

# The formal properties of phonological precedence

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Conference on Precedence Relations

## 1. Introduction

My aim is to examine some basic assumptions about the phonological relation ‘precedence’. I aim to ask “What sort of relation is it?” in the sense of “What are its formal properties?” In particular, I’m going to explore the possibility that the phonological precedence relation is intransitive.

The standard view, by the way, is that precedence relations are transitive. So, in a string like [kæt], there is overt encoding of precedence relations not only of  $k < \text{æ}$  and  $\text{æ} < t$ , but also  $k < t$ .

The standard view follows from equating precedence with temporal order. In a temporal order,  $k$  certainly does precede  $t$ ; total orders are transitive. However, the phonological precedence relation is abstract – it doesn’t encode temporal order, but rather is *interpreted* as temporal order in the phonetic component. So, the phonological precedence relation doesn’t have to have the same formal properties as temporal order; it simply has to be convertible into such an order.

An *intransitive* phonological precedence relation effectively encodes *immediate precedence*. An intransitive, asymmetric, irreflexive relation would encode [kæt] as  $k < \text{æ}$ ,  $\text{æ} < t$ ; there’s no need for  $k < t$ .

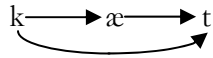
The first issue I’m going to deal with is ‘how is this possible?’ How can the phonological precedence relation be intransitive, but get converted into a transitive relation later on, in the phonetic component?

The second issue is “Why is this a good idea?” I’m going to argue that constraint form favors intransitive precedence.

Finally, I’m going to look at some challenges for the proposal, and some ways to overcome them.

I’m not going to deal with every facet and implication of this proposal here today – there’s simply not enough time. However, the handout contains other points of interest, such as the lexicon and morpho-phonology. I’ve written a commentary on these sections, which is available online, and you’re welcome to ask me about them in the question period.

[2 mins]

- (1) *General enterprise*
- What are the formal properties of phonological relations?
- (2) *Issue*
- Is phonological precedence *immediate* precedence or not?
- Slightly more technical:  
Is the phonological precedence relation *intransitive* (i.e. immediate precedence) or is it *transitive* with an additional notion of adjacency?
  - Immediate precedence is *less powerful* than transitive precedence.
- (3) *Proposal in brief*
- That the phonological precedence relation ( $P^<$ ) encodes *immediate* precedence.
- (4) *What is 'phonological precedence' ?*
- A relation that holds in the phonological module between autosegments on the same tier.
  - In the phonetic module,  $P^<$  is *translated* into a phonetic relation, which (ultimately) is realized as temporal ordering of articulatory gestures (or acoustic events).
- (5) *Expected view*
- $P^<$  does not directly encode temporal precedence (the phonetic relation it's translated into does that).
  - Even so, the assumption is that it has the formal properties of a precedence relation:
    - (a) *Irreflexive*: it's never the case that  $xP^<x$
    - (b) *Asymmetric*: if  $xP^<y$ , then it's not the case that  $yP^<x$
    - (c) *Transitive*: if  $xP^<y$  and  $yP^<z$ , then  $xP^<z$
- (6) *Why assume?*
- Ultimately the  $P^<$  relation must be translated into temporal precedence. Temporal precedence results in a linear order – it is connected and strict (i.e. irreflexive, asymmetric, transitive).
- The minimal assumption is that nothing special happens to  $P^<$  on its way to being translated into temporal precedence. Therefore,  $P^<$  is assumed to be a strict linear order.
  - Temporal precedence:
    - if  $k$  precedes  $a$ , then  $a$  can't precede  $k$ .
    - if  $k$  precedes  $a$ , and  $a$  precedes  $t$ , then  $k$  precedes  $t$
    - $k$  cannot precede itself.
- (7) *Example of expected view*
- /kæt/       $\{kP^<a, kP^<t, aP^<t\}$
- Note: no  $kP^<k$ ; no  $aP^<k$
- 
- A note on abbreviation:

$P^<$  holds between root nodes, which formally must be members of a denumerably infinite set of discrete elements (like Natural numbers). Here, I use ‘ $k$ ’, ‘ $\alpha$ ’, ‘ $t$ ’ to refer to the discrete elements that are associated to the features for [k], [æ], [t]: i.e.  $\{1P^<2, 1P^<3, 2P^<3\}$  and  $\{1A[k], 2A[\alpha], 3A[t]\}$ , where  $A$  is the association relation.)

- (8) *Alternative proposal*  
 $P^<$  is irreflexive and asymmetric, but is *intransitive*  
 (and therefore not strictly connected).
- (9) *Implications in brief*  
 (a) Accounts for significant gaps in constraint/rule types.  
 (b) Accounts for significant gaps in types of lexical items.  
 (c) Requires different approach to  $P^<$  preservation.

## 2. Implementation

Let’s take an example like the English string ‘cat’. With an intransitive precedence relation, it would look as in (10).  $k < \alpha$ ,  $\alpha < t$ . Crucially, there is no  $k < t$ . So, how is this phonological output translated into phonetic temporal order, which is transitive?

- (10) *Intransitively ordered [kat]*  
 $\{kP^<\alpha, \alpha P^<t\}$ ; crucially there is no  $\{kP^<t\}$   
 • How is such an output translated into phonetic/temporal order?

We need interpretive principles like those in (11). Each phonological precedence relation is converted into a phonetic one, then the ‘fix-up’ principles are applied to impose additional relations. The imposition of additional relations converts the intransitive relation into a transitive one.

This is straightforward and possible because, in most cases, intransitive, asymmetric, irreflexive relations are a subset of *transitive, asymmetric, irreflexive* ones.

- (11) *Interpretive principles (< is the phonetic ordering relation)<sup>1</sup>*  
 • If  $xP^<y$  then  $x < y$  (basic conversion)  
 (a) If  $x < y$  and  $y < z$  then  $x < z$  (imposition of transitivity)  
 (b) If  $x < y$  then  $\neg(y < x)$  ((re)imposition of asymmetry)

However, there are intransitive relation sets that cannot be translated into transitive ones. An example is in (12). (12) is perfectly fine with an intransitive precedence relation, but it has a problem when one tries to convert it to a transitive one. Note that there is a

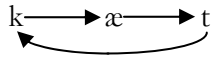
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<sup>1</sup> Connectedness also needs to be imposed: For all  $x, y$ ,  $x < y$  or  $y < x$ . This may be imposed on the *phonological* relation, at either input or output, or the phonetic relation. Different levels of imposition have different consequences.

phonological precedence relation between t and k. This isn't ruled out by the formal restrictions on the relation itself because it's still intransitive, locally asymmetric, irreflexive. However, the problem with translating this into a transitive relation becomes immediately apparent. (11a) imposes transitivity, so that  $k < a$  and  $a < t$  means that  $k < t$ , but t already  $< k$ , so violating (11b) – rendering the set not asymmetric.

(12) *Problem with intransitivity*

- Without transitivity, an output could 'curl back' (i.e. a non-terminating order)<sup>2</sup>



- Here,  $kP^<aP^<tPk(P^<aP^<t\dots)$
- This output crashes when it's  $P^<$  relation is converted into a linear order:  
i.e. (11a) introduces the relation  $k < t$ , so the relation is no longer asymmetric (11b) because  $t < k$ .

However, cases like (12) don't actually matter. What *does* matter is that the phonological Generator is capable of making *some* outputs whose phonological precedence relations can be translated into phonetic precedence. As long as *some* are made, some derivations will work. Of course, this general approach – relying on interface uninterpretability to rule out problematic forms – is a centerpiece of Minimalism. It is also important in phonological theories other than OT. In fact, although 'crash' and uninterpretability receives very little discussion in OT, it's no less important, as I've argued elsewhere.

To summarize, intransitive phonological precedence relation configurations that cannot be translated into transitive phonetic ones will 'crash' at the phonetic interface. This crash may spell doom for the derivation, or in OT it may mean that the 'next best' winner will be chosen, until one with a translatable precedence relation is found, as I've argued in other work.

So, having an intransitive phonological precedence relation does not pose formal problems. It's consistent with current views about how grammar works.

[5 mins]

<sup>2</sup> See Raimy (2000) for use of such an order. Raimy proposes that such an ordering relation can be transitional in the derivation, and triggers a particular repair (reduplication). But no such 'curling back' order exists in phonological outputs.

- (13) *Legibility, or why it doesn't matter*
- Intransitivity allows for outputs with potentially fatal  $P^<$  orderings – i.e.  $P^<$  orderings that cannot be translated into temporal order.
  - However, it does not *disallow* outputs with interpretable  $P^<$  orderings. For example, the output  $\{k < \text{æ}, \text{æ} < t\}$  can be generated, and it is unambiguously translatable into a linear order  $\{k < \text{æ}, \text{æ} < t\}$ .
  - So, the problem really is: what happens to outputs that somehow end up with a ‘contradiction’ (e.g. a temporal curling-back or disconnectedness)?
    - $A_1$ : Crash/Derivation failure. Such outputs are illegible at the Phonology-Phonetics interface (after most work in rule-based derivational theories).
    - $A_2$ : Elimination. Such outputs are rejected at the Phonology-Phonetics interface; the ‘next best’ output is taken (de Lacy to appear).
  - In short, because of crash/elimination, it doesn't matter if *some* phonological outputs fail. As long as *some* are phonetically legible, the grammar will work.

### 3. Evidence

In section 3:

So, what extra mileage will an intransitive phonological precedence relation get us compared to a transitive one? In what way will it explain startling gaps? There are two places to look: rules/constraints, and the lexicon. I'm going to focus on constraints here. The lexicon is mentioned later on in the handout, but we won't have time to cover it.

- (14) *Places to look*
- Two places to look for evidence for the formal properties of relations:
- The lexicon
  - Constraints/rules

A typical syntagmatic constraint is schematized in (15). The ubiquitous  $*xy$ . This constraint means “incur a violation for all  $x$ 's that immediately precede a  $y$ ”. There are lots of well-known examples of constraints like this, like Joe Pater's  $*NC_\sigma$ , but also constraints on local assimilation and dissimilation, on sonority sequences (like syllable contact), feature co-occurrence constraints; the list goes on. For segmental restrictions, this sort of constraint is common.

How do we formally express these constraints?

With an intransitive precedence relation, it's straightforward.  $*xy$  is  $*xP^<y$ .

With a transitive precedence relation, it's less straightforward.  $*xP^<y$  will not only ban  $[xy]$  sequences, but all strings in which  $x$  precedes  $y$ , regardless of what stands between: i.e.  $[xay]$ ,  $[xaby]$ ,  $[xabcy]$ , etc. An additional relation is needed: adjacency. So,  $*xy$  is  $*\{xP^<y, xAy\}$ . If a negation operator is allowed in our constraint definition system (and it's not obvious that it should be!), we could reduce the adjacency relation as in the bottom of (15).

However, let's suppose there are two phonologically primitive relations 'precedence' and 'adjacency', for the moment.

- (15) A typical constraint:  $*xy$ :  $x$  *immediately precedes*  $y$ . ( $x$  precedes  $y$  and  $x$  is adjacent to  $y$ ).
- With intransitive precedence:  $*\{xP^<y\}$  “ $x$  must not immediately precede  $y$ ”
  - With transitive precedence:  $*\{xP^<y, xAy\}$ , “ $x$  must not both precede and be adjacent to  $y$ .”
    - $A$  is the adjacency relation.
    - The alternative, define ‘immediately precede’ through negation:  
 $xP^<y$  and there is no  $z$  s.t.  $xP^<z$  and  $zP^<y$ )

The interesting aspect of constraints is what we don't get. If phonological precedence is transitive, why don't we have constraints that are simply like (16a)? This constraint bans  $x$  before  $y$ , with no specification of adjacency. It's a true ‘long-distance’ constraint: one that bans not only  $xy$ , but also  $xay$ ,  $xaby$ ,  $xabcy$ , and so on ad infinitum.

Similarly, there's no evidence for ‘mirror-image’ constraints like  $*xAy$ , which simply requires  $x$  and  $y$  to be adjacent. The constraint in (16b) therefore says don't have  $xy$  or  $yx$ .

To ban such constraints we'd need special restrictions in CON that ensured that constraints could only mention *contiguous* strings. In contrast, an intransitive precedence relation directly encodes immediate precedence. If  $x$  *intransitively precedes*  $y$ , then  $x$  is necessarily adjacent to  $y$ . Consequently, there is simply no way to define a constraint  $*xP^<y$  where  $x$  is not adjacent to  $y$ . Similarly, there is no overt adjacency relation with intransitive precedence, so no constraints with the form  $*xAy$ .

Consequently, having intransitive precedence instead of transitive precedence explains why there are massive gaps in constraint and rule types.

- (16) *Non-existing constraints*
- (a) Long distance:  
 $*xP^<y$                     “ $x$  must not precede  $y$ ;  $x$  is not necessarily adjacent to  $y$ .”
- (b) Mirror-image:  
 $*xAy$                       “ $x$  is adjacent to  $y$ ; no precedence implied.”

[ 8 mins]

### 3.1 Long distance constraints

The problem with this argument is that many people *have* talked about ‘long distance’ processes, and even mirror-image rules. So, let's examine the claim that there are no long-distance constraints of the form  $*xP^<y$ , where  $x$  is not necessarily adjacent to  $y$ .

- (17) *Assuming transitive phonological precedence, why don't we get constraints of the form*  
 $*\{xP^<y\}$  “ $x$  must not precede  $y$  ( $x$  and  $y$  aren't necessarily adjacent)”  
 (rule equivalent:  $x \rightarrow z / \_ w_0 y$ , where  $w_0$  is any number of segments.)

An example is given in (18).

- (18) *A pathological constraint*  
 $*NP^{\leq}C$  [anta], [anuta], [anulat], [nadalowap],  
 cf. [atna], [tana], etc. etc.

One issue that arises here is what motivation there is for a long-distance precedence constraint. There's some discussion in (19) in that regard. I'm not going to dwell on it here. After all, apparent long-distance processes are common.

- (19) *Functional plausibility?*<sup>3</sup>
- Strict formalist viewpoint: such constraints could exist because they're formally definable.
  - Functional motivation: Perhaps  $*xP^{\leq}y$  constraints don't exist because there's no functional motivation for them?  
 Argument: if there were some perceptual benefit to having two segments  $x,y$  in a word no matter where they were.
    - Onnis et al. (2005): improved segmentation performance if a word begins with a plosive *and* there's a phonological similarity between the first and third segment.
    - More generally: infants are aware early on of non-adjacent dependencies (for syntax; may indicate understanding of hierarchical structure).
    - Generally, it's not clear how aware learners are of non-adjacent dependencies.

One might object that *of course* we get constraints of the form  $*xP^{\leq}y$  without implied adjacency: we get them in vowel and consonant harmony.

More precisely, why can't we say that rounding harmony is motivated by a constraint  $*\nabla^{\alpha_{\text{ROUND}}}\text{p}^{\leq}\nabla^{-\alpha_{\text{ROUND}}}$ , with transitive precedence? Well, the problem is iterativity. Harmony is fundamentally iterative. The feature specification of vowel  $n$  depends on the value for vowel  $n-1$ , not vowel  $n-2$  or vowel #1.

This is clear in blocking. As is well known, in some languages certain segments or positions can block harmony from applying. For the input /putati/, [a] might block rounding

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<sup>3</sup> From a strict formalist point of view, such constraints could in principle exist because they're formally definable. From a functionalist point of view, one might wonder whether such long-distance constraints could ever be motivated by performance mechanisms. Well, there are undeniable long-distance dependencies in phonology, as in harmony and dissimilation. So we know that non-adjacent segments can affect each other. There is also a little perceptual work that suggests some effects over long distances. Onnis et al. (2005) showed that segmentation performance improved if a word begins with a plosive *and* there's a phonological similarity between the first and third segments, which, by the way, were consonants. While it's generally unclear how well learners are aware of non-adjacent relationships between segments, they are at least aware of some.

harmony, ending up with [putati] instead of \*[putaty]. In such cases, it's clear that the value of the final vowel is fully dependent *on the preceding vowel*.

This concept of local dependency is lost in a constraint like  $*V^{\alpha\text{ROUND}}P < V^{-\alpha\text{ROUND}}$  – it's truly long distance. The effect is a lot of bizarre problems.

Let's take blocking. Recent analyses of blocking, like McCarthy's span theory approach, say that blocking is the initiation of a new harmony domain. So in [putati], the [a] is blocked for independent reasons from harmonizing with the [u], and [a] initiates a new [-round] harmony domain. Can a constraint like  $*V^{\alpha\text{ROUND}}P < V^{-\alpha\text{ROUND}}$  capture anything like this idea? No. The competitor [putati] incurs two violations of  $*V^{\alpha\text{ROUND}}P < V^{-\alpha\text{ROUND}}$ :  $u < a$ ;  $u < i$ . Its competitor \*[putaty] incurs two violations, too:  $u < a$ ,  $a < y$ . At this point, other non-harmony markedness constraints would *have to* step in to choose the winner: but this eventuality is undesirable because the final vowel's round feature is supposed to agree with the preceding one's.

The problem is compounded when more specific constraints are used. For example  $*V^{+\text{ROUND}}P < V^{-\text{ROUND}}$  *always* favors more globally harmonizing strings, so blocking is simply impossible: all blockers end up being transparent.

(20) *Long-distance effects: Vowel harmony*

Q: Can't harmony be expressed as  $*X^{\alpha\Gamma}P < X^{-\alpha\Gamma}$ ?

A: No. Harmony is fundamentally iterative:  $X_n$  depends on  $X_{n-1}$ , not on  $X_{n-2}$  or  $X_1$ , etc. In contrast,  $*V^{\alpha\Gamma}P < V^{-\alpha\Gamma}$  is fundamentally non-iterative – truly long-distance.

- *Blocking*

Suppose [a] blocks round harmony: [putati] cf. \*[putaty].

How could this be captured with a true long-distance precedence constraint?

- *Iterativity in blocking*

The reason that blocking occurs is because  $V_3$  can't ignore  $V_2$ 's feature specification (i.e. 'iterativity'): i.e. in \*[putaty], [y] can't ignore the fact that there's a [-round] [a] between it and [u].

- *Bizarre effect #1*

$*V^{\alpha\text{ROUND}}P < V^{-\alpha\text{ROUND}}$

[putati] = 2; [putaty] = 2!

[putatite] = 3; [putatyte] = 3!; [putatyte] = 3!

- *Bizarre effect #2*

$*V^{+\text{ROUND}}P < V^{-\text{ROUND}}$

[putati] = 2; [putaty] = 1 = always wins.

[putatite] = 3; [putatyte] = 3; [putatite] = 3; [putatyte] = 1.

- *Alternatives*

Gafos (1996) argues that all vowel harmony is local. Formally motivated by constraints of the  $\{x^{\alpha_F}P^<y^{-\alpha_F}, xAy\}$  sort.

So, there's an inherent iterativity in harmony. Theoretical proposals have always emphasized this, from McCarthy's V-C planar segregation approaches, to Gafos' (1996) local harmony approaches. More recently, Rose & Walker avoid the issue by invoking long-distance correspondence relations; their constraints don't mention precedence relations.

(21) *Long-distance effects: Consonant harmony*

Argued by Rose & Walker (2000) and others that long-distance C harmony is agreement through non-local correspondence relations.

- No constraints of the  $xP^<y$  type.

Well, what about dissimilation, could dissimilation be motivated by a constraint like  $*xP^<x$ , where  $x$  refers to the same segment type? While Suzuki (1998) seems to advocate just such a constraint, Alderete (1997) and Ito & Mester (1996) argue that dissimilation is instead about trying to minimize the number of segment types in a domain. Struijke (2001) makes the same point in a different way: dissimilation is what happens when only one feature value is allowed to be faithfully preserved in a particular domain. None of their approaches has constraints that refer to a long-distance precedence relation.

(22) *Dissimilation*

- *Not*  $*xP^<y$ , but rather  $*xP^<x$ .

- Suzuki (1998) seems to advocate a constraint of this type:

$*X\dots X$

- General approach: avoidance a domain that contains more than one  $x$ .
- Alderete (1997?): local conjunction within a domain:  $*[x\&x]_{\text{DOMAIN}}$
- Struijke (2001): preservation of just one feature value within a domain; neutralization of others.
- In blocking cases, it's clear that  $*X\dots X$  means  $\{X$  followed by the next available X-like element). e.g. Latin /l...l/  $\rightarrow$  [l...r]: /nav-alis/  $\rightarrow$  [navalis]; /sol-alis/  $\rightarrow$  [solaris]; /litor-alis/  $\rightarrow$  [litoralis], \*[litoraris]; cf. /vulgar-iter/  $\rightarrow$  [vulgariter], \*[vulgaliter]. (Also Akkadian:  $-m$  dissimilation is blocked by intervening round vocoids).

So, 'long-distance' effects in phonology are not truly long-distance. They're either local /iterative effects, or minimization of types in a domain. There's no evidence for a constraint of the form  $*XP^<Y$ , where X and Y are not adjacent.

[12½ mins]

### 3.2 Mirror image constraints/rules

If there is a separate adjacency relation, then we could also ask why we don't get constraints of the form  $*xAy$ , that ban both  $xy$  and  $yx$ .

(23) Is adjacency separate?

Not necessarily?

$x < y$  and there is no  $z$  s.t.  $x < z < y$

or see adjacency as a primitive:  $xAy = x < y$  *or*  $y < x$

- (24) A mirror image rule:  $x \rightarrow y / \underline{z}$  or  $\underline{z} (x \rightarrow y / \underline{z} \% \_)$  (Anderson 1974, Bach 1968:4.)

This issue has come up before – a while ago. Anderson and Bach, among others, argued that such mirror-image rules are useful. The rules essentially said  $xAz \rightarrow yAz$ . However, the arguments were primarily from rule-simplification as a part of the evaluation metric. In OT at least, the evaluation metric through rule or constraint simplification isn't of concern any more.

- (25) Mirror-image rules were proposed primarily to allow rule simplification. Rule simplification allowed a different calculation for the evaluation metric.
- A mirror image rule like  $x \rightarrow y / \underline{z} \% \_)$  could be the interaction of two rules  $x \rightarrow y / \underline{z}$  and  $x \rightarrow y / \underline{z}$ .
  - In OT, there's no evaluation metric that is measured in terms of the number of symbols in the rule component. So,  $*xAy$  could be  $*xP^<y$  and  $*yP^<x$  together.
  - A convincing mirror-image rule would be one in which a constraint  $*xAy$  is motivated, but not  $*xP^<y$  and  $yP^<x$ .

When apparent mirror-image rules are looked at carefully, there's often a directional bias. For example, Anderson's example of Faroese has homorganic glide epenthesis between vowels. The glide epenthesizes only when there's a high vowel available, and the glide copies that high vowel. The high vowel can be left or right of the epenthesis target site. However, directional bias is evident when the target site is flanked by two high vowels. In this case, the leftmost one wins, as in [si:jur], not \*[si:ɥur]. So, there's still need for a separate rule involving precedence.

- (26) *Faroese* (Anderson 1972)
- $\emptyset \rightarrow \text{glide}^{[\text{around}]} / \mathbf{V}^{\text{HIGH,around}} \% \_)$   
 e.g. [si:jur] 'custom', [mæawur] 'man'
- But when there's a choice: copy from the left.
- $\emptyset \rightarrow \text{glide}^{[\text{around}]} / \mathbf{V}^{\text{HIGH,around}} \underline{\quad}$   
 $\emptyset \rightarrow \text{glide}^{[\text{around}]} / \underline{\quad} \mathbf{V}^{\text{HIGH,around}}$

In general terms, to show that there are constraints of the  $*xAy$  type, it's necessary to show that there are no constraints  $*xP^<y$  and  $*yP^<x$ . For example, if it was always true that absence of [t] implied absence of [l] and vice-versa, then there's evidence for  $*tAl$ . Otherwise, not. There's no evidence that I'm aware of for a constraint or rule that necessarily uses adjacency rather than precedence in its definition.

[ 14½ mins]

- (27) *What's a true mirror-image rule?*  
 → If  $*_{xy}$  then  $*_{yx}$ .  
 e.g. if  $*_{tl}$  then  $*_{lt}$  (cf English)  
 • Sonority distance effects: clearly separable (Gouskova 2001?)
- (28) *The coda mirror (Scheer 2001, and other publications)*  
 • If  $x$  is allowed  $\{\#,C\}_-$ , then it is also allowed  $_{\{\#,C\}}$   
 • More accurately, the coda mirror defines environments for the application of particular processes, not phonotactic environments.

#### 4. Challenges

So far, it looks like having an intransitive phonological precedence relation – in other words, immediate precedence – is a good thing: it explains why we don't get certain constraint or rule types.

However, it faces some major challenges. The challenges are so major that they may be crippling. Let's take a look at them in section 4.

One major challenge comes from processes that affect segment count. For example, take a string  $/xyz/$  and delete  $/y/$ . The disturbing thing here is that the candidates  $[xz]$  and  $[zx]$  are equally faithful in terms of precedence relations. Why? Because if precedence is intransitive, then in  $/xyz/$  there is no  $xP^<z$  relation. In  $[xz]$ , neither of the underlying precedence relationships still exist, and neither do they in  $[zx]$ , so we have equal precedence faithfulness. Informally put, if the middle of a string is deleted, there should be nothing to stop the two halves metathesizing, depending on the whims of markedness.

The same problem arises with epenthesis. Take underlying  $/xyʒ/$  and epenthesize  $w$ . Both candidates  $[xwʒ]$  and  $[ʒwx]$  are equally faithful in terms of precedence. Argh. Metathesis has the same sort of problem: underlying  $/xyʒ/$  means that  $[xʒy]$  and  $[ʒyx]$  are equally faithful, precedence-wise.

- (29) *Challenges: Loss of order*  
 • What happens if the string is disturbed in the output?  
 $/xP^<y, yP^<ʒ/$  → delete  $y$ :  $[xP^<ʒ]$ ,  $[ʒP^<x]$  are equally faithful.  
 $/xP^<ʒ/$  → epenthesize  $w$ :  $[xwʒ]$ ,  $[ʒwx]$  are equally faithful.  
 $/xyʒ/$  → metathesis  $[xʒy]$ ,  $[ʒyx]$  are equally faithful  
 (cf transitive precedence:  
 $/xP^<y, yP^<ʒ, xP^<ʒ/$  → delete  $y$   $[xP^<ʒ]$ , cf.  $[ʒP^<x]$  is less faithful.)

Note that transitive precedence has no such problem. In  $/xyʒ/$ ,  $x$  precedes  $ʒ$ , so deletion to  $[xz]$  still preserves that relation.

Is there any way to save intransitive precedence?

Well, yes. It's to propose that GEN is unable to literally delete or epenthesize anything. This proposal is of course, not new (P&S 1993/2003 containment model). However, theories that adopted this proposal conceived of deletion as unassociated segments and epenthesis as empty prosodic positions. These ideas are not tenable any more, given recent advances. So, the alternative is to say that *all deletion is coalescence*, and *all epenthesis is split* (also called *breaking*).

To give an example, take the underlying string  $/xy\zeta/$ .  $/xy/$  coalesce to form  $x$ . The candidate  $[x_{1,2}\zeta]$  preserves the underlying precedence relation between  $/y\zeta/$ . In contrast, the candidate  $[\zeta x_{1,2}]$  does not preserve any underlying precedence relation.

Strict and non-strict versions of precedence-faithfulness constraints can even be defined so as to allow deletion as coalescence, as in (30).

- (30) *Deletion: All deletion is coalescence*  
 $/x_1y_2\zeta_3/ \rightarrow [x_{1,2}\zeta_3]$   $2P^<3$  is preserved;  $1P^<2$  is not  
 $[\zeta_3w_{1,2}]$  neither  $2P^<3$  nor  $1P^<2$  is preserved
- LINEARITY-STRICT “If  $xP^<y$  in the input then  $x'P^<y'$  in the output.”
  - LINEARITY-NONSTRICT “If  $xP^<y$  in the input then  $x'P^<y'$  in the output unless  $x' \neq y'$ .”

Splitting would work in a similar way: in (31)  $/xz/ \rightarrow [xyz]$ , the underlying relation  $xP^<\zeta$  is preserved because one of  $x$ 's correspondents still immediately precedes  $\zeta$ 's correspondent.

- (31) *Epenthesis is splitting*  
 $/x_1\zeta_2/ \rightarrow [x_1y_1\zeta_2]$   $1<2$  is preserved

So, there's a way to slide out of the epenthesis and deletion problem. But doesn't it create a lot of concerns? For example, how can deletion be coalescence? Shouldn't the coalesced segment show features from both input segments?

Well, no. Nothing in the theory requires that the output segment of coalescence necessarily show features from both input segments. This is called ‘vacuous coalescence’, and is inescapable once complex cases of coalescence are examined.

The same goes for splitting. If a segment splits in two, or three, or whatever, shouldn't *all* the split segments have features from the underlying segment? Well, no again. Struijke (2001) argues that there are ‘existentially quantified’ faithfulness constraints that are satisfied when just one of a segment's output correspondent's bears its features. Consequently, as long as features show up in one input segment's output correspondent, the other is free to be unmarked. There remains the option for all features to be faithfully copied in all output correspondents, too.

- (32) *Problems?*  
 Q: How can deletion be coalescence? Shouldn't the coalesced segment show features from both segments?  
 A: No – vacuous coalescence.

Q: How can epenthesis be breaking? Shouldn't the broken segments have features from the underlying segment?

A: No: Struijke (2001):  $\exists \text{IDENT}[F]$  requires preservation of underlying features in only one location:  $/i/ \rightarrow [i]$ , or  $/i/ \rightarrow [ij]$  are both possible with split.

The big challenge would be a case where there is a choice between coalescence and deletion. How would such a case be handled if all deletion is coalescence?

(33) *HoP-HoT?*

Q: What about cases where there is a choice between coalescence and deletion?

A: Such choices are rare. Such cases could be analyzed as visible coalescence and vacuous coalescence.

An example is provided in (34). Here,  $/an/$  coalesces to form  $[\tilde{a}]$ , so clearly  $\text{IDENT}[\text{nasal}]$  is active. However,  $/am/$  becomes  $[a]$ , not  $[\tilde{a}]$  with nasalization. It's hard to see how the  $/am/ \rightarrow [a]$  case is *not* deletion here.

I mention this case because it looks eminently reasonable. I haven't found a case like this yet, though. There are cases where  $/n/$  coalesces and  $/m/$  is preserved, but I haven't found cases where  $/m/$  is visibly deleted.

In other cases, an apparent choice between deletion and coalescence might be analyzable as vacuous coalescence vs. visible coalescence, rather than coalescence vs. deletion. The same goes for epenthesis and split.

(34) *A hypothetical challenge*

(a)  $/an/ \rightarrow [\tilde{a}]$

(b)  $/am/ \rightarrow [a]$

(a) shows that  $[+\text{nasal}]$  is preserved and that coalescence takes place.

If deletion is coalescence, shouldn't  $/am/ \rightarrow [\tilde{a}]$ ?

Metathesis is another story entirely. The only viable way it could work is for two underlying segments to both split and coalesce at the same time. How horribly complicated. It's so complicated it's not obviously wrong. But it sure ain't obviously right.

[I'll now skip to section 5.]

[20 mins 40 secs]

(35) *Metathesis*

•  $/x_1y_2/ \rightarrow [x_{1,2}y_{1,2}]$  (simultaneous coalescence and split).

#### 4.1 The lexicon [*not covered in this talk*]

The other place to look for evidence about precedence and adjacency relations is the lexicon. Are there lexical items that use long-distance precedence relations, for example?

For example, what about the morpheme in (36) which specified  $p < a$  and  $p < i$ , but not  $a < i$  or  $i < a$ . For such a morpheme, the order of [a] and [i] would be driven by markedness concerns. Actually, this sort of morpheme looks quite good. It looks similar to Charles Reiss' Rotuman analysis from yesterday.

- (36) *If precedence is separate from adjacency, we could have precedence-underspecified lexical forms like /p < a, p < i/, where the order of [a] and [i] is left up to the grammar.*
- Stressed *á* is preferable to stressed *í*, so with a penultimate-stress language:  
[páí] cf. [piá-to].
  - This example looks reasonable: local metathesis brought about by stress-sonority constraints.
  - But it is not the *only* way to get such a change; metathesis could apply to forms with fully-specified input precedence relations.

The problem is that such 'metathetic' morphemes can become quite bizarre. For example, if a segment has no precedence relations to other segments, then it can float, as in (37a). If groups of segments are related, but not group-to-group, then entire strings of morphemes can float around depending on markedness. The same goes for weird metathesis like the iterative metathesis in (37b).

- (37) *Floating segments*
- (a) /p < i < k, a/ → 'floating segment' [apik], [paik], [piak], [pika].
  - (b) *String* metathesis /p < i, a < k/ → [piak] cf. [akpi]
  - (c) *Iterative* metathesis /p < k, a < i/ → [apik], [paki]
  - (d) *Long-distance* metathesis /a < f < i < t < o, p, k/ → [pafitok], [kafitop] (difference motivated by, e.g. local assimilation, dissimilation).

It seems that freedom to underspecify precedence relations in the input is dangerous. It allows a great deal of power that we don't see. One way to minimize this power is to put a restriction on GEN. Specifically, GEN cannot add precedence relations between different segments of the same morpheme. This principle rules out underspecified morphemes like those in (37): all of them require the addition of a precedence relation in the output.

- (38) *General*
- GEN cannot add precedence relations between different segments of the same morpheme.
- All the morphemes above involve introduction of a precedence relation between elements of the same morpheme.
  - Recall that if epenthesis is split, then /xy/ → [xwy] does not introduce a new precedence relation between w and z.

However, this principle can *only* apply to a theory that views epenthesis as split and deletion as coalescence. Otherwise, epenthesis can allow parts of morphemes to float around, as in /p < i, a < k/ → [piʔak] or [akipi].

The point here is that the lexicon is probably very restricted in terms of underspecification of precedence. The restrictions are probably so severe that it's impossible to see whether transitive or intransitive precedence is more correct here.

(39) *Separable adjacency*

Could we have /pʌæ/?

Comes out as [æp] or [pæ], depending on circumstances:

e.g. /t-pʌæ/ → [tæp], but /pʌæ-k/ → [pæk].

- With intransitive precedence, no: there's no adjacency relation.

#### 4.2 Morpho-phonology [*not covered in this talk*]

The final big challenge to intransitive precedence is morphemes that break up the internal order of another morpheme, like infixes and interfixes. If true epenthesis is bad for the underlying order of segments, what havoc would an infix wreak?

For example, in (40), if the infix /ab/ appears inside /xyz/, what distinguishes the competitor [yz-ab-x] from [z-ab-xy]? The infix effectively breaks up the underlying string, and the two broken parts can float around, influenced by the whims of markedness.

(40) *Infixes?*

/ab-xyz/ → [x-ab-yz] competes with [yz-ab-x], [z-ab-xy], etc.

The problem here can only be addressed by asking what morpheme concatenation is. Morpheme concatenation is the imposition of a precedence relation or relations between two morphs, with reference to morphological or syntactic structure.

Certainly, a translation principle is needed.

It's straightforward enough with both transitive and intransitive precedence.

With intransitive precedence, if  $M_1$  is supposed to precede  $M_2$  then we can literally impose an ordering between some element of  $M_1$  and one of  $M_2$ . Even if an epenthetic element intervenes, since all epenthetic elements are due to split, the epenthetic segment will belong to  $M_1$  or  $M_2$ .

This leads to another way to think about maintaining morph order. Define an M-Span as the contiguous string that minimally includes all members of that morpheme.

Then impose faithfulness constraints on the edges of the M-Span.

( $x$  is at the left edge of an M-Span if there is no  $y < x$  in the M-Span).

(41) *What is morphological precedence?*

- With transitive precedence:

If  $M_1$  'precedes' (asymmetrically c-commands, or whatever)  $M_2$ , then every member of  $M_1$  precedes every member of  $M_2$

- Introduce a precedence relation between the rightmost element of  $M_1$  and leftmost of  $M_2$  (effectively, concatenate the strings).

- With intransitive precedence  
If  $M_1$  precedes  $M_2$  then some member of  $M_1$  precedes some member of  $M_2$
- *M-span*  
A morpheme's M-span is the contiguous string that minimally includes all members of that morpheme.
- ANCHOR-LEFT-MSP If  $x$  is at the left edge of the M-Span in the input, then  $x'$  is at the left edge of the M-Span in the output.

For infixes, the result is to keep the parts of the root morpheme from metathesizing. So, [x] stays at the left edge in (42) because that's the only way to maintain it as the left of the M-Span.

- (42) *Infixes and M-Spans*
- |            |           |                  |
|------------|-----------|------------------|
| /ab-xyz/ → | [x-ab-yz] | ANCHOR-LEFT-MSP  |
|            | [yz-ab-x] | *ANCHOR-LEFT-MSP |
|            | [z-ab-xy] | *ANCHOR-LEFT-MSP |

As fun as this might seem, it gets worrying with transfixes. In a transfix – as in root-and-pattern morphology. However, /ia-kbt/ comes out as [kibat], happily. And no other form is possible that *also* preserves the left and right edges of morphemes.

- (43) *Transfixes*
- /ia-kbt/ → [kibat]
- ANCHOR-LEFT-MSP bans transposition of the vowels.
  - ANCHOR-LEFT-MSP bans everything but [kibat]~[kitab]
  - ANCHOR-RIGHT-MSP bans [kitab].
  - Only [kibat] is possible.

The theory here makes an interesting prediction. It won't be able to handle cases where there are more than 2 vowels and 3 consonants, as in (44). In /iau-kbtp/, the outputs [kibatup] and [bitabup] are equally faithful, precedence-wise.

I wonder if there are any such cases, and whether they'd ever give rise to alternations. Looking through Ussishkin's work on Semitic root-and-pattern morphology, I can't see any relevant cases.

- (44) *Larger transfixes*
- /iau-kbtp/ → [kibatup]
- Should be impossible to rule out markedness-driven [kibatup] and [bitabup].
- Any such cases?

- (45) *Haplology*
- What about morphological deletion?
- /xy-xy/ → [xy]?
- de Lacy (1998): All haplology is coalescence.

## 5. Summary

I will now summarize (in section 5). I am very skeptical that I have said anything here today that will ever be adopted by the field. After all, a lot of it sounds insane. All deletion is coalescence? All epenthesis is split? Come on.

That's fine. As Woody Allen said, "I don't want to become immortal through my work, I want to become immortal by not dying."

I think one of the reasons that it won't excite many people is that I've merely skimmed the surface here. The idea that phonological precedence is a fundamentally different kind of relation from what's been assumed so far has radical and far-reaching implications – certainly more than can be talked about in a 20 minute talk, and certainly requiring more attention than I've given it.

Nonetheless, I hope that this talk has conveyed one interesting fact: that intransitive phonological precedence is not *obviously* wrong. If this is a valid summation, then it at least emphasizes the importance of precision in defining phonological formalism.

This point has come up several times before. Alan Prince's continuing work on the formal properties of OT is a case in point. Kornai's (1994) book is another good example, and work on learnability and computation is also helping us steam ahead. Sagey's (1988) paper on the basis of the No-Crossing Constraint is an example of where close attention to the formal properties of phonological relations gave some insight into phonological restrictions. Eric Raimy's work on reduplication is a more recent and on point example that pays close attention to the formal properties of precedence relations, and uses them in significant ways.

However, there remain extremely basic questions about formalism that we all accept that haven't really been addressed, at least not in the detail needed.

(46) *Formal properties?*

- Useful to examine formal properties of relations: doing so may reveal conditions that are easy to overlook.
- If Phonological Precedence is transitive, why do constraints only refer to immediate precedence?

The value of looking at such details is clear. They raise questions that haven't been examined particularly closely. In the present case, why is it that there are no constraints of the form  $*_xP^<y$  where  $x$  and  $y$  are not necessarily adjacent? Why is there no need for a constraint  $*_x\cancel{A}y$ ? And something I didn't get to talk about – why do we lack so many imaginable precedence-underspecified morphemes? If it achieves nothing else, thinking about intransitivity at least is a reminder about how many fundamental questions have yet to be asked, and a pointer to finding out more stuff that we don't know.

- (47) *The catches with intransitive precedence*
- Requires a radically new view of deletion and epenthesis: i.e. there is none, only coalescence and split.
  - Requires little change to current conceptions of morphological order.
  - Makes testable predictions for root-and-pattern morphology with morphemes of more than 3 segments.
  - Restricts constraints to immediate precedence, and neither transitive precedence nor adjacency.

[23½ mins]

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**Other issues***1. Hidden benefits of epenthesis as split*

In fact, there might be a hidden benefit here. There's always been controversy over the morphological affiliation of an epenthetic segment. In some analyses, epenthetic segments are assumed to be root segments if they are epenthesized next to a root; in other cases they're affixes. If epenthesis is *split*, then the morphological affiliation of epenthetic segments is set: all epenthetic elements are morphologically affiliated.