Word and affix ordering with Optimality Theory*

LSA 2019

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There is considerable evidence that affix ordering is influenced by both syntactic and phonological factors:

- We see reflexes of syntactic hierarchy / semantic scope in affix order, e.g. the Mirror Principle (Baker 1985).
- But there are many cases where affix-ordering seems controlled by phonological constraints (e.g. Woolford, 2010; McCarthy, 1981).
- These two factors also interact with 'purely morphological' factors like templates (e.g. Bantu CARP, Hyman, 2003) or bigram affix ordering (Ryan, 2010).

Our model needs to allow these factors to interact.

- This is often done via ordering constraints like LINEARITY (McCarthy & Prince, 1995).
- These constraints often don't calculate ordering directly from the syntax, though — the phonology is assumed to get ordering as part of the input.

In this talk, I'm going to motivate a model of affix ordering that starts from the following premises:

- Insofar as affix ordering can be influenced by phonology, we should model it using the same models we use for other phonological phenomena, i.e. violable constraints.
- Insofar as affix ordering can be influenced by the syntax, it should be via the same factors that influence all linearization — as above the word level, so below.

These two premises lead us to a violable-constraint model for linearizing all syntactic structure (not just morphology). This has the benefit of making predictions about the relationship between word order and affix order.

- I call this general approach Optimal Linearization.
- In this talk I'll present a subset of Optimal Linearization that can account for a miniature typology including only the 'harmonic' word orders (i.e. universally head-final or head-initial).[1].
- I'll give two Optimal Linearization constraints that can model this typology, and then I'll demonstrate that they can help us model the syntactic aspects of affix ordering as well.

*Thanks first foremost to Kyle Johnson, Kristine Yu, and Ellen Woolford for much fruitful discussion. Thanks as well to Kaden Holladay for bringing the Arabic case, and Zukoff's analysis, to my attention. This material benefited considerably from discussion at the UMass Syntax Workshop; special thanks to Jonathan Bobalijk for helping me understand the typological predictions. The author is supported by the National Science Foundation Graduate Research Fellowship under Grant No. 1451512. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

[1] For a more detailed look at the model proposed here, including an extension to allow it to capture disharmonic orders, see Kusmer (In prep)

The rest of this talk will proceed as follows:

- First, I'll discuss a particularly recalcitrant puzzle in Arabic verbal morphology that motivates having affix ordering depend on both syntax and phonology.
- Next, I'll introduce two Optimal Linearization constraints, HeadFinality and Antisymmetry, which together account for the harmonic word orders.
- I'll then return to Arabic and show that they give us the desired pattern for free.
- I'll conclude by discussing some of the typological predictions of this approach to affix ordering.

1 A puzzle from Arabic

Arabic noncontatenative morphology is the poster-child for doing morpheme-ordering in the phonology:

- Roots consist solely of consonants; various arrangements of vowels (and other consonants) within the root give different 'Forms'.
- The distribution of vowels is fairly easily accomplished by assuming that there are certain prosodic & phonotactic restrictions on words.
- See e.g. Tucker (2010) for an example of this style of analysis.

However, the reflexive affix *(-)t-* poses a problem:

(1) Forms with reflexive */t/* (example root *ktb* "write") (Zukoff, 2017)

Infixal	VIII	Reflexive	*(ʔi)k-**t**-ataba*	cf. **-**t**-aktaba*
Prefixal	V	Reflexive + Causative	***t**-akattaba*	cf. **ka-**t**-attaba*
	VI	Reflexive + Applicative	***t**-akaataba*	cf. **kaa-**t**-ataba*
	X	Causative + Reflexive	*(ʔi)s-**t**-aktaba*	cf. **sak-**t**-ataba*

The reflexive affix is sometimes an infix and sometimes a prefix.

- There is no good phonological generalization here — in each Form there is a phonotactically & prosodically plausible alternative with the reflexive placed differently.
- Most analyses stipulate that the prefixal and infixal forms are simply different morphemes.[2]
- For example, Tucker (2011) proposes two different Align constraints, one targeting prefixes generally and one targeting the infixal *t*; these are ranked differently.

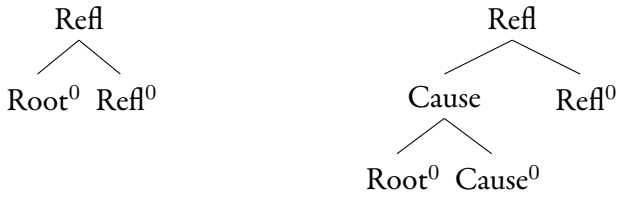
Zukoff (2017) had an insight: Under some reasonable assumptions about the syntax, these Forms can be distinguished *syntactically*:

- In the (infixal) Form VIII, the Reflexive head is the closest one to the root (by c-command).
- In the other forms, some other head intervenes.

[2] As noted by Tucker (2011), this doesn't commit us to saying that they're different syntactic objects — only that there is suppletion in how they are spelled out.

For example, assuming that morphologically-complex words are created by head-movement:

(2) a. Form VIII: b. Form V:



Zukoff proposes to link this syntactic difference to c-command:

- In (infixal) Form VIII, the root and the Reflexive head symmetrically c-command each other.
- In prefixal forms, the Reflexive head asymmetrically c-commands the root.
- This is an attractive option: In syntax, asymmetric c-command is commonly assumed to map onto linear precedence (Kayne, 1994).

Zukoff models the influence of c-command on the affix order by proposing a new principle of syntax-phonology mapping: in which asymmetric c-command (partially) determines the ranking of constraints.

- Asymmetric c-command in the syntax determines the *ranking* of various ALIGN constraints in the phonology.
- When c-command fails to rank two constraints, a language-specific "default ranking" that takes effect when no asymmetric c-command obtains.
- This is a lot of new machinery!
- I think we can capture his core insight (that the infixal form corresponds to the case of mutual c-command between Root and Refl) without any new principles of syntax-phonology mapping.

In the next section, I'm going to move from affix order to word order; when we come back to Arabic, I'll show you that the constraints we need to get word order right give us the Form VIII puzzle for free.

2 Optimal Linearization

Optimal Linearization is, at its core, a realization of the Minimalist notion that syntax should include only those things necessary for both semantics and phonology:

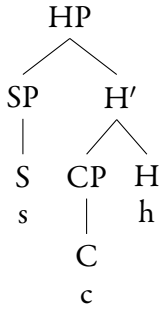
- Semantics doesn't pay attention to linear order, so neither should the syntax.
- More to the point: linearization should be part of the process of externalization and happen only at the PF branch.
- As such, we should model it the same way we generally model other PF phenomena: With violable constraints.

In order to understand the Optimal Linearization constraints, it will be helpful to move from thinking about affix order to thinking about sentence-level word order.

- In this talk, I'm only going to model a subset of the possible word orders; see Kusmer (in prep) for a fuller model.
- In particular, I'm going to try to capture a simple two-language-class typology consisting only of harmonically head-initial and harmonically head-final languages.

In other words, for the moment we want the following syntactic structure to map to one of the following two orders (and no others):[3]

(3) a.



b. (i) **Head Initial:** *shc*
(ii) **Head Final:** *sch*

We need to model two languages; this requires two constraints:

- Each one prefers one of these two orderings; when undominated, that ordering will result.
- I'll look at HeadFinality first, which prefers head-final orderings.
- Then I'll look at Antisymmetry, which prefers head-initial orderings.

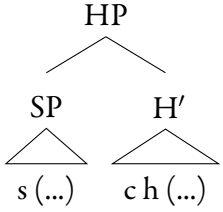
2.1 *HeadFinality*

Intuitively, for any given maximal XP we want HeadFinality to:

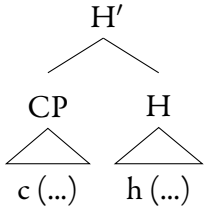
- Always order the specifier before everything that isn't the specifier.
- Always order the complement before the head.

Another way to think about this is to consider each of the branching nodes in (3) separately:

(4) a.



b.



[3] Throughout, I'm going to draw my trees in a 'head-final' fashion; remember, though, that syntax trees have no order! Also, I'm going to use X′ levels, but this is just for expositional reasons — nothing hinges on having a special status for medial layers.

In both cases, the node in question has two daughters: one that shares a label with it and one that doesn't.

- That is: The relationship between SP and HP is the same as the relationship between CP and H′
- I don't know of a name for distinguishing these two relationships.
- I'm going to name these daughters the **descendent** (/ endogenous) and the **in-law** (/ exogenous).[4]

Recall that a head-final order is one that puts SP < H′ and CP < H.

- In other words, a head-final order is one that always puts the in-law before the descendent.
- This leads us to a constraint definition:

(5) HeadFinality: Assign one violation for each node in the syntax for which some lexical item spelling out (a part of) its descendent precedes some lexical item spelling out (a part of) its in-law.

The tableau in (6) tabulates the violations of HeadFinality accrued by each of the 6 possible linearizations of the basic tree in (3-a).

(6)

	(3-a)	HeadFinality
	shc	*H′
→	sch	
	csh	*HP
	chs	*HP
	hcs	*HP *H′
	hsc	*HP *H′

The constraint selects the right winner:

- Because there are only two nodes with in-laws, there are a maximum of two constraints.
- Only the fully head-final order gets no violations.

2.2 *Antisymmetry*

In order to get head-initial orders, we need a constraint to oppose HeadFinality.

- It's tempting to have a HeadInitiality constraint that's the inverse of HeadFinality, but...
- Head-initial orders aren't the inverse of head-final orders: Specifiers don't change sides.
- So we need to find some other way to define our opposing constraint.

I propose we take a (metaphorical) page from Kayne's (literal) book:

- Antisymmetry is a constraint that enforces correspondence between asymmetric c-command and linear precedence.
- Unlike Kayne, it only considers c-command between heads. This frees us from stipulations about segments & categories, and will have some benefit later.

[4] Thanks to syntax-Twitter for helping me choose these terms. My favorite runner-up was **heir & spare**.

(7) ANTISYMMETRY: Assign one violation for each pair of heads α, β, where α asymmetrically c-commands β and a lexical item spelling out (a part of) β precedes a lexical item spelling out (a part of) α.

There's an interesting wrinkle in how this constraint functions:

- In the basic structure in (3-a), there's only one asymmetric c-command relationship between heads:
- As such, ANTISYMMETRY only orders $h < c$; it doesn't care about s.
- Luckily, HEADFINALITY does!

(8)

	(3-a)	ANTISYMMETRY	HEADFINALITY
→	shc		*H′
	sch	*$h < c$	
	csh	*$h < c$	*HP
	chs	*$h < c$	*HP
	hcs		*HP *H′
	hsc		*HP *H′

We still get the unique, fully head-initial winner:

- Out of the orders that respect ANTISYMMETRY, HEADFINALITY picks the 'most head-final' one.
- This results in specifiers always being linearized on the left.
- This is emergence of the unmarked (McCarthy & Prince, 1994): The effects of a lower-ranked constraint are visible exactly when a higher-ranked one doesn't care.

An interim summary:

- HEADFINALITY penalizes branching nodes that aren't linearized with the in-law preceding the descendent.
- ANTISYMMETRY penalizes non-correspondence between asymmetric c-command and precedence.
- Together, they give us both of the harmonic word orders.
- The fact that specifiers are always left emerges naturally from the interaction of these two constraints.

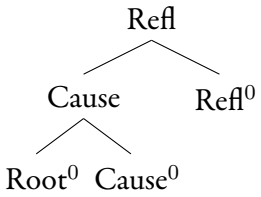
3 BACK TO ARABIC

These two constraints are enough to capture the Arabic reflexive problem discussed above.

- For reasons of time, I'm only going to worry about whether or not the Reflexive is an infix, and will exclude candidates where it's infixal but positioned later in the word.
- For some discussion of how to place the infix more precisely, see the Appendix.

First consider a prefixal form, e.g. Form V (Reflexive + Causative). By assumption, after head movement, the complex head containing the verb has the following structure:

(9) Form V:
Asymmetric c-command



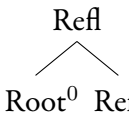
The causative is expressed by word-internal prosodic changes; this is well-captured by existing theories, so we only care about the Reflexive:

(10)

(9)		Antisymmetry	HeadFinality
→	***t*-*akattaba***		*Refl
	k-***t***-*attaba*	*Refl<Rt	

The tableau in (10) shows that the correct ranking is Antisymmetry≫ HeadFinality. When we apply that ranking to Form VIII, we get the correct result — the reflexive becomes an infix:

(11) a. Form VIII:
No asymmetric c-command



b.

(11-a)		Antisymmetry	HeadFinality
	t*-*aktaba		*Refl
→	*k*-***t***-*ataba*		

This is the emergence of the unmarked again:

- Without asymmetric c-command between Refl & Rt, Antisymmetry is powerless to establish an ordering.
- Note that HeadFinality will assigns a violation exactly when Refl *precedes* the root; it doesn't care whether Refl actually *follows* root.
- This allows HeadFinality to select the infixed form.
- The constraints we designed for word order get us affix order for free.

In addition to getting the affix ordering right, this model also correctly captures the relationship between word order and affix order:

- The ranking Antisymmetry≫ HeadFinality corresponds to a head-initial word order.
- Arabic is, broadly, head-initial. (Dryer & Haspelmath, 2013)

4 Typological implications

The great strength of OT is that it is an inherently typological theory: Any constraint set comes with a predicted ('factorial') typology based on reranking the constraints.

- Above the word level, we've already seen that the Optimal Linearization constraints shown here give us two languages: The harmonically head-initial and harmonically head-final languages.
- Below the word level, they'll also give us two languages: One with only suffixes, and one with only(-but-one) prefixes.

The interesting prediction is the connection between word order and affix order:

- Both prefixes and head-initial orders are controlled by Antisymmetry; both suffixes and head-final orders are controlled by HeadFinality.
- As such: The system predicts that **only head-initial languages may be prefixing.**
- This is a known typological generalization going back to Greenberg (1963).
- More recently, Roberts (2017) takes a close look at the handful of purported exceptions; he concludes there aren't any exceptions.

Note, though, that this generalization is only one way: Head-initial languages may also be suffixing (e.g. English).

- The Optimal Linearization constraints only make clear predictions about affix direction in the case of head-movement.
- But we already believe that there's more than one way for something to become an affix — e.g. affix-hopping.
- More work is needed to understand how those other mechanisms interact with the model proposed here.

There are two related predictions made by this model that are less obviously correct, both concerning the relationship between syntax and affix order. First:

- This system seems to predict that the closest affix to the root will *always* be non-prefixing (due to mutual c-command).
- This is maybe less troubling if we assume that all roots come with a categorizing head (e.g. v, n) which in nearly all cases is closer to the root than any other affixes.
- We would then only see this particular kind of disharmonic affixation for certain kinds of low-attaching morphemes, possibly explaining it's rarity.

The second prediction concerns side-switching affixes:

- Given this model, we expect to find cases where a suffix becomes a prefix whenever it scopes over another morpheme.

- Marušic (2003) argues that no affixes switch sides *for phonological reasons*; it's less clear that his discussion applies to the kind of syntactically-motivated switching predicted here.

In fact, there are a couple of cases that look plausible.

- In Huave, a morpheme called the "theme vowel" is a suffix on reflexives, middles, & statives, but a prefix on transitives and causatives.[5]
  - If we posit that the theme vowel is v^0 and that the additional arguments for transitive & causative verbs are introduced by phonologically-null heads below v^0, followed by roll-up head movement of the root to v^0, Optimal Linearization will derive the side switching.
- The Lithuanian reflexive is a suffix to the verb, unless one of a particular class of prefixes is present, in which case it's also a prefix (though the second one, not the first). (Ryan, 2010; Embick & Noyer, 2001)

It remains to be seen whether these last two predictions will hold up to closer scrutiny.

5 Conclusions

I've tried to motivate a new model of linearization that I call Optimal Linearization:

- This takes seriously the notion that linearization is a PF-phenomenon and therefore models it using the same tools we use for other PF phenomena.
- All that's needed is a set of new input-output correspondence constraints, for which the input is the syntactic structure.

Having constraints that reference the syntax in this way isn't a new idea:

- Prosodic structure generally seems to mirror syntactic structure; it's hard to see how you could do this without constraints making reference to the syntax.
- In particular, the Match (Selkirk, 2011) constraints need to know about constituency and labelling (to decided which XPs are clauses).
- The constraints I've proposed here need to know about dominance & c-command (both deducible from constituency) and labelling.

The version of Optimal Linearization presented here thus follows common assumptions about the nature of the syntax-PF interface in order to linearize syntactic structures. I've shown that it's capable of capturing a simplified two-way typology of harmonic word orders, and of making predictions about the relationship between word order and affix direction.

[5] Most other verbal affixes in Huave occur on the same side as the theme vowel. Marušic (2003) considers but then dismisses the claim in Noyer (1993) that this switch is for phonological reasons. Noyer simply specifies that the prefix and suffix theme vowels are different affixes and derives the rest of the side-switching from there.

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6 Appendix

I see two options for how to position the Arabic Reflexive infix, given the Optimal Linearization constraints:

1. **Prosody:** Language-internal prosodic factors force the infix to appear in the word onset.
2. **Output-output correspondence:** Cross-linguistic pressure for paradigm leveling forces the infix to appear as close to its prefixal position as possible.

I won't decide between these options here, but I will note that the OO-Correspondence analysis may have bearing on why side-switching affixation is rare.

6.1 Option 1: Prosody

Tucker (2011) notes that Iraqi Arabic shows weight-sensitive stress; furthermore, only coda consonants contribute a mora. He follows Sherer (1994) in positing two constraints to achieve this:

(12) a. *App(end-to-σ): Coda consonants are not adjoined directly to the syllable node.
b. *μ/C: Consonants are not moraic.

The ranking *App $\gg$ μ/C ensures that all (and only) coda consonants are parsed as moras.

- If all segments in the input are inherently ordered, these constraints serve to parse (C)VC sequences as heavy syllables.
- If a consonant is unordered in the input (as is the case with the infixal Reflexive morpheme), these constraints will instead force that consonant not to occupy a coda.
- That is, HeadFinality$\gg$ *App $\gg$ *μ/C. (In (13), all moraic consonants are marked with subscript μ.)

(13)

	[$_{Refl}$ /t/ + /kataba/]	HeadFinality	*App	*μ/C
→	k-t-a.ta.ba			
	t-kataba	* W		
	kat.ta.ba		* W	
	katμ.ta.ba			* W

This is getting close to the desired result, but there's a problematic candidate: The one that parses /t/ as the onset of a non-initial syllable.

- *ComplexOnset is necessary, but won't suffice — we want a complex onset in the output!
- Word-initial clusters are often different cross-linguistically; in particular, many languages seem to allow unparsed word-initial consonants in the case of clusters. (See Green 2003 on Greek, Irish.)
- Note that in Arabic, word-initial consonant clusters trigger epenthetic /ʔi-/ at a phrase boundary, where as medial clusters get broken up by epenthesis. While not conclusive, this at least suggests that word-initial clusters have some different status in Arabic.
- Green (2003) allows for word-initial unparsed consonants via a constraint restricting unparsed consonants to word edges; he calls this Consonant-at-Margin (C@M).
- This gets us what we need: C@M & *CompOns rule out all the remaining relevant candidates. (In (14), <C> indicates an unparsed consonant.)

(14)

	[$_{Refl}$ /t/ + /kataba/]	HF	*App	*μ/C	*CompOns	C@M
→	<k>ta.ta.ba					
	<t>kataba	*W				
	kat.ta.ba		*W			
	katμ.ta.ba			*W		
	ka.<t>ta.ba					*W
	ka.tta.ba				*W	

6.2 *Option 2: Output-output correspondence*

Option 1 mostly falls out of independent facts about Arabic stress, but doesn't tell us anything about the cross-linguistic typology of position-switching affixes.

- As noted in section 4, position-switching affixes seem to be rare at best. Maybe there's a constraint militating against them in specific?
- For example: Linearity-OO: An output-output faithfulness constraint against metathesis.
- For our purposes here, we need this to be defined at the segment level (not the morpheme level).

(15) Linearity-OO: Assign a violation if a pair of segments appear in the order $\alpha\beta$ in the output, but in the order $\beta\alpha$ in a different form expressing at least the two morphemes containing these segments.

(16)

	[$_{Refl}$ /t/ + /kataba/]	HF	Linearity-OO
→	k-t-ataba		*
	t-kataba	*W	L
	kataba-t		****** L

Including this in our constraint set does possibly nice things for typology:

- Full side-switching will only happen if Linearity-OO is outranked by both the relevant Optimal Linearization constraints and a constraint against infixation.
- Otherwise, affixes not in their "normal" (i.e. positioned by the highest-ranking Optimal Linearization constraint) position will be minimally infixed.