Optimal Linearization:
Word Order Typology with Violable Constraints

Abstract. Insofar as linearization is a post-syntactic phenomenon pertaining to phonological forms, it is desirable that it be modelled in a violable constraint framework parallel to other PF-branch phenomena. This paper presents such a model, with the goal of capturing the Final-over-Final Condition (FOFC), a typological generalization that head-final phrases embed only other head-final phrases while head-initial phrases may embed phrases of either headedness. The specific model proposed here, termed Optimal Linearization, is couched in Optimality Theory and comprises a set of three interacting violable constraints for mapping syntactic structure to linear order. One constraint, ANTISYMMETRY, closely mimics the action of Kayne's familiar Linear Correspondence Axiom. An opposing constraint HEADFINALITY penalizes deviations from an idealized head-final order. Lastly, a domain-specific constraint HEADFINALITY-α enforces head-final ordering only within one constituent, allowing for FOFC-respecting disharmonic orders. Optimal Linearization has several advantages beyond typology, including offering insight into the leftward direction of specifiers as the emergence of an unmarked preference for head-finality. Linearizing at PF also allows us to model cases where phonological or prosodic properties of words affect their order; this is illustrated with the example of Irish pronoun postposing.

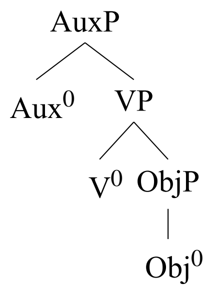
1. Introduction

Even with all the advances in syntactic theory over the last few decades, the relationship between syntactic structure and linear order remains somewhat mysterious. The Headedness Parameter, which states that all heads are either to the left or the right of their complement, has two significant flaws: First, it says nothing about how the specifier position is ordered with respect ot the rest of the phrase. Recent work has made it clear that the specifier, insofar as it can be coherently defined on purely syntactic grounds, is always linearized to the left of its head (e.g. Kayne 1994; Abels & Neeleman 2012:a.o); the Headedness Parameter offers no explanation as to why this should be the case.

The second failure of the Headedness Parameter is an empirical one: Depending on one's assumptions, the model either undergenerates or overgenerates. The undergeneration case is commonly known: If we assume that the Headedness Parameter can't be set for individual heads, we predict that all phrases in a language will have identical headedness. This is an easily falsifiable prediction. German is a frequently-studied example of a language with mixed-headedness; casting our net a bit more broadly, WALS (Dryer & Haspelmath 2013) lists 66 languages in which the relative ordering of the verb and its object differs from the ordering of adposition and noun. This is a small percentage of the sample, to be sure, but it represents only one of the ways that a language might display mixed-headedness; whatever model we use, it clearly must rule in these mixed cases. On the other hand, if we allow languages to set the Headedness Parameter differently for each individual phrase type, we miss the very real typological gaps in headedness relations between phrases. The best known of these is the Final-over-Final Condition (Sheehan et al. 2017): If a phrase is head-final, then its complement will be as well, so long as they are part of the same extended projection (Grimshaw 1991); if a phrase is head-initial, its complement may have either headedness. This is illustrated with a schematic tree in (1); any part of a tree with the same geometry will have the same word order prediction. If we are allowed to set the Headedness Parameter individually for each phrase, we predict 4 possible orderings for this tree; empirically, though, the Final-over-Final Condition (FOFC) rules out the order in which VP is head-initial but AuxP is head-final:

(1) **The Final-over-Final Condition:** The complement of a head-final phrase is also head-final.

(2) a.



b.

	Aux Initial	**Aux Final**
V Initial	Aux V Obj (e.g. English)	* V Obj Aux
V Final	Aux Obj V (e.g. Evenki[1])	Obj V Aux (e.g. Hindi)

The FOFC has been argued for extensively in the literature, notably in a recent book by Sheehan et al. (2017); evidence for the constraint is presented there and in the references contained therein. While it has certainly not gone unchallenged as a generalization (see for instance Abels 2016; Paul 2014), it seems at least to be statistically prevalent enough to be worth pursuing. I will present a small sample of the evidence here, taken from WALS (Dryer & Haspelmath 2013), and will discuss a few possible counterexamples below.

WALS does not code directly for the kind of disharmonic orders that interest us here, but it does include a proxy: Feature 94A covers the placement of "adverbial subordinators", a subset of complementizers, with respect to their embedded clause; we can take this as tracking the order of C and its complement S.[2] We can then look at the relationship between these embedding complementizers and the headedness of the language overall (as measured by Feature 95A, "Relationship between the order of Object and Verb and the order of Adposition and Noun Phrase"). The results are tabulated in (3).

[2]However, see Paul 2014 for reasons why treating Feature 94A in this way is somewhat problematic; certainly, this is not a perfect, unbiased measure of the direction of C. It will be sufficient to illustrate the phenomenon here, however, as long as the statistical conclusions are taken with a grain of salt.

(3) **The FOFC in WALS**:

	C S	**S C**
Head-Initial	258 (87%)	1 (0.001%)
Head-Final	37 (13%)	85 (99.99%)

As can be seen, languages in which a head-final C embeds an otherwise head-initial clause are vanishingly rare[3], with only one such language listed in WALS.[4] This provides evidence for only a small subset of the range of cases covered by the FOFC, and the reader is directed to the existing literature for exemplification of the other cases. Nonetheless, it can be seen that the FOFC is a very strong trend in this data. [5]

There do exist some likely counterexamples to the FOFC. A commonly cited one is sentence-final particles (SFPs); forr example, Paul 2014 presents convincing evidence that SFPs in Mandarin are functional heads in the C-layer,[6] making them apparently head-final above an otherwise head-initial TP. Biberauer 2017 discusses the issue of SFPs for the FOFC extensively and considers ways that they could be understood as FOFC-compliant; however, even if they are true exceptions they seem to form an interesting natural class. In light of the statistical prevelance of the FOFC, it seems desireable to develop a model of linearization that captures it but provides ways to carve out principled classes of exceptions where necessary. I will proceed from that premise here; see section 6 for further discussion of how we might account for exceptions.

If our goal is to proceed as though the FOFC were truly universal, this not only rules out setting the Headedness Parameter individually by phrase but in fact rules the middle-ground option as well: If we are only allowed to set the Headedness Parameter separately for certain domains (for example, for the vP phase and the CP phase), we still have no explanation for why there should be an asymmetry between head-final phrases and head-initial phrases in terms of what they embed. Something stronger

[3] Difference of proportions: $\chi^2 = 227.8$, df $= 1$, $p < 0.0001$.

[4] The one language listed is Buduma (Lukas & Nachtigal 1939), a Chadic language. Sheehan, Biberauer, Roberts, & Holmberg (2017) discuss this case and conclude that it is not in fact a true counterexample.

[5] The low percentage of C S languages which are head final in this data (13%) is a sampling artifact — head-final languages are under-represented in Feature 94A generally. Note that the disharmonic case does comprise 30% of the head-final languages in this sample.

[6] Though see Erlewine 2017 for evidence that at least some of the SFPs are at vP rather than CP; this doesn't change the conclusion with respect to the FOFC.

than the Headedness Parameter is needed.

More contemporary approaches to linearization fare no better. Most of these take Kayne's Linear Correspondence Axiom as a starting point and map asymmetric c-command to linear precedence (see e.g. Dobashi 2009). This has the benefit of explaining why specifiers are always on the left — they do always c-command the head — but at the cost of ruling out head-final phrases entirely. Analyses based on the LCA typically resort to hypothesizing complex movement in the syntax with little independent support. Leaving aside the stipulative nature of such an account, it is difficult to see how it could explain the FOFC: If surface-head-final phrases are generated by moving a complement higher in the structure, why shouldn't we be able to move a surface-head-initial complement in such a way as to violate the FOFC?[7]

In this paper, I will propose a model of linearization which provides some explanation for the two issues discussed above, namely: Why are specifiers always on the left? And, what is the explanatation for the FOFC? I start from the perspective that linearization is a PF phenomenon (Kayne 1994; Chomsky 1995b) and should be modelled the same way we model other phonological processes, namely with violable constraints. This accords with a growing body of evidence that phonological or prosodic factors sometimes play a role in determining word order; for example, Bennett et al. 2016 show that prosodically-light pronouns in Irish may be postposed, while Bosnian / Serbian / Croatian 2nd position clitics have long been argued to sometimes be positioned relative to a prosodic constituent rather than a syntactic one (e.g. Halpern 1992; Bošković 2001:and many others). I will join López (2009); Elfner (2012), and others in proposing that we can model these cases of PF displacement with Optimality Theory (Prince & Smolensky 1993/2004) by having constraints on linearization come into competition with prosodic markedness constraints. In contrast to these earlier models, however, I propose that the mapping from syntactic structures to linear strings occurs fully post-syntactically: Rather than proposing a single "word order faithfulness" constraint penalizing deviance from a pre-specified order (as does e.g. Bennett et al. 2016), I propose a family of constraints which enforce certain relationships between syntactic structure and word order, working together to derive the correct output. Modelling

[7] In fact, Abels & Neeleman 2012 demonstrate that, in the absence of restrictions on what movements are possible, the LCA is too permissive even to account for many of the generalizations which originally motivated it.

linearization in this way has the benefit of making clear, well-defined typological predictions, in the form of factorial typology: Different rankings of constraints should predict all and only the classes of word order actually observed.

I will call this general approach Optimal Linearization, and will demonstrate that, given the right constraint set, we can predict the typological gap described as the FOFC while still offering a coherent explanation for why specifiers are always left.[8] My proposed constraint set models word order typology as arising from the competition of two core constraints: One, HEADFINALITY, encodes a general preference for heads and their non-maximal projections to follow their sisters. The other, ANTISYMMETRY, encodes a competing preference for syntactic objects higher in the tree to be linearized earlier in the string; it closely mimics the effect of the familiar LCA (Kayne 1994). These are both violable constraints; in some cases satisfaction of one constraint will entail violation of the other. Competition of these two constraints will derive the two harmonic word orders (head-initial and -final). Within this framework, the leftward position of specifiers occurs not because the specifier c-commands the head, but rather because the terminals within the specifier *fail* to c-command it; specifiers are therefore placed on the left as the grammar tries to achieve the "most head-final" ordering possible with heads still preceding their complement. Finally, a third constraint HEADFINALITY-α is identical to HEADFINALITY except that it considers only the order of those heads dominated by some node α. The addition of this constraint allows us to derive exactly those disharmonic orders compatible with the FOFC. Finally, I'll show in section 5 that Optimal Linearization is capable of accounting for those cases where phonological or prosodic factors seem to play a role in the determination of word order, and at least in the Irish case discussed by Bennett et al. (2016) fairs better than the previous model.

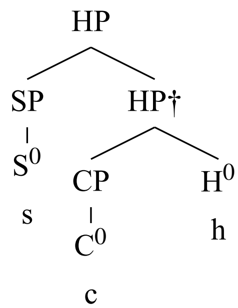
2. Harmonic Word Orders

I'll introduce Optimal Linearization by illustrating how it models a subset of the complete typology. In particular, I will start by considering only the "harmonic" word orders — those word orders that are consistently head-initial or head-final in all phrases. Intuitively, we want the Optimal Linearization

[8] In particular, I aim to capture the ordering of specifiers and complements; I will not take up the positioning of adjuncts here. See section 6 for thoughts on how this system might be extended to address the ordering of adjuncts.

procedure to take a syntactic structure like (4a) and produce one of the two orders in (4b) (and no others). (The nodes have been named corresponding to their structural position — so the specifier is SP, the head is HP, and the complement is CP.)

(4)



a. **Head-Initial:** shc
b. **Head-Final:** sch

In a violable-constraint framework, it's natural to have these two orders be generated by interaction between two constraints which may be ranked differently by different languages: In langauges where one constraint (call it HEADFINALITY) is dominant, the output will be the head-final order *sch*; in languages where the other constraint (call it ANTISYMMETRY) is dominant, the output will be the head-initial order *shc*. Further, we want this to extend to all phrases — that is, if there is more material in SP or CP, we want those phrases to be linearized the same way as HP. The goal of this section will be to define the constraints HEADFINALITY and ANTISYMMETRY to achieve exactly this result.

Before getting to the constraints themselves, however, I first need to introduce the rest of the Optimal Linearization model.

2.1 Some housekeeping

It's worth taking a second to formalize what exactly the complete model looks like.[9] The general architecture of OT involves two core components: GEN takes an *input* and generates from it a number of *candidates* (i.e. potential outputs); EVAL takes the input and candidate set and, using a set of ranked violable constraints, selects a winner, which is the output of the model overall. Any given language is

[9] While I endeavor to introduce the formal mechanisms of OT in this text, readers unfamiliar with the framework are referred to McCarthy 2002 for a more complete introduction.

taken to have a fixed ranking of constraints. Taken together, GEN, EVAL, and the ranked constraints are a function from the possible inputs in the language to the possible outputs.

In Optimal Linearization, the input to GEN is the output of the narrow syntax, i.e. a phrase marker produced by some particular theory of syntax. While Optimal Linearization is compatible with a variety of syntactic theories, I will use structures compatible with Merge-based derivations and the Minimalist Program generally (Chomsky 1995b). I will assume that the candidates created by GEN are strings composed of whatever phonologically-contentful Vocabulary Items are produced by the Spell-Out of the set of syntactic terminals in the input. I'll refer to these vocabulary items generically as "words". The set of candidates produced by GEN will be the full set of possible orders of words, so if there are n syntactic terminals mapped to phonologically-contentful words, there are $n! = n(n-1)(n-2)...$ candidates from which a single unique winner will be selected. Phonologically null syntactic terminals remain part of the input to the linearization component, but are never present in any of the candidates.

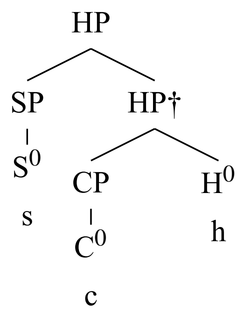
As a matter of notational convention, I will use capital letters to denote syntactic terminals (A, B) and lower case letters to refer to the words corresponding to them (a, b). In addition, I will reserve the letters {X, Y, Z} for variables ranging over syntactic labels; letters from the beginning of the alphabet denote specific syntactic objects. The symbol $<$ denotes string precedence, so $x < y$ means some word x precedes some word y. As a last notational convention, I will draw all syntactic trees in a head-final fashion; remember, however, that syntactic trees have no order!

2.2 HEADFINALITY

Having dispensed with the preliminaries, let's now turn to the derivation of head-final orders. This will be accomplished by a constraint HEADFINALITY which, given the input (5a), prefers the order in (5b) to all other possible orders (5c).[10]

[10]Optimal Linearization requires that we be able to distinguish minimal (non-phrasal) nodes from non-minimal (phrasal) ones. To help visually distinguish these classes, I've labelled all non-minimal (phrasal) nodes as "XP", here and in all other trees; however, this should be understood to be purely notational — the constraints will function identically if nodes are labelled as in Bare Phrase Structure (Chomsky 1995a) or similar models. For expositional reasons it will be convenient to have unique labels for each node; accordingly, I've marked the phrasal, non-maximal nodes with †; again, this is purely notational and should not be understood to refer to some special theoretical status for these nodes.

(5)



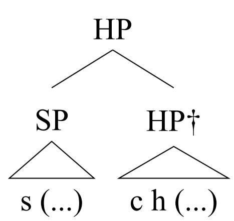
a. → sch

b. *shc, *csh, *chs, ...

Let's think about what properties the winning order *sch* has that the other possible orders don't. First, it orders the specifier *s* before everything that isn't the specifier; any order that doesn't have *s* initial will be dispreferred. Put another way, the correct output has HP† following its sister. Second, the correct output orders the complement *c* before the head *h*; any order that has $h < c$ will be dispreferred — H^0 follows its sister.

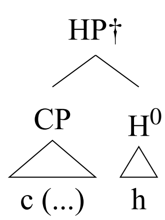
By visualizing each branching node separately, it can be seen that these two ordering conditions share a structural description. One ordering relation relates the daughters of HP to each other; the other relates the daughters of HP† to each other. In each case, the daughter that shares a label with the node in question (HP† for HP; H for HP†) is set to follow the daughter that doesn't (SP for HP; CP for HP†).

(6) a.



→ s < {c, h}

b.



→ c < h

It's going to be useful to have a pair of terms that distinguish these two structural relations. I'm going to call the daughter that shares a label with its parent the 'descendant' or 'endogenous daughter'; the one that doesn't share a label with it I'll call the 'in-law' or 'exogenous daughter'. When two nodes undergo Merge, the one which projects becomes the descendant and the one that doesn't becomes the in-law. Specifiers and complements will always be in-laws of the nodes immediately dominating them; heads and their non-maximal projections will always be descendants.

Intuitively, then, HEADFINALITY is a constraint that prefers orders in which, for every branching node, the material dominated by its in-law precedes all material dominated by its descendant. Optimality Theory constraints are generally stated in terms of the output configurations they disprefer, i.e. the configurations which incur violations of the constraint. Putting HEADFINALITY into that form:

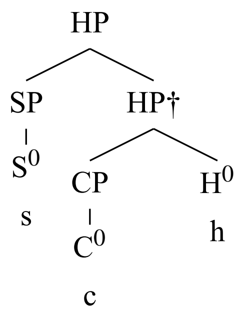
(7) HEADFINALITY : Assign one violation for each branching node XP dominating a pair of terminal nodes X^0 & Y^0 such that:

a. Y^0 is dominated by the in-law of XP;
b. X^0 is not dominated by the in-law of XP; and[11]
c. $x < y$.

I'll illustrate the action of this constraint in an OT tableau. The candidate orders are listed in the leftmost column; the next column lists which branching nodes incur violations of HEADFINALITY. In this input, there are only two branching nodes and so the constraint scores a maximum of two violations. The arrow indicates the winning candidate *sch*, the only candidate which scores no violations.

[11] If X^0 is dominated by XP but not dominated by the in-law of XP, then it is by definition dominated by the descendant of XP. Once we turn to linearizing movement structures in section 3, we will encounter cases in which a particular head is dominated by both the in-law and the descendent of XP; defining the constraint as shown here will prevent it from giving contradictory orders in these cases.

(8) a.



b.

(a)	HEADFINALITY
a. shc	*H†
b. → sch	
c. csh	*HP
d. chs	*HP
e. hcs	*HP *HP†
f. hsc	*HP *HP†

While this is a simple example, it serves to illustrate the action of HEADFINALITY generally. The constraint will linearize any XP in the same fashion as HP in this example — with everything contained in the specifier foremost, and X^0 final.

2.3 ANTISYMMETRY

The constraint HEADFINALITY suffices for deriving harmonically head-final word orders. In order to derive the head-initial orders we need a constraint that opposes HEADFINALITY. That is, we want some constraint ANTISYMMETRY such that the same tree in (8) is mapped to the order *shc* whenever ANTISYMMETRY$\gg$ HEADFINALITY. It may at first seem tempting to make ANTISYMMETRY the inverse of HEADFINALITY — that is, have it require the descendant to proceed the in-law. However, this won't work, as head-initial orders and head-final ones are not symmetric: In both orders, the specifier must precede everything that follows it. We need to look for something else that will create head-initial orders than just the reverse of HEADFINALITY.

I propose that we follow Kayne 1994 and make ANTISYMMETRY a constraint that enforces correspondence between asymmetric c-command and precedence. Unlike Kayne, however, I will only consider relationships between terminal nodes. This frees us from making stipulations about segments

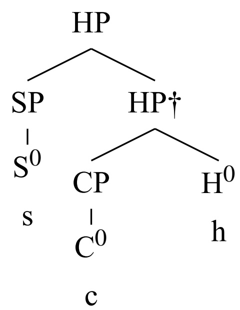
& categories, and will also have some other benefits that I will make clear momentarily. Intuitively, then, the constraint that we're looking for is one that penalizes words that occur in the opposite order as the asymmetric c-command relation between their terminals. More formally:[12]

(9) ANTISYMMETRY: Assign one violation for each pair of terminal nodes X^0 & Y^0, where:
  a. X^0 asymmetrically c-commands Y^0; and
  b. $y < x$.

This constraint ranges over pairs of nodes that stand in an asymmetric c-command relation. In the basic spec-head-comp structure we've been investigating so far, there is only one such pair: The head H^0 asymmetrically c-commands everything in CP (namely C^0). As such, ANTISYMMETRY will score a maximum of one violation whenever $c < h$. However, ANTISYMMETRY will not order the specifier S^0 with respect to either of the other heads — while the phrase SP asymmetrically c-commands both h and c, S^0 itself does not. How, then, will the system order the specifier? Conveniently, we already have a constraint which accomplishes this: HEADFINALITY requires that HP be linearized such that everything in SP precedes everything in HP†. In a violable constraint system like OT, low-ranked constraints remain active even when dominated by a higher ranked constraint; even when ANTISYMMETRY$\gg$ HEADFINALITY, then, HEADFINALITY is still active and can enforce the leftward position of the specifier. I've presented this in tableau form below. ANTISYMMETRY eliminates the three candidates in which $c < h$; of the three that remain, only one fails to incur a violation of HEADFINALITY for HP, namely the one that orders the specifier on the left.

[12] The definition of ANTISYMMETRY given here assumes that heads will always asymmetrically c-command the contents of their complement. In contemporary syntactic theories based on Merge (Chomsky 1995b), this is problematic in that it requires non-branching complements to project a unary phrasal node. However, it is possible to redefine ANTISYMMETRY so that it will order non-branching complements correctly even without this unary projection: If ANTISYMMETRY only considers c-command relationships from minimal, *non-maximal* nodes (i.e. only those heads that have projected at least one phrasal node), then heads will asymmetrically c-command non-branching complements in the relevant sense. For ease of exposition I will continue to draw unary projections so that the c-command relationships will be intuitive.

(10) a.



b.

(a)	ANTISYMMETRY	HEADFINALITY
a. → shc		*HP†
b. sch	$*h < c$	
c. csh	$*h < c$	*HP
d. chs	$*h < c$	*HP
e. hcs		*HP *HP†
f. hsc		*HP *HP†

This is a case of "the emergence of the unmarked" (McCarthy & Prince 1994): The lower-ranked constraint acts to select the winner exactly when the higher-ranked one fails to choose. In this case, the higher-ranked ANTISYMMETRY doesn't select between the different placements of the specifier *s* within the string — it only requires that the head precede its complement. The fact that the specifier is on the left in the winning candidate is a reflection of the system choosing the "most head-final" order among those compatible with the order $h < c$. Optimal Linearization thus gives us new insight into a previously-mysterious fact about word order typology, namely that specifiers are always left-most even in otherwise "head-initial" languages. Put another way, it has always been somewhat problematic that so-called head-initial languages are never fully head-initial, but rather always require specifiers to precede the head. Optimal Linearization lets us understand this fact as a preference for head-finality emerging even in otherwise head-initial languages.[13]

So far we've considered only a single, abstract tree where the specifier and the complement con-

[13] A reviewer points out that Optimal Linearization is in this regards similar to the Basic Branching Constraint (BBC) of Haider 1992, 2012. In Haider's model, syntactic trees themselves are ordered and are universally head-final at their base; but all movement (including head-movement) is universally leftward, allowing for derived head-initial environments. Optimal Linearization also comes to the conclusion that head-initial orders are in some sense 'more complex' than head-final ones, but locates this complexity differently: Whereas for Haider head-initial orders involve additional syntactic structure, in Optimal Linearization they involve a constraint interaction.

tain only a single word. Hopefully it is clear that adding more words to either specifier or complement will behave in the expected way: HEADFINALITY will provide pressure to linearize all the specifier material before head & complement and also all the complement material before the head; ANTISYMMETRY, likewise, will provide pressure to linearize the head before all the complement material — the head, after all, does asymmetrically c-command all of its complement. The same general pattern of linearization will be replicated within each XP, just as we'd expect.[14] There is one class of syntactic structure not yet accounted for, however, namely structures involving movement. This is what I'll turn to in the next section.

3. Linearizing Movement

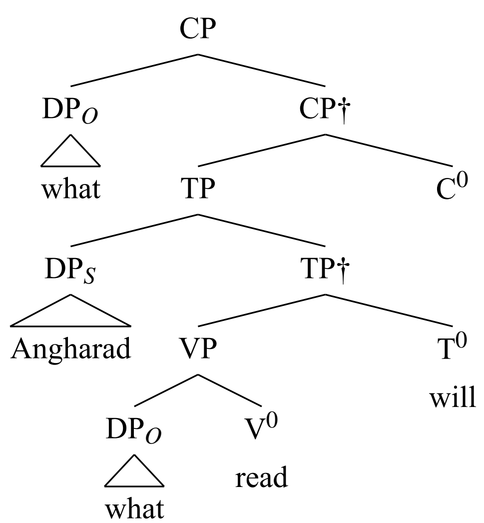
One of the goals of any linearization algorithm must be to explain why moved items appear in the location that they do (and only that one). That is: Once an XP has moved, what prevents it from being linearized according to its base position? And what prevents it from being spelled out twice, once according to each position? In most traditional theories of linearization there is an operation of "copy-deletion" which applies before linearization and transforms the tree at PF such that moved items are only in one position. However, Johnson 2016 outlines some possible undesirable consequences of introducing this extra transformation between the syntax and the linearization. Instead, I propose to keep to the original intuition that it is linearization itself that forces moved items to be spelled out in a particular location. The input to Optimal Linearization, then, will still have moved items in all of their positions. I will assume for the moment that GEN only creates candidates that have exactly one word for each (phonologically-contentful) syntactic terminal, even if that terminal has multiple copies. In other words, when confronted with multiple copies of some syntactic object, GEN will only access the lexical entry for that syntactic terminal once; the candidates generated by GEN are then all possible

[14]A reviewer asks how Optimal Linearization might account for lexical exceptions to language-wide word order, for example the limited set of postpositions in German. A benefit of using a violable-constraint framework is that markedness constraints can override the 'default' word order in specific cases. These markedness constraints might target some general property shared by the exceptional vocabulary items (for instance, a particular prosodic property), or might simply be indexed to particular vocabulary items. For cases like German *entlang* 'alongside', which alternates between prepositional and postpositional use, we might hope to find systematic differences between the two positions (for instance, in prosodic phrasing), which would indicate a markedness constraint penalizing one order. Alternatively, we might use a variable-output model (for example, a MaxEnt grammar — Hayes & Wilson 2008) and a lexically-indexed constraint.

orders of the lexical entries accessed.[15] This prevents moved items from being linearized in multiple positions (a.k.a. multiple exponence). This may or may not be a desirable assumption, as multiple exponence of movement chains has been proposed as an analysis of resumption (e.g. Sichel 2014) and verb-doubling predicate clefts (e.g. Koopman 1984; Kandybowicz 2006; Cable 2004). If we want to capture these phenomena using multiple exponence, we would need to relax this restriction on GEN but then add additional constraints to enforce single spellout in all but the relevant contexts. Such a project is beyond the scope of this paper, so for the moment I'll use the constrained version of GEN.

With that in mind, let's consider what we want the Optimal Linearization constraints to do in the case of movement structures. I'll use English *wh*-movement as an illustrative example; (11) presents a simplified structure for an object *wh*-question.[16]

(11)



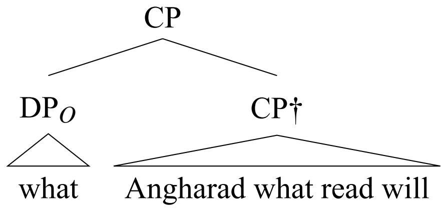
Let's first consider how we want HEADFINALITY to treat the moved item. Recall that HEADFINALITY scores violations based on branching nodes. There are 5 branching nodes in (11), but one of them (CP†) has a branch with no phonologically-contentful words (C^0) and so will never score a violation. The remaining 4 branching nodes are as follows:[17]

[15] Note that this model of GEN means that movement does not increase the size of the candidate set: Moving some item does not add any more words to the candidates, and therefore the number of permutations does not increase. If GEN were allowed to generate multiple copies of words, the candidate set would become infinite.

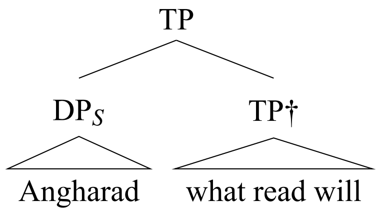
[16] More specifically, this is an embedded question.

[17] The trees in example (12) show the words that would correspond to the syntactic objects dominated by a given node. In (a), the word *what* is repeated because the terminal node it spells out appears in both CP and CP†, not because GEN would generate a candidate containing two occurrences of *what*.

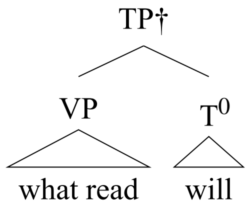
(12) a.



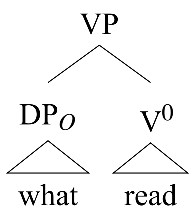
b.



c.



d.



At once we can see that there's a problem. HEADFINALITY will score a violation for any branching node for which material in its descendant precedes material in its in-law. (12a) shows that the constraint will score a violation for CP if *Angharad* (which is in the descendant CP†) precedes *what* (which is in the in-law DP$_O$). (12c), however, shows that the constraint will score a violation for TP whenever *what* (which is in the descendant TP†) precedes *Angharad* (which is in the in-law DP$_S$). This produces produces a contradictory ordering for this tree.

Of course, the problem is that the constraint as defined can't distinguish between the 'high' and 'low' positions of the moved item. We want *what* to be linearized according to its higher position,[18]

[18] This may not always be true if for instance *wh-in situ* languages covertly raise the *wh* item (e.g. Watanabe 1992; Cole & Hermon 1998) — in covert movement in general it seems that the linearization scheme must pick the lower copy, or possibly an intermediate one. Fully accounting for these facts is beyond the scope of this paper, but we might propose that for instance there are two versions of each of the Optimal Linearization constraints, one which sees the lower copy and one the higher; the ranking of these versions relative to each other would determine whether movement overt or covert.

namely spec,CP. In other words, we want the constraint HEADFINALITY to consider DP_O only when it is evaluating the node CP; the contents of DP_O should not be relevant for the linearization of any lower branching node. In order to accomplish this, I will borrow from Abels 2003 the idea of *total domination*. Intuitively, some node X dominates a node Y only if it dominates all copies of Y. Formally:

(13) X **totally dominates** Y iff all copies of Y are dominated by a copy of X.

In (11), DP_O is totally dominated by only two items: itself (total domination is reflexive) and CP. All of the other terminal nodes are totally dominated by everything which (non-totally) dominates them — in the absence of movement, domination and total domination are identical. This allows us to revise our definition of HEADFINALITY to linearize the moved item according to its highest position:

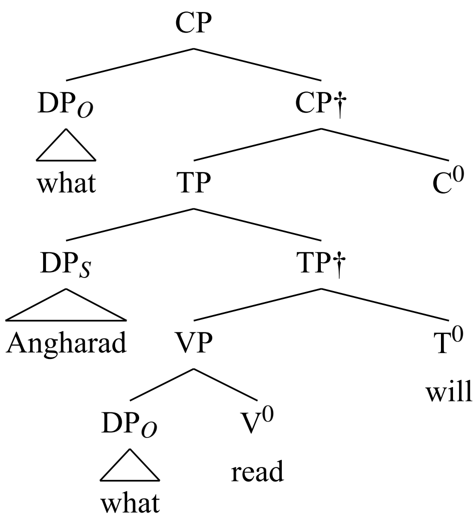
(14) HEADFINALITY (revised): Assign one violation for each branching node XP **totally dominating** a pair of terminal nodes X^0 & Y^0 such that:
  a. Y^0 is dominated by the in-law of XP;
  b. X^0 is not dominated by the in-law of XP; and
  c. $x < y$.

Because CP is the only branching node which totally dominates *what* in (11), the only way for *what* to violate HEADFINALITY is for it to follow anything contained in CP but not in DP_O, i.e. any word in CP†other than itself. As such, *what* (and in fact all of DP_O, if it were larger) will be linearized leftmost, in accordance with its moved position. I've illustrated this in the tableau in (15); space does not permit me to include all 24 candidate orders, so I've chosen a representative set. The winning candidate is a fully head-final pseudo-English.[19]

Spellout of intermediate copies, if necessary, could be achieved by appealing to cyclic spellout of a phase before the object in question has finished moving. Further refinement would be needed to ensure that overt and covert movement could coexist in the same language.

[19] Here we see the relevance of defining HEADFINALITY such that the material in the in-law must precede the material 'not in the in-law' (as opposed to 'in the descendent'), as mentioned in fn. 11: *what* is contained in both CP's in-law and descendent. If the constraint were defined in terms of the descendent, it produce the nonsensical ordering of *what* > *what*. The problem gets worse if the moved item has multiple words, for example if DP_O were *which book*: Here the constraint would both require *which* > *book* (since *which* is in the in-law and *book* is in the descendent) and *book* > *which* (since the reverse is also true).

(15) a.



b.

(a)	HF
a. → what Angharad read will	
b. Angharad what read will	*CP
c. what Angharad will read	*TP†
d. Angharad will read what	*CP *TP†

Of course, to achieve the correct head-initial order for English we need to consider ANTISYMMETRY. Here, we face a similar problem: V^0 still asymmetrically c-commands everything (non-reflexively) dominated by DP_O, and so ANTISYMMETRY will exert pressure for *read* < *what* as though *wh*-movement had never occurred. Again, what we want is a notion of *total c-command* parallel Abels 2003: V^0 fails to c-command *what* in all of its positions, and therefore won't be ordered before it. Total c-command is easy to formalize:

(16) a. X **totally c-commands** Y iff:
(i) X does not dominate Y; and
(ii) everything that totally dominates X also totally dominates Y.

b. X **asymmetrically totally c-commands** Y iff X totally c-commands Y and Y does not totally c-command X.

In (11), V^0 does not totally c-command DP_O: for one, V^0's immediate mother VP does not totally dominate DP_O. In fact, there is nothing that totally c-commands the moved item. All that remains, then, is to update our definition of ANTISYMMETRY to use total c-command:

(17) ANTISYMMETRY(revised): Assign one violation for each pair of terminal nodes X^0 & Y^0, where:

a. X^0 asymmetrically **totally c-commands** Y^0; and
b. $y < x$.

Again, I've illustrated the action of this constraint in a tableau; as before, it fails to order any specifier, but HEADFINALITY emerges to accomplish that.

(18)

		ANTISYMMETRY	HEADFINALITY
a.	what Angharad read will	**will* < *read*	
b.	Angharad what read will	**will* < *read*	*CP
c. →	what Angharad will read		*TP†
d.	Angharad will read what		*CP *TP†

With this last modification to the constraints, Optimal Linearization will now linearize all moved phrases according to their highest position.[20]

4. Disharmonic Word Orders

Up to this point, I've restricted my attention to only the two harmonic word orders. There is a third order compatible with the Final-over-Final Condition: A head-initial phrase can embed a head-final one (but not the reverse). For example, German embedded clauses have a head-initial complementizer but are otherwise head-final[21] (19a); for an example lower in the clause, verbal auxiliaries in many of the Mande languages (Kastenholz 2003) precede the VP, while the verb itself follows its complement (19b).

[20] A reviewer asks to what extent the winning candidate is affected by details of the syntactic analysis, in particular by the addition or subtraction of functional material; for example, in (11) I have omitted vP; how would the linearization change if it were included? If the additional material is phonologically contentful, then the resulting candidates will be different and no direct comparison is possible; on the other hand, if the additional material is phonologically null, it will have no affect on the linearization whatsoever: Because only contentful words are present in the output candidates (by assumption), no violations will ever be scored involving a node dominating no contentful material. In essence, linearization operates on a "flattened" structure with null heads (and their immediate projections) are removed; this is reminiscent of the way the MATCH constraints as defined in Elfner 2015; Bennett et al. 2016 flatten syntactic structure to prosodic structure.

[21] Under the most common analyses of V2, matrix clauses are also an example of a mixed-headed order; I'll stick to embedded clauses here in order to avoid the complexities of head movement.

(19) a. German:

... dass Fritz mich gesehen hat.
that Fritz me seen has

"...that Fritz has seen me."

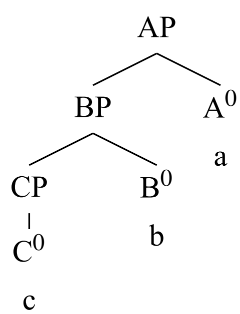
b. Evenki: (Bulatova & Grenoble 1999)

atirka:n ə -či -n sukə -βa ga -mu: -ra
old.man NEG -AOR -3SG ax -ACC take -A.DESID -RA

"The old man did not want to take the ax."

Abstractly, the FOFC-compliant disharmonic order follows the schema in (20), where the unordered syntactic tree is mapped to the linearization shown: AP is linearized in a head-initial fashion, while BP is head-final.

(20) a.



b. **Disharmonic order:** acb

At present, the Optimal Linearization constraint set includes just two constraints, giving a maximum of two rankings / language classes. In order to allow for the disharmonic order, we'll need to add an additional constraint. I propose that this constraint is a relativized version of HEADFINALITY which only considers those nodes (reflexively) dominated by some node α. For example, in (20), α is BP; the constraint would score a violation for BP (which does reflexively dominate itself) if $b < c$, but would not consider the ordering of a at all. This leaves ANTISYMMETRY free to order AP head-initially.

This constraint captures the core generalization of the FOFC: head-finality "propagates down" the tree such that any node dominated by a head-final node will also be head-final itself. Formally, HEAD-

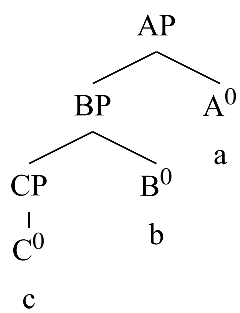
FINALITY-α is defined nearly identically to HEADFINALITY except for a clause specifying its domain of application:

(21) HEADFINALITY-α : Assign one violation for each branching node XP **dominated by** α and totally dominating a pair of terminal nodes X^0 & Y^0 such that:

a. Y^0 is dominated by the in-law of XP;
b. X^0 is not dominated by the in-law of XP; and
c. $x < y$.

HEADFINALITY-α and HEADFINALITY are in a subset ("stringency") relationship: HEADFINALITY-α will always assign a strict subset of the violations assigned by HEADFINALITY. In practical terms, this means that whenever they are ranked "together" (i.e. both above or both below ANTISYMMETRY), their effects will be indistinguishable. Only under the ranking HEADFINALITY-$\alpha \gg$ ANTISYMMETRY$\gg$ HEADFINALITYwill they give rise to the disharmonic order. This is illustrated in the tableau in (22):

(22) a.



b.

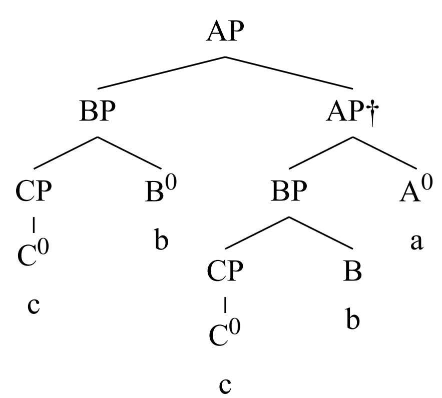
(a)	HF-BP	ANTISYM	HF
a. abc	*BP		*AP *BP
b. bac	*BP	$*a < b$	*AP *BP
c. bca	*BP	$*a < b * a < c$	*BP
d. cba		$*a < b * a < c * b < c$	
e. cab		$*a < c * b < c$	*AP
f. → acb		$*b < c$	*AP

Undominated HEADFINALITY-α effectively divides the syntactic structure into two domains:

everything below α is linearized purely by HEADFINALITY-α , while everything above it is linearized by the combination of ANTISYMMETRY and HEADFINALITY, just as in the harmonic word order case. It's worth taking a moment to demonstrate that this applies even when movement is involved. There are two relevant cases: Movement of α itself, and movement of some phrase within α to a position outside of it. In both cases, we want the moved item to be head-final within itself, but positioned in a head-initial fashion with respect to the rest of the clause.

The case where α itself moves is illustrated in (23), where BP has moved to the specifier of AP. Both copies of BP (reflexively) dominate themselves, and so both are linearized head-finally; likewise, both copies of CP are dominated by a copy of BP, and so CP would also be linearized head-finally (if there were any other material in it). The only change is that A^0 no longer totally c-commands B^0 and C^0, so ANTISYMMETRY will fail to order it before them; instead, the general constraint HEADFINALITY will emerge to order the specifier on the left.

(23) a.



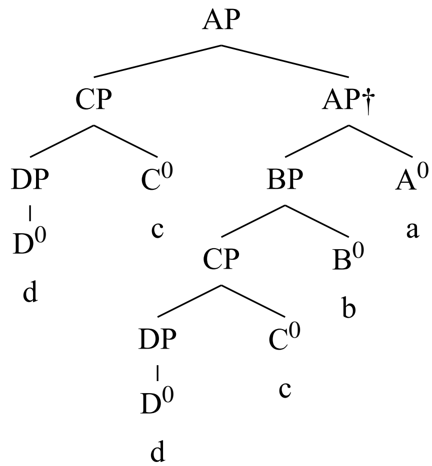
b.

(a)	HF-BP	ANTISYM	HF
a. abc	*BP		*AP *BP
b. bac	*BP		*AP *BP
c. bca	*BP		*BP
d. → cba		$*b < c$	
e. cab		$*b < c$	*AP
f. acb		$*b < c$	*AP

Movement from within α requires a slightly larger tree to fully see. In (24), α = BP as before;

this time, the complement of BP has moved up to the specifier of AP. Once again, HEADFINALITY-BP applies within CP, which is dominated (though not totally dominated) by BP; only the general HEADFINALITY orders the material in CP with respect to *a* and *b*, however, putting the moved item on the left.

(24) a.



b.

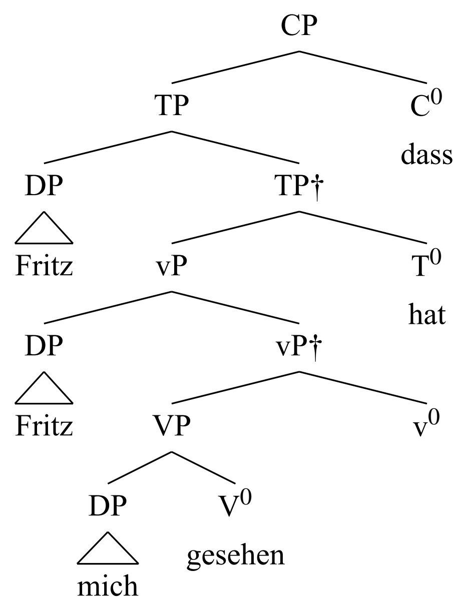
(a)	HF-BP	ANTISYM	HF
a. → dcab			*AP†
b. cdab	*CP		*AP† *CP
c. adcb	*CP		*AP *AP†
d. abdc			*AP *AP† *BP
e. dcba		$*a < b$	

I'll close this section by illustrating how the constraints described here linearize embedded clauses in German. German is a well-known case of a disharmonic word order: Complementizers are on the left, but the rest of the clausal spine is head-final. Thus, the domain of head-finality is TP; that is, HEADFINALITY-TP is undominated. I've given a simplified syntactic structure in (25). [22]

[22] For the purposes of this illustration, I'm ignoring the morphology of the verb itself. A reviewer asks how the model presented here might interact with the morphology component of the grammar. In general, Optimal Linearization requires that vocabulary insertion happen prior to or simultaneous with linearization. Since Optimal Linearization is a violable constraint framekwork, it seems particularly attractive to pursue a similar model for vocabulary insertion, such as Optimal Interleaving (Wolf 2008), which would allow the spell-out of individual morphemes to interact with linear order. Integrating Optimal Linearization with a derivational model of morphology like Distributed Morphology (Embick & Noyer 2001) would be challenging insofar as that model performs operations on ordered trees; thus, the success of Optimal Linearization as a model for morphology rests somewhat on whether similar empirical coverage can be obtained without such a derivation.

(25) a. ... dass Fritz mich gesehen hat.
that Fritz me seen has
"...that Fritz has seen me."

b.



(26)

(25b)	HF-TP	ANTISYM	HF
a. → dass Fritz mich gesehen hat		3: *V < O, *Aux < V, *Aux<O	*CP
b. Fritz mich gesehen hat dass		7: ... *C<S, *C<O, *C<V, *C<Aux	
c. dass Fritz hat gesehen mich	*TP, *VP	0	*TP, *VP, *CP
d. dass Fritz hat mich gesehen	*TP	1: *V<O	*TP, *CP

As shown in (26), the constraint HEADFINALITY-TP eliminates all candidates in which any head below TP is not final within its phrase. ANTISYMMETRY further eliminates those candidates where C^0, the only head not in the domain of head-finality, is not initial. The interaction of these two constraints derives the correct disharmonic word order.

5. PF Effects on Word Order

Optimal Linearization is the proposal that linearization of syntactic structures, insofar as it is a post-syntactic phenomenon, should be calculated using a violable constraint framework. The focus of this paper so far has been on using Optimal Linearization to model word-order typology, in particular the

FOFC, but an additional benefit of modelling linearization at PF is that it allows word order to interact with PF-specific aspects of language like phonology and prosody. There is a growing body of evidence to suggest that these PF factors can have an influence on word order: For example, 2nd position clitics in Bosnian / Serbian / Croatian sometimes seem to interrupt syntactic constituents, but never interrupt prosodic ones (e.g. Halpern 1992; Bošković 2001:and many others). Anttila et al. (2010) has shown that prosodic factors can influence the choice of syntactic frame for English ditransitives; more recently, Shih & Zuraw 2017 shows that segmental features influence adjective-noun order in Tagalog. López 2009 proposes that Clitic Right Dislocation in Romance is motivated by a prosodic constraint on phrasing the verb together with its extended projection. Along similar lines, Edmiston & Potsdam 2017 argues that right-extraposition of clauses follows from prosodic markedness constraints. Clemens To appear argues that pseudo noun incorporation in Niuean is the result of a constraint requiring the verb to be prosodically phrased together with its argument; this analysis is extended to Mayan VOS orders by Clemens & Coon 2016. All of these cases seem to represent what we might call "PF displacement": PF-specific properties of language can create deviations from the word order expected on the basis of syntax.[23]

Optimal Linearization is far from the first proposal for violable linearization at PF. López 2009; Edmiston & Potsdam 2017; Clemens To appear, and Clemens & Coon 2016 all rely on violable linearization in some form. Perhaps the most developed model of violable linearization is the one used by Bennett et al. 2016 to model Irish pronoun postposing, which is one of the clearest cases of PF displacement. Their model relies on a single word order faithfulness constraint penalizing deviations from a target order specified by the syntax. This is sharply different from Optimal Linearization: While both rely on violable constraints to enforce word order, the Bennett et al. 2016 model assumes that that order is given to PF by the syntax; Optimal Linearization instead calculates the word order directly at PF via the competition of multiple constraints. The primary benefit of the Optimal Linearization approach is that it models word order typology generally: If linearization is governed by a single faithfulness constraint, we gain no insight into why different languages are faithful to different word orders. It's

[23] Another very interesting proposal is Contiguity Theory (Richards 2016), which proposes that prosodic factors affect syntactic derivations and help determine word order, rather than merely being responsible for certain deviations.

worth taking a moment, however, to demonstrate that Optimal Linearization is in fact capable of modelling PF displacement, in particular the Irish pronoun postposing case; in fact, I argue that Optimal Linearization actually fairs better in this specific case than the word-order faithfulness model.

Elfner 2012, expanded by Bennett et al. 2016, show that Irish light object pronouns often appear far to the right of where object DPs would generally be expected, with no detectable difference in semantic or pragmatic import. For example, in (27) the pronominal object appears after the clause-final adjunct:

(27)	Fuair	sé	___	óna	dheartháir	an lá cheana	é
	get.PAST	he		from.his	brother	the-other-day	it

“He got it from his brother the other day.” (Bennett et al. 2016:171)

Bennett et al. present convincing evidence that this displacement lacks the signature of a syntactic movement process. For one, this displacement seems to be optional, and doesn’t correspond to any semantic or pragmatic effect. For another, the displacement often has rather implausible landing sites. An example of this is given in (28), where a light expletive pronoun has been displaced into the middle of a conjunction; if this were syntactic movement, it would be lowering movement and would seemingly violate the Coordinate Structure Constraint.

(28)	is	cuma	___	’na	shamhradh	é	nó	’na	gheimhreadh
	COP.PRES	no.matter		PRED	summer	it	or	PRED	winter

“It doesn’t matter whether it’s summer or winter.” (Bennett et al. 2016:183)

A final property of pronoun postposing that makes it a poor example of syntactic movement is that it affects only light, stressless pronouns; stressed pronouns appear in their expected position. This leads Elfner 2012 to propose that the postposing is a kind of prosodic repair: A constraint STRONGSTART (Selkirk 2011) militates against phonological phrases which begin with a light (sub-minimal word) element; this constraint outranks some relevant constraint enforcing linearization, and the result is that light pronouns are pronounced later in sentence in order to achieve a more harmonic prosody. The definition of STRONGSTART given by Bennett et al. is in (29); paraphrased, it will assign one violation for each node in the prosodic parse that is at least as big as a word but which begins with something smaller than a word. Stressless pronouns are argued to be light clitics rather than prosodic words, and hence are affected by STRONGSTART.

(29) STRONGSTART: Prosodic constituents above the level of the word should not have at their left edge an immediate sub-constituent that is prosodically dependent [i.e. smaller than a word]. (Bennett et al. 2016:198).

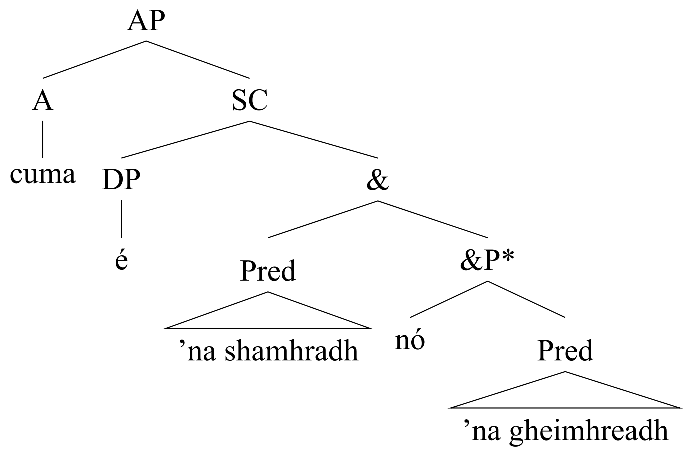
This notion of PF displacement captures the properties of pronoun postposing elegantly. Crucially, it introduces the idea that linearization is violable — the same insight on which Optimal Linearization is built. The particular implementation, however, assumes that the structure has already been ordered by PF; the authors are purposely vague about how this is arrived at, but propose a faithfulness constraint NOSHIFT penalizing deviations from the underlying order:[24]

(30) NOSHIFT: If a terminal element α is linearly ordered before a terminal element β in the syntactic representation of an expression E, then the phonological exponent of α should precede the phonological exponent of β in the phonological representation of E.
(Bennett et al. 2016:202)

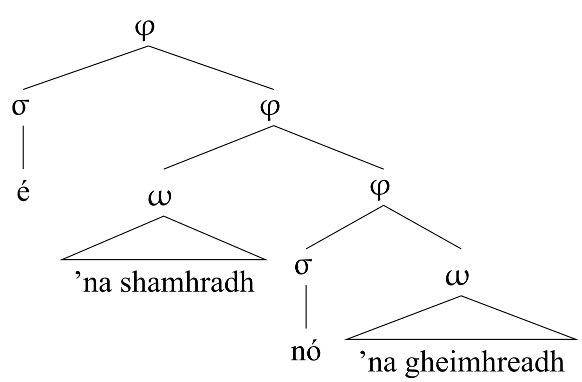
To illustrate how this enables them to account for pronoun shift, let's consider the schematized syntactic structure of (29) given by Bennett et al. The details of their prosodic analysis are beyond the scope of this paper, but the "faithful" prosody they predict is given in (32); the weak pronoun *é* winds up at the left edge of the phrase corresponding to the small clause.

[24]Clemens (2014, To appear) argues that a linearization constraint like NOSHIFT may not be necessary because the MATCH constraints have the effect of penalizing word orders that do not keep syntactic constituents contiguous in the surface string. (See section 6.2 for illustration of this property.) While this is sufficient to discriminate between the VOS / VSO word orders Clemens is concerned with, it isn't sufficient in the Irish case: One of the postposing orders (namely, total postposing to the right edge of the clause) does not interrupt the contiguity of any syntactic constituents. Thus, some linearization-specific constraint is necessary; as I'll show below, the Optimal Linearization ones fair somewhat better than NOSHIFT.

(31) Syntactic structure of (28) (Bennett et al. 2016:184):



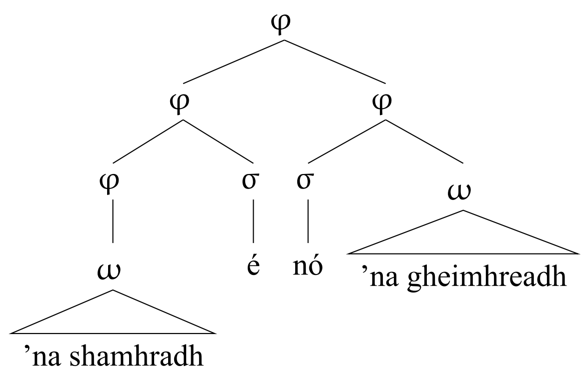
(32) Partial prosodic structure of (28) (Bennett et al. 2016:216):[25]



This structure, preferred by NOSHIFT and the other constraints enforcing prosodic phrasing, fares poorly with STRONGSTART: The highest phonological phrase has a sub-word element as its left-most daughter. If STRONGSTART dominates NOSHIFT, a postposing structure like (33), in which no φ begins with a σ, is preferred:

[25] In this and all prosodic structure examples, φ represents a phonological phrase, while ω represents a prosodic word. These are two of the commonly-assumed levels of the prosodic hierarchy (Ito & Mester 2012). In tableaux, I will use parentheses to represent prosodic phrasing, and will leave prosodic word status unmarked.

(33) STRONGSTART-respecting word order:

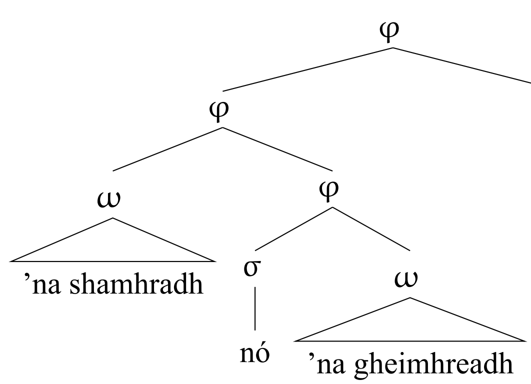


(34)

(31)	STRST	NOSHIFT
a. (é ('na shamhradh (nó 'na gheimhreadh))) = (32)	1	0
b. → ((('na shamhradh) é) (nó 'na gheimhreadh)) = (33)	0	1

This is the desired result. Bennett et al. acknowledge that there is another possible output, namely the one in which the pronoun is postposed all the way to the end of the clause; they note that, in general, the landing site of pronoun postposing can be arbitrarily far to the right, and that the different landing sites are in free variation. They state that their proposed analysis correctly predicts the alternative structure in (35):

(35) Alternative ordering of (28) (Bennett et al. 2016:218):



However, it is not clear from their proposal that this result is, in fact, predicted. The NOSHIFT constraint, as written, assigns additional violations for each pair of syntactic elements which get reordered. But what counts as a syntactic element? If the answer is “all syntactic terminals” or even “all XPs”, the result should be that additional violations will be assigned the further right the pronoun is displaced. Put another way, in the winning order of (34), the pronoun has only changed orders with the first predicate; in the order in (35) it has changed orders with the disjunction and the second predicate as well, and so NOSHIFT should assign additional violations. The result is that the candidate with minimal linear displacement should always win (modulo other prosodic factors); this is illustrated below.

(36)

(31)	STRST	NOSHIFT
a. (é (’na shamhradh (nó ’na gheimhreadh))) = (32)	1	0
b. → (((’na shamhradh) é) (nó ’na gheimhreadh)) = (33)	0	1
c. ((’na shamhradh) ((nó ’na gheimhreadh) é)) = (35)	0	3

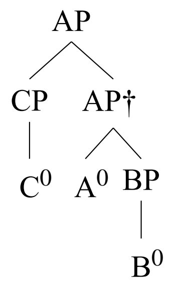
Empirically, this seems to be the wrong prediction in the Irish case, and in fact Bennett et al. never show more than one violation of NOSHIFT being assigned to any given candidate. The definition of NOSHIFT given is deliberately intended to cover a number of possible ways of arriving at the desired linearization; given this, we might understand Bennett et al. to be assuming some linearization scheme which assigns at most one violation for postposing this pronoun.[26]

Optimal Linearization is such a scheme. While Irish is generally head-initial and so should have ANTISYMMETRY $\gg$ HEADFINALITY, I’ve shown that the ordering of specifiers is controlled by HEADFINALITY. That constraint crucially assigns violations by counting branching nodes in the syntax which are not linearized head-finally, rather than by counting pairs of words. Take the simplified example in (37). HEADFINALITY will assign a single violation whenever AP is not linearized head-finally, i.e whenever *a or b* precedes *c*. No further violations are assigned as *c* is displaced rightward

[26]This is somewhat difficult to accomplish with a single constraint. The violable linearization scheme given in Bennett et al. 2016 is essentially a “string edit distance” function, i.e. a function that calculates how many changes would need to be made to one string of characters in order to produce another. In this system, some linearization (i.e. a string) is given by the syntax, and NOSHIFT scores each candidate on how “distant” it is from the target linearization. A distance function based on swapping characters in the string will always run into the problem described above: Every swap incurs additional penalties, and so there will always be pressure for extremely local displacement.

— the first two candidates each receive only one violation.

(37) a.



b.

(a)	HEADFINALITY
a. bac	1
b. bca	1
c. → cba	0

HEADFINALITY, then, is the tool with which to analyze the Irish postposing case: No additional violations are assigned as the pronoun is displaced further rightward. If both STRONGSTART and ANTISYMMETRY dominate HEADFINALITY, we achieve the correct result.

(38)

(31)	ANTISYM	STRST	HF
a. (é ('na shamhradh (nó 'na gheimhreadh))) = (32)	0	1	0
b. → ((('na shamhradh) é) (nó 'na gheimhreadh))= (33)	0	0	1
c. → (('na shamhradh) ((nó 'na gheimhreadh) é)) = (35)	0	0	1

Both of the winning candidates in (38) respect both STRONGSTART and ANTISYMMETRY. Both violate HEADFINALITY in that some element of the conjunction precedes the pronoun, but crucially they both violate this equally and so both emerge as winners. Thus, the Optimal Linearization constraints fare better than the plain NOSHIFT. More needs to be done to understand how these constraints interact with other prosodic faithfulness and markedness constraints (e.g. the MATCH constraints), but Optimal Linearization is at least compatible with PF displacement, and in at least this case is preferable to having a single "linearization faithfulness" constraint.

6. Conclusion

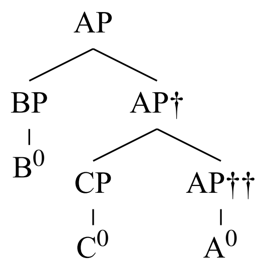
Optimal Linearization is the proposal that linearization is accomplished at PF by a set of violable constraints which make reference to the syntactic structure I've shown that this model is capable of making detailed predictions about word order typology; I've also shown that it gives new insight into the asymmetric positioning of specifiers, allowing us to understand it as an emergence of an unmarked preference for head-finality. Finally, I've shown that this approach allows us to account for cases of PF displacement and in fact fairs better than approaches based on a single word order faithfulness constraint.

6.1 Remaining issues

There is one notable aspect of linearization which has not been taken up here, namely the ordering of adjuncts. The constraints as presently defined will treat adjuncts identically to specifiers. For example, in (39), take CP to be some modifier phrase adjoined to AP. Similar to the specifier case, C^0 neither c-commands nor is c-commanded by any other head in this structure, and so ANTISYMMETRY is silent on its ordering; HEADFINALITY will prefer to order AP† head-finally, i.e. with $c < a$. Similar logic results in $b < c$. From this we can generalize that adjuncts will universally be linearized before their head but after the specifier, regardless of constraint ranking.[27]

[27] If multiple specifiers are present, this same logic will linearize them all on the left.

(39) a.



b.

(a)	ANTISYM	HEADFINALITY
a. abc	0	2
b. bac	0	1
c. → bca	0	0
d. cba	0	1
e. cab	0	1
f. acb	0	2

This is not a desirable result, insofar as right-adjunction is quite common. Perhaps more interestingly, adjuncts are known to be extremely variable in their distribution (Ernst 2001), both across and within specific kinds of adjuncts. Untangling this complex distribution will require other factors beyond the three constraints presented here. In some cases, the complex distribution of adjuncts has been taken to reflect more complex syntactic structure (as in e.g. Cinque 1999). In other cases, it seems that the syntactic (or possibly prosodic) weight controls whether adjuncts are on the left or the right of their head, as in English examples like *a big dog* vs. *a dog bigger than me*. Sheehan 2017 presents evidence that the positioning of adjuncts is, in fact, subject to the FOFC, so the constraints presented here still have a role to play in any analysis of their distribution, but considerably more refined tools will be needed.

There is an important aspect of the FOFC that these constraints do not capture: It only applies within certain domains. For example, German DPs appear to be head-initial, even though they are often contained inside the head-final TP; more generally, DP-internal ordering and the ordering of elements in the clausal spine seem to be independent of one another as far as the FOFC is concerned. Biberauer et al. 2014 codifies this by restricting the FOFC to looking at heads within one Extended Projection (Grimshaw 1991). Optimal Linearization is certainly compatible with such a notion; one possible analysis would involve a stringent version of HEADFINALITY that is relativized not to some node but rather to an entire Extended Projection — for instance, in the case of German, one that examined only nodes in the verbal EP. There's also another possible explanation: Perhaps linearization proceeds by phase (as in e.g. Fox & Pesetsky 2005), with the possibility that the linearization constraints are ranked differently for the DP-phase and the CP-phase. Adapting Optimal Linearization to such a model will require careful thought about the nature of phases, phase edges, and the candidates. Dobashi 2009 considers the "assembly problem" inherent in linearization by phase and develops a model in which the output of spelling out each phase is a prosodic object; we might imagine that something like Optimal Linearization is at work at each phase in such a model.

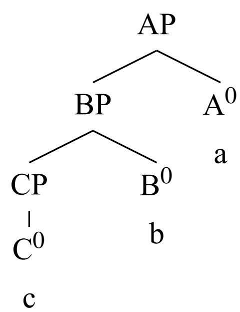
As noted in the introduction, while the FOFC is at least a very strong statistical trend, there are possible counterexamples. One benefit of modelling the FOFC using a violable constraints is that exceptions are expected: If some markedness constraint dominates ANTISYMMETRY, for example, it might force the appearance of a final-over-initial structure. This predicts that exceptions to the FOFC will fall into natural classes that may be independently argued to be marked. For example, consider the oft-cited class of sentence-final particles (SFPs), functional elements which appear at the right edge of the clause; some specific examples include question particles in Mandarin and elsewhere, or sentence-final negation. We've already seen one possible way in which these particles might be marked: If it is true that these particles are prosodically light, then the constraint STRONGSTART would penalize linearizing them in a head-initial fashion, triggering prosodic displacement parallel to the Irish pronoun case discussed above. Clearly further research is needed to determine both whether this is in fact a viable analysis for all SFPs and whether other exceptions to the FOFC also fall into cross-linguistically marked natural classes.

6.2 Optimal Linearization and MATCH

As we've just seen, Optimal Linearization, by virtue of using violable constraints, allows for the possibility that markedness constraints may drive deviations from more standard linearizations. This includes the possibility that syntactic constituents may be non-contiguous in the surface representation.

The MATCH constraints, as commonly defined, have the side-effect of opposing discontiguous linearizations of syntactic structures. For example, in (40) MATCH-XP will prefers linearizations that keep *b* & *c* contiguous: MATCH-XP prefers candidates in which there is a prosodic constituent containing both and only *b* & *c*, and if they are discontiguous no such constituent can exist.

(40) a.



b.

(a)	MATCH-XP	MATCH-φ
a. (((*c*) *b*) *a*)	0	0
b. (*b* *a* (*c*))	1	0
c. ((*b*) *a* (*c*))	1	1

There's another interesting interaction between MATCH and linearization, here. Let's say that some markedness constraint prefers the order *bac*, such that BP is discontiguous. In this case, MATCH-XP will not be able to match BP, and MATCH-φ (which penalizes 'unnecessary' prosodic structures which don't match a prosodic constituent) opposes the creation of a prosodic constituent for BP at all. In general, prosodic displacement destroys prosodic structure. This may not always be empirically correct — it might be possible to 'partially' match a constituent.

The problem here is that the MATCH constraints are categorical; matching is all-or-nothing. But it's possible to imagine similar constraints that are gradient. For such a constraint, a prosodic constituent containing only *b* in (40) would match BP *less well*, but would still match it. One way to implement this is discussed by Ito & Mester 2018: Instead of Match Theory, they propose Syntax-Prosody Correspondence in the sense of McCarthy & Prince 1995. In that system, each candidate comes with an arbitrary relation between syntactic objects and prosodic objects, meaning that a syntactic object and a prosodic one can be in correspondence even without containing exactly the same material. An independent constraint then enforces similarity between objects that are in correspondence, and can do so in a gradient fashion — for instance, scoring more constraints for each syntactic terminal not contained in the prosodic constituent. Insofar as Optimal Linearization allows for the possibility of prosodic displacement, it seems more compatible with this more flexible model.

6.3 Summary

This is far from the first time that PF constraints have been proposed which make reference to the syntax. There is a large family of "prosodic faithfulness" constraints which enforce correspondence between syntactic and prosodic structures. For example, the MATCH constraints (Selkirk 2011) ensure that syntactic constituents are matched by prosodic constituents that dominate the same set of terminal nodes. These constraints must have access to the syntactic structure, and in fact must even have access to the labelling of syntactic nodes in order to distinguish words, phrases, and clauses. Similarly, Clemens 2014 proposes the constraint ARG-φ, which penalizes prosodic structures in which heads and their arguments are not phrased together; this constraint needs access to selection relations.

The Optimal Linearization constraints fit this pattern: They use c-command, dominance, and labelling to choose between differently-ordered candidates. In so doing, they accomplish three main things. First, it captures the same empirical facts about linearization that are encoded in the classical Headedness Parameter, but does so using a constraint-based model consistent with how other PF-branch phenomena are treated. This frees us from having to stipulate properties like the placement of specifiers, instead allowing these properties to emerge from constraint interactions. Second, Optimal Linearization additionally allows for the disharmonic orders consistent with the FOFC without needing to stipulate any new syntactic principles — we can build syntactic trees exactly as before while still deriving the correct orders. And finally, Optimal Linearization provides a model for interactions between linearization and phonological or prosodic markedness that, in at least some cases, fits the empirical data better than a single word-order faithfulness constraint does.

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