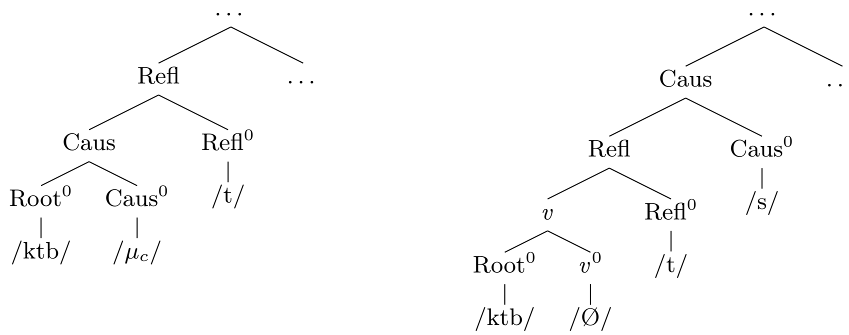
4.3 Forms with Reflexive and Causative

Before moving on, let us consider the Forms which contain both the Reflexive and the Causative. We have already explained the Reflexive of the Causative (Form V), repeated in (41a). The Causative of the Reflexive (Form X), the last prefixal instantiation of Reflexive from Table 4, is given in (41b).

[31] Notably, this root also has a Form V form *taʕallama* meaning 'teach oneself, learn' (Fischer 2002:99), which seems to transparently add reflexive semantics to the Form II meaning. This matches well with the proposed syntactic structures, as the Form II structure (40b) is contained within the Form V structure (34a).

(41) **Syntactic structures with Reflexive and Causative**

a. Form V *takat$_c$taba* b. Form X *(ʔi)staktaba*



In order to get both the Causative and Reflexive morphemes to be prefixal in Form X, we must again posit a null v head. This is the same head that was present in the Form IV causative. Form X frequently functions as the reflexive of the Form IV causative (Wright 1896:44, Ryding 2005:584), so it should not be surprising that it contains the same null v head. For example, the root $\sqrt{kbr}$ 'great' makes a Form IV causative *ʔakbar-* 'deem (s.t.) great/important' (Schramm 1962:362, Fischer 2002:100), and a Form X form *stakbar-* 'consider oneself great/important' (ibid.), which serves as its Reflexive.

As has been evident from the various forms involving the Causative head, the phonological exponent of Causative varies across Forms: it is /μ_c/ in Forms II and V, /ʔ/ in Form IV, and /s/ in Form X. I will not here take a stance on exactly what conditions this allomorphy. A first approximation might be that it is a combination of structurally-conditioned allomorphy and phonologically-conditioned allomorphy as follows. The /μ_c/ exponent appears in the specific morphosyntactic context when Caus is sister to Root; the other exponents arise in the elsewhere context. The alternation between /ʔ/ and /s/ in the remaining forms is conditioned by phonological context: /ʔ/ before vowels, /s/ before consonants. There is comparative evidence indicating that the glottal stop /ʔ/ that expones Causative in Form IV derives historically from /s/ via sound change (Yushmanov 1961:49). This provides suggestive evidence in favor of unifying these two allomorphs against the other.

While this seems like a plausible explanation, it would lead to an inexorable circularity problem when paired with the phonological analysis to be proposed in Section 4.5 below, where the /ʔ/ morpheme (but not the /s/ morpheme) must be indexed to a constraint preventing it from surfacing in pre-consonantal position. Although a more insightful approach to the latter problem might resolve the circularity, I will at this point need to simply assert that these two allomorphs, just like the /μ_c/ allomorph, are distinguished on the basis of their morphosyntactic context. Each of the three allomorphs would thus be conditioned by a distinct specific context. Therefore, any combination of two allomorphs with their context specified will suffice to generate the correct distribution via Vocabulary Insertion.[32]

4.4 Vocalic Melodies and Morphological Structure

We have now seen how the syntactic structures underlying the Form system can derive the relative ordering of the verbal derivational morphemes and the root via the MAP. One major piece which remains to be explained is the "vocalic melody", i.e. the quality and position of the vowels interspersed among the root and the verbal derivational morphemes. The difficulty in predicting the positions of these vowels in different Forms and Aspect/Voice categories is one of the factors that has led McCarthy (1979, 1981) and others to posit prosodic templates, which essentially stipulate their position. If we can derive the behavior of the vocalic melodies through the same sorts of interactions that we have used to explain the behavior of the verbal derivational morphemes, this will further show that Arabic's nonconcatenative profile is just epiphenominal.

[32] It may also be worth noting here that there is another odd fact about the /ʔ/ exponent: it is absent on the surface in the Imperfective. While, e.g., McCarthy (1979:244) schematizes the Form IV Imperfective Passive as *yu*$\boxed{\text{ʔ}}$*aktabu*, the actual surface form is [yuktabu], with the /ʔ/ and the following vowel "missing". Citing Brame (1970:255), McCarthy (1979:243) simply assumes that there is deletion by some mysterious later rule. Nevertheless, the glottal stop in Form IV Perfectives cannot be epenthetic in a fashion equivalent to [ʔi]-insertion in phrase-initial position, because it is retained in post-consonantal position phrase-medially. How exactly to handle this whole complex of issues is an important question for future consideration.

4.4.1 Phonological and Morphological Generalizations about the Vocalic Melodies

Following much of the literature (including McCarthy 1979, 1981), I analyze the vocalic melody as the combined exponent of Aspect and Voice, since it co-varies with the combined properties of those two features, as shown in Table 5.[33,34] For Perfective Active, Perfective Passive, and Imperfective Passive, the same combination of vowels in the same order appears across the different Form categories. For the Imperfective Active, the situation is less clear; nevertheless, the vowel melody is still consistent for each given Form across roots. We can maintain the short underlying representations (UR's) proposed in Table 5 for even the lengthier Forms, because the patterns of what I will neutrally call "vowel propagation" are describable in purely phonological terms, as stated in (42).[35]

Table 5: Vocalic Melodies (3SG.MASC forms of $\sqrt{ktb}$; data from McCarthy 1981:385)

	Perfective		Imperfective	
Forms	**Active**	**Passive**	**Active**	**Passive**
Form I	*k**a**t**a**b-a*	*k**u**t**i**b-a*	*y-**a**kt**u**b-u*	*y-**u**kt**a**b-u*
Form II	*k**a**tt**a**b-a*	*k**u**tt**i**b-a*	*y-**u**k**a**tt**i**b-u*	*y-**u**k**a**tt**a**b-u*
Form V	*t**a**k**a**tt**a**b-a*	*t**u**k**u**tt**i**b-a*	*y-**a**t**a**k**a**tt**a**b-u*	*y-**u**t**a**k**a**tt**a**b-u*
Form X	*st**a**kt**a**b-a*	*st**u**kt**i**b-a*	*y-**a**st**a**kt**i**b-u*	*y-**u**st**a**kt**a**b-u*
Aspect/Voice UR's:	/a/	/ui/	(*unclear*)	/ua/

(42) **Phonological conditions on vowel propagation**
Assuming the sonority scale $a \succ u \succ i$, whenever additional vowels are required to create phonotactically well-formed structures, the most sonorous vowel propagates.

This holds for all Forms and all Aspect + Voice (henceforth, AV) categories. Even in the Imperfective Active where the situation is murkier, this generalization holds true on the surface. Given that vowel propagation is phonologically predictable from shorter UR's, our analysis can and should at least in part derive the quality and position of these vowels (i.e. the vocalic melody) in the phonology. To this end, I will capture the generalization in (42) by splitting up the faithfulness/correspondence constraint INTEGRITY (McCarthy & Prince 1995) — which penalizes input segments which correspond to multiple output segments — into individual constraints referencing individual vowels, ranked (inversely) according to their sonority value:[36]

(43) **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 $\gg$ INTEGRITY[u]-IO $\gg$ INTEGRITY[a]-IO

This implementation of INTEGRITY will correctly select *which* vowel splits when splitting occurs (and that no more than one underlying vowel will propagate in any given output), but it does not on its own explain *when/where* splitting occurs. Because we have embedded our analysis within an OT system, it is clear that splitting will be motivated only when higher-ranked constraints can be satisfied by doing so (i.e.

[33] Note that Arabic has only three vowels: /a,u,i/ (with long variants which may or may not be phonemic). Therefore, we would expect some overlap between Aspect/Voice UR's even in the absence of shared morpheme exponents.
[34] The vocalic melody of Form I has somewhat more variation than is indicated by this table, whereby individual roots can select for different vocalic melodies (McCarthy 1981:402–404; cf. Gafos 2018). I assume that this is allomorphy in the morphosyntax. We can understand this allomorphy as being permitted just in Form I because — unlike in the other Forms, where additional heads intervene — Aspect and Voice are sufficiently local to the Root. I leave the details for future study.
[35] In order to maintain the *left-to-right* autosegmental association convention, McCarthy (1981:401) has to stipulate a prior rule that associates /i/ to the right edge first.
[36] Bye & Svenonius (2012:489) similarly parametrize violation of INTEGRITY to different kinds of vowels (albeit in the opposite direction, favoring splitting of shorter vowels) in their analysis of what amounts to a vocalic melody in Tamashek (Berber).

ℂ ≫Integrity). In the fuller phonological analysis to be presented in Section 4.5 below, it will become clear that both markedness constraints *and* alignment constraints play such a role. This will ultimately be an argument for locating word-internal ordering in the phonological component.

Let us now turn to the AV morpheme's ordering properties, focusing on its position relative to the Root. Consider the most basic verbal form, a Form I Perfective (Passive) like *kutiba* (← /ktb, ui, a/). In this case, we see that the AV morpheme's exponent is *less external* than the Root's exponent at *both* edges: on the left, Root *k* is closer to the edge than AV *u*; on the right, Root *b* is closer to the edge than AV *i*. Focusing in on the left edge, the simplest explanation for this distribution would be that the AV morpheme's alignment constraint ranks *below* the Root's alignment constraint, i.e. Align-Root-L ≫ Align-AV-L.[37] This is confirmed by the (simplified) derivation in (44).

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

/ktb, ui, a/	Align-Root-L	Align-AV-L
a. ☞ **ku**tiba		*
b. *(ʔ)***uk**tiba	*!	

In theory, the choice of (44a) over (44b) could be attributed to syllable well-formedness considerations: the latter has an extra coda and (assuming the [ʔ] is added later) an extra onsetless syllable. On the other hand, this kind of alternative explanation is not available in, for example, the Form VII Perfective (Active) *n**ka**taba* (45). In Table 7 below, I identify the Form VII morpheme /n/ as the "Middle", though its morphosemantic characterization is not crucial here. What is crucial is that its syntactic structure include a null *v*, exactly parallel to the Form IV Causative, so as to generate the ranking Align-Mid-L ≫ Align-Root-L. Assuming the high ranking of Align-Mid-L, we can see that the ranking of the remaining alignment constraints that is needed in order to generate the desired output is the same as posited above in (44): Align-Root-L ≫ Align-AV-L. Candidate (45a) is preferred over (45b) despite the fact that syllable well-formedness would seem to favor (45b): the former has a complex onset, which the language does not tolerate on the surface (as evidenced, e.g., by the need for phrase-initial *ʔi*-epenthesis), whereas the latter has just an extra coda, which are freely tolerated in the language. We can thus be confident that it is the alignment ranking that is determining the relative order of the Root and the AV morpheme here.

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

/n, ktb, a, a/	Align-Mid-L	Align-Root-L	Align-AV-L
a. ☞ *(ʔi)*n**ka**taba		*	**
b. n**ak**taba		**!	*
c. *(ʔi)***k**n**a**taba	*!		**
d. *(ʔ)***a**n**k**ataba	*!	**	

With the ranking determined, we now have a puzzle. Everything about the syntax should lead us to believe that both Aspect and Voice are syntactically higher than Root. Therefore, we should expect, based on the Mirror Principle, for the exponent of these categories to be *more external* than the exponent of the Root. Translated into the Mirror Alignment Principle framework, we would expect Align-AV-L to dominate Align-Root-L. This is exactly the opposite of the ranking we just needed for the phonological derivations.

However, we already have a tool at our disposal for accounting for an unexpectedly-high ranking of Align-Root-L in the language; namely, the Default Ranking Statement in (38), which asserts that, *in the absence of asymmetric c-command*, Align-Root-L gets ranked higher. In order to leverage this solution, it would have to be the case that Aspect and Voice *do not* asymmetrically c-command Root in the morphosyntactic structure which feeds the calculation of the MAP.

I suggest that a generalization implicit to the current analysis may point to exactly this sort of structure. Based on the sort of evidence provided in Table 5, we can securely state the generalization that Aspect and Voice are *always* exponed together as a portmanteau morpheme in the language. This sort of fact ought

[37] Nothing in the analysis hinges on whether there is a single alignment constraint referencing the single surface AV morpheme, or two separate alignment constraints referencing Aspect and Voice, respectively, since the factors determining the ranking of the constraint(s) would be the same in either approach. Whether there are cases of portmanteau morphemes where this question becomes crucial is an interesting question for future consideration.

to be captured through the application of syntactic and/or morphological processes of the language, rather than through accidents of Vocabulary Insertion. Put another way, there should be something special about the structural relationship between Aspect and Voice.

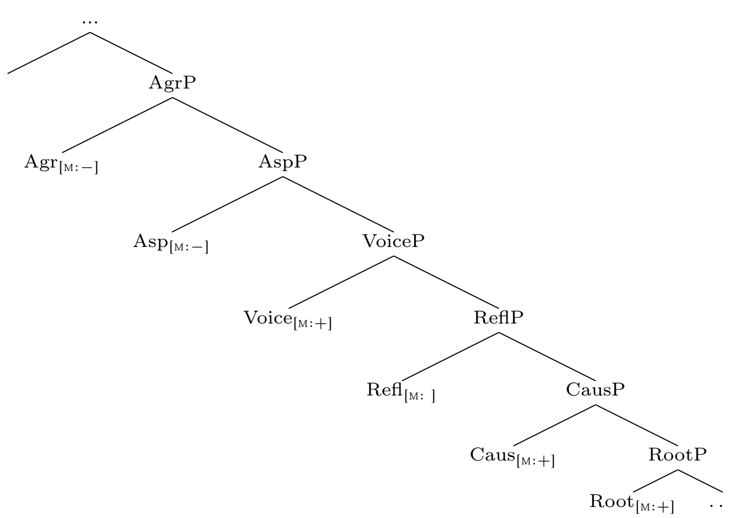
While other implementations are likely possible, I will here sketch a solution using Harizanov & Gribanova‘s (2019) post-syntactic *amalgamation* operation. I will show that cyclic application of the amalgamation operation can yield a distinctly “counter-cyclic”–looking structure, where Aspect and Voice are sisters within the larger complex head structure, but displaced from the spine of that complex head by a segment of Asp; in other words, a structure where the (lowest segments of) Aspect and Voice do not c-command Root, nor vice versa. This is derived by an unusual configuration of feature values of the morphological feature driving amalgamation.

4.4.2 Deriving the Aspect + Voice Structure through Amalgamation

Harizanov & Gribanova (2019) propose almagamation as the morphological process by which heads generated by the syntax are combined (as complex head-adjunction structures) to form morphologically complex words. 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 and restrictions as other types of movement (i.e. Internal Merge). Amalgamation adjoins one head to a structurally local head, driven by a morphological feature (abbreviated M) present on individual heads. This occurs either by *lowering* (Embick & Noyer 2001), which is driven by the **minus** value [M:−], or by its mirror-image *raising*, which is driven by the **plus** value [M:+]. Heads may also be unspecified for this feature ([M:]), in which case they do not trigger head adjunction, though they can still host it. Amalgamation proceeds cyclically from the lowest head upwards. When multiple heads with specified values for M are present in the same domain, amalgamation (typically) leads to what is traditionally referred to as “roll-up head movement”.

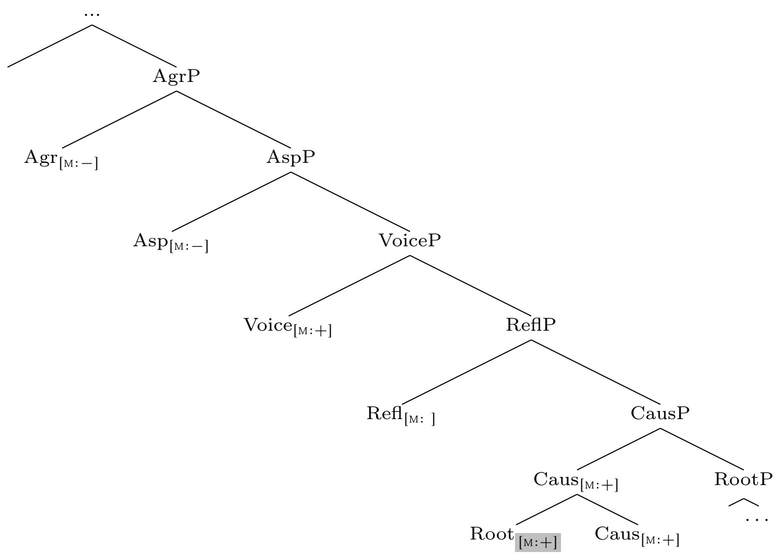
We can generate the special relationship between Aspect and Voice by positing an unusual configuration of M values on the heads comprising the verbal domain. I illustrate this with the derivational sequence in (46–52), which tracks the cyclic application of amalgamation applied to the underlying syntactic structure of a Form V form (reflexive of the causative). In this case, Root and Caus both have + values for M. This means that first Root will raise and adjoin to Caus (47), and then Caus (which is now itself a complex head) raises to adjoin to Refl (48). However, Refl is unspecified for M; therefore it does not trigger amalgamation, and remains in place.[38]

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

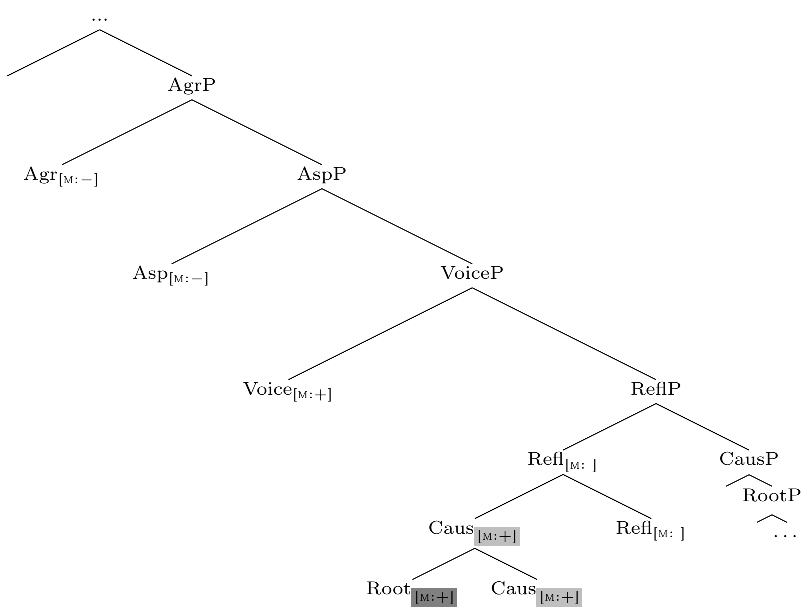


[38] I follow Harizanov & Gribanova (2019) in notating the value of M on all segments of each head, and considering that feature discharged when it is raised/lowered by amalgamation-driven movement. Features which are discharged by the current step of amalgamation are notated with light gray; features which have been discharged by an earlier step of amalgamation are notated with dark gray.

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

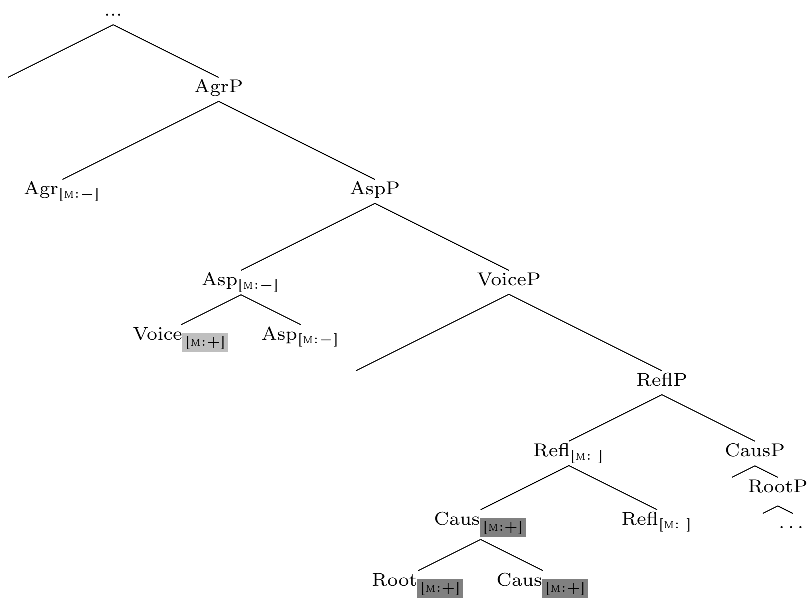


(48) **Second amalgamation step: Caus raises to Refl**

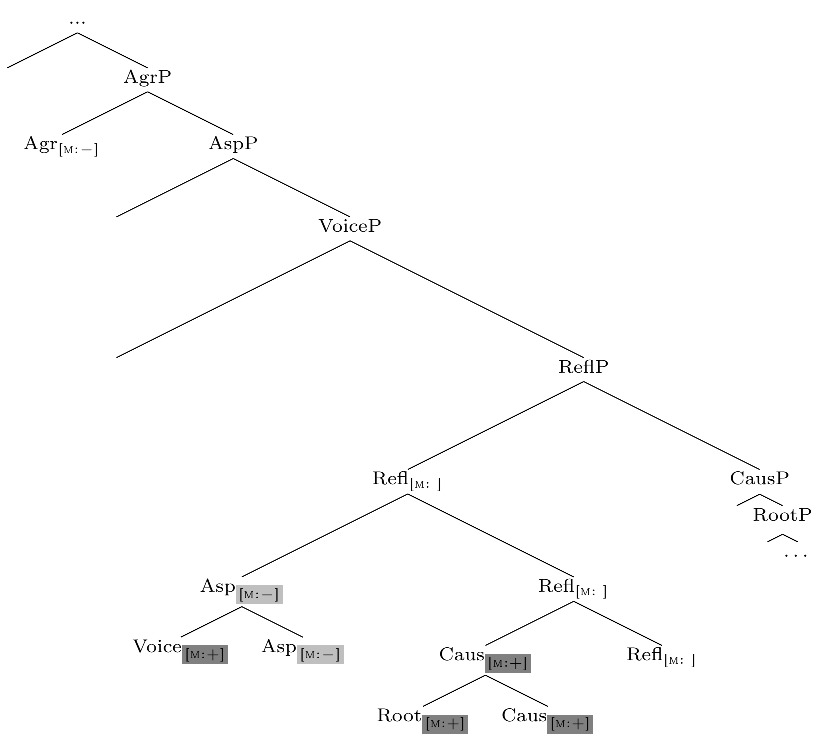


The derivation proceeds to the next highest head, Voice, which bears a + value, and thus triggers raising to Asp. But because Refl did not undergo amalgamation, this raising step applies only to the Voice head, which is not complex. This yields the structure in (49), where there are now two separate complex heads within the verbal domain. While we might expect this to result in two separate morphological words, the presence of the − values on the higher heads counters this expectation. If Asp is specified for [M:−], this will trigger *lowering* of the complex Asp head down to the complex Refl head (50). (Harizanov & Gribanova 2019:488 explicitly state that this configuration is sufficiently local to permit amalgamation to proceed unabated.) Lastly, the − value on Agr leads to one more lowering step (51), completing the morphological word, which is shown in its final form in (52).

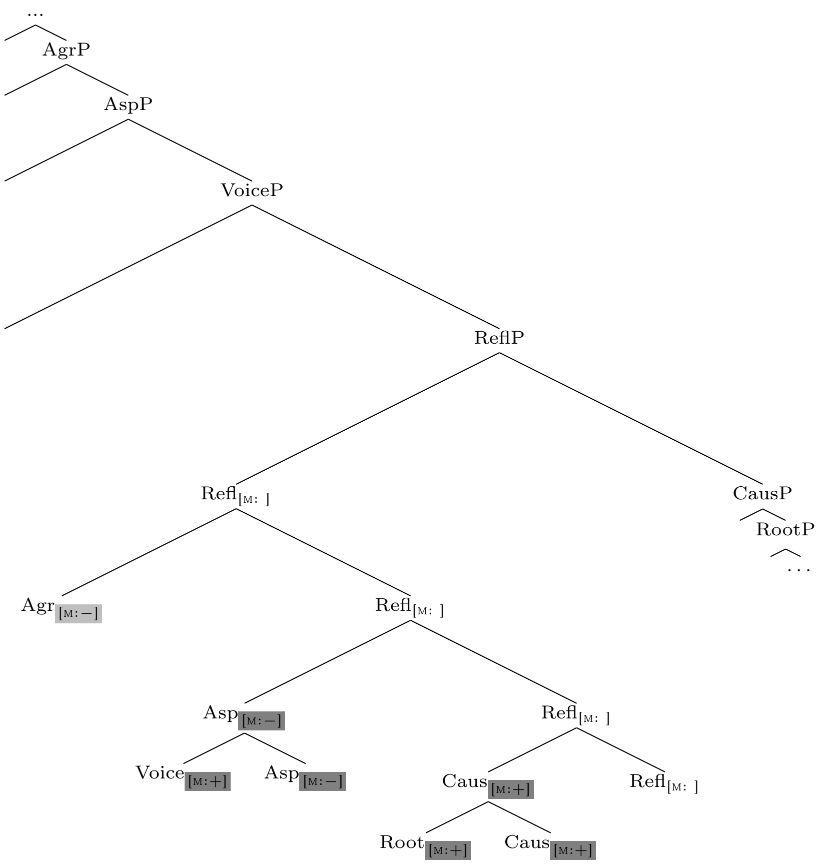
(49) **Third amalgamation step: Voice raises to Asp**



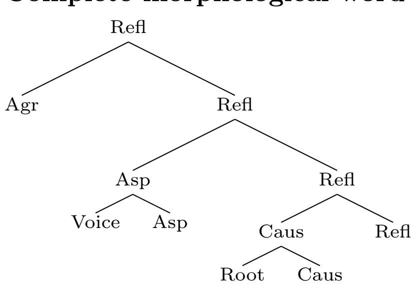
(50) **Fourth amalgamation step: Asp *lowers* to Refl**



(51) **Fifth and final amalgamation step: Agr lowers to Refl**



(52) **Complete morphological word**



The result of the lowering step in (50) is that the two distinct complex heads are joined into one single complex head. However, the result is not one of perfect "roll-up head movement", but rather something which looks distinctly "counter-cyclic"; that is to say, Voice looks like it has moved first, despite being in the middle of the syntactic domain.[39] It may seem strange to identify this complex constituent as Refl, since it constitutes the full verb word. This strangeness may be alleviated somewhat if we consider the verbal derivational morphemes (Refl, Caus, Appl, etc.) as "flavors" of little *v*.

The only complicating factor is the distribution of M values on the verbal derivational morphemes (i.e. the little *v* morphemes). For this account to work, it cannot be the case that Refl is always unspecified for M, or that Caus is always specified for +. When the structural order of these two are reversed in Form X ([... **[Caus [Refl** [*v* [Root]]]]], cf. (41b)), in order to apply the same logic as presented here for Form V, we would need to say that Refl is [M:+] but Caus is [M:]. We can resolve this by saying that the distribution of

[39] An alternative approach appealing to traditional roll-up head movement would work as well, as long as Voice did literally move first, i.e. prior to roll-up head movement.

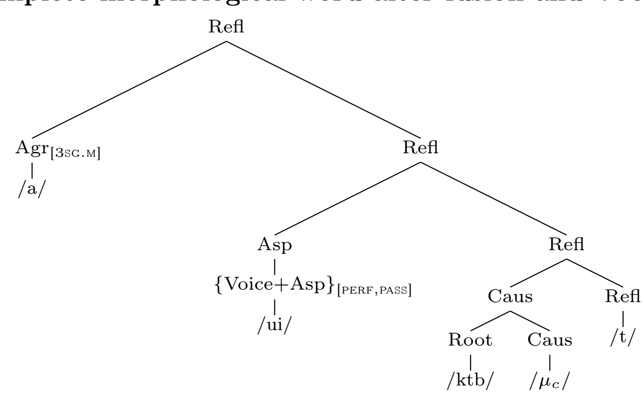
the M feature is *structurally predictable* for the little v morphemes: by default, they are specified as [M:+]; but if they are selected for by Voice (i.e., the highest little v head), they are instead unspecified. We could view this as a type of *impoverishment* (Bonet 1991, Noyer 1992; et seq.): M $\rightarrow$ 0 /_Voice. This will work as long as impoverishment occurs *before* amalgamation.

4.4.3 Local conclusions

The behavior of the AV morpheme constitutes a Mirror Principle violation: given the underlying syntactic structure, we would expect the AV morpheme's exponent to be more external in the word than it actually is. In the preceding analysis, we can identify the specific configuration of amalgamation features as the source of that Mirror Principle violation, as long as we couple it with a MAP-based implementation of the Mirror Principle. Namely, the "counter-cyclic" structure resulting from amalgamation bleeds the asymmetric c-command relation between (the lowest segments of) Aspect and Voice, on the one hand, and Root, on the other, which is the normal way in which Mirror Principle behavior is enforced. This allows the Default Ranking Statement (38) to subordinate ALIGN-AV below ALIGN-ROOT, creating the surface violation of the Mirror Principle. This combination of factors — counter-cyclic amalgamation plus DRS — could be a general recipe for generating Mirror Principle violations and templatic morphology cross-linguistically, including the CARP template in Bantu (as alluded to in footnote 17).

The special structure resulting from this sequence of amalgamation operations may also help explain the consistent portmanteau exponence of Aspect and Voice. This is the only configuration of heads within the verb word (other than Root and the first head it attaches to) where the lowest segments stand in symmetric c-command. Suppose that this configuration uniquely induces some sort of *fusion* operation (Halle & Marantz 1993) which fuses the lowest segments into a single feature bundle.[40] If we assume the traditional approach to Vocabulary Insertion within DM, including insertion into terminal nodes governed by the subset principle (Halle & Marantz 1993, Halle 1997; et seq.), this would generate consistent portmanteau exponence of Aspect and Voice. The final complex head for a Form V (reflexive of the causative) 3SG MASCULINE PERFECTIVE PASSIVE *tukuttiba*, with Vocabulary Insertion of its exponents, is shown in (53).

(53) **Complete morphological word after fusion and Vocabulary Insertion**



Lastly, this analysis makes an interesting prediction about portmanteau morphemes cross-linguistically.[41] For portmanteau morphemes derived through this sort of "counter-cyclic" amalgamation + fusion sequence of operations, we predict that their alignment should not be (fully) subject to the MAP (or indeed to the Mirror Principle more generally), because they lack the kinds of c-command relations typically found within complex heads. Rather, their ordering should instead be based on other principles, such as Default Ranking Statements. On the other hand, apparent portmanteau morphemes that are actually the result of contextual allomorphy, or exponents inserted through spanning (Svenonius 2012, Merchant 2015), *would* be expected to participate in the MAP in the normal way. I leave investigation of this prediction for future work.

[40] In order to maintain the (lack of) c-command relations with the Root, this fusion operation must leave the intermediate segment of Asp intact. This would not be the case if we were dealing with an operation like *M-Merger* (Matushansky 2006) or *Coalescence* (Hsu 2019).

[41] Thank you to Ezer Rasin for pointing this out to me.

4.5 A Sketch of the Phonological Analysis

The (post-syntactic) morphological interactions described above will lead to the low ranking of ALIGN-AV in all cases. This leaves the grammar free to manipulate the position of the AV vowels for phonological purposes. What we observe across the different Form categories is that the AV vowels surface in the positions where they are needed in order to avoid phonotactic/syllabic well-formedness violations. In a strictly concatenative system, these kinds of violations would more typically be avoided through phonological processes like epenthesis or deletion. However, because of the low alignment ranking governing these vowels' morphemes, and the idiosyncratic segregation of consonants and vowels in the underlying representation of the morphemes in this part of the structure, mobility of the AV vowels is preferred to epenthesis.[42]

As alluded to earlier, consonant clusters at the left edge are allowed under certain circumstances. When they are allowed (at the word level), they are repaired by preposed epenthesis of [ʔi] (or [ʔu] when the first vowel is [u]) when they occur in phrase-initial position. We can preliminarily describe the distribution of initial clusters in the verbal system in terms of Form categories and Aspect categories, as shown in Table 6.

Table 6: Distribution of clustering forms in the verbal system

Non-clustering forms	**Clustering forms**
All Imperfectives (initial prefixes: /y,t,ʔ,n/)	Perfective Form VII (initial Middle /n/ + Root-C_1)
Perfective Form IV (initial Caus /ʔ/)	Perfective Form VIII (initial Root-C_1 + Refl /t/)
Perfective Forms V & VI (initial Refl /t/)	Perfective Form X (initial Caus /s/ + Refl /t/)

Talking about clustering in terms of initial position cannot be the whole story, however, once we consider the behavior of Reflexive /t/ in the Imperfective. Contrary to what the analysis would otherwise predict (as will be laid out below), the Imperfective of Forms V & VI exhibits an extra vowel after the Reflexive /t/ (54a). When these facts are considered, the behavior of Reflexive /t/ can be best understood as being driven by a requirement that it never surface in pre-consonantal position. This is true of the other Imperfective forms in (54b), as well as all the corresponding Perfective forms.

(54) **Imperfectives with Reflexive /t/** [3.SG.MASC PASSIVE]

a. Form V: *yu**t**$\boxed{a}$kattabu* (**yu**t**kattabu*)
   Form VI: *yu**t**$\boxed{a}$kaatabu* (**yu**t**kaatabu*)

b. Form VIII: *yuk**t**atabu*
   Form X: *yus**t**aktabu*

I will not seek to provide a deep explanation of these facts here. I will assume that the "non-clustering" behavior of the Forms listed in Table 6 and the restriction evident from the Imperfective Reflexives in (54) are driven by a constraint against pre-consonantal affixes, which applies to a lexically specific set of affixes: *AFX$_i$/_C (where the subscript i indicates lexical class membership; cf., e.g., Pater 2009). This set includes Reflexive /t/, Causative /ʔ/, and the Imperfective agreement prefixes.[43] Once we assume the proper operation of this constraint (or whatever it is standing in for), we can derive the distribution of morphemic material — basically, consonants from the Root and the verbal derivational morphemes, and vowels from the AV morpheme — across the different Forms and AV categories through the combination of three factors:

[42] Because the roots are underlyingly consonant-only, and the language does not allow three-consonant clusters, the root segments will necessarily be split up by vocalic elements. Therefore, whether those vocalic elements belong to the AV vowels or whether they are epenthetic, the phonological constraint CONTIGUITY (Kenstowicz 1994, McCarthy & Prince 1995) will be violated all the same. As long as ALIGN-AV or DEP-IO outrank INTEGRITY, splitting will generally be preferred to epenethesis.

[43] One possible deeper explanation of this behavior is that it in some way avoids phonological neutralization. Some of the consonants among the set might reasonably be expected to delete or neutralize in pre-consonantal position. Preventing the affix from surfacing in pre-consonantal position would therefore stave off the need for a neutralizing repair. This could be coupled with some paradigm uniformity effect (especially among the imperfective prefixes) to (over-)apply to consonants which wouldn't be threatened by neutralization. But this is very speculative.

(55) **Additional components of the phonological analysis**

a. The MAP-driven alignment rankings
b. A constraint against three-consonant clusters (*CCC)
c. A preference for splitting higher sonority vowels (cf. (42–43))

Many of the MAP rankings involved in the Form system have already been motivated above. These are summarized, along with their proposed syntactic structures, in Table 7. Table 8 outlines the exponents of the relevant morphemes.

Table 7: Morphosyntactic structure and alignment analysis of verbal Forms

Form	Perf. Act.	Syntactic structure	Alignment Ranking		
I	*kataba*	[*v* [Root]]	Align-Root-L	($\gg$ Align-*v*-L)	
II	*ka**t**$_c$taba*	[Caus [Root]]	Align-Root-L	$\gg$ Align-Caus-L	
III	*ka**a**$_v$taba*	[Appl [Root]]	Align-Root-L	$\gg$ Align-Appl-L	
IV	***ʔ**aktaba*	[Caus [*v* [Root]]]	Align-Caus-L	$\gg$ Align-Root-L	($\gg$ Align-*v*-L)
V	***t**akat**$_c$taba*	[Refl [Caus [Root]]]	Align-Refl-L	$\gg$ Align-Root-L	$\gg$ Align-Caus-L
VI	***t**akaa$_v$taba*	[Refl [Appl [Root]]]	Align-Refl-L	$\gg$ Align-Root-L	$\gg$ Align-Appl-L
VII	*(ʔi)**n**kataba*	[Mid [*v* [Root]]]	Align-Mid-L	$\gg$ Align-Root-L	($\gg$ Align-*v*-L)
VIII	*(ʔi)k**t**ataba*	[Refl [Root]]	Align-Root-L	$\gg$ Align-Refl-L	
X	*(ʔi)**st**aktaba*	[Caus [Refl [*v* [Root]]]]	Align-Caus-L	$\gg$ Align-Refl-L	$\gg$ Align-Root-L

Table 8: Morphemes involved in verbal Forms

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 Refl)	X

Using the rankings from Table 7 and the exponents from Table 8, we can now derive the segmental distributions of the complex Forms. Space prevents a complete accounting here, so I will limit myself to presenting a few representative cases. I will first consider the different types of Perfective Forms with single-consonant left-oriented affixes, and then turn to more complex structures.

Throughout this section, I will omit the alignment constraints for the agreement affixes (though they will be discussed where relevant), and only consider candidates with agreement affixes in the correct position. As can be seen from structures like (53), I assume Agr to be the highest head in the complex head which constitutes the verb word. Therefore, its alignment constraint will always be highest ranked. In the Perfective, agreement is marked by suffixes. In the Imperfective, agreement is marked simultaneously by a left-edge element and a right-edge element, which is probably best viewed as a circumfix. These affixes always achieve their desired edgemost positions, in accordance with their undominated alignment constraints.

4.5.1 Single-affix Perfective Forms

Since we are using *Afx$_i$/_C to specially prevent clustering for certain affixes, the basic case is instantiated by the affixes to which this constraint is not indexed, i.e., those which do allow a consonant to follow. One such affix is the /n/ prefix in Form VII: Perfective Active [**n**kataba]. In Table 7, I identify Form VII as the "Middle". Its morphosemantic characterization is not crucial here. What is crucial is that its syntactic structure include a null *v*, exactly parallel to the Form IV Causative, so as to generate the ranking Align-Mid-L

≫ Align-Root-L. Also, as just mentioned, its exponent /n/ must *not* be indexed to *Afx_i/_C. Given these assumptions, we straightforwardly derive initial clustering in (56).[44]

(56) **Form VII Perfective Passive** [nkutiba][45] (*Afx_i/_C not active)

/n, ktb, ui, a/	*Afx_i /_C	Align-Mid-L	Align-Root-L	Align-AV-L	Integrity
a. ☞ nkutiba	n/a		*	**	
b. nuktiba			**!	*	
c. nukutiba			**!	*	*
d. knutiba		*!		**	

The ranking Align-Mid-L ≫ Align-Root-L is determined by the MAP; the ranking Align-Root-L ≫ Align-AV-L is determined by the DRS. Without any intereference from *Afx_i/_C, these constraints straightforwardly select the desired order. Candidate (56d) is ruled out because it aligns the Root leftward at the expense of the Middle affix. Candidates (56b,c) are in turn ruled out because they align the AV morpheme leftward at the expense of the Root. This leaves the desired initial-cluster candidate (56a).

The Form VII Middle contrasts minimally with the Form IV Causative. As mentioned, the two Forms have parallel syntactic structures, and thus parallel alignment rankings. However, unlike the Middle /n/, the Causative /ʔ/ *is* indexed to *Afx_i/_C.

(57) **Form IV Perfective Passive** [ʔuktiba] (*Afx_i/_C active for /ʔ/)

/ʔ_i, ktb, ui, a/	*Afx_i /_C	Align-Caus-L	Align-Root-L	Align-AV-L	Integrity
a. ʔkutiba	*!		*	**	
b. ☞ ʔuktiba			**	*	
c. ʔukutiba			**	*	*!
d. kʔutiba		*!		**	

As in the previous tableau, candidate (57d) is ruled out because it left-aligns the Root rather than the syntactically higher morpheme, which here is Causative. Unlike the previous tableau, the candidate that maximally satisfies the top two alignment constraints, candidate (57a), fatally violates *Afx_i/_C, because Causative /ʔ/ is a member of the relevant lexical set. The optimal way of fixing the *Afx_i/_C problem is by pulling the AV vowel leftward, which ensures that the [ʔ] is pre-vocalic, as in candidates (57b,c). This would not be the optimal configuration if only alignment were at stake; that would again be (57a). But since alignment is competing against other (morpho)phonological constraints (here, *Afx_i/_C), the ranking of those constraints above the alignment constraints (here, specifically Align-Root-L) can drive “mis-alignment”/“re-alignment”. But note that the manner of mis-/re-alignment is not random, but rather follows from the ranking. For example, the problem cannot be fixed by “metathesizing” the [ʔ] and the Root-initial [k], which would be in some sense a more “local” operation, given that initial-clustering is the default state of affairs. But this is candidate (57d), which continues to be ruled out by alignment.

Lastly, winning candidate (57b) is preferred over candidate (57c) because the latter violates Integrity, the constraint penalizing the splitting of underlying segments (cf. (43)). Candidate (57c) has split the underlying /u/ of the AV morpheme into two surface exponents, and therefore incurred one violation of Integrity. A potential benefit of this splitting is that it has avoided a two-consonant cluster, and thus improved over the winning candidate in its performance with respect to a phonotactic constraint like NoCoda or *CC. Therefore, we know also that Integrity outranks these constraints. As we will see below, splitting is *only* motivated when it can avoid the occurrence of a three-consonant cluster (*CCC).

The preference for winning candidate (57b) over an alternative candidate [ʔuk$\boxed{\text{it}}$ba], which swaps the middle root consonant (/t/) and the rightmost AV vowel (/i/), is not yet explained. Both are equally well-formed with respect to phonotactics (both have one medial coda, just in different syllables) and with respect to the relevant alignment constraints (as currently formulated). The preference for (57a) relates to the well-known requirement that the verb stem (minus suffixal agreement) end in a VC sequence. McCarthy (2005)

[44] In the remaining discussion, I omit the phrase-initial epenthetic segments [ʔi].
[45] Form VII does not actually permit a passive, so this is not a real form. I use the passive for expository purposes, since it contains two distinct vowels, as opposed to the active, which has only [a]'s. All other Forms considered do form passives.

derives this through paradigm uniformity, driven by the fact that there are C-initial agreement suffixes, which would induce *CCC violations when attaching to a CC-final stem.

One other way of accounting for this, within an alignment-based approach, is to say that the alignment constraints on the Root and the AV morpheme are not simply left-alignment constraints, but rather constraints that require alignment to *both edges*. Such a constraint would essentially sum the violations of a left-oriented alignment constraint and a right-oriented alignment constraint simultaneously. If we adopted this approach, this would show that the AV morpheme's alignment constraint still exerts pressure, even though it is totally dominated. That is to say, *ʔuk**t̲i**ba* ≻ **ʔuk**i̲t**ba* because the former places the rightmost segment of the AV morpheme further to the *right* than its competitor.

This might also help ensure that only AV vowels end up splitting in order to fix phonotactic problems. Consider a case like the Form V Perfective Passive [t**u**k**u**ttiba] (which will be analyzed in the following subsection). This Form displays splitting of its underlying /u/, because it requires three vowel slots in its stem rather than two. The agreement suffix contains an /a/. If the choice of which vowel to split was made purely on the basis of sonority, we would expect this suffix /a/ to be the one that splits: *[tukitt**a**b**a**]. However, this displaces the right edge of the AV's exponent further from the right edge of the word. So, if the AV alignment constraint also has a right-orientation, and Align-AV dominates the constraint(s) preferring splitting of the most sonorous vowel, then the right prediction is maintained. It would be difficult to write-off the possibility of suffix splitting through an appeal to cyclicity, because AV splitting/mobility does occur in order to keep the Imperfective agreement prefixes from surfacing in pre-consonantal position (as will be illustrated below), indicating that the two domains do interact transparently.[46]

Lastly, admitting *both edge* alignment into the system could also provide an explanation for the behavior and existence of circumfixes generally, including Arabic's imperfective subject agreement markers. Since the distinction between *left edge* vs. *both edge* alignment is not particularly relevant for the facts under consideration, I will continue to refer to these as left-alignment constraints throughout the rest of this paper.

We can adduce one more minimal comparison among this set of Forms. The Perfective of Form VIII also has a single left-oriented affix, the Reflexive /t/, which surfaces as the *second*-member of an initial cluster: [k**t**utiba]. We know from other Forms that Reflexive /t/ is also a member of the lexical set indexed to *Afx$_i$/_C. If it was not about pre-consonantal position but rather about initial clusters writ-large, we would not expect a cluster here. But since, as discussed at length above, in this Form Align-Root-L dominates Align-Refl-L, alignment will dictate that the Reflexive /t/ should surface immediately after the Root-initial consonant. Since the AV morpheme wants to be left-aligned to the greatest extent possible (and, for good measure, since three-consonant clusters are not tolerated), alignment will dictate that the next segment is a vowel. This means that alignment satisfaction in this case coincides with active satisfaction of the *Afx$_i$/_C constraint.

(58) **Form VIII Perfective Passive** [ktutiba] (*Afx$_i$/_C active for /t/, but superfluous)

/t$_i$, ktb, ui, a/	*Afx$_i$ /_C	Align-Root-L	Align-Refl-L	Align-AV-L	Integrity
a. ☞ k**t**utiba			*	**	
b. ku**t**tiba	*!		**	*	
c. ku**t**utiba			**!	*	*
d. **t**kutiba	*!	*		**	

In tableau (58), I have indicated a crucial ranking of Align-Refl-L ≫ Align-AV-L. This is necessary in order to select (58a) over (58c). However, there is nothing about the MAP + DRS system as currently constituted that asserts this ranking. There are several possible solutions. Perhaps the most preferable solution is to say that Integrity actually outranks both these constraints in this particular derivation. This will properly select (58a) over (58c). However, if the ranking Integrity ≫ Align-AV were a general property of the system, this might lead to the blocking of splitting in certain cases where it is actually called

[46] It is not impossible that the AV morpheme could simply have a right-oriented alignment constraint. However, this would likely predict that the Form I Perfective Active, whose AV morpheme is best analyzed as having a single vowel /a/, would surface with an initial cluster: *[ktab-]. However, as long as we do not have a true explanation for the distribution of clustering and non-clustering Forms, it cannot be ruled out that this form is disallowed by virtue of its initial cluster, not by virtue of misalignment of its AV vowel.

for. This needs to be checked further, but I currently do not see any cases where this would definitively be a problem.

Another solution would be to add another Default Ranking Statement, which either prefers the *higher* ranking of ALIGN-REFL or (more likely) the *lower* ranking of ALIGN-AV. This is not terribly desirable, as it is nothing more than an additional stipulation. Currently, the generally low ranking of ALIGN-AV can be attributed to the current DRS preferring higher Root-alignment (when coupled with the post-syntactic amalgamation operations discussed in Section 4.4.2, which break the relevant c-command relations).

One final option is to say that there is actually no ranking between these two constraints in this derivation. The summed violations between the two constraints is identical for the two relevant candidates. If we assume that this leads to a real tie, evaluation can be passed on to INTEGRITY, which will properly select (58a) over (58c). However, this is not the typical way of dealing with crucial non-ranking, which would be free variation between the remaining candidates. If, though, the alignment constraints formed some sort of unified block, this assumption would be more tenable.

4.5.2 Multiple-affix Perfective Forms and the Imperfective

Lastly, I will consider the Perfective and the Imperfective of Form V, a Form with two left-oriented verbal derivational morphemes (Reflexive /t/ and Causative /μ_c/). These forms will illustrate how *CCC and *AFX$_i$/_C conspire to induce vowel propagation. Let us start with the Form V Perfective Passive [tukuttiba], whose analysis is given in tableau (59).[47]

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

/t$_i$, μ_c, ktb, ui, a/		*CCC	*AFX$_i$ /_C	ALIGN-REFL-L	ALIGN-ROOT-L	ALIGN-CAUS-L	ALIGN-AV-L	INTEG
a.	**t**ku$t_c$tiba		*!		*	***	**	
b.	**t**uk$t_c$tiba	*!			**	***	*	
c. ☞	**t**uku$t_c$tiba				**	****	*	*
d.	**t**u$k_c$kutiba				***!	**	*	
e.	kut_c**t**utiba			*!**		**	*	

As before, *AFX$_i$/_C eliminates the left-edge clustering candidate (59a), where Reflexive /t/ surfaces in pre-consonantal position, and the MAP-driven alignment ranking rules out various candidates like (59d,e). What's different than in (57) is that, in this case, the number of consonants present makes it impossible to satisfy *CCC without splitting the vowels. This is why (59b), which has better left-aligned the Causative morpheme, is rejected in favor of (59c), which has split its /u/. An alternative candidate [tuk$\boxed{\text{i}}$ttiba], which splits the AV /i/ rather than the AV /u/, is ruled out by the preference for splitting the most sonorous vowel. As introduced in (43) above (repeated here), we can analyze this if we split the INTEGRITY constraint into individual constraints referencing individual vowels, ranked (inversely) according to their sonority value:

(60) **Integrity sub-ranking**
INTEGRITY[i] $\gg$ INTEGRITY[u] $\gg$ INTEGRITY[a]

In subsequent tableaux, for reasons of space, I will continue to consider only candidates that split the most sonorous vowel, and represent INTEGRITY as a single constraint.

Many analyses of Arabic nonconcatenative morphology in the literature have not specifically addressed the imperfective forms, which are marked for agreement simultaneously by prefixes and suffixes. The current account has all the necessary components to explain imperfective forms without additional machinery. The only piece which I omit from the tableau is the alignment constraint governing the agreement markers. As mentioned above, if we ascribe to them a *both edge* alignment constraint, this will generate their circumfixal status. Like with the agreement markers in the Perfective, their syntactically high position will lead to a

[47] I assume that the consonantal mora exponing Causative necessarily associates to a root node *to its right*. This is sensible insofar as we should expect the moraic portion of a doubled consonant to be in coda position not onset position. This assumption precludes a candidate [**t**uk$k_c$utiba], where the exponent of Causative is the second half of the doubled Root-initial /k/. This candidate would otherwise be preferable to (59c), because the Causative's exponent would be closer to the left edge.

correspondingly high ranking of their alignment constraint. As a representative case, consider the Form V Imperfective Passive [yutakattabu]:

(61) **Form V Imperfective Passive** [yutakattabu] (*AFX$_i$/_C active for /t/ and /y/)

/t$_i$, μ_c, ktb, ua, y$_i$(-)u/	*CCC	*AFX$_i$ /_C	ALIGN-REFL-L	ALIGN-ROOT-L	ALIGN-CAUS-L	ALIGN-AV-L	INTEG
a. y**t**ku$t_c$tabu	*!	*!*	*	**	****	***	
b. y**t**uka$t_c$tabu		*!	*	***	*****	**	*
c. yu**t**ka$t_c$tabu		*!	**	***	*****	*	*
d. yu**t**ak$t_c$tabu	*!		**	****	*****	*	*
e. yuk**t**a$t_c$tabu			***!	**	*****	*	*
f. ☞ yu**t**aka$t_c$tabu			**	****	*******	*	**

With two left-oriented affixes that cannot be pre-consonantal, the output will necessarily begin in a CVCV sequence. *AFX$_i$/_C thus rules out candidates like (61a–c). Candidate (61a), which is the best output in terms of alignment, also violates undominated *CCC. Candidate (61d) achieves the necessary #CVCV shape, but ends up with three consecutive consonants medially in an attempt to get the Causative slightly further left and to minimize vowel splitting. Since *CCC is ranked higher, this is not an optimal strategy. Candidate (61e) takes a different approach to resolving the *AFX$_i$/_C for Reflexive /t/: it swaps the position of /t/ and the first root consonant (à la Form VIII), allowing the [t] to be pre-vocalic. However, this fatally worsens the form's alignment, specifically ALIGN-REFL-L. (All other types of re-ordering will fail as well, due to the MAP.) This leaves only winning candidate (61f), which puts all the necessary affixes in non-pre-consonantal position and avoids long strings of medial consonants, all while maximally satisfying the highest ranked alignment constraints (most relevantly, ALIGN-REFL-L). This comes at the expense of increased violation of some lower ranked alignment constraints (ALIGN-ROOT-L and ALIGN-CAUS-L) and three-way splitting of the AV's underlying /a/ (incurring an additional INTEGRITY violation[48]). But given these constraints' relatively low ranking, the desired output is nonetheless selected.

As a final point, consider again the nature of vowel splitting in this system. The behavior of vowel splitting seems to be an argument *against* a cyclic concatenation approach to morpheme ordering. If the vowels were linearized with respect to any lower constituent first, and then propagated to fill any subsequently necessary vowel slots, we would not expect to observe the situation at hand in the imperfective passive. It seems clear that the imperfective agreement prefix is higher than the other verbal derivational morphemes. If the vowels were linearized cyclically, we might expect that the underlying /u/ should get linearized internal to the first stem consonant, and that the underlying /a/ should spread into all remaining positions. When the imperfective agreement prefix is added subsequently, we rightly expect spreading into the newly necessary position by the [u]. However, if the existing positions of the vowels were already set, we should *not* expect the stem-initial [u] to be replaced by [a]. On the other hand, if vowel positioning were determined completely in parallel, as in the MAP approach, the distribution can be governed purely by the phonology, as presented above. It must be stated, however, that the peculiarities of the AV morpheme, and the as-yet-incomplete analysis of initial (non-)clustering, leaves room for push back.

4.6 Local Conclusions

The MAP approach offers new insights about the relationship between the verbal (morpho)syntax of Arabic and its (morpho)phonological system, and provides a more complete and consistent account of its phonological complexities and typological unusualness. Adopting the MAP approach also brings nonconcatenative morphological processes under the umbrella of phenomena which illustrate the Mirror Principle:

(62) **The Mirror Principle** (Baker 1985:375)
Morphological derivations must directly reflect syntactic derivations (and vice versa).

[48] Strictly speaking, given the definition of INTEGRITY in (43), this candidate should have *three* INTEGRITY violations. This makes no difference here.

By using *Alignment rankings* determined via phonological analysis, rather than just linear order, to infer the underlying word-internal structure, we can apply Mirror Principle reasoning to infer syntactic structure from surface morpheme order for any sort of morphological system, concatenative or otherwise.

5 Discussion and Conclusion

Issues of space prevent a full presentation of alternatives and a full accounting of how the MAP interacts with the existing literature on the phonology-morphology interface. Nevertheless, in this section, I will briefly situtate the MAP within the major debate on the nature of the phonology-morphology interface ("$\mathbf{P} \gg \mathbf{M}$" vs. subcategorization), focusing on the MAP's relevance for the theory and typology of infixation. The section will then conclude by reviewing the main claims and results of the paper, with an eye towards future extensions of the framework.

5.1 The Phonology-Morphology Interface

Much of the recent literature on the phonology-morphology interface can be seen as a debate between two approaches: the "$\mathbf{P} \gg \mathbf{M}$ approach" (McCarthy & Prince 1993b) and the prosodic/phonological subcategorization approach (Inkelas 1990).

In the $\mathbf{P} \gg \mathbf{M}$ approach, situated within Optimality Theory (Prince & Smolensky [1993] 2004) and its descendents, a substantial amount of morphological information is admitted into the phonological computation, while (typically) little to no phonological information is admitted into the morphological computation.[49] When phonological factors impact morphological "processes" — like allomorph selection, morpheme order (e.g. infixation, mobile affixation), reduplication, etc. — phonological/prododic ("**P**") constraints are said to outrank morphological ("**M**") constraints. The $\mathbf{P} \gg \mathbf{M}$ approach (at least in its traditional version) clearly predicts that all such interactions should be *phonologically optimizing*. That is to say, in any case where phonology influences morphology, the resulting distribution should result in structures which are *less marked* phonologically than other locally similar alternatives.

The prosodic/phonological subcategorization approach, normally couched within Sign Based Morphology and Cophonology Theory (Orgun 1996, Inkelas, Orgun, & Zoll 1997, et seq.), can be seen as the reverse model of the phonology-morphology interface. In this approach, a substantial amount of *phonological* information is admitted into the *morphological* computation, while little to no morphological information is admitted into the phonological computation. Phonology impacts morphology in the form of phonological subcategorization frames which are specified for particular morphemes/constructions. These subcategorization frames are taken to be *inviolable* (e.g. Yu 2007, Paster 2009). That is to say, this is a theory where morphological concatenation is effectuated through declarative concatenation operations, not through constraint interaction of any kind. Because of this, the subcategorization approach does not predict that phonology-morphology interactions need to be phonologically optimizing, and indeed predicts that phonologically perverse interactions of this sort should be attested.

The Mirror Alignment Principle framework falls squarely within the $\mathbf{P} \gg \mathbf{M}$ camp. In theory, alignment constraints could be viewed as operating within an autonomous morphological component (see, e.g., Trommer 2001). This would be consistent with the analysis of Chichewa in Section 3, since only morphological information is necessary for the computation (whether or not bigram morphotactic constraints are employed). However, the analysis of Arabic in Section 4 shows that the alignment constraints crucially interact with purely phonological constraints (like *CCC and INTEGRITY), and also crucially depend on the phonological content of the morphemes involved. This means that the MAP requires alignment to be calculated in a *bona fide* phonological computation, of exactly the sort envisioned by the $\mathbf{P} \gg \mathbf{M}$ approach.

In the next subsection, I will discuss how the introduction of the MAP impacts the broader $\mathbf{P} \gg \mathbf{M}$ model, and show that it might actually alleviate some of the criticisms leveled against $\mathbf{P} \gg \mathbf{M}$ by proponents of subcategorization. In particular, it provides a potential mode of explanation for certain non-optimizing cases of infixation adduced by Yu (2002, 2003, 2007).

[49] Wolf's (2008) "Optimal Interleaving" framework within OT with Candidate Chains (McCarthy 2007) essentially collapses the phonological and morphological computations into a single serial computation. While slightly different than traditional $\mathbf{P} \gg \mathbf{M}$ implementations, this approach most certainly embodies the notion that phonological constraints directly influence morphological computation.

5.2 Infixation

The MAP, having been inspired by the **P** ≫ **M** models, inherently shares with traditional **P** ≫ **M** analyses the notion that infixes are "failed prefixes/suffixes". That is to say, the morphemes which ultimately surface as infixes would "prefer" to be aligned to an edge of the word (via ALIGN-X-L/R), but get displaced from that edge by the force of higher-ranked constraints. The majority of cases analyzed in this way have employed phonological/prosodic constraints as the drivers of infixation.

Consider the case of Sundanese (Austronesian).[50] In Sundanese, the plural/distributive is marked by a left-oriented affix /ar/ (Anderson 1972, Cohn 1992).[51] When the root is vowel-initial (Table 9a), this affix surfaces as a *bona fide* prefix. However, when the root begins with a consonant, this affix instead surfaces as an infix immediately after that consonant (Table 9b).

Table 9: Sundanese /ar/ affixation (Cohn 1992:201)

a. **Vowel-initial roots** → prefix			b. **Consonant-initial roots** → infix		
	SG	PL		SG	PL
'you'	*anjɨn*	***ar**-anjɨn*	'well' (ADJ)	*damaŋ*	*d-**ar**-amaŋ*
'patient'	*ayɨm*	***ar**-ayɨm*	'forget'	*poho*	*p-**ar**-oho*

As with many other similar cases in the literature, this prefixation/infixation alternation can be analyzed as avoidance of onsetless syllables. That is to say, the grammar wants to place the plural affix at the left edge (ALIGN-PL-L ≫ ALIGN-ROOT-L, presumably dictated by the MAP); however, it is yet more important to avoid ONSET violations (ONSET ≫ ALIGN-PL-L). In the case of consonant-initial roots, the desired prefixal alignment would lead to an extra ONSET violation (because the affix is itself vowel-initial). And so the prefixal candidate (63a) is eschewed in favor of the infixal candidate (63b), as long as all relevant Input-Output faithfulness constraints also outrank ALIGN-PL-L (e.g. LINEARITY as applied to candidate (63c)). On the other hand, in the case of vowel-initial roots (64), an ONSET violation will occur regardless of whether the affix surfaces at the left edge or not, so it defaults to its desired prefixal position (64a).

(63) **Infixation to avoid ONSET violation for C-initial roots** (Table 9b)

/paho, ar/	FAITH	ONSET	ALIGN-PL-L	ALIGN-ROOT-L
a. .**ar**-.pa.ho.		*!		**
b. ☞ .p-**a.r**-a.ho.			*	
c. .**ra**-.pa.ho.	*!			**

(64) **Prefixation by default for V-initial roots** (Table 9a)

/ayɨm, ar/	FAITH	ONSET	ALIGN-PL-L	ALIGN-ROOT-L
a. ☞ .**a.r**-a.yɨm.		*		**
b. .a.-**ar**-.yɨm.		**!	*	
c. .a.y-**a.r**ɨm.		*	*!*	
d. .**r**-a.yɨm.	*!			*

While cases like Sundanese can viewed as prosodically-driven infixation, there are many other cases for which the same cannot be said. Consider actor focus infixation in Atayal (Austronesian; Egerod 1965, Rau 1992; cf. Huang 2018) exemplified in Table 10. In this pattern, the morpheme *m* is infixed after the first consonant of the root.[52]

[50] I will only here discuss affix placement itself; on the interaction between affix placement and nasal harmony, see Anderson (1972).

[51] The /r/ may surface as [l] under dissimilatory pressures; see, e.g., Bennett (2015), Stanton (to appear), and references therein.

[52] There are cases where [m] rather appears to "replace" the initial consonant (Egerod 1965:263–265): e.g., *biq* 'give' → *miq* (AF) (Rau 1992:32). Rau (1992:32) states that this is primarily limited to cases where the root-initial consonant is labial /p,b/ or a glottal stop /ʔ/. If these cases are viewed as coalescence rather than deletion of the root-initial consonant, then the analysis suggested below will still be compatible with the facts.

Table 10: Atayal animate actor focus (Yu 2007:35, ex. 45; data from Egerod 1965:263–266)

Root	**Root + AF**	**Gloss**
qul	q*m*ul	'snatch'
kat	k*m*at	'bite'
kuu	k*m*uu	'too tired, not in the mood'
hŋuʔ	h*m*ŋuʔ	'soak'
skziap	k*m*ziap	'catch'
sbil	s*m*bil	'leave behind'

Yu (2007) argues that this pattern cannot be described in terms of phonological optimization, and thus serves as counter-evidence to the **P** ≫ **M** model. However, this argument does not consider *alignment itself* as a trigger for output optimization. The articulated alignment approach inherent to the MAP provides a means of accounting for this otherwise "non-optimizing" pattern.

If Align-Root-L outranks Align-A[ctor]F[ocus]-L, alignment on its own will generate infixation, as shown in (65). Infixation will be minimal, because of the force of Align-AF-L's gradient evaluation, even though it's dominated. Infixation (65b) could have been blocked in favor of suffixation (65c), but this is avoided by ranking Align-AF-L above Contiguity.[53,54]

(65) **Atayal AF infixation**

/kuu, m/	Align-Root-L	Align-AF-L	Contiguity
a. **m**-kuu	*!		
b. ☞ k-**m**-uu		*	*
c. kuu-**m**		**!	

This analysis shows that phonologically "non-optimizing" patterns can in fact be derived in an optimizing phonological computation as long as we expand the set of constraints that can be optimized for. In fact, the parade example of prosodically-driven infixation — agent focus /um/-infixation in Tagalog (McCarthy & Prince 1993a, Prince & Smolensky [1993] 2004, Orgun & Sprouse 1999, McCarthy 2003, Klein 2005, Yu 2007) — has been convincingly shown by Zuraw (2007) to instead be a case of alignment-driven infixation. (Zuraw 2007:298–299 uses the constraints Anchor-Stem ≫ Leftmost, but this translates directly into Align-Root-L ≫ Align-AF-L in the terminology of this paper.) The current approach also helps resolve a problem adduced by Yu (2007), namely, that some infixes seem to "subcategorize" for phonological units that

[53] We know independently that Contiguity must be violable in the language based on its permission of morpheme-internal epenthesis (see note 54 below).

[54] A few more notes about Atayal are in order. As Yu (2007:35, n. 12) mentions in a footnote, the *m* infix is usually/always preceded by a schwa (or some similar, short, contextually-predictable vowel); that is to say, *kmuu* should really be transcribed [kəmuu]. While much of the early literature on Atayal assumes that schwa need not be posited as a phoneme because of its generally predictable distribution, Huang (2018) argues that there are at least some such reduced vowels that have to be present underlyingly. This raises the specter that the AF morpheme could have an underlying representation of the shape VC rather than just C. This would bring Atayal in line with the Sundanese case, and open up the possibility of a prosodic optimization account; Atayal does not allow (word-initial) onsetless syllables (Rau 1992:21). However, regardless of its underlying representation, a purely prosodic account of the AF morpheme will be incomplete once we consider an additional fact about morpheme order.

As can be observed from the forms in Egerod (1965), not all active/agent stems built with the *m* morpheme display infixal ordering; many show prefixal ordering. For some roots, both an infixal and prefixal form is attested, but with differences in meaning. According to Rau (1992:37–38), infixal forms are transitive while prefixal forms are intransitive/stative: compare *h-**m**-utaw* [həmutaw] 'drop' vs. ***m**-hutaw* [məhutaw] 'fall'. This suggests that, just like with the Arabic Reflexive /t/ from Section 4, syntactic differences correlate with ordering differences as mediated by the MAP. (I leave detailed investigation of the (morpho)syntactic structures involved here for future research.) Prefixal ordering is generated when the MAP (plus any attendant relevant Default Ranking Statements) transmits the ranking Align-AF-L ≫ Align-Root-L, whereas infixal ordering is generated when it transmits the reverse ranking Align-Root-L ≫ Align-AF-L (as shown in (65)).

This makes it relatively safe to assume that both instances share the same underlying representation for the AF morpheme. However, this actually does not resolve the question of what is its proper UR: pre-tonic syncope (Huang 2018) would delete an underlying schwa in the prefixal case. In any event, even if this case of infixation could in the end be attributed to prosodic optimization, many other of the infixation patterns adduced by Yu (2007) can only be accounted for with this sort of alignment-based analysis.

are not "genuine units of prosody" (McCarthy & Prince 1986, 1993b), like initial/final consonants. If these cases are derived simply through the interaction of alignment constraints, which are calculated over segments rather than higher-level prosodic units, we expect the segment to be a possible unit of infixal displacement.

5.3 Conclusion

This paper has introduced and developed a new proposal regarding the nature of morpheme ordering, based on the operation of the Mirror Alignment Principle (MAP) at the morphology-phonology interface. The MAP is an algorithm that translates hierarchical structural relations (asymmetric c-command) between morphosyntactic terminals into ranking domination relations between alignment constraints on the exponents of those morphosyntactic terminals in the phonological component of the grammar (namely in CON). This algorithm provides a principled means of capturing so-called "Mirror Principle" effects (Baker 1985, 1988), whereby the order of morphemes in a complex word mirrors the order of syntactic derivation and hierarchical morphosyntactic structure.

The MAP approach eschews the more traditional cyclic morphological concatenation approach to morpheme ordering and the Mirror Principle, instead determining the linear order of morphemes by concatenating their phonological exponents through simultaneous global evaluation in the phonology. Dispensing with morphological concatenation allows for the possibility of bringing nonconcatenative morphological processes back into the fold of Mirror Principle-related phenomena. As demonstrated in Section 4, linking the relative ranking of alignment constraints in individual derivations to correlated differences in syntactic structure allows for a principled explanation of what would otherwise constitute a ranking paradox in Arabic's nonconcatenative morphological system. The alignment rankings which are necessary for the phonological analysis, when viewed through the lens of the Mirror Alignment Principle, point to morphosyntactic representations which look completely sensible from a cross-linguistic perspective, and may even reveal mirror-image ordering properties similar to those seen in Bantu in Section 3.

The MAP framework indeed straightforwardly captures the sorts of mirror-image morpheme orderings seen in Chichewa and other Bantu languages. Differences in syntactic structure map directly onto differences in alignment rankings, which generate different surface orders. These mirror-image ordering properties are embedded within a larger, more complex system of asymmetric compositionality and fixed ordering, collectively referred to as the "CARP template" (Hyman 2003). While I have not tried to adjudicate between different possible analyses of the CARP template, this paper has shown that the MAP is flexible enough to join with many different kinds of approaches to the problem, located in various modules of the grammar.

Additionally, the use of alignment constraints in the general implementation of morpheme ordering furnishes another desideratum. First, morphological concatenation algorithms (such as the one proposed in Embick 2007, 2015) have no built-in means of resolving the linear indeterminacy between concatenated elements. That is to say, a morphosyntactic structure [x[yz]] could be linearized as *x*-[*y*-*z*], *x*-[*z*-*y*], [*y*-*z*]-*x*, or [*z*-*y*]-*x*, and still obey the concatenation algorithm (and thus the Mirror Principle), which itself has no left/right ordering instructions. By implementing the entire procedure using alignment constraints, we avail ourselves of the inherent directionality of Generalized Alignment: the possible orders are weeded out according to the language particular choice of direction of alignment for a particular (class of) morpheme.

This is not to say that there might not be other principles involved in determining the direction of alignment for individual morphemes or classes of morphemes. For example, Trommer (2001) uses typological ordering facts to assert universal preferences for the direction of alignment of different kinds of agreement morphemes/features. None are exceptionless (though for each exception he does construct a consistent analysis within his framework of "Distributed Optimality"), so it is not clear that this should universally limit possible directionality in individual languages. Kusmer (2019) introduces constraints relating to "antisymmetry" and "head-finality", concepts familiar from syntactic linearization, into word-level morphophonological computations. While his system is not directly compatible with the MAP, it may be possible to leverage these concepts in explaining the direction of alignment in certain instances.

While this paper has limited the application of the MAP to word-level phenomena, the MAP is in principle capable of contributing to the ordering properties of higher-level constituents, as well. The syntactic structure obviously furnishes phrases in addition to heads, and the prosody/phonology furnishes constituents above the level of the word. Generalized Alignment, implemented in various ways, has long been appealed to in this domain (e.g. Truckenbrodt 1995, Selkirk 2009, among many others) to relate constituents of the respective types. The MAP could play a part in determining the ranking of alignment constraints for different constituents according to the hierarchical structure of the phrase/sentence-level syntax, as opposed to just complex heads. These alignment-based ordering properties might assert themselves only in cases of indeterminacy in syntactic linearization (cf. Kayne 1994), or perhaps they could play an even more central role in syntactic linearization itself. Therefore, the Mirror Alignment Principle provides us a number of directions for future investigation across multiple domains of the (morpho)syntax-phonology interface.

References

Anderson, Stephen R. 1972. On Nasalization in Sundanese. *Linguistic Inquiry* 3(3):253–268.

———. 1996. How to Put Your Clitics in Their Place. *The Linguistic Review* 13(3–4):165–192.

Arad, Maya. 2003. Locality Constraints on the Interpretation of Roots: The Case of Hebrew Denominal Verbs. *Natural Language & Linguistic theory* 21(4):737–778.

Arregi, Karlos & Andrew Nevins. 2012. *Morphotactics: Basque Auxiliaries and the Structure of Spellout.* Dordrecht: Springer.

Baker, Mark. 1985. The Mirror Principle and Morphosyntactic Explanation. *Linguistic Inquiry* 16(3):373–415.

———. 1988. *Incorporation: A Theory of Grammatical Function Changing.* Chicago: University of Chicago Press.

Banerjee, Neil. 2019. Templatic Morphology Through Syntactic Selection: Valency-Changing Extensions in Kinyarwanda. *Glossa* 4(1):1–31.

Bat-El, Outi. 2003. The Fate of the Consonantal Root and the Binyan in Optimality Theory. *Recherches linguistiques de Vincennes* 32:31–60.

———. 2011. Semitic Templates. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell Companion to Phonology.* Blackwell Publishing.

Bennett, William G. 2015. Assimilation, Dissimilation, and Surface Correspondence in Sundanese. *Natural Language & Linguistic Theory* 33(2):371–415.

Bermúdez-Otero, Ricardo. 2012. The Architecture of Grammar and the Division of Labour in Exponence. In Jochen Trommer (ed.), *The Morphology and Phonology of Exponence*, 8–83. Oxford: Oxford University Press.

Bonet, Eulàlia. 1991. Morphology after Syntax: Pronominal Clitics in Romance. PhD Dissertation, MIT.

Brame, Michael K. 1970. Arabic Phonology: Implications for Phonological Theory and Historical Semitic. PhD Dissertation, MIT.

Bye, Patrik & Peter Svenonius. 2012. Non-concatenative Morphology as Epiphenomenon. In Jochen Trommer (ed.), *Morphology and Phonology of Exponence*, 427–495. Oxford: Oxford University Press.

Chomsky, Noam. 1986. *Knowledge of language: Its Nature, Origin, and Use.* Westport, CT: Praeger.

———. 1995. *The Minimalist Program.* Cambridge, MA: MIT Press.

Cohn, Abigail C. 1992. The Consequences of Dissimilation in Sundanese. *Phonology* 9(2):199–220.

Egerod, Søren. 1965. Verb inflexion in Atayal. *Lingua* 15:251–282.

Embick, David. 2007. Linearization and Local Dislocation: Derivational Mechanics and Interactions. *Linguistic Analysis* 33(3–4):303–336.

———. 2015. *The Morpheme: A Theoretical Introduction.* Boston/Berlin: Walter de Gruyter.

Embick, David & Rolf Noyer. 2001. Movement Operations after Syntax. *Linguistic Inquiry* 32(4):555–595.

Fischer, Wolfdietrich. 2002. *A Grammar of Classical Arabic.* 3rd edn. New Haven: Yale University Press.

Gafos, Adamantios. 1998. Eliminating Long-Distance Consonantal Spreading. *Natural Language & Linguistic Theory* 16(2):223–278.

———. 2018. Stems in Arabic Morphology and Phonology. In Elabbas Benmamoun & Reem Bassiouney (eds.), *The Routledge Handbook of Arabic Linguistics*, 62–86. Abingdon: Routledge.

Golston, Chris. 1996. Direct Optimality Theory: Representation as Pure Markedness. *Language* 72(4):713–748.

Good, Jeff. 2005. Reconstructing Morpheme Order in Bantu: The Case of Causativization and Applicativization. *Diachronica* 22(1):3–57.

Halle, Morris. 1997. Distributed Morphology: Impoverishment and Fission. In Benjamin Bruening, Yoonjung Kang & Martha McGinnis (eds.), *PF: Papers at the Interface* (MIT Working Papers in Linguistics 30), 425–450. Cambridge, MA: MITWPL.

Halle, Morris & Alec Marantz. 1993. Distributed Morphology and the Pieces of Inflection. In Ken Hale & Samuel Jay Keyser (eds.), *The View from Building 20: Essays in Honor of Sylvain Bromberger*, 111–176. Cambridge, MA: MIT Press.

Hargus, Sharon & Siri G. Tuttle. 1997. Augmentation as Affixation in Athabaskan Languages. *Phonology* 14(2):177–220.

Harizanov, Boris & Vera Gribanova. 2019. Whither Head Movement? *Natural Language & Linguistic Theory* 37(2):461–522.

Henderson, Brent. 2019. Chimiini Lexical, Productive and Doubled Verb Suffixes. Poster presented at the 2019 LSA Annual Meeting New York.

Hsu, Brian. 2019. Coalescence: A Unification of Bundling Operations in Syntax. *Linguistic Inquiry* (early access):1–49. doi:10.1162/ling_a_00372.

Huang, Hui-chuan J. 2018. The Nature of Pretonic Weak Vowels in Squliq Atayal. *Oceanic Linguistics* 57(2):265–288.

Hyman, Larry M. 2003. Suffix Ordering in Bantu: A Morphocentric Account. In Geert Booij & Jaap van Marle (eds.), *Yearbook of Morphology 2002*, 245–281. Kluwer.

Hyman, Larry M. & Sam Mchombo. 1992. Morphotactic Constraints in the Chichewa Verb Stem. In *BLS 18: Proceedings of the Eighteenth Annual Meeting of the Berkeley Linguistics Society: General Session and Parasession on The Place of Morphology in a Grammar (1992)*, 350–364.

Inkelas, Sharon. 1990. *Prosodic Constituency in the Lexicon* Outstanding Dissertations in Linguistics Series. New York: Garland Publishing.

Inkelas, Sharon, Cemil Orhan Orgun & Cheryl Zoll. 1997. The Implications of Lexical Exceptions for the Nature of Grammar. In Iggy Roca (ed.), *Constraints and Derivations in Phonology*, 542–551. Oxford: Clarendon Press.

Inkelas, Sharon & Cheryl Zoll. 2007. Is Grammar Dependence Real? A Comparison Between Cophonological and Indexed Constraint Approaches to Morphologically Conditioned Phonology. *Linguistics* 45(1):133–171.

Julien, Marit. 2002. *Syntactic Heads and Word Formation*. Oxford/New York: Oxford University Press.

Kastner, Itamar. 2016. Form and Meaning in the Hebrew Verb. PhD Dissertation, NYU.

———. 2019. Templatic Morphology as an Emergent Property. *Natural Language & Linguistic Theory* 37(2):571–619.

———. 2020. *Voice at the Interfaces: The Syntax, Semantics, and Morphology of the Hebrew Verb* (Open Generative Syntax 8). Berlin: Language Science Press.

Kayne, Richard S. 1994. *The Antisymmetry of Syntax*. Cambridge, MA: MIT Press.

Kenstowicz, Michael. 1994. Syllabification in Chukchee: A Constraints-Based Analysis. In Alice Davison, Nicole Maier, Glaucia Silva & Wan Su Yan (eds.), *Proceedings of the Formal Linguistics Society of Mid-America 4*, 160–181. Iowa City: Department of Linguistics, University of Iowa.

Klein, Thomas B. 2005. Infixation and Segmental Constraint Effects: UM and IN in Tagalog, Chamorro, and Toba Batak. *Lingua* 115(7):959–995.

Kusmer, Leland. 2019. Optimal Linearization: Word and Affix Order with Optimality Theory. Paper presented at the 2019 LSA Annual Meeting New York.

LeTourneau, Mark S. 1997. Underspecification of Lexical Entries for Arabic Verbs. In Mushira Eid & Robert R. Ratcliffe (eds.), *Perspectives on Arabic Linguistics X: Papers from the Tenth Annual Symposium on Arabic Linguistics*, 93–122. Amsterdam/Philadelphia: John Benjamins Publishing Company.

Marantz, Alec. 1997. No Escape from Syntax: Don't Try Morphological Analysis in the Privacy of Your Own Lexicon. *University of Pennsylvania Working Papers in Linguistics* 4(2):Article 14.

Matushansky, Ora. 2006. Head movement in Linguistic Theory. *Linguistic Inquiry* 37(1):69–109.

McCarthy, John J. 1979. Formal Problems in Semitic Phonology and Morphology. PhD Dissertation, MIT.

———. 1981. A Prosodic Theory of Nonconcatenative Morphology. *Linguistic Inquiry* 12(3):373–418.

———. 2003. OT Constraints are Categorical. *Phonology* 20(1):75–138.

———. 2005. Optimal Paradigms. In Laura Downing, Tracy Alan Hall & Renate Raffelsiefen (eds.), *Paradigms in Phonological Theory*, 170–210. Oxford: Oxford University Press.

———. 2007. *Hidden Generalizations: Phonological Opacity in Optimality Theory*. London: Equinox Publishing.

McCarthy, John J. & Alan Prince. 1986. Prosodic Morphology. *Linguistics Department Faculty Publication Series* 13 (1996 version).

———. 1993a. Generalized Alignment. In Geert Booij & Jaap van Marle (eds.), *Yearbook of Morphology 1993*, 79–153. Kluwer.

———. 1993b. Prosodic Morphology I: Constraint Interaction and Satisfaction. *Linguistics Department Faculty Publication Series* 14 (2001 version).

———. 1995. Faithfulness and Reduplicative Identity. In Jill Beckman, Suzanne Urbanczyk & Laura Walsh Dickey (eds.), *Papers in Optimality Theory* (University of Massachusetts Occasional Papers in Linguistics 18), 249–384. Amherst, MA: Graduate Linguistics Student Association.

McPherson, Laura & Mary Paster. 2009. Evidence for the Mirror Principle and Morphological Templates in Luganda Affix Ordering. In Akinloye Ojo & Lioba Moshi (eds.), *Selected proceedings of the 39th Annual Conference on African Linguistics*, 56–66. Somerville, MA: Cascadilla Proceedings Project.

Merchant, Jason. 2015. How much context is Enough? Two Cases of Span-Conditioned Stem Allomorphy. *Linguistic Inquiry* 46(2):273–303.

Muysken, Pieter. 1981. Quechua Causatives and Logical Form: A Case Study in Markedness. In Adriana Belletti, Luciana Brandi & Luigi Rizzi (eds.), *Theory of Markedness in Generative Grammar: Proceedings of the 1979 GLOW Conference*, Pisa: Scuola Normale Superiore.

Myler, Neil. 2015. A Long, Hard Look into the Mirror. Talk Presented at NYU Syntax Brown Bag, NYU.

Noyer, Rolf. 1992. Features, Positions and Affixes in Autonomous Morphological Structure. PhD Dissertation, MIT.

Orgun, Cemil Orhan. 1996. Sign-Based Morphology and Phonology with Special Attention to Optimality Theory. PhD Dissertation, University of California, Berkeley.

Orgun, Cemil Orhan & Ronald L. Sprouse. 1999. From "MParse" to "Control": Deriving Ungrammaticality. *Phonology* 16(2):191–224.

Paster, Mary. 2006. Phonological Conditions on Affixation. PhD Dissertation, University of California, Berkeley.

———. 2009. Explaining Phonological Conditions on Affixation: Evidence from Suppletive Allomorphy and Affix Ordering. *Word Structure* 2(1):18–37.

Pater, Joe. 2009. Morpheme-Specific Phonology: Constraint Indexation and Inconsistency Resolution. In Stephen Parker (ed.), *Phonological Argumentation: Essays on Evidence and Motivation*, 123–154. London: Equinox.

Potter, Brian. 1996. Minimalism and the Mirror Principle. In Kiyomi Kusumoto (ed.), *Proceedings of the North East Linguistic Society 26*, 289–302. Amherst, MA: Graduate Linguistics Student Association.

Prince, Alan & Paul Smolensky. [1993] 2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden, MA: Blackwell Publishing.

Rau, Der-Hwa Victoria. 1992. A Grammar of Atayal. PhD Dissertation, Cornell University.

Rice, Keren. 2000. *Morpheme Order and Semantic Scope: Word Formation in the Athabaskan Verb*. Cambridge: Cambridge University Press.

Ryan, Kevin M. 2010. Variable Affix Order: Grammar and Learning. *Language* 86(4):758–791.

Ryding, Karin C. 2005. *A Reference Grammar of Modern Standard Arabic*. Cambridge: Cambridge University Press.

Sande, Hannah & Peter Jenks. 2018. Cophonologies by Phase. In Sherry Hucklebridge & Max Nelson (eds.), *NELS 48: Proceedings of the Forty-Eighth Annual Meeting of the North East Linguistic Society*, vol. 3, 39–53. Amherst, MA: Graduate Linguistics Student Association.

Sande, Hannah, Peter Jenks & Sharon Inkelas. 2020. Cophonologies by Ph(r)ase. *Natural Language & Linguistic Theory.* doi:10.1007/s11049-020-09467-x.

Schramm, Gene M. 1962. An Outline of Classical Arabic Verb Structure. *Language* 38(4):360–375.

Selkirk, Elisabeth. 2009. On Clause and Intonational Phrase in Japanese: The Syntactic Grounding of Prosodic Constituent Structure. *Gengo Kenkyu* 136:35–73.

Stanton, Juliet. to appear. Aggressive reduplication and dissimilation in Sundanese. *Phonological Data & Analysis* .

Stiebels, Barbara. 2003. Transparent, Restricted and Opaque Affix Orders. In Uwe Junghanns & Luka Szucsich (eds.), *Syntactic Structures and Morphological Information*, 283–315. Berlin: Mouton de Gruyter.

Svenonius, Peter. 2012. Spanning. Ms., CASTL, University of Tromsø.

Trommer, Jochen. 2001. Distributed Optimality. PhD Dissertation, University of Potsdam.

Truckenbrodt, Hubert. 1995. Phonological Phrases: Their Relation to Syntax, Focus, and Prominence. PhD Dissertation, MIT.

Tucker, Matthew A. 2010. Roots and Prosody: The Iraqi Arabic Derivational Verb. *Recherches linguistiques de Vincennes* 39:31–68.

———. 2011. The Morphosyntax of the Arabic Verb: Toward a Unified Syntax-Prosody. In *Morphology at Santa Cruz: Papers in Honor of Jorge Hankamer*. University of California, Santa Cruz: Linguistics Research Center.

Ussishkin, Adam. 2000a. The Emergence of Fixed Prosody. PhD Dissertation, University of California, Santa Cruz.

———. 2000b. Root-and-Pattern Morphology without Roots or Patterns. In *NELS 30: Proceedings of the North East Linguistic Society*, 655–670. Amherst, MA: Graduate Linguistics Student Association.

———. 2003. Templatic Effects as Fixed Prosody: The Verbal System in Semitic. In Jacqueline Lecarme (ed.), *Research in Afroasiatic Grammar II*, 511–530. Amsterdam: John Benjamins Publishing.

———. 2005. A Fixed Prosodic Theory of Nonconcatenative Templatic Morphology. *Natural Language & Linguistic Theory* 23(1):169–218.

Wallace, Katherine. 2013. A Concatenative Approach to Semitic Templatic Morphology. Ms., NYU.

Wolf, Matthew. 2008. Optimal Interleaving: Serial Phonology-Morphology Interaction in a Constraint-Based Model. PhD Dissertation, University of Massachusetts, Amherst.

Wright, William. 1896. *A Grammar of the Arabic Language*, vol. I. 3rd edn. Cambridge: Cambridge University Press.

Yu, Alan C. L. 2002. Understanding Infixes as Infixes. Paper Presented at the Second North American Phonology Conference, Montreal.

———. 2003. The Morphology and Phonology of Infixation. PhD Dissertation, University of California, Berkeley.

———. 2007. *A Natural History of Infixation*. Oxford: Oxford University Press.

Yushmanov, Nikolai Vladimirovich. 1961. *The Structure of the Arabic Language*. Washington, D.C.: Center for Applied Linguistics of the Modern Language Association of America.

Zimmermann, Eva. 2017. *Morphological Length and Prosodically Defective Morphemes* (Oxford Studies in Phonology and Phonetics 1). Oxford: Oxford University Press.

Zukoff, Sam. 2017. The Mirror Alignment Principle: Morpheme Ordering at the Morphosyntax-Phonology Interface. In Snejana Iovtcheva & Benjamin Storme (eds.), *Papers on Morphology* (MIT Working Papers in Linguistics 81), 105–124. Cambridge, MA: MITWPL.

Zuraw, Kie. 2007. The Role of Phonetic Knowledge in Phonological Patterning: Corpus and Survey Evidence from Tagalog Infixation. *Language* 83(2):277–316.