The Mirror Alignment Principle:
Morpheme Ordering at the Morphosyntax-Phonology Interface (Part I: Bantu)*

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1 Introduction

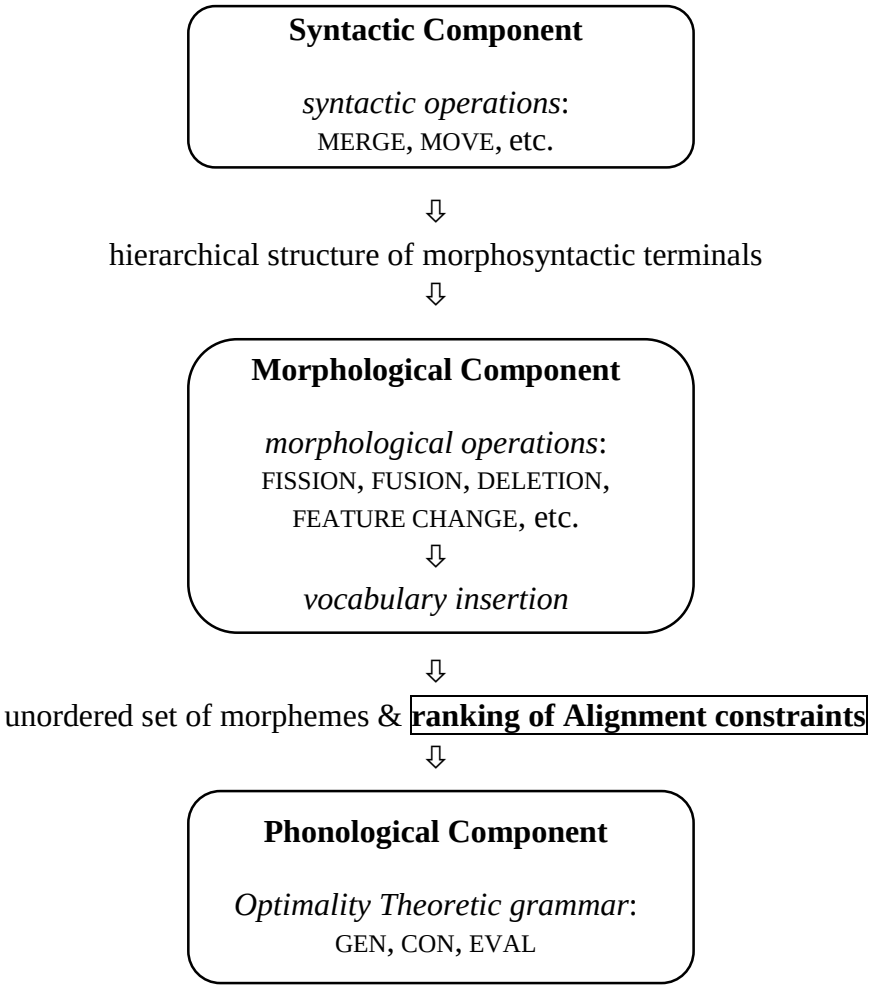
- It has long been recognized that morpheme order correlates with syntactic structure (Muysken 1981, Baker 1985, 1988). Baker termed this generalization the "Mirror Principle".
    - Morphemes that surface closer to the root are lower in the syntactic tree.
    - Morphemes that surface farther away from the root are higher in the syntactic tree.
- However, few detailed proposals have been made about how this correlation is formally implemented in the grammar.
    - Simple "prefixation/suffixation" operations in the syntax/morphology cannot explain nonconcatenative morphological systems (Semitic "root-and-pattern" morphology, infixation, etc.).
    - Embick (2007) develops a framework related to Kayne's (1994) "Linear Correspondence Axiom" for syntactic linearization, but it underdetermines morpheme ordering with respect to language-specific properties (cf. Embick 2015), and also will have difficulty with nonconcatenative morphology.

➢ I propose a new mechanism that plays a crucial role in determining morpheme order: **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* in CON in the phonology.
    - All possible morpheme orders are generated by GEN, and the optimal surface order is selected by EVAL.

- This proposal assumes a modular, feed-forward grammar with the characteristics schematized in (1) below (cf. Embick 2015).
    - The syntax generates a hierarchical structure of morphosyntactic terminals (following Chomsky's (1995, *et seq.*) Minimalist Program).
    - This hierarchal 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 the hierarchical structure (cf. Arregi & Nevins 2012).
    - Vocabulary Insertion endows the morphosyntactic terminals with phonological content at the end of the morphological component.
    - 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.

* I am thankful to Adam Albright, Michael Kenstowicz, Isa Kerem Bayirli, David Pesetsky, Donca Steriade, and Martin Walkow for useful discussion and feedback. All mistakes are my own. If you want to see the full version in paper form, a draft is available at http://web.mit.edu/szukoff/www/pdfs/MAP_generals.pdf.

(1) The modular grammar



- The part of this grammar 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 an algorithm which converts c-command relations into ranking relations.
    - I call this the **Mirror Alignment Principle (MAP)**.

Roadmap

- Section 2 lays out the formal details of the proposal, showing how the use of Alignment constraints (McCarthy & Prince 1993, Prince & Smolensky 1993/2004) can restrictively generate morpheme ordering when connected to the syntax.
- Section 3 discusses Mirror Principle effects in Bantu, and how the morphology can be used to account for the effects of the so-called "CARP" template (Hyman 2003; Good 2005).
- *Phonology Circle 2/29: I'll show how this framework can begin to make headway on the Classical Arabic system of nonconcatenative morphology, accounting for apparently paradoxical ordering conditions through reference to syntactic structure, and deriving the phonological facts without appeal to prosodic templates.*

2 The Mirror Alignment Principle

2.1 Generalized Alignment

- McCarthy & Prince (1993:2) define *Generalized Alignment* as follows:

(2) Generalized Alignment [GA]

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

$\forall$ 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 are constraints on the morphology-phonology interface, as they modulate the relationship between morphological categories and prosodic categories.
- Since morpheme ordering is about determining the (linear) relationship between morphemes in the phonological representation, these constraints can be used to enact morpheme ordering.

Consider the following schematic example:

- A word 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 1993).
- Each morpheme is referenced by an Alignment constraint,[1] and all three constraints are defined over the *prosodic word*, and all with reference to the *right edge*, as shown in (3):

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

a. ALIGN(X, R; PWD, R)
   Assign one violation mark for each segment intervening between the right edge of morpheme X and the right edge of the prosodic word.[2]
b. ALIGN(Y, R; PWD, R)
   mutatis mutandis
c. ALIGN(Z, R; PWD, R)
   mutatis mutandis

- Each Alignment constraint will be maximally satisfied when its morpheme is absolute rightmost within the prosodic word; however, in any candidate output, only one morpheme can successfully attain this position.
  - Satisfaction of one Alignment constraint entails increased violation of the others.
  - These constraints, therefore, will be in *direct competition* for a particular position in the output (here, final position in the prosodic word).

[1] I omit discussion of the Alignment of the Root at present.

[2] Gradient evaluation of Alignment constraints is crucial for the proposal.

(4) Violation profiles

/Root, X, Y, Z/	ALIGN(X, R; PWD, R)	ALIGN(Y, R; PWD, R)	ALIGN(Z, R; PWD, 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 permutations of the three Alignment constraints each correspond to the selection of one of the six candidate orders.

2.2 The Mirror Alignment Principle

- Assuming free ranking permutation, we would expect all of these rankings to be permissible, and we would have no prior expectation of which of the six candidate orders the language should display; the factorial typology expects languages of all six sorts.

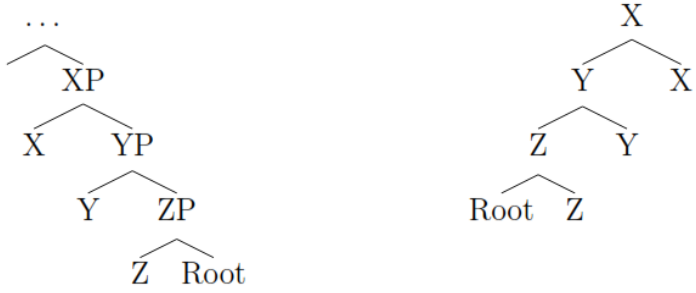
- It has long been recognized that the order in which morphemes appear within a word generally reflects the relative positions that their corresponding morphosyntactic terminals occupy in the hierarchical morphosyntactic structure (Muysken 1981, Baker 1985; cf. Bybee 1985).
    - Specifically, a morpheme 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.
    - Baker (1985) terms 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 say 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) below:

(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
  - X surface farthest away

    ⇒ This is candidate order (4)f [Root-Z-Y-X].

- The ranking of the three Alignment constraints in (3) which will generate candidate order (4)f [Root-Z-Y-X] is the one shown in (6):

(6) Generating the Mirror Principle order

a. *Ranking*: ALIGN(X, R; PWD, R) » ALIGN(Y, R; PWD, R) » ALIGN(Z, R; PWD, R)

b. *Tableau*:

/Root, X, Y, Z/	ALIGN(X, R; PWD, R)	ALIGN(Y, R; PWD, R)	ALIGN(Z, R; PWD, 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 shows that mapping hierarchical syntactic relations onto ranking relations among Alignment constraints generates the Mirror Principle-compliant order of morphemes.

- If we characterize hierarchical relations in the normal way using c-command, this mapping can be defined as in (7).

(7) The Mirror Alignment Principle (The MAP)

> If a terminal node α asymmetrically c-commands a terminal node β, then, in the phonological component, the Alignment constraint referencing α dominates the Alignment constraint referencing β.[3]

Shorthand: **If α c-commands β → ALIGN-α » ALIGN-β**

- When ALIGN-α and ALIGN-β reference the same edge, this 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.
- If, on the other hand, they reference different edges, then satisfaction of this condition will be essentially vacuous.
  - Such would be the case when one morpheme is (descriptively) a prefix and the other is (descriptively) a suffix, e.g. ALIGN-α-Left but ALIGN-β-Right.

2.3 Local summary

- The Mirror Principle can be implemented in a framework with the following properties:
  - The surface order of morphemes is determined in the phonological component.
  - This is determined by the interaction of ranked, competing Alignment constraints.
  - Hierarchical structure is causally linked to the ranking of Alignment constraints.

➢ The 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 ascribed to a Generalized Alignment approach to morpheme ordering, because it eliminates free ranking of Alignment constraints.

- In a strong sense, this proposal does not attribute the *decision* on morpheme ordering to the phonology, but rather only the *implementation* of morpheme ordering. The *decision* is made elsewhere, namely by the syntax and morphology.

3 Bantu and the Mirror Principle

3.1 Mirror-image morpheme orders in Chichewa

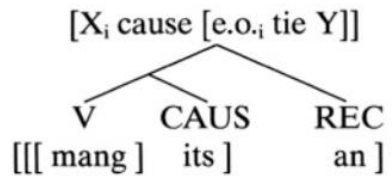
- Baker (1985) demonstrates that, in certain Bantu languages, given two meaningful elements in verbal derivation, such as Causative and Reciprocal, a reversal in interpretation correlates with a reversal in the linear order of the morphemes that expone those meanings.

[3] The structure over which this is calculated is the output of the morphological component, not necessarily the output of the narrow syntax. This will be justified in Section 3.

- This generalization can be seen with the following contrast from Chichewa:

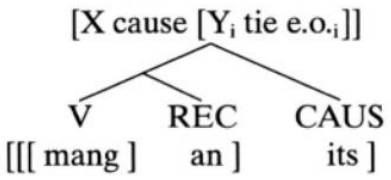
(8) Orders of Causative and Reciprocal in Chichewa (Hyman 2003:247, ex. 2)

a. Reciprocalized Causative



'cause each other to tie'

b. Causativized Reciprocal



'cause to tie each other'

- When the Reciprocal meaning "scopes" over that of the Causative ((8)a), the Reciprocal morpheme *-an-* is more external in the linear order than the Causative morpheme *-itɕ-*.
- On the other hand, when the Causative meaning scopes over the Reciprocal meaning ((8)b), that order is reversed and Causative *-itɕ-* 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 (9).
    - These verbal derivational morphemes are suffixal in Chichewa (and the other Bantu languages), so they have right-oriented Alignment constraints.

(9) Mirror Alignment Principle Rankings for the structures in (8)

a. Reciprocalized Causative ((8)a):
Rec c-commands Caus → **ALIGN-REC-R » ALIGN-CAUS-R**

b. Causativized Reciprocal ((8)b):
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.

(10) Phonological derivations

a. Reciprocalized Causative ((8)a): ALIGN-REC-R » ALIGN-CAUS-R

/maŋ$_{ROOT}$, itɕ$_{REC}$, an$_{CAUS}$/	ALIGN-REC-R	ALIGN-CAUS-R
a. ☞ maŋ-an-itɕ		** (itɕ)
b. maŋ-itɕ-an	*!* (an)	
c. an-maŋ-itɕ		***!** (itɕ, maŋ)
d. itɕ-maŋ-an	*!**** (an, maŋ)	

b. Causativized Reciprocal ((8)b): ALIGN-CAUS-R » ALIGN-REC-R

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

- This demonstrates 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.
- 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.

We can see from this example that the ranking between these Alignment constraints differs across different syntactic derivations.

- 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.
- It thus seems appropriate that morphosyntactic differences could alter their ranking.

This would not be the case for purely phonological constraints, which are not sensitive to differences in morphosyntactic structure, so we should not expect their ranking to change in this way. (Though compare the operation of lexically-indexed constraints (e.g. Pater 2009), or cophonology theory (cf. Inkelas & Zoll 2007).)

3.2 The CARP template in Bantu

- While many Bantu languages do indeed display the behavior outlined in the above section for Chichewa, the full picture is a great deal more complicated.
- Hyman (2003:247-8) shows that there are at least two major problems for assuming that the Mirror Principle operates without exception in Bantu.

❖ First, not all Bantu languages permit the sorts of reversals illustrated above for Chichewa.
  - For example, Chimwiini shows none of this behavior (Hyman 2003:258).
- And those languages that do show this behavior, including Chichewa, generally permit it only with certain pairs of suffixes rather than as a whole throughout the system.
  - For example, Chichewa does not show mirror-image orders for Causative and Applicative (Hyman 2003:248).

❖ Second, there is an interpretive asymmetry:
  - In languages which do permit mirror-image orderings, one type of ordering permits *both scopal interpretations* while the other permits only the one correlated with the surface order (Hyman 2003:248, Good 2005:30-41).
  - Good (2005:36-7, 40-1; based on Satyo 1985) shows this in detail for combinations of Applicative and Causative in Xhosa.

- Both of these problems point to the existence of the "CARP template" (Hyman 2003; Good 2005, McPherson & Paster 2009).
    - The Bantu languages permit verbal formations involving multiple affixes from the set of Causative (C), Applicative (A), Reciprocal (R), and Passive (P).
    - It is always permissible to have those affixes surface in that linear order, i.e. Causative before Applicative before Reciprocal before Passive, *regardless of the relative scopal interpretation of those affixes*.

- Chichewa's Causativized Reciprocal in (8)b, with the order **Root-Rec-Caus** (R→C), is not typical within the family.
    - Many Bantu languages do not permit this surface order, and instead express the semantic equivalent using the CARP-obeying order **Root-Caus-Rec** (C→R).
    - The interpretation of this surface form, **Root-Caus-Rec**, is thus ambiguous, since it can also be used to express the Reciprocalized Causative, as expected.
- Even in languages where both orders are permitted, the CARP-obeying order has the potential to express both meanings.
    - Yet, the CARP-violating orders have only one possible interpretation, the one which is properly correlated with the surface morpheme order via the Mirror Principle.

- This state of affairs, focusing specifically on Chichewa, exemplifying a language which permits (certain) CARP violations, is summarized in table (11).
    - "Semantically CARP-violating" means that an element farther to the right in the CARP acronym semantically scopes below an element farther to the left in the acronym.

(11) Orders and Interpretations in Chichewa

		Surface Morpheme Order	
		CARP-obeying	*CARP-violating*
		ROOT-CAUS-REC	**ROOT-REC-CAUS**
Semantic Interpretation	*CARP-obeying* [[[ROOT] CAUS] REC]	a. ✓ (*MP-obeying*)	b. × (*MP-violating*)
	CARP-violating [[[ROOT] REC] CAUS]	c. ✓ (*MP-violating*)	d. ✓ (*MP-obeying*)

- Order↔interpretation pairs that obey the Mirror Principle (i.e., where interpretation and order are either both CARP-obeying or both CARP-violating) are always licit ("✓").
    - (11)a = ✓ : semantically CARP-obeying, linearly CARP-obeying ∴ MP-obeying
    - (11)d = ✓ : semantically CARP-violating, linearly CARP-violating ∴ MP-obeying
        - **NB**: *In languages like Chimwiini, (11)d is not licit.*
    - ➢ Any verbal form can be interpreted as having the outer affix take semantic scope over the inner affix.

- One MP-violating order↔interpretation pair is licit ((11)c), but the other ((11)b) is not.
    - (11)c = ✓ : semantically CARP-violating, linearly CARP-**obeying** ∴ MP-violating
    - (11)b = × : semantically CARP-obeying, linearly CARP-**violating** ∴ MP-violating

❖ Since both (11)a and (11)d are licit, **MP-obeying** order↔interpretation pairs are always licit.
❖ Since both (11)a and (11)c are licit, **linearly CARP-obeying** orders are always licit.

- The only illicit order↔interpretation pair is (11)b, the one which satisfies neither of these conditions: it is not MP-obeying, nor is it linearly CARP-obeying.

- Since being linearly CARP-obeying is a sufficient condition, the linearly CARP-obeying order permits two interpretations:
    - The one which is MP-obeying ((11)a), and
    - The one which is MP-violating ((11)c).
    - ➢ Linearly CARP-obeying orders are thus semantically ambiguous.

- These facts can be accommodated within the present proposal if we assume that the CARP template is indeed encoded in the grammar in some way, and its effects are located *in the morphological component*.

3.3 Generating CARP in the morphology

- Hyman (2003) proposes an analysis whereby a CARP constraint ("TEMPLATE") competes with a Mirror Principle constraint ("MIRROR") to determine morpheme order.
    - We could pursue a similar analysis, where a CARP constraint in CON in the phonological component dominates the Alignment ranking transmitted by the MAP.
- Such an analysis might undermine the predictive power of the MAP, since it would seem to allow for the possibility that an arbitrarily determined order could supersede the MAP.
    - Though this could perhaps be reined in with an articulated theory of templates.
    - Good (2005) sketches a diachronic solution (based on proposals in Bybee 1985) where at least the CA part of the template reflects the historical order in which those morphemes changed from free morphemes to suffixes.
- While this is probably a viable approach, I will instead pursue an analysis which locates the explanation for CARP in the morphological component, as a morphological operation.
    - This approach might allow for a more constrained theory than the phonological approach, since morphological operations are already an object of study in DM.
    - In Section 3.4, we'll see evidence in favor of this morphological approach to the present problem (though it's far from definitive).
        - ❖ Stronger evidence for a morphological approach comes from the behavior of Aspect & Voice in Arabic, which I'll talk about at Phonology Circle (2/29).

The chart in (12) below previews the analysis to be presented in this subsection.
- A *morphological operation* (optionally) applies to semantically/syntactically CARP-violating structures.
- When this operation applies, it alters the hierarchical structure in such a way that the Mirror Alignment Principle generates the observed surface orders.

(12) CARP effects

Interpretation:	Root < Caus < Rec		Root < Rec < Caus	
Syntactically CARP-violating?	No		Yes	
Morphological Operation applies?	No		Yes	No
Linear Order:	Root-Caus-Rec ((11)a)		Root-Caus-Rec ((11)c)	Root-Rec-Caus ((11)d)

In the following discussion:

- I use Chimwiini to refer to cases where CARP must be obeyed at all costs, and
- I use Chichewa to refer to cases where CARP-violation is possible.

3.3.1 The syntax

❖ The syntax can generate all semantic scopal orders; distinct scopal orders generate distinct hierarchical structures.

- This is supported by syntactic evidence: there are extraction asymmetries between CARP-obeying orders which represent distinct scopal relations (Hyman 2003:260).
- In Chichewa, Causative and Applicative always surface in that order (linearly CARP-obeying).
- When this order corresponds to an Applicativized Causative (C < A), and gets passivized, only the Applicative argument can be promoted to subject:

(13) Applicativized Causatives in Chichewa (Hyman 2003:260, ex. 22)
(Caus *-its*, Appl *-il*, Pass *-idw*, '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'

- When this order corresponds to a Causativized Applicative (C > A), and gets passivized, only the Causee can be promoted to subject:

(14) Causativized Applicatives in Chichewa (Hyman 2003:260, ex. 23) ('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'

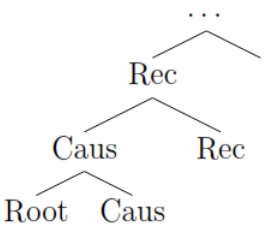
c. ?* [$_{\text{APPL}}$ *makásu*] *a-ná-lím-its-il-idw-á* [$_{\text{CAUSEE}}$ *aná*]
'hoes were used to make the children cultivate'

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

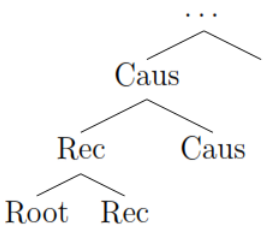
- So, we have two possible structures for Causative and Reciprocal:

(15) Structures generated in the syntax (post head-movement)[4]

a. Rec scopes over / c-commands Caus



b. Caus scopes over / c-commands Rec



- Since semantic structure correlates with syntactic structure, being "semantically CARP-violating" is equivalent to being "syntactically CARP-violating".
- Syntactic CARP violation: an element farther to the right in the CARP acronym is syntactically lower than (asymmetrically c-commanded by) an element farther to the left in the acronym.
  - E.g., if Rec is lower than Caus ((15)b), the structure is syntactically CARP-violating.

❖ The syntactic structure is simultaneously submitted both to the morphological component (i.e., the first step in the PF branch) and to the semantic component (i.e., LF). *Any subsequent modifications that happen on either branch have no effect on the other.*

i. If the hierarchical structure happens to be syntactically CARP-obeying, as in (15)a, then nothing further needs to be said.
   - It passes through the morphological component without any adjustments.
   - The MAP is calculated over the original syntactic structure.
   - ➢ The phonology generates a CARP-obeying order **Root-Caus-Rec** (C→R).
   - Semantic interpretation (Caus < Rec) perfectly matches the surface linear order of morphemes, satisfying the Mirror Principle.
   - This derivation, represented in table (11) by cell (11)a, happens in all Bantu languages (both Chimwiini and Chichewa).

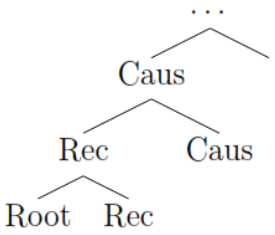
ii. The action happens if the hierarchical structure happens to be syntactically *CARP-violating*, as in (15)b.
   - Just in this case, the morphological component *may* perform an operation on the hierarchical structure.

[4] It is not important whether head movement takes place in the narrow syntax or (early) in the morphological component.

3.3.2 The morphology

❖ When the morphological component receives a syntactically CARP-violating structure (like (15)b), the morphological component *has the ability to* (though may not ultimately decide to) repair the problematic structure.

(16) Syntactically CARP-violating input to the morphology ((15)b)



- Since we are in the morphological component, we can formalize the problematicity of the structure using *morphological markedness constraints* (cf. Arregi & Nevins 2012) which penalize particular (asymmetric) c-command relations:

(17) CARP morphological markedness constraints[5]

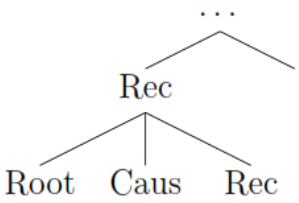
a. Constraints on Pass
   i. Pass may not be c-commanded by Caus (*Caus > Pass)
   ii. Pass may not be c-commanded by Appl (*Appl > Pass)
   iii. Pass may not be c-commanded by Rec (*Rec > Pass)
b. Constraints on Rec
   i. Rec may not be c-commanded by Caus (*Caus > Rec)
   ii. Rec may not be c-commanded by Appl (*Appl > Rec)
c. Constraint on Appl
   i. Appl may not be c-commanded by Caus (*Caus > Appl)

- There will be essentially two ways to satisfy these markedness constraints (without deleting a terminal):
  - Remove all asymmetric c-command relations between CARP elements:
    - Creates a flat structure ((18)a)
  - Create new asymmetric c-command relations between CARP elements:
    - Creates a structure identical to that with the reverse scopal relation ((18)b).

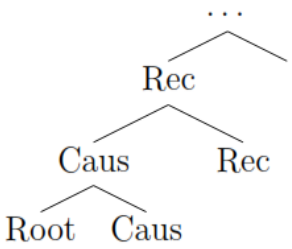
[5] Identifying separate, pairwise constraints rather than a monolithic constraint could help explain why certain CARP-violating orders but not others are allowed to surface in some languages. This is an empirical question.

(18) Modified structures

a. Flattening operation (~ fusion?)



b. Reversal operation (~ metathesis?)



- Having removed all asymmetric c-command relations, a flattening operation ((18)a) would bleed the MAP entirely, and thus leave the surface linear order completely underdetermined.
  - If there were a (language-specific) default ranking statement that applies in the absence of a MAP-prescribed ranking, that statement could apply in this case.
    - ❖ Such a default ranking statement is necessary, and does a lot of work, in the analysis of Arabic that I'll present at Phonology Circle (2/29).
- However, this default ranking statement would basically recapitulate the morphological markedness constraints. This is a significant duplication problem.

(19) Default Ordering statements

a. Rankings of Pass

i.	ALIGN-PASS-R » ALIGN-CAUS-R	cf. *Caus > Pass
ii.	ALIGN-PASS-R » ALIGN-APPL-R	*Appl > Pass
iii.	ALIGN-PASS-R » ALIGN-REC-R	*Rec > Pass

b. Rankings of Rec

i.	ALIGN-REC-R » ALIGN-CAUS-R	*Caus > Rec
ii.	ALIGN-REC-R » ALIGN-APPL-R	*Appl > Rec

c. Rankings of Appl

i.	ALIGN-APPL-R » ALIGN-CAUS-R	*Caus > Appl

- The reversal operation ((18)b) does not suffer from the duplication problem, and doesn't require adding any default statements.
  - We can worry that this operation may be too powerful.
  - But if it can only be enacted in response to markedness constraints, then it will only apply in a restricted set of cases (i.e., those penalized by markedness constraints).

➢ Either sort of operation (and perhaps others as well) are thus consistent with the MAP, though bring up their own set of issues.

- Since the syntactic structure was submitted to LF prior to this operation, this operation has no effect on semantic interpretation.
  - The syntactically-CARP-violating structure ((15)b) can be, and in fact must be, interpreted *as is*, even if its surface linear representation will ultimately not reflect that hierarchy.

❖ If the operation applies, the hierarchical structure that results is identical ((18)b) (or at least equivalent ((18)a)) to that of the syntactically CARP-obeying derivation ((15)a).
  - Therefore, when the MAP is calculated over this new structure, it will produce the same ranking as for the syntactically CARP-obeying derivation.
  - The surface linear order for these two derivations will be identical/homophonous: **Root-Caus-Rec** (C→R).

❖ If, on the other hand, the operation had not applied, the syntactic structure that was the input to the morphological component ((15)b) would serve as the input to the MAP.
  - This would produce a ranking that selects the linearly CARP-*violating* surface order: **Root-Rec-Caus** (R→C).

➢ Therefore, the two ways that a semantically/syntactically CARP-violating input can surface, i.e. linearly CARP-violating ((11)d) or linearly CARP-obeying ((11)c), are derived by whether or not the morphological operation applies to that input.

3.3.3 The Bantu micro-typology

- As mentioned above, Bantu languages differ on whether or not they permit linearly CARP-violating orders (for specific pairs of morphemes). Simplifying:
  - Some languages (Chichewa) permit linearly CARP-violating derivations like ((11)d).
  - Some languages (Chimwiini) don't.
- All Bantu languages have linearly CARP-obeying derivations, both for syntactically CARP-obeying inputs ((11)a) and for syntactically CARP-violating inputs ((11)c).

❖ This Bantu micro-typology hinges on one question: is the operation *obligatory* or *optional*?

i. Obligatory = Chimwiini
- The operation applies every time the morphology receives a syntactically CARP-violating structure.
  - This results in derivations like (11)c (linearly CARP-obeying),
  - But never (11)d (linearly CARP-violating).
- CARP template is strictly adhered to.
- All surface forms involving CARP affixes are ambiguous.

ii. Optional = Chichewa
- The operation can, but need not, apply when the morphology receives a syntactically CARP-violating structure:
  - When it does apply, it results in derivation like (11)c (CARP-obeying).
  - When it doesn't, it results in derivation like (11)d (CARP-violating).
- Non-CARP-obeying interpretation (Rec < Caus) available for both linear orders.
- CARP-obeying interpretation (Caus < Rec) available only for the CARP-obeying order.

Lingering question: why is there no Bantu language where the operation *never* applies, such that it always has derivation (11)d, never derivation (11)c?

3.3.4 Local summary

- The result of this sequence of events is again summarized in the following chart:

(20) CARP effects

Interpretation:	Root < Caus < Rec		Root < Rec < Caus	
Syntactically CARP-violating?	No		Yes	
Morphological Operation applies?	No		Yes	No
Linear Order:	Root-Caus-Rec ((11)a)		Root-Caus-Rec ((11)c)	Root-Rec-Caus ((11)d)

- In this system, there is no way to generate (11)b, a structure which is linearly CARP-violating and simultaneously does not comply with the Mirror:
  - *Interpretation*: [[[Root]Rec]Caus] → ✖ *Order*: **Root-Caus-Rec**
- This is because semantic interpretation is fixed prior to any operations that take place in the morphological component, and the only (relevant) operation which can affect morpheme ordering is the one which creates the CARP syntactic hierarchy.
  - There is nothing which will transform a syntactically CARP-obeying structure into a morphologically CARP-violating one.

3.4 CARP and allomorphy: in favor of the morphological approach(?)

- I have adopted an approach that locates CARP effects in the morphology rather than in the phonology. One way to disambiguate between the two approaches is to look at allomorphy.
- There may be a piece of evidence from Luganda that supports the morphological approach, though there are significant complications. Regardless, it will illustrate the form of the argument which could support the morphological approach given the right evidence.

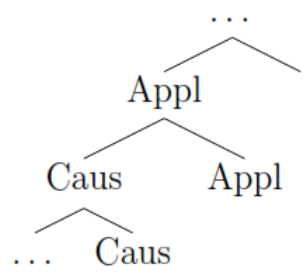
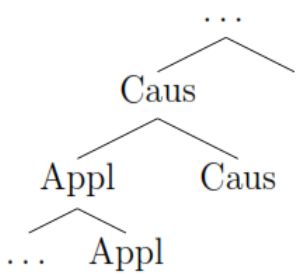
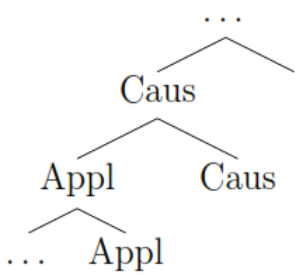
3.4.1 The type of evidence we're looking for

- Based on the discussion in Section 3.3.1, we know that the semantically ambiguous linearly CARP-obeying forms are generated with distinct syntactic structures.
- If we reject the morphological approach to CARP, and instead locate the CARP effects in the phonology, then these distinct structures should persist through the morphological component, remaining distinct for the purposes of Vocabulary Insertion.

➢ This structural difference should be able to condition differences in allomorphy between the two CARP-obeying derivations.
  - This allomorphy may or may not overlap with a CARP-violating order.

- The syntactic structures at play are illustrated in (21):

(21) Structures at Vocabulary insertion

Linearly CARP-obeying		*Linearly CARP-violating*
a. 	b. 	c. 
Semantically CARP-obeying	*Semantically CARP-violating*	

- The two derivations which result in linearly CARP-obeying orders, (a) and (b), have different syntactic structures.
- The semantically CARP-violating one, (b), has the same syntactic structure as the derivation which results in a linearly CARP-violating order, (c).

If we are assuming phonological CARP, and thus no morphological operations:

- Whatever allomorph of Caus or Appl surfaces in (c) should also surface in (b) (just in the opposite order), since they have the same hierarchical structure at the point of Vocabulary Insertion.
    - If we find a special allomorph in (c), it should also show up in (b):

(22) Allomorphy in the phonological approach

a. Derivation (a) : …X-Y…
b. Derivation (c) : …Y-**X′**… (*…Y-X…)
c. Derivation (b) : …**X′**-Y… (*…X-Y…)

- If we do find a special allomorph in (c), but it doesn't surface in (b), then we know that the structures must not be identical.
    - This means that something in the morphology must have altered the structure.
    - We would then expect that the same allomorphs should appear in (a) and (b).

(23) Allomorphy in the morphological approach

a. Derivation (a) : …X-Y…
b. Derivation (c) : …Y-**X′**… (*…Y-X…)
c. Derivation (b) : …**X**-Y… (*…X′-Y…)

➢ This would be direct evidence for the morphological approach.

- Phonological CARP also predicts that (a) and (b) should be able to display distinct allomorphs even when the CARP-violating order is not permitted.
    - This is situation is perhaps attested (Hyman 2003, Myler 2013).
    - But I believe that these sorts of examples can be handled also in the morphological approach using Base-Derivative faithfulness in the phonology.
    - If so, this situation does not adjudicate between the two approaches.

3.4.2 Possible evidence in Luganda

- Depending on how we interpret the data, we may have the right sort of evidence in favor of the morphological approach in Luganda.

- McPherson & Paster (2009) [McP&P] detail the range of possible combinations of two CARP elements in Luganda.
    - For the most part, they find that only CARP-obeying orders are permitted.
    - There is, however, one CARP-violating order which may be grammatical for their speakers: **Applicative-Causative**.

- The default shapes for these two morphemes are Causative /-is-/ and Applicative /-ir-/:

(24) Causative and Applicative (McP&P:57)

a.	Simple causative:	*n-a-mu-zin-**is**-a*	'I made him dance'
b.	Simple applicative:	*a-n-zin-**ir**-a*	'he is dancing for me'

- We would thus expect that, if the two affixes could appear in the same verbal form, that verbal form would contain the string […-is-ir-…] or […-ir-is-…].

- The CARP-obeying order (C→A) does appear to be freely attested, but we don't get exactly the expected […-is-ir-…] string:

(25) Causative-Applicative

*n-a-mu-zin-**is-iz**-a=ŋga mufumbiro*
'I used to make him dance in the kitchen' (McP&P:58, ex. 5)

- We could treat the [-iz-] string as a (morphologically-conditioned) allomorph of Applicative.
- But more likely this example includes an additional suffix, "Transitive" /i̯/ (aka "short causative"), which in some contexts surfaces as [y], but in others coalesces with and palatalizes/spirantizes a preceding consonant: /…ri̯V…/ → […zV…].
    - The Transitive frequently co-occurs with the Causative in Bantu (Hyman 2003, Good 2005), perhaps especially when Causative co-occurs with Applicative.
- We need to know more about why the Transitive appears in this example, but it thus seems that nothing special needs to be said with respect to allomorphy.

- In their direct elicitation, McP&P did not find the CARP-violating order (A→C) to be grammatical; however, they report the following as a grammatical example from their corpus:

(26) Applicative-Causative?

*ba-ji-tu-mu-fumb-**ir-iz**-a*
'they make us cook it for her' (McP&P:59, ex. 9)

- The question is: **what is the *-ir-iz-* string here**? Options: Applicative /ir/ + …
  i. Unexpected allomorph of Causative /iz/ (rather than /is/)
  ii. Expected allomorph of Causative /is/ + Transitive /ị/ with otherwise unexpected (morpho)phonological change: /…isịa/ → […iza]
  iii. Second Applicative /ir/ + Transitive /ị/ with expected (morpho)phonological change: /…irịa/ → […iza]
  iv. Unexpected allomorph of Transitive /iz/ (rather than /ị/)

- According to Good's (2005:27-8) analysis, option (iii) seems to be fairly widely attested in Bantu, sometimes co-occurring with an overt Causative before the first Applicative:

(27) Kinyarwanda (Good 2005:28, ex. 13c; from Kimenyi 1980:109)

*U-ra-andik-iish-ir-**iz**-a*	*iyo*	*kárámu*	*íki*?
2S-PRS-write-CAUS-APPL-**APPL.TRANS**-FV	that	pen	what

"Why are you writing with that pen?"

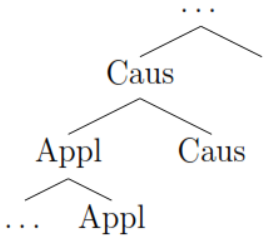
- APP.TRANS *-iz-* < APPL /ir/ + TRANS /ị/

- So option (iii), strange as it is, seems like a good bet based on comparative evidence.
  - But there does not seem to be Luganda-internal evidence that would rule out option (i) (so perhaps speakers could analyze the pattern that way even if it had a different origin).

- If option (i) were true, then it would be evidence in favor of the morphological approach:

- Since the allomorph would not be phonologically conditioned, it would be a "suppletive" allomorph generated by Vocabulary Insertion.
- The context for insertion of Causative /iz/ could be sisterhood to Applicative.

(28) Structure of Applicative-Causative



(29) Vocabulary entries for Causative
a. CAUS ↔ *-iz-* / sister to APPL
b. CAUS ↔ *-is-* (elsewhere)

- When Causative and Applicative co-occur in the CARP order (which is presumably semantically ambiguous), Causative always surfaces with the elsewhere form [-is-].
    - This means that CARP must be in effect **prior to Vocabulary Insertion**:

- When the CARP order is used to express the semantically CARP-violating meaning [[[Root]Appl]Caus], its syntactic structure should be the one in (28).
    - If this structure persisted until Vocabulary Insertion, and CARP was enforced later with a templatic constraint in the phonology, we would expect the [-iz-] allomorph.
    - This would yield a contrast between linearly CARP-obeying orders:
        - Semantically CARP-obeying → […-**is**-ir-(i̯)…] (→ …-**is**-iz-…)
        - Semantically CARP-violating → *[…-**iz**-ir-(i̯)…] (→ …-**iz**-iz-…)

➢ This does not appear to be the case. Therefore, the CARP template must have been triggered by an operation *in the morphology*.
    - This operation bleeds the structure which conditions the insertion of the special /iz/ morph, forcing the insertion of the elsewhere /is/ morph.

❖ Even if Luganda doesn't hold up, this is the roadmap for disambiguating the two approaches (especially the first situation).

4 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.

- This framework is straightforwardly able to capture mirror-image morpheme orderings seen in certain Bantu languages.
    - Differences in syntactic structure map directly onto differences in Alignment rankings, which generate different surface orders.
- In order to accommodate the effects of the CARP template within a framework where morpheme ordering is mediated by the MAP, I proposed that CARP should be identified as a constraint(s) in the morphology.
    - This constraint triggers a structural repair, creating a structure which (directly or indirectly) leads to the surface CARP order via the MAP.
    - Evidence from Luganda may support the morphological approach to CARP over the phonological one, but this evidence is far from conclusive.

- At Phonology Circle (2/29), I'll show the MAP can also account for certain complex Mirror Principle-like ordering properties of verbal derivational affixes in Classical Arabic (and also show how it yields a better phonological analysis than previous approaches).

- While I have limited the application of the MAP here to the word-level, it is in principle capable of ordering higher-level constituents.
    - If there are Alignment constraints on phrase-level constituents operative in the phrase-level phonology, then a MAP algorithm which applies to phrase-level constituents would provide ranking relations between their Alignment constraints.
    - It is thus possible that certain aspects of higher-level ordering could be attributed to this same system.

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