On acting locally and thinking globally*

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1. Introduction

•Classic rule-based phonology posits derivations which consist of a succession of representations <*input*, *intermediate*$_1$, *intermediate*$_2$, ..., *intermediate*$_n$, *output*>.

•The phonological rules posited in an analysis of any given language can be thought of as constraints which define which derivations are well-formed in the language and which derivations are not.

•For example, the following rule (considered in isolation, independent of the question of rule ordering)...:

(1) [-sonorant] → [-voice] / _#

•...tells us that derivations like <..., pad, pat, ...> which have two consecutive representations that are identical except that the first has a word-final voiced obstruent and the second has a word-final voiceless obstruent, are well-formed.

•Standard-format rewrite rules like these impose constraints on permissible relations between two consecutive derivational steps. A natural question to ask is whether the grammars of natural languages can impose conditions on well-formed relations between *non-consecutive* steps.

•Postal (1972: 140-141) and Kisseberth (1973) point out that standard generative grammar—rule-based phonology, and, at that time still, transformational syntax—already included such conditions in the form of rule-ordering.

•Suppose that a language has the final devoicing rule in (1), which is ordered before the following apocope rule:

(2) [+vocalic] → Ø / _#

•Having the rules in this order ensures that final devoicing will not apply in environments derived by apocope. So now, as regards final devoicing, the grammar says that derivations like <..., pad, pat, ...> are well-formed, but derivations like <.... pada, ..., pad, pat, ...> are not.

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The (im)permissibility of performing final devoicing on an intermediate form like /pad/ cannot be known without also knowing whether there was a previous intermediate form /padV/.

Rule ordering is thus a type of 'global' constraint.

•Question: Are there constraints on permissible relations between non-consecutive derivational stages beyond those that can be expressed by rule-ordering?

In particular, can the structural descriptions of individual rules mention information about the shape of derivational steps other than the one that was the output of the previous rule, as originally suggested by Lakoff (1969, 1970)? (If yes, such environments can probably replace some or all extrinsic rule-ordering statements: Kisseberth 1973).

•In phonology, Anttila (1969), Campbell (1971a,b, 1972), Lakoff (1972), Dressler (1972), Pyle (1972), McCawley (1973), Miller (1973, 1974), Underhill (1976), among others, answered 'yes'.[1]

•But orthodox consensus developed around the response in Kiparsky (1973a, 1976):

Individual rules can't have global environments.

But UG furnishes one global condition on rule application, namely the Revised Alternation Condition: "Obligatory neutralization rules apply only in nonderived environments." Class of derived-only rules subsequently re-identified as the cyclic rules (Mascaró 1976), then as the structure-changing lexical rules (Kiparsky 1982). Phenomenon came to be known as 'non-derived environment blocking', or NDEB.

•Most recently, the question of global rules has returned to prominence with the appearance of OT with Candidate Chains (McCarthy 2007a)[2].

This is a version of Optimality Theory (Prince & Smolensky 2004 [1993]) in which the candidates are (approximately) multi-step derivations.

[1] I exclude from this list works arguing for (a) global rules of the NDEB type, (b) allowing access to future (rather than past) derivational history, in the form of surface-structure constraints on rule-application, and (c) global rules which have the function of enforcing base-reduplicant identity. In an OT context, the interest of (b) and (c) is in no way particular to the question of derivational history.

[2] For a shorter introduction to the theory, see McCarthy (2006). Other work in or about OT-CC includes Becker (2005), Wilson (2006), McCarthy (2007b), Lee (2007), Shin (2007), Ahn (2008), Baković & Pająk (2008), Barlow & Keare (2008), Beltzung (2008), Collischon (2008), Dinnsen & Faris-Trimble (2008), Jacobs (2008), Nagle (2008), Walker (2008), Wolf (2008, to appear), Kavitskaya & Staroverov (2008, 2009), Zhang & van de Weijer (2008), Gouskova & Hall (2009), Shaw (2009), and Tihonova (2009).

When the chains are compared, all of their intermediate stages are on view. So information about derivational history can influence whether or not certain unfaithful mappings will appear in the winning candidate.

This has been cited as both a virtue (Wolf 2008, esp. ch. 4) and a liability (Wilson 2006) of OT-CC.

•Today's topic: how does OT-CC compare in its 'global' potential to rule-based phonology?

Overall conclusion: OT-CC is at least as restrictive as, and probably more restrictive than, even standard rule-based phonology which does not permit 'global' environments in rules.

Loophole in rule-based phonology, pointed out a number of times: rules can be defined so as to leave behind diacritic markers of their application, so later rules can in principle have full knowledge of derivational history. This opens the floodgates as far as global rules go.

2. Nonderived Environment Blocking

2.1 NDEB, and why it's less of a problem in rule-based phonology than you might think

•Existence first pointed out by Kenstowicz & Kisseberth (1970), Kiparsky (1973a, 1976).

•Phenomenon: certain rules apply only if their structural description comes to exist via:

Morpheme concatenation (on the current cycle)

Or

Application of a previous rule (on the current cycle).

•These rules fail to apply in environments which existed already in the input (to the current cycle).

•Example of phonologically-derived environment (we'll see a morphologically-derived-environment example in a bit): Lowering of long vowels in Tiberian Hebrew (data from Prince 1975, via Burzio to appear). Vowels in pretonic open syllables lengthen (a-b), and lower to mid if high (c-d):

(3)	a.	[ktabtém]	'we.MASC write'
	b.	[ka:táb]	'he writes'
	c.	[ʃimká:]	'your names'
	d.	[ʃe:mót]	'names'

•But high vowels that are underlyingly long do not lower:

(4) [qiːtór] ‘smoke’

•If rules can’t refer to derivational history, we can’t model this successfully (at least not under the most straightforward formulation of the rules involved):

(5)	/ʃimot/	/qiːtor/
Stress, syllabification	ʃi.mót	qiː.tór
Open-σ lengthening	ʃiː.mót	qiː.tór (*applies vacuously*)
Long high Vs lower	ʃeː.mót	qeː.tór
	[ʃeː.mót]	*[qeː.tór]

•Stated using a rule with a global environment:

(6) [long] → [-high]
Condition: Focus is underlyingly short

•But are these global conditions actually necessary?

•Suppose that we have the following rules, which apply in the order shown:

(7) *Diacritic-feature analysis of NDEB in Tiberian Hebrew*
a. [+L] → [-L]
b. [short] → [+L] / _'$C$$_0$V
c. [short] → [long] / _'$C$$_0$V
d. [long, +L] → [-high]
e. [+L] → [-L]

•[+L] could be a diacritic feature, or it could be any feature drawn from the representational inventory of UG that isn’t independently needed underlyingly in Tiberian Hebrew. If it isn’t systematically absent from the language’s URs, we just need a rule like (7a) that wipes it out across the board. Then, the only segments that re-acquire [+L] are those that non-vacuously undergo lengthening.

•And since [+L] is now part of the structural description of lowering (7d), it’s only derivedly-long high vowels that will lower.

•Finally, we get rid of [+L] across the board again, with rule (7e) (unless it’s a diacritic feature and phonetically uninterpretable, in which case there’s no harm in leaving it around for the rest of the phonological derivation).

•As was pointed out a number of times (in phonology: Kenstowicz & Kisseberth 1970, Lightner 1971: 531-532, Dinnsen 1974, McCawley 1976: 175; in syntax: Postal 1971, 1972:

140,[3] Lehmann 1972: 542-543), the ability to use diacritic features (or diacritically-employed phonological features) to keep a record of previous events means that derivational-history effects aren't incompatible with rule-based phonology at all, even if we ban the explicit use of 'global' environments.[4]

> Parallel: Trace theory in syntax (Chomsky 1973). On the crypto-global nature of trace theory, see Bach (1977:135ff.), Postal & Pullum (1978), Lightfoot (1980:155ff.), Harris (1993: 181-182&ff.).
>
> Also, unparsed/unfilled input structures kept in output in Containment theory of faithfulness (Prince & Smolensky 2004 [1993]) and hidden structure posited in Turbidity theory (Goldrick & Smolensky 1998, Goldrick 2000). Resembles Dinnsen's (1974) proposal that all global rules can be attributed to phonetically-null segment (specified minus for all features) left behind by segmental 'deletion'.

•As we shall see, this gives rule-based phonology the power to do everything that OT-CC can, and probably more.

•But in any case, the diacritic line of analysis for NDEB effects was largely not pursued.

2.2 NDEB in OT-CC

2.2.1 Premises of OT-CC, and application to NDEB

•Candidates constructed as chains of intermediate forms, beginning with the original input, and ending with the candidate output.

•Universal well-formedness conditions on chains:

(8) *Gradualness*: Each link of the chain differs from the previous link by only a single basic operation. (In McCarthy 2007a: delete one segment, epenthesize one segment, change one feature-value, metathesize two adjacent segments.)
(9) *Harmonic improvement*: Each link is more harmonic than the previous one, given the constraint hierarchy of the language in question.

•Illustration, using a morphological NDEB effect: intervocalic /k/-deletion in Turkish (data from Inkelas 2000). Applies only to velars that become intervocalic through morpheme concatenation:

[3] Postal (1972: 140): "For this theory [*Aspects*-M.W.] in conjunction with a view that there are *arbitrary* syntactic features available, allows the coding of properties of early trees into later trees by transformational feature marking. I made use of just such a device... positing a feature [Doom] whose function is exactly to mark in later trees a contrast between certain properties of earlier trees that is otherwise obliterated by intervening cyclically applied rules." (Emphasis in original.)
[4] A similar strategy is called upon by Levine (1976) and Pelletier (1980) to demonstrate that theories with and without extrinsic rule-ordering possess equivalent generative power.

(10)

/bebek/	[be.bek]	'baby'
/bebek-i/	[be.be.i]	'baby-ACC'
/bebek-e/	[be.be.e]	'baby-DAT'
/sokak/	[so.kak]	'street'
/sokak-ɪ/	[so.ka.ɪ]	'street-ACC'

•Analysis of this in OT-CC requires that morpheme concatenation be an identifiable 'single basic operation' in the chains.

•Assumption for purposes of this talk: morphemes are unlinearized in the input, as in Prince & Smolensky (2004 [1993]), so input for 'street-ACC' is {sokak, ɪ}.

> One of the operations in GEN is to take two phonological strings and impose a linear order relation between them. (Not clear that there must be, or that there couldn't be, a faithfulness constraint against doing so, since polymorphemic outputs that obey the constraint are presumably unpronounceable.[5])
>
> See Wolf (2008), esp. ch. 2-3, for a more elaborate view, with only abstract morphosyntactic structure in the input, and insertion of phonologically-complex morphs as the operation.[6]

•Required ranking for harmonic improvement:

(11) *UNLIN » *VGV » MAX-C

(12) *VGV = One violation-mark for every intervocalic velar.

(13) *UNLIN ≈ One violation-mark for every pair of strings which lack any linear-order relation relative to one another. [Compare to MPARSE as defined in Prince & Smolensky (2004 [1993]).]

•*UNLIN » *VGV makes morpheme linearization harmonically-improving:

[5] At least, this is true if all the morphemes involved are segmental strings realized with the vocal-tract articulators—or, more formally, if some of the pairs of morphemes involve material on disjoint sets of autosegmental tiers. It is conceivable that the grammar might fail to impose timing relations between segmental morphemes and tonal/intonational ones (Beckman & Pierrehumbert 1986, Gussenhoven 2004: §11.3). The same could be true of manually- vs. non-manually-realized morphemes in signed languages. See also Jouitteau (2004) for arguments that in some spoken languages, morphemes can be realized gesturally; this, if correct, creates similar possibilities.

[6] Applications and further developments of this proposal can also be found in Wolf (to appear), McCarthy (to appear), and Kimper (2009).

(14)

/{sokak, ɪ}/	*UNLIN	*VGV
a. sokakɪ *is more harmonic than:*		2
b. {sokak, ɪ}	1	1

•*VGV » *MAX-C makes velar-deletion harmonically-improving:

(15)

/sokakɪ/	*VGV	*MAX-C
a. sokaɪ *is more harmonic than:*	1	1
b. sokakɪ	2	

•Harmonically-improving chains for input {sokak, ɪ}:

(16)

Chains:	*LUMSeq:*
a. <{sokak, ɪ}>	<>
b. <{sokak, ɪ}, sokakɪ>	<"linearize">
c. <{sokak, ɪ}, sokakɪ, soakɪ>	<"linearize", MAX-C@3>
d. <{sokak, ɪ}, sokakɪ, soakɪ, soaɪ>	<"linearize", MAX-C@3, MAX-C@5>
e. <{sokak, ɪ}, sokakɪ, sokaɪ>	<"linearize", MAX-C@5>
f. <{sokak, ɪ}, sokakɪ, sokaɪ, soaɪ>	<"linearize", MAX-C@5, MAX-C@3>
g. <{sokak, ɪ}, {soak, ɪ}>	<MAX-C@3>
h. <{sokak, ɪ}, {soak, ɪ}, soakɪ>	<MAX-C@3, "linearize">
i. <{sokak, ɪ}, {soak, ɪ}, soakɪ, soaɪ>	<MAX-C@3, "linearize", MAX-C@5>

•Each chain above is shown with its LUMSeq (short for "localized unfaithful mapping sequence"). This is a record of the operations ("localized unfaithful mappings") that have been performed in the course of the chain.

> Following McCarthy (2007a) I notate LUMs by the "basic" faithfulness constraint (MAX, DEP, IDENT, etc.) that they violate—except for morpheme-linearization, owing to its ambiguous faithfulness status, as mentioned earlier.
>
> The '@' notation is used to differentiate between LUMs violating the same constraint at different points in the representation. Here, MAX-C@3 is deletion of the root-medial /k/, and MAX-C@5 is deletion of the root-final /k/.

•Chains (d), (f), and (i) converge on the same output; Likewise chains (c) and (h).

•By hypothesis, before candidate comparison, convergent chains are *merged*. The merged candidate contains:

The candidate output form, and

An rLUMSeq ("r" for "reduced"), which preserves only those ordering relations among LUMs that are shared in common by all of the chains that have been merged together.

(•Chains that converge on no other chain can be regarded as undergoing merger vacuously.)

•Final set of candidate chains with rLUMSeqs:

(17)

Output	*rLUMSeq*	*Merged from*
a. [{sokak, ɪ}]	<>	(16a)
b. [sokakɪ]	<"linearize">	(16b)
c. [soakɪ]	{<"linearize">, <MAX-C@3>}	(16c, h)
d. [soaɪ]	{<"linearize", MAX-C@5>, <MAX-C@3>}	(16d, f, i)
e. [sokaɪ]	<"linearize", MAX-C@5>	(16e)
f. [{soak, ɪ}]	<MAX-C@3>	(16g)

•When the candidates produced by chain merger are evaluated, their rLUMSeqs scrutinized by a constraints of the PRECEDENCE(A,B) family. It is these constraints which are responsible for crucially favoring candidates with opaque orders.

•Here, the relevant constraint is:

(18) PREC("linearize", MAX-C)
Assign one violation-mark for every time that the rLUMSeq contains either:
a. A violation of MAX-C that is not preceded by an instance of "linearize", or
b. A violation of MAX-C that is followed by an instance of "linearize".

•Notice that in every rLUMSeq that contains MAX-C@5, this LUM is ordered after "linearize": assuming *VGV to be only relevant high-ranked markedness constraint, it doesn't become harmonically-improving to delete the root-final /k/ until after the root and suffix are linearized.

•By the same token, *no* rLUMSeq asserts an ordering relation between "linearize" and MAX-C@3. The root-internal /k/ is intervocalic from the beginning and therefore it's harmonically improving to delete it both before (16h, i) and after (16c, d, e, f) linearization, and when linearization never happens at all (16g).

•Consequently: candidates with MAX-C@3 violate PREC("linearize", MAX-C), but candidates with MAX-C@5 do not:

(19)

/{sokak, ɪ}/	PREC("linearize", MAX-C)	*UNLIN	*VGV	Max-C
a. [{sokak, ɪ}] <>		W1	L1	L
b. [sokakɪ] <"linearize">			W2	L
c. [soakɪ] {<"linearize">, <MAX-C@3>}	W1		L1	1
d. [soaɪ] {<"linearize", MAX-C@5>, <MAX-C@3>}	W1		L	W2
☞ e. [sokaɪ] <"linearize", MAX-C@5>			1	1
f. [{soak, ɪ}] <MAX-C@3>	W1	W1	L	1

•Examples like this one show that the NDEB restriction on Turkish intervocalic velar deletion could not be described as "the rule only applies in affixed words"; rather, it's "the rule applies only in environments where affixation crucially contributes to the rule's structural description being met".

•Compare that to Mascaró's (1976) formulation of the Strict Cycle Condition (which originated with Chomsky 1973, and was brought into phonology by Kean 1974):

(20) For a cyclic rule to apply properly in any given cycle *j*, it must make specific use of information proper to (i.e. introduced by virtue of) cycle *j*.

•In OT-CC, it's no longer necessary to stipulate something like this as a primitive axiom of phonological theory—rather, the fact that NDEBed processes like Turkish intervocalic velar deletion only come "un-blocked" in crucially derived environments follows automatically from the mechanism of chain merger, and its ability to separate crucial from non-crucial orderings.

> Importantly, that mechanism is independently required in order to deal with counter-feeding and counter-bleeding opacity (McCarthy 2007a). The ability to deal with NDEB as well comes for free (indeed it was not originally anticipated as an application of the theory).

2.2.2 An example of what OT-CC can't do

•Suppose we have a language which has an NDEBed process of intervocalic velar deletion, just like Turkish, and which also deletes prevocalic schwa:

(21)
a. /patak/ → [pa.tak]
b. /patak-e/ → [pa.ta.e]
c. /gidə-e/ → [gi.de]
d. /nokə/ → [no.kə]
e. /nokə-e/ → [no.e]

•The crucial case is (21e). In rule-based terms, addition of the suffix /-e/ makes possible schwa-deletion, yielding intermediate /nok-e/. The velar is now in a derived intervocalic environment, making it eligible for the NDEBed rule of velar deletion, which applies to give surface [no.e].

•OT-CC cannot model this language. Let's see why. Required rankings:

(22) PREC("linearize", MAX-C), *UNLIN » *VGV » MAX-C
(just like real Turkish)

(23) *UNLIN » *əV » MAX-V
(schwa deletes prevocalically; morpheme concatenation can create new schwa-vowel sequences)

•Harmonically-improving chains for input /{nokə, e}/:

(24)

Chain	*LUMSeq*
a.<{nokə, e}>	<>
b. <{nokə, e}, nokəe>	<"linearize">
c. <{nokə, e}, nokəe, noəe>	<"linearize", MAX-C>
d. <{nokə, e}, nokəe, noəe, noe>	<"linearize", MAX-C, MAX-V>
e. <{nokə, e}, nokəe, noke>	<"linearize", MAX-V>
f. <{nokə, e}, nokəe, noke, noe>	<"linearize", MAX-V, MAX-C>
g. <{nokə, e}, {noə, e}>	<MAX-C>
h. <{nokə, e}, {noə, e}, noəe>	<MAX-C, "linearize">
i. <{nokə, e}, {noə, e}, noəe, noe>	<MAX-C, "linearize", MAX-V>

•Chains (d), (f), and (i) are convergent; so are (c) and (h). Merger yields:

(25)

Output	*rLUMSeq*	*merged from*
a. [{nokə, e}]	<>	(24a)
b. [nokəe]	<“linearize”>	(24b)
c. [noəe]	{<MAX-C>, <“linearize”>}	(24c, h)
d. [noe]	{<MAX-C>, <“linearize”, MAX-V>}	(24d, f, i)
e. [noke]	<“linearize”, MAX-V>	(24e)
f. [{noə, e}]	<MAX-C>	(24g)

•Now we can see the problem: the merged chain that ends in our desired winner, [noe], has an rLUMSeq which asserts no ordering relation between “linearize” and MAX-C.

Therefore, it will violate PREC(“linearize”, MAX-C).

•This is because the /k/ was intervocalic from the beginning, and so it was harmonically improving to delete it both before (24i) and after (24d, f) morpheme concatenation. (As well as both before (24d, i) and after (24f) schwa-deletion.)

•Result: ERCs (Prince 2002, 2003) for /{nokə, e}/ → [noe] to beat /{nokə, e}/ → [noke] are inconsistent with those required for /nokə/ → [nokə] to beat/nokə/ → [noə]:

(26)

Input	*W~L*	PREC (“lin”, MAX-C)	*UNLIN	*VGV	MAX-C	*əV	MAX-V
{nokə, e}	noe ~ noke	L		W	L		
nokə	<nokə> ~ <nokə, noə>	W		L	W		

•In sum: what matters in the OT-CC analysis of NDEB is not whether the “environment” for the NDEBed process is derived; what matters is whether the harmonically-improving status of the process is derived or not.

To borrow a phrase from Blumenfeld (2003): Once NDEBed, always NDEBed.
(Extra-special thanks to Donca Steriade for pointing out this prediction to me.)

•I do not know of any counterexamples to this prediction.

Mascaró (1976) argues that when underlyingly stressed vowels in Catalan are vacuously re-stressed by pre-stressing suffixes, they then can undergo an NDEBed process of lowering. However, Mascaró (2003) shows that the argument doesn’t actually go through.

Dissimilation of vowel length in Chimwi:ni (Kenstowicz & Kisseberth 1977, Selkirk 1986) looks like an example, but upon closer examination proves not to be (Wolf 2008: 307-310).

•But, you may be wondering, what about un-blocking of NDEB in environments that are vacuously derived *morphologically*? Isn't that a counter-example?

Most famous example (Kiparsky 1973a): loss of *hache aspiré* in derived words in French: *le héros* versus *l'héroïne*. See also Burzio (2000), Yu (2000), Nelson (2003) for discussion of this and related examples.

•Reasonable to account for such cases by assuming that exceptional behavior is associated with some diacritic feature (e.g. index to a lexically-specific faithfulness constraint) which fails to percolate up in derived words.

Prediction: pseudo-DEEs like the *hache aspiré* example should then only be possible under derivation in which the affix forms the morphological head of the derived word. (Or, more generally, which the exceptional root is *not* the head.)

Compare to account of loss of inflectional irregularity (*stand* ~ *stood* but *grandstand* ~ *grandstanded*, **grandstood*) in Pinker & Prince (1988: 110-114), a phenomenon to which Kiparsky (1973a) compares the *hache aspiré* facts.[7]

'True' morphological DEEs, by contrast, should be possible in environments derived by any kind of affixation (including classically inflectional things like case endings, as seen in the Turkish example).

2.3 Comparison with rule-based approaches

•One strategy for dealing with rules that apply only in morphologically-derived environments is to write some kind of representational reflex of the morphological boundary into the definition of the rule, e.g. for Turkish[8]:

(27) [+cons, +dorsal] → Ø / V_+V

Resembles diacritic-feature account of un-blocking in phonologically-derived environments described earlier—the /+/ serves as a kind of diacritic marker of the string's (morphological) derivational history.

For other accounts relying on representational differences between derived vs. underived environments, see e.g. Kula (2008), van Oostendorp (2006).

[7] Nelson (2003: 144-145) has a conceptually related proposal: derived words like *l'héroïne* can be OO-faithful not to the listed, exceptional underived form *le héros*, but instead to the 'default', grammar-generated form **l'héros*, whose use is blocked by listed *le héros*.

[8] Thanks to David Embick for raising this alternative, and getting me to think about it more seriously.

•One empirical drawback of this approach is that it fails to predict the once/always limitation. Consider again input /nokə+e/ in our hypothetical language:

(28)	UR	/nokə+e/
	ə → Ø / _(+)V	nok+e
	[+cons, +dorsal] → Ø / V_+V	no+e
	SR	[noe]

•After schwa deletion, the /k/ is between heteromorphemic vowels, so it meets the structural description of the velar deletion rule.

So a boundary-marker approach to morphological DEEs predicts that this is a possible language, while OT-CC predicts that it is not.

Historical aside: in attributing morphological influence on phonology to constraints that refer to derivational history rather than to boundary markers, my proposal to implement morphological NDEB in OT-CC bears a close (and unintentional) resemblance to the proposal in Pyle (1972).

•As many of us know, the 'standard' view in rule-based phonology came to be that individual rules cannot refer to 'global' environments, but that there were general UG principles with access to derivational history which prevented certain kinds of rules from applying in nonderived environments.

(29) The Revised Alternation Condition (Kiparsky 1973a): Nonautomatic neutralization rules apply only in nonderived environments. ['nonautomatic' = has lexical exceptions]

(30) The Strict Cycle Condition (Mascaró 1976): Cyclic rules apply only in environments derived on the current cycle.

(31) Or, the Elsewhere Condition (Kiparsky 1973b) blocks application of lexical rules in nonderived environments (Kiparsky 1982).[9]

•Problems: First, even if UG contained any of these principles, the possibility of rules leaving behind traces of their application means that potentially any kind of rule could be restricted to applying in derived environments only—all that's needed is for the NDEBed rule to mention in its structural description the diacritic marker that is left behind by one or more earlier rules.

•Second, there are counter-examples to all of these conditions:

[9] See Cho (2008) for a recent implementation of this idea in an OT context.

Contra the RAC, intervocalic velar-deletion in Faroese (Anderson 1981) and postnasal plosive deletion in English (Bermúdez-Otero 2008) are both nonautomatic neutralization rules, and yet they apply in nonderived environments.

Contra the SCC and blocking of lexical rules via the Elsewhere condition, (optional) Finnish vowel coalescence (Kiparsky 1993) and English postnasal plosive deletion (Bermúdez-Otero 2008) both apply in nonderived environments, even though both are cyclic/lexical.

Also, there are post-cyclic/post-lexical processes which are limited to applying in nonderived environments (Mascaró 1976, Shaw 1985, Kaisse 1986, 1990, Hargus 1988, 1989, Iverson & Wheeler 1988, Rice 1988, Hualde 1989, Clark 1990, Kiparsky 1993, Bolognesi 1998, Łubowicz 2002, Blaho 2003).

3. Mutual counterbleeding

•Suppose we have a language with the following two phonological rules (loosely inspired by some of the Hungarian facts used by Vago [1977] to argue in support of extrinsic rule ordering):

(32) 1 2 3 → 1 3
[+cons] [+cons] [-voc]
Condition: 1=2
(i.e., Geminates shorten to singletons before a consonant or glide, e.g. /abbwi/→[abwi])

(33) [-voc, -cons] → [+voc] / CC_{C, #}
(i.e., Glides vocalize after a consonant cluster, unless a vowel follows, e.g. /ustw/ → [ustu])

•These rules each stand in a potentially-bleeding functional relationship relative to the other. For an input like /abbw/:

Applying degemination first produces [abw], which no longer meets the structural description of vocalization.

Applying vocalization first produces [abbu], which no longer meets the structural description of devocalization.

•If, contra *SPE*'s assumption of one-at-a-time application, these rules are allowed to apply simultaneously, we get a mutually-counterbleeding interaction /abbw/ → [abu].

The structural description of both rules is met in the input, so both apply, even though each rule obliterates part of the environment of the other. (Baković 2007

dubs this hypothetical mode of rule-interaction "mutually-assured destruction".)

•Even with one-at-a-time application, we can produce such an interaction in rule-based phonology using the trick of rules leaving behind 'traces' of their application (Dinnsen 1974):

(34)

1	2	3	→	1	2	3
[+cons]	[+cons]	[-voc]			X	

Condition: 1=2
(Notation: X = null segment marked minus for all features)

(35) [-voc, -cons] → [+voc] / C{C,X}_{C, #}

•Derivation:

(36)

Underlying	/abbw/
Degemination	abXw
Vocalization	abXu
X → Ø	abu
Surface	[abu]

•Questions: Can OT-CC model interactions like this, and if so, does it impose any limits on possible mutual-counterbleeding interactions?

•I→O mappings that need to occur:

(37)
a. /abbwi/→[abwi]
b. /ustw/ → [ustu]
c. /addw/→ [adu]
d. /etw/ → [etw], *[etu]
e. /obbi/ → [obbi], *[obi]

•Assume relevant constraints are as follows:

(38) *GEM-C: One violation-mark for every geminate followed by a consonant or glide.

(39) *GEM: One violation-mark for every geminate.

(40) *CCG{C#}: One violation-mark for every glide preceded by two consonants and not followed by a vowel.[10]

[10]Of course, the right way to define this constraint would be in terms of syllable structure, but I'm choosing here for purely expositional reasons to state the constraint solely in terms of the string, so as not to have to worry about, e.g., whether syllabification operations need to take place as a distinct step in

(41) NoDegem: One violation-mark for every input geminate which has been mapped to an output singleton.

(42) Ident(voc): One violation-mark for every input segment whose output correspondent has a different specification for the feauture [vocalic] (i.e., no vocalization).

•Chains we need to deal with:

(43) *Chains for /abbwi/:*
<abbwi> (Do nothing)
<abbwi, abwi> (Degeminate; desired winner)

(44) *Chains for/ustw/:*
<ustw> (Do nothing)
<ustw, ustu> (Vocalize; desired winner)

(45) *Chains for /addw/:*
<addw> (Do nothing)
<addw, addu> (Vocalize)
<addw, addu, adu> (Vocalize, then degeminate; desired winner)
<addw, adw> (Degeminate)
(Hypothetical **<..., adw, adu> invalid because not harmonically improving relative to any of the constraints under consideration)

(46) *Chains for /etw/:*
<etw> (Do nothing)
(Hypothetical **<etw, etu> invalid because not harmonically improving relative to any of the constraints under consideration)

(47) *Chains for /obbi/:*
<obbi> (Do nothing; desired winner)
<obbi, obi> (Degeminate)

the candidate chains. For recent work on the status of prosodic-structure-building operations in Harmonic Serialism, see Elfner (2009) on syllabification and Pruitt (2009) on foot-parsing.

•ERCs for winner-loser pairs and for harmonic improvement of medial steps (latter type separated from others by double horizontal border):

(48)

W ~ L	*GEM-C	*GEM	*CCG{C,#}	NODEGEM	ID(voc)	PREC(ID(voc), NODEGEM)
<abbwi, abwi> ~ <abbwi>	W	W		L		L
<ustw, ustu> ~ <ustw>			W		L	
<addw, addu, adu> ~ <addw>	W	W	W	L	L	
<addw, addu, adu> ~ <addw, addu>		W		L		
<addw, addu, adu> ~ <addw, adw>					L	W
<obbi> ~ <obbi, obi>		L		W		W
addu > addw (w.r.t. input /addw/)	W		W		L	
adu > addu (w.r.t. input /addu/)		W		L		

•Running RCD (Tesar 1995, Tesar & Smolensky 1998, 2000) on the above yields:

(49) *GEM-C, *CCG{C,#} » PREC(ID(voc), NODEGEM) » *GEM » NODEGEM, IDENT(vocalic)

•The ERCs are consistent, so the set of input-output mappings in (37) represents a possible language, given OT-CC and the constraints used.

•So how and why exactly does this work?

Ranking *GEM » NODEGEM makes it harmonically-improving to degeminate at any point.

Ranking PREC(ID(voc), NODEGEM) » *GEM results in degemination being blocked when it hasn't been crucially preceded by glide vocalization—that is, when there hasn't been any vocalization for degemination to counterbleed.

Ranking *GEM-C » PREC(ID(voc), NODEGEM) means that degemination is allowed, even if there has been no vocalization for it to counterbleed, when degemination is necessary to avoid surface geminate+C sequences.

Sum result: degemination is observed only before a consonant, or before an underlying glide that's been vocalized.

•So: OT-CC can model at least some mutual-counterbleeding interactions. Are there any such interactions that it *cannot* model?

•Yes, because it must be possible for the process that occurs second (under the pressure of the PREC constraint)—above, degemination—to be harmonically improving even after the first process—above, vocalization—has occurred. Therefore, the theory of markedness will impose substantive limitations.

•Example of something that's likely to be impossible (again inspired by Vago 1977): suppose we have a language with both regressive velar assimilation and progressive retroflex assimilation (see Steriade 2001 on the latter):

(50) C → [velar] / _[velar]
(e.g. /anka/ → [aŋka])

(51) C → [retroflex] / [retroflex]_
(e.g. /aɳta/ → [aɳʈa])

•Simultaneous application of these would yield mutually-counterbleeding interaction /eɖke/→[egʈe]: the two place features swap positions (a strikingly perverse result, in light of Steriade's [2001] proposal about the perceptual basis of directionality in place assimilation).

In OT-CC, one or the other change would have to occur first, giving intermediate representation /eɖʈe/ or /egke/. Difficult to see how it could be harmonically improving to subsequently turn either of these into [egʈe].

•Important: Even one-at-a-time rule application does not necessarily rule out the /eɖke/→[egʈe] mapping. One way: prior to application of the assimilation rules in (50-51) is ordered a rule that epenthesizes some arbitrary segment between a retroflex and a velar. This will bleed the 'normal' assimilation rules, making them irrelevant, and then something like the following happens :

(52)	UR	/eɖke/
	Ø → X / [retroflex]_[velar]	eɖXke
	[retroflex] → [velar] / _X	egXke
	[velar] → [retroflex] / X_	egXʈe
	X→ Ø	egʈe
	SR	[egʈe]

•This approach, in essence uses the medial epenthetic X—which might be any segment we like—as a marking which indicates 'there used to be a retroflex-velar sequence here'.

This trick is presumably not recapitulable in OT-CC, since all chains leading to /egXʈe/ will need to first pass through either /egXke/ or /eɖXʈe/, and, as before, it's hard to see what would motivate going from either of these places to /egXʈe/.

(•For a not-unrelated analytical gambit, see Odden [2008: §3.2.3] on Tachoni tone: penultimate H on root causes delinking (or prevents docking) of inflectional floating H, and the continued (latent) presence of the floating H conditions deletion of the root H.)

•Again, given the way in which rules can introduce diacritic indicators of conditions on earlier levels, it's hard to see that there are *any* kinds of global effects which rule-based phonology can't mimic, even if we don't allow explicitly 'global' environments in rules.

But OT-CC is still OT, so what is and what is not a possible harmonically-improving intermediate step is subject to substantive limitations given by the theory of markedness.

•One could try to limit the diacritic use of phonological features in a rule-based approach by imposing stipulations against absolute neutralization, like the Revised Alternation Condition (Kiparsky 1973a, 1976), and/or by appealing to structure preservation (to prevent introduction of structures never present underlyingly for use as diactritics). But:

The RAC is false (see above), and

Structure-preservation can be bypassed by assigning the relevant rules to the part of the phonology where structure preservation doesn't hold (the postlexical level, in Lexical Phonology terms [Kiparsky 1985]).

•The big question: do mutual-counterbleeding interactions ever occur in real languages? The best I can say right now is 'maybe':

Ballard (1971) suggests that certain diachronic changes (*əŋ > ən, *əŋ > eŋ) in Wenzhou occurred simultaneously, interacting in this way.

In synchronic phonology, there are a few possible examples of *mutual dissimilation* of varying degrees of plausibility:

(53)		
	Latin /t+t/ → [s+s]	(Wells 1949, van Oostendorp 2008)
	'Afar /aC+á/ → [oC+í]	(Bliese 1975)
	Tocharian B /ā(C)e/→ [o(C)o]	(Adams 1978a,b, 1988a: 21-22, 1988b)
	Tachoni /H +H/ → ØØ	(Odden 2008: §3.2.3)

•Whatever we end up finding, though, there seem to be good reasons to think that OT-CC's predictions about the possibility of such effects are at least somewhat more limiting than those of rule-based phonology.

4. A word about 'obligatory counterbleeding'

•Some of you have probably noticed that the analyses presented above for both NDEB and for mutual counterbleeding have required us to contravene the B » PREC(A,B) ranking metaconstraint assumed by McCarthy (2007a) as part of the original OT-CC proposal.[11]

•Here's why this was assumed. In Bedouin Hijazi Arabic (Al-Mozainy 1981), syncope of high vowels in medial open syllables counterbleeds palatalization of velars before front vowels. In rule-based terms:

(54)

Underlying forms	/ħaːkim-iːn/	
Palatalization	ħaːkʲimiːn	
Syncope	ħaːkʲmiːn	
Surface form	[ħaːkʲmiːn]	'ruling (masc. pl.)'

•In OT-CC this is analyzed (McCarthy 2007a) by calling on PREC(IDENT(back), MAX-V): this favors chains where palatalization precedes syncope.

•Problem: Imagine a language like Bedouin Hijazi Arabic, with the following ranking:

(55)

/ʃarib-at/	PREC (ID(bk), MAX)	*ki	'SYNCOPATE'	MAX-V	ID (back)
a. ☞ <ʃaribat>			1		
b. <ʃaribat, ʃarbat>	W1		L	1	

•Here, syncope is blocked just in case there's no underlying pre-/i/ velar whose palatalization could be counterbled by /i/-syncope.

•Recall that in the hypothetical mutual-counterbleeding example from earlier, we spoke of degemination in just such terms.

•In Wolf (2008: §4.4.1) I accordingly refer to this predicted effect as 'obligatory counterbleeding'.

[11] There is a second motivation for giving up on the ranking metaconstraint: it allows us to assume that PREC constraints are ranked above faithfulness in the initial state of L1 acquisition, making it possible to use OT-CC to account for the emergence of non-target-like opacity in child phonology (Wolf 2008: §4.4.2, Tihonova 2009).

•Do any cases of obligatory counterbleeding exist? We can answer that question in two ways. The first way is to give a cautious 'yes'.

•Kisseberth & Abasheikh (1975) argue for the existence of a global rule involving the Chimwi:ni perfective suffix /-i:ɬe/ (I'm using /ɬ/ to denote a lateral flap). See also Kenstowicz & Kisseberth(1977), Hyman (1993).

•This suffix triggers spirantization of certain preceding consonants:

(56) /p, t, t̪/ → [s]
/k/ → [ʃ]
/ɬ/ → [z]

•And when these spirantizations occur, the long initial vowel of the suffix shortens:

(57) [ku-ɬipa] 'to pay' /ɬip-i:ɬe/ → [ɬis-iɬe] 'he paid'
[ku-laṯa] 'to let go' /laṯ-i:ɬe/ → [las-iɬe] 'he let go'
[x-ʃi:ka] 'to hold' /ʃi:k-i:ɬe/ → [ʃi:ʃiɬe] 'he held'
[x-kuɬa] 'to grow' /kuɬ-i:ɬe/ → [kuziɬe] 'he grew'

•The suffix vowel stays long if it's preceded by a consonant that doesn't spirantize. Three situations where this occurs: (a) preceding consonant isn't subject to the spirantization rule, (b) preceding consonant is a sibilant already, (c) preceding consonant is one of /p, t, t̪, k, ɬ/, but the stem it's part of is a lexical exception to spirantization:

(58) a. /pamb-i:ɬe/ → [pamb-i:ɬe] 'he decorated'
b. /kos-i:ɬe/ → [kos-e:ze] 'he made a mistake'[12]
(cf. x-kosa 'to make a mistake')
c. /set-i:ɬe/ → [set-e:ɬe] 'he stamped on'

•Moreover, there are a few stems which end in consonants other than /p, t, t̪, k, ɬ/, and which exceptionally do undergo spirantization. And with these stems, the perfective's vowel shortens:

(59) /big-i:ɬe/ → [biš-iɬe] 'he hit'
/law-i:ɬe/ → [laz-iɬe] 'he went out'

•This qualifies as a mutual counterbleeding interaction if the longness of the vowel is in some way a pre-requisite for spirantization.

•It's hard to say for sure that this could be the case, but it's not entirely implausible: long vowels are often higher/more peripheral than their short counterparts, and

[12] The consonant of the perfective suffix is changed to [z] following a stem that ends in /s, z, ʃ/ or /ɲ/.

vowels' capacity to induce assibilation with a preceding consonant is arguably positively correlated with increasing height (Hall & Hamann 2006, Hall, Hamann & Zygis 2006, Telfer 2006).

> See Gussenhoven (2007) on a possible perceptual motivation for the common historical development of long vowels becoming higher.

•The other way to answer the question "does mutual counterbleeding exist?" is to say "why start worrying about that now?". This is a valid response in the sense that rule-based phonology actually had the ability to mimic such interactions all along, and so it's not (relatively speaking) a problem if OT-CC does too.

•Hyman (1993: 217-218), citing personal communication from Sarah Taub, points out that a non-global, rule-based account of the Chimwi:ni shortening/spirantization interaction can be had if we assume that shortening applies first, and that it's shortening that makes spirantization possible, instead of the other way around:

(60)

-i:ɬ → -iɬ / T_

T → [+continuant, +strident] / _ iɬ

(where 'T' is shorthand for the class of segments capable of undergoing assibilation)

(•Note that it's not obvious that the corresponding switcheroo could be pulled off in OT-CC, since it's hard to see what would be responsible for allowing spirantization before short [i] but blocking it before long [i:].)

•And to get the hypothetical Bedouin Hijazi Arabic′ scenario in (54), we just have to add 'after a velar' to the environment for syncope:

(61)

URs	ħa:kim-i:n	ʃarib-at
Syllabification	ħa:.ki.mi:n	ʃa.ri.bat
[velar] → [-back] / [+voc, -back]	ħa:.kʲi.mi:n	*doesn't apply*
[+voc, +high, -long] → Ø / [velar]_$	ħa:kʲ.mi:n	*doesn't apply*
SRs	[ħa:kʲ.mi:n]	[ʃa.ri.bat]

5. Conclusion

•OT-CC differs from standard-based rule-based phonology in that choices about whether or not to do something at one point in a derivation can be *directly* influenced by previous derivational history.

•But even without global environments, rule-based phonology can still produce all of the same kinds of derivational-history effects as OT-CC, and can produce effects which OT-CC can't.

•This also holds for two other classes of global rules I didn't have time to talk about today:

> OT-CC can produce a pattern that Wilson (2006) dubs 'counterfeeding from the past', and which he says doesn't exist. But, as I'll show in talk at the upcoming LSA in Baltimore (Wolf 2010), this is actually attested in the form of rule-ordering paradoxes in modern Greek dialects described by Kaisse (1975, 1976), and in any case the ability to transmit derivational-history information via diacritics means that standard rule-based phonology allows this too.[13]
>
> OT-CC cannot produce mutual counterfeeding-on-focus, as noted by Kavitskaya & Staroverov (2009: §2.2). (This is related to Moreton's [1999] demonstration of the impossibility of modeling exchange rules in markedness-and-faithfulness OT.) In Wolf (2009), I show that OT-CC can produce mutual counterfeeding where one of the processes counterfeeds the other on the environment, but only if the two clauses of PREC constraints are split apart into separate constraints. Rule-based phonology, once again, permits both kinds of mutual counterfeeding.

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[13] Similar ordering paradoxes have also been argued for in other ancient (Adams 1972) and modern (Newton 1971, 1972a,b) Greek dialects. Odden (2008: §2) shows that Sympathy theory (McCarthy 1999) is also capable of modeling this same type of interaction.

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