Comparative Markedness

John J. McCarthy
jmccarthy@linguist.umass.edu

Version of January 26, 2002

Abstract

The markedness constraints of classic Optimality Theory assign violation-marks to output candidates without reference to the input or to other candidates. This paper explores an alternative conception of markedness that is *comparative*: markedness constraints compare the candidate under evaluation with another candidate, the most faithful one. Comparative constraints distinguish two situations: the candidate under evaluation contains an instance of a marked structure that is also present in the fully-faithful candidate ("inherited" violation); or the candidate under evaluation contains an instance of a marked structure that is not present in the fully faithful candidate ("new" violation). The empirical consequences of comparative markedness are explored, including grandfathering effects (i.e., blocking by emergent markedness constraints), derived environment effects, non-iterating processes, coalescence paradoxes, and counter-feeding opacity. Theoretical questions concerning harmonic ascent and other topics will also be discussed. Comparative markedness is found to have some advantages and some disadvantages in comparison with classic OT and alternatives like local conjunction, stratal OT, sympathy, and targeted constraints.

§1. Introduction

Optimality Theory (Prince and Smolensky 1993) has two principal types of constraints, faithfulness and markedness. Faithfulness constraints militate against input-output disparity, while markedness constraints impose restrictions on the output without reference to the input. For example, the input-output mapping /ab/ → *ʔab* violates the faithfulness constraint DEP (no epenthesis), and the output form *ʔab* violates the markedness constraints NO-CODA and NO-VOICE (≡*[–son, +voice]).

In this article, I explore the implications of a different approach to markedness. Suppose that markedness constraints assign violation-marks to output candidates by comparing them to the fully faithful candidate (FFC), which is present in every candidate set.[1] The idea is to allow the markedness constraints to distinguish between:

-Mappings that fail to correct a marked configuration in the FFC. E.g., the mapping /ab/ → *ʔab* fails to correct the marked voiced obstruent in the FFC *ab*. That is, the NO-VOICE violation in *ʔab* is "old" because the fully faithful candidate *ab* has the same violation.

and

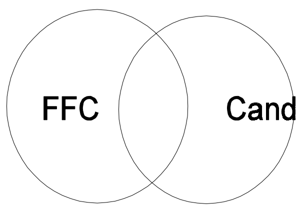
-Mappings that introduce new marked configurations. E.g., the mapping /ampa/ → *amba* introduces a voiced obstruent that is not present in the FFC *ampa*. That is, the NO-VOICE violation in *amba* is "new" because the fully faithful candidate *ampa* doesn't have this violation.

[1] Candidates are compared with the FFC, rather than the input itself, because inputs may lack syllabification or other fully predictable structure. See §3 and §6.2 for further discussion.

More formally, the proposal is that every traditional markedness constraint M should be replaced by two freely rankable constraints, ${}_{O}M$ and ${}_{N}M$. The notation ${}_{O}M$ is a reminder that these markedness constraints only refer to violations that are old, in the sense that they are shared with the FFC. The notation ${}_{N}M$ is similarly a reminder that these markedness constraints only refer to violations that are new, in the sense that they are not shared with the FFC. For example, ${}_{O}$NO-VOICE is violated by the /ab/ → *ʔab* mapping, while ${}_{N}$NO-VOICE is violated by the /ampa/ → *amba* mapping. Dividing traditional M up in this way yields some new results, as we will see below. I call this approach **comparative markedness**.

Taken together, ${}_{O}M$ and ${}_{N}M$ assign the same violation-marks as a traditional, non-comparative markedness constraint M. This is best seen with a Venn diagram:

(1)



The circle on the left stands for all the violations of standard OT markedness constraints incurred by the FFC. The circle on the right stands for all the violations of standard OT markedness constraints incurred by the candidate under evaluation, Cand. Cand's violation-marks can be partitioned into two subsets: those shared with the FFC (Cand∩FFC) and those that are not shared with the FFC (Cand–FFC). The shared violations, the region in the middle, are the ones that I am calling old or inherited. Comparative markedness theory counts them as ${}_{O}M$ violations. Cand's violation-marks that are not shared with the FFC — the portion of the right circle that does not overlap with the left circle — can be thought of loosely as new, since they refer to something about Cand that is different from the FFC. Comparative markedness theory counts them as ${}_{N}M$ violations. From this, it's clear that all of Cand's traditional markedness violations are accounted for, some being assigned to ${}_{O}M$ constraints and some to ${}_{N}M$ constraints.

The next section looks informally at one consequence of comparative markedness, the analysis of grandfathering effects, where a marked structure is permitted when it is old but forbidden when it is new. Later sections fill in the formal details of the theory as a whole and of the analysis of grandfathering effects. Applications to derived environment effects, non–iterative processes, coalescence paradoxes, and counter-feeding opacity are also discussed, as are issues raised by this approach, such as determination of the fully-faithful candidate and the problem of harmonic ascent.

§2. Grandfathering Effects

Suppose that typological evidence has established the presence in UG of a classic OT markedness constraint M — for example, some languages have no M-violating structures, some languages have processes that actively eliminate M-violators, and so on. In a particular language L, M is ranked below antagonistic faithfulness constraints, so it cannot compel unfaithful mappings. But M is nonetheless observed to block processes in L from creating M-violating structures. M is emergent in L, like emergence of the unmarked in McCarthy and Prince (1994). I call this a "grandfathering effect".[2]

Situations like this are by no means uncommon. Archangeli and Pulleyblank (1994) call them "target conditions", since they specifically affect the target of a phonological process. Their relevance to comparative markedness theory was discovered by Paul de Lacy, who offers the following example:

(2) Mekkan Arabic [–voice] Assimilation (Abu-Mansour 1996, Bakalla 1973)

a. Voiced obstruent assimilates to following voiceless (cf. Mascaró and Wetzels 2001)

/ʔagsam/	ʔaksam	'he swore an oath'
/mazkuːr/	maskuːr	'mentioned'

b. But not vice-versa. Assimilation can't create marked voiced obstruents

/ʔakbar/	ʔakbar, *ʔagbar	'older'

c. Voiced obstruents, even codas, are mapped faithfully from input

/ʔibnu/	ʔibnu	'his son'
/ʔadʒuːz/	ʔadʒuːz	'old'

In this Arabic dialect, coda obstruents become voiceless before a voiceless obstruent (2a). There is no general process of coda devoicing, however, as shown by (2c). Most importantly, voiceless coda obstruents do not become voiced before voiceless obstruents (2b). This is a grandfathering effect: though this language permits voiced obstruents in codas and elsewhere, they cannot be created by the voicing assimilation process. The markedness constraint NO-VOICE blocks assimilation but cannot itself compel unfaithfulness.

In comparative markedness theory, there are actually two NO-VOICE constraints, $_{N}$NO-VOICE and $_{O}$NO-VOICE. $_{N}$NO-VOICE is violated by new instances of voiced obstruents, those not present in the FFC. $_{O}$NO-VOICE is violated by old instances of voiced obstruents, those already present in the FFC. For example, **ʔagbar* violates each of these constraints once: $_{N}$NO-VOICE is violated by the *g*, whose counterpart in the FFC *ʔakbar* is not voiced; and $_{O}$NO-VOICE is violated by the *b*, whose counterpart in the FFC is also voiced. To block assimilation, $_{N}$NO-VOICE must be ranked above the markedness constraint AGREE(voice),[3] which is itself ranked above the faithfulness constraint IDENT(voice), as shown in (3).

[2]In American jurisprudence, a grandfather clause is a provision in a law that exempts persons already engaged in activities affected by that law. The term was first used to describe laws in some southern states that exempted persons whose ancestors ("grandfathers") had voted prior to 1867 from impediments to voting, such as poll taxes and literacy tests. The intended effect was to apply these impediments only to the descendants of slaves.

[3]Sources of the AGREE constraint include Bakovic (2000), Beckman (1998), Gnanadesikan (1997), and Lombardi (1999). Like all markedness constraints, AGREE will have old and new versions. I suppress this irrelevant complication here.

(3) Mekkan Arabic: $_N$No-Voice $\gg$ Agree(voice) $\gg$ Ident(voice)

/ʔagsam/	$_N$No-Voice	Agree(voice)	Ident(voice)
a. ☞ ʔaksam			*
b. (FFC) ʔagsam		*!	
/ʔakbar/			
c. (FFC) ☞ ʔakbar		*	
d. ʔagbar	*!		*

In (3a, b), top-ranked $_N$No-Voice is satisfied by both candidates because neither introduces a new voiced obstruent. This leaves the choice up to Agree(voice), which favors the candidate with assimilation. In (3c, d), though, there is a candidate **ʔagbar* with a new voiced obstruent, and its encounter with $_N$No-Voice is fatal. Assimilation is effectively blocked.[4]

To show that two putatively distinct OT constraints are in fact distinct, it is sufficient to show that they are ranked non-adjacently in some language's hierarchy. As required, $_O$No-Voice is ranked at a different place in Mekkan Arabic's hierarchy than $_N$No-Voice. Because some underlying voiced obstruents make it faithfully to the surface, even in coda position, Ident(voice) must be ranked above $_O$No-Voice, as in (4).

(4) Mekkan Arabic: Ident(voice) $\gg$ $_O$No-Voice

/ʔibnu/	Ident(voice)	$_O$No-Voice
a. ☞ ʔibnu		*
b. ʔipnu	*	

By transitivity of the rankings in (3) and (4), $_N$No-Voice and $_O$No-Voice are indeed ranked separately in Mekkan Arabic. As ranked, $_N$No-Voice is visibly active over inputs like /ʔakbar/, but $_O$No-Voice shows no visible activity.

The key to analyzing this and other examples of grandfathering effects is the ranking of the old and new versions of a markedness constraint. The new version, $_N$M, is ranked above the markedness constraint responsible for the process that is blocked. The old version, $_O$M, is ranked below the relevant faithfulness constraint, so it cannot affect M-violating structures that are already present in the input/FFC. This same schematic ranking is at work in derived environment effects, as I will show later (§4.2). The opposite ranking, with $_O$M high and $_N$M low, is also attested, as I will demonstrate in §5.

---

[4]Another way to satisfy Agree(voice) is by progressive assimilation: **ʔakpar*. I assume, as is now standard (Beckman 1998, Lombardi 1999), that the positional faithfulness constraint Ident-Ons(voice) is ranked above Agree.

In classic OT, which has only non-comparative markedness constraints, there is no general solution to the problem of grandfathering effects. Consider, for example, how one might analyze Mekkan Arabic using only the constraints NO-VOICE, AGREE(voice), and IDENT(voice). If NO-VOICE is ranked above AGREE(voice), then assimilation is correctly blocked in *ʔakbar*. But by transitivity, NO-VOICE also dominates IDENT(voice). This predicts that Mekkan should have no voiced coda obstruents whatsoever, and that is false (see (2c)). To accommodate this language, then, the classic theory must enrich its constraint set in other ways, perhaps by dividing the AGREE and/or IDENT constraints according to values of the feature [voice]: AGREE(+voice) vs. AGREE(–voice), IDENT(+voice) vs. IDENT(–voice). Obviously, though, this is a highly localized solution to a specific problem; it does not address the broader issue of how to analyze grandfathering effects in general.

We will return to the analysis of grandfathering effects in §4.1, but first it is necessary to formalize some of the new notions that have been treated intuitively up to this point.

---

§3. Formalization

As the discussion in §2 indicated, $_{\mathrm{O}}$M and $_{\mathrm{N}}$M are defined in such a way that they recognize, respectively, a candidate's failure to remove some instance of a marked configuration and a candidate's introduction of a new instance of a marked configuration, relative to the FFC. What we need, then, is a way of talking about a specific instance of a marked configuration in a candidate and a way of talking about what it means to inherit a marked configuration or to introduce a new one. We also need an unambiguous characterization of the FFC itself, a matter that will be taken up in §6.2.

Intuitively, a constraint violation is new if the corresponding material in the FFC does not violate that constraint. For instance, the mapping /ampa/ → *ʔamba* introduces a new NO-VOICE violation relative to the FFC *ampa*. Differences between candidates that are not relevant to a constraint's applicability do not make a violation new. For example, the mapping /an+ba/ → *amba* does not introduce a new NO-VOICE violation relative to the FFC *anba*. Although the underlying /b/ is involved in a place assimilation process in *amba*, that is irrelevant to applying NO-VOICE. Furthermore, a simple count of violation-marks is not enough to determine newness. The mapping /ampab/ → *ambap* introduces a new NO-VOICE violation relative to the FFC *ampab*, even though both *ambap*and *ampab* have exactly one NO-VOICE violation-mark.

To express these intuitions formally, it is necessary to explore what it means to apply a markedness constraint to a form. Two notions will be essential. One is the **locus of violation** of a markedness constraint in a candidate. This is the portion of the candidate that meets the constraint's structural description. It is sufficient to determine that the constraint is violated, but no larger. The other notion is **t-correspondence**. This is a version of correspondence that has been transitivized, using the shared input to link two output candidates. Together, these elements provide a foundation for defining comparative markedness.

The locus of violation of a markedness constraint M in a candidate form C comprises exactly as much of C as is necessary to support the assignment of a single violation-mark by M. For example, the locus of violation of NO-VOICE in *amba* is the segment *b*. Other aspects of this form are irrelevant to applying NO-VOICE and so are outside its locus of violation in this candidate.[5]

What is relevant to applying a constraint is determined by the formulation of the constraint itself. The constraint NO-VOICE and a constraint against voiced coda obstruents are formulated differently and so have different (though sometimes overlapping) loci of application. The locus notion in constraint-based OT is therefore analogous to an important concept in *SPE*'s formalization of phonological rules called "is applicable to with the analysis". A *SPE* rule A → B / X__Y is applicable to a form F with the analysis $\varphi_1\psi_1\psi_2\psi_3\varphi_2$ if and only if the following conditions are met:

(5) "Is applicable to with the analysis" in *SPE* (Chomsky and Halle 1968: 391)

a. $F = \varphi_1\psi_1\psi_2\psi_3\varphi_2,$

and b. X is contained in ψ_1, A is contained in ψ_2, and Y is contained in ψ_3.

Where X *is contained in* Y iff $X = X_1 \ldots X_m$, $Y = Y_1 \ldots Y_m$, and for all X_i and Y_i,

X_i and Y_i are units,

and the specified features constituting X_i are a subset of the specified features constituting Y_i.

In other words, the rule A → B / X__Y is applicable to F if some segment(s) in F contain the featural specifications of X, A, and Y, in that order with nothing intervening. If F happens to contain several loci of application of the same rule, then each locus will have a distinct analysis, in this sense. For example, the phonological rule [+syll] → Ø / __[+syll] is applicable to the string *paetoi* with two distinct analyses. In one analysis, ψ_2 is *a* and ψ_3 is *e*. In the other analysis, ψ_2 is *o* and ψ_3 is *i*. Hence, *paetoi* → *peti*.

An OT markedness constraint is like the structural description of an *SPE* phonological rule, but at once simpler and more complex. The OT constraint is simpler because it does not need to distinguish between the targeted element and the context, so the terms XAY can be collapsed. Like a phonological rule, a markedness constraint identifies certain configurations, and the way that it identifies them is by analyzing forms approximately as in (5). Specifically, a markedness constraint *A imposes an analysis $\varphi_1\psi\varphi_2$ onto a candidate output form *cand* if *cand* = $\varphi_1\psi\varphi_2$ and A is contained in ψ. (I limit the discussion to negatively stated, non-Alignment markedness constraints.) The locus of violation of a markedness constraint M in a candidate C is just exactly ψ. For each distinct analysis that M imposes, one violation-mark is assigned. For example, the constraint ONSET, defined as $*[_\sigma V$, has two loci of violation in the candidate $[_\sigma pa][_\sigma e][_\sigma to][_\sigma i][_\sigma ka]$. These loci are identified by the two analyses that ONSET imposes on this candidate, $\varphi_1[_\sigma e\varphi_2$ and $\varphi_1[_\sigma i\varphi_2$. ONSET therefore assigns two violation-marks to this candidate, one for each locus of violation.

[5]The issue of what is relevant to applying a rule or constraint arises particularly forcefully in the analysis of derived environment effects (cf. §4.2). For example, Kiparsky's (1973) Alternation Condition says that neutralization rules only apply in derived environments. The precise conditions that make an environment derived are by no means obvious. In Mascaró's (1976) theory of strict cyclicity, a rule is applying in a derived environment if it "makes specific use of information assigned" by a previous rule on the same cycle. Formalization of "makes specific use of information" will present similar difficulties.

In another respect, though, OT markedness constraints are more complex than *SPE* rules. The problem is that the *SPE* definition in (5) is embedded in a purely segmental theory of phonological representation, but contemporary phonology, whether rule-based or constraint-based, requires reference to much richer structures, making (5) technically inapplicable. In rule-based phonology specifically, this has been regarded as a non-issue; most analysts assume that *SPE*'s model of segmental rule application in (5) still works for autosegmental and metrical structures. This is not as incoherent as it seems, since there exist formally equivalent linear encodings of autosegmental and metrical structure (Idsardi 1992, Kornai 1994). This makes (5) technically applicable to present-day phonological representations and rules, perhaps requiring only some some minor adjustments to the definition of "is contained in". For example, if I say that $\varphi_1[_\sigma e\varphi_2$ is an analysis of the form *pa.e* by the constraint ONSET, then I am expediently adopting a linearized representation of hierarchical prosodic structure.

Another complication is that OT markedness constraints and autosegmental or metrical rules have, in practice, been formulated in remarkably diverse ways.[6] Without a consistent constraint- or rule-writing language, it is not possible to produce something like (5) that will serve for contemporary phonology. Needless to say, a general solution to this problem is beyond the scope of this article. Fortunately, though, a general solution is not required because stipulation will suffice for present purposes. I assume that the definition of a markedness constraint includes a function that takes a form and returns the set of all violation loci in it.[7] Ultimately, the goal is to avoid this stipulation by deriving this result from a theory of constraint application comparable to (5).

The next step in formalizing comparative markedness theory is defining what it means for two candidates from the same input to share a locus of violation. $_{\mathrm{O}}$M constraints assign marks only to loci that are shared with the FFC; $_{\mathrm{N}}$M constraints assign marks only to loci that are not shared with the FFC. This sharing relation holds between two candidates derived from the same input, so it must be mediated by some version of correspondence theory (McCarthy and Prince 1995, 1999). Correspondence theory relates inputs to outputs, so a correspondence relation that is transitivized by way of the input is required. This is called *t-correspondence*.

(6) T-correspondence

Let *cand1* and *cand2* be two candidates from input *in*. Let *s1* be a unit in *cand1* and *s2* be a unit in *cand2*. Then *s1* **t-corresponds** to *s2* iff *s1* corresponds to some unit *s-in* in *in* and *s2* also corresponds to *s-in*.

---

[6] Here is an example of the issues that can arise. Autosegmental and metrical phonology have arguably eliminated the need for variables in structural descriptions, but this has not stopped analysts from positing rules or constraints that refer to variable expressions like C_0. Now suppose someone has proposed the hypothetical OCP-like constraint $*uC_0u$. This constraint will appear to have a non-shared locus of violation whenever two candidates differ in the contents of C_0, such as *putku* and *puku* from input /putku/. Although evidence is not at hand, this result does not seem right: the violation of $*uC_0u$ in *puku* ought to be old, rather than new, relative to the FFC *putku*. The problem is that an irrelevant difference between candidates — the number of intervening consonants — is made to seem relevant because it is included in the analysis that the constraint imposes. Autosegmental structure, of course, eliminates the need for the expression C_0 and so should eliminate this problem.

[7] I am grateful to Marc van Oostendorp for this suggestion and for others that I have not yet been able to incorporate into this article.

In other words, the elements in different candidate forms t-correspond if they correspond to the same elements in the input. Each candidate brings with it its own correspondence relation $\Re_i$, so different relations are involved in each link of the chain. With *s-1* $\Re_1$ *s-in* $\Re_2$ *s-2*, we can sensibly compare loci of violation that include *s1* and *s2* in the two candidates *cand1* and *cand2*. A special case arises when *cand1* equals *cand2* in (6) — that is, when the FFC itself is under evaluation. Obviously, every segment in the FFC t-corresponds to itself. This means that the FFC can never violate an $_N$M markedness constraint, though it may violate $_O$M constraints. (Relatedly, $_N$M violations can never be forced by faithfulness alone — there must also be some high-ranking markedness constraint to compel the violation.)

A simpler alternative would compare candidates with the input itself, rather than the FFC, asking whether a candidate's markedness violations are literally inherited from the input. This would eliminate the need for a *t*-correspondence relation. This alternative is unworkable, however, under present understanding of the nature of inputs. Inputs may lack fully predictable structure, such as syllabification, or they may have it wrong.[8] If so, then every ONSET violation will seem to be new even if, intuitively, it is not. The FFC, unlike the input, is fully formed, and so its markedness violations can be sensibly compared to those of any other candidate. For further discussion, see §6.2.

The definition of t-correspondence in (6) is the basis for determining whether a locus of constraint violation is shared or not.

(7) Shared locus of violation

Two candidates, *cand1* and *cand2*, **share a locus of violation** of the markedness constraint M iff

a. there exists a locus of violation ψ_1 of M in *cand1*,
and b. there exists a locus of violation ψ_2 of M in *cand2*,
and c. every element of ψ_1 t-corresponds to some element of ψ_2,
and d. every element of ψ_2 t-corresponds to some element of ψ_1.

In other words, two candidates share a locus of violation if they both violate a constraint and the elements responsible for the violation t-correspond to one another. The definitions of the comparative markedness constraints themselves depend upon (7). First comes the constraint against old instances of marked structures:

(8) $_O$M

Let *cand* be a candidate, *in* its input, and *ffc* the fully faithful candidate derived from *in*. Let M stand for a markedness constraint of classic OT. Then the comparative markedness constraint $_O$M assigns one violation-mark to *cand* for each locus of M violation in *cand* that is shared with *ffc*.

The constraint against new instances of marked structures is defined in parallel fashion:

[8] Because the syllabification of tautomorphemic sequences is never contrastive, it is reasonable to assume that no faithfulness constraints whatsoever protect syllabification. It makes no difference, then, whether inputs are syllabified or how they are syllabified. See §6.2 for discussion.

(9) $_{\mathrm{N}}$M

Let *cand* be a candidate, *in* its input, and *ffc* the fully faithful candidate derived from *in*. Let M stand for a markedness constraint of classic OT. Then the comparative markedness constraint $_{\mathrm{N}}$M assigns one violation-mark to *cand* for each locus of M violation in *cand* that is not shared with *ffc*.

For example, **ʔagbar* in (3d) contains two loci of NO-VOICE violation. One of those loci is *g*. It is a voiced obstruent, but it does not t-correspond to a voiced obstruent in the FFC *ʔakbar*. By virtue of this *g*, then, **ʔagbar* receives one violation-mark from $_{\mathrm{N}}$NO-VOICE. The other locus of violation is *b*. It too is a voiced obstruent, and moreover it t-corresponds to a voiced obstruent in the FFC. By virtue of this *b*, **ʔagbar* also receives one violation-mark from $_{\mathrm{O}}$NO-VOICE.

To sum up, $_{\mathrm{N}}$M and $_{\mathrm{O}}$M keep track of new and old markedness violations in a candidate. A markedness violation is new if the corresponding locus in the FFC **is not** similarly marked; a markedness violation is old if the corresponding locus in the FFC **is** similarly marked. This formalization of comparative markedness theory immediately answers the question of why there are no equivalent distinctions among faithfulness constraints. That is, why don't we have $_{\mathrm{N}}$F and $_{\mathrm{O}}$F to parallel $_{\mathrm{N}}$M and $_{\mathrm{O}}$M? The reason: the FFC, by definition, has no faithfulness violations, so $_{\mathrm{O}}$F (≈"don't allow faithfulness violations to persist from the FFC") can never be violated. In effect, all faithfulness constraints are $_{\mathrm{N}}$F constraints.

---

§4. Prohibiting New Marked Structures

This section looks at the effects of ranking $_{\mathrm{N}}$M high and its $_{\mathrm{O}}$M counterpart low. There are three parts. In §4.1, grandfathering effects are examined more fully in light of the formalization in §3. In §4.2, I show how derived environment effects can also be analyzed with this ranking. Then §4.3 compares comparative markedness with an alternative approach, local conjunction of markedness and faithfulness constraints.

§4.1 Grandfathering Effects Revisited

The discussion in §2 introduced grandfathering effects and showed how voicing assimilation in Mekkan Arabic can be analyzed with comparative markedness constraints. This section documents the grandfathering phenomenon more fully.

In a grandfathering effect, a markedness constraint of UG is observed in some language to block an otherwise general phonological process, but not to affect instances of the marked structure that are inherited from the input. In Mekkan Arabic, the markedness constraint with this force is NO-VOICE. In its two versions, it blocks assimilation when it would create voiced obstruents ($_{\mathrm{N}}$NO-VOICE dominates AGREE(voice)) and permits underlying voiced obstruents to emerge unscathed (IDENT(voice) dominates $_{\mathrm{O}}$NO-VOICE). A similar example, whose significance for comparative markedness theory was also recognized by Paul de Lacy, comes from a Portuguese-based creole of Sri Lanka.

(10) Place Assimilation in Sri Lankan Portuguese Creole (Hume and Tserdanelis 1999)

a. Labials and dorsals assimilate in place

/maːm–su/	maːnsu	'hand (gen. sg.)'
/maːm–pə/	maːmpə	'id. (dat. sg.)'
/maːm–ki/	maːŋki	'id. (verbal N)'
/miːtiŋ/	miːtinsu	'meeting'
	miːtimpə	'id. (dat. sg.)'
	miːtiŋki	'id. (verbal N)'

b. But coronals don't assimilate

/siːn/	siːnsu	'bell'
	siːnpə, *siːmpə	'id. (dat. sg.)'
	siːnki, *siːŋki	'id. (verbal N)'

The problem is to explain why coronals are not affected by this assimilation process. The situation is analogous to Mekkan Arabic, where voiceless obstruents are likewise not subject to assimilation.

Just as voiceless obstruents are less marked than voiced, coronals are less marked than labials or velars, a claim that is extensively supported in the literature on coronal unmarkedness (Paradis and Prunet 1991). In OT, this means that there exists a markedness constraint or constraints against labials and velars, and that either the markedness constraint(s) against labials and velars are always ranked above the constraint against coronals or there is no constraint against coronals. Prince and Smolensky (1993) take the first option with their fixed hierarchy ⟦*Lab, *Dors ≫ *Cor⟧. De Lacy (2002) argues for the second: there is a single constraint against labials or velars (*Lab|Dors) and there is no constraint that militates against just coronals. I adopt de Lacy's approach here (see fn. 9).

Since labials and velars are more marked than coronals, we may expect to see a grandfathering effect: a language that has labials and velars generally, but that blocks a process from creating them when the alternative is to preserve an underlying coronal. This is the situation in Sri Lankan Portuguese Creole. This language has consonants, including codas, at all three places of articulation. Assimilation is free to replace a labial with a velar or coronal or to replace a velar with a labial or coronal, but it will never replace a coronal with a labial or velar. This means that the comparative markedness constraint $_{N}$*Lab|Dors is ranked above Agree(place), which is itself ranked above Ident(place). Standing at the bottom of the hierarchy, below Ident(place), is $_{O}$*Lab|Dors, since there is no general process neutralizing labials and velars to coronals. Tableau (11) supplies the necessary ranking arguments:

(11) Sri Lankan Portuguese Creole: $_{\mathrm{N}}$*LAB|DORS ≫ AGREE(place) ≫ IDENT(place) ≫ $_{\mathrm{O}}$*LAB|DORS

<table>
<tr><th>/maːm–su/</th><th>$_{\mathrm{N}}$*LAB|DORS</th><th>AGREE(place)</th><th>IDENT(place)</th><th>$_{\mathrm{O}}$*LAB|DORS</th></tr>
<tr><td>a. ☞ maːnsu</td><td></td><td></td><td>*</td><td>*</td></tr>
<tr><td>b. (FFC) maːmsu</td><td></td><td>*!</td><td></td><td>**</td></tr>
<tr><td>/maːm–ki/</td><td colspan="4"></td></tr>
<tr><td>c. ☞ maːŋki</td><td></td><td></td><td>*</td><td>**</td></tr>
<tr><td>d. (FFC) maːmki</td><td></td><td>*!</td><td></td><td>***</td></tr>
<tr><td>/maːm/</td><td colspan="4"></td></tr>
<tr><td>e. (FFC) ☞ maːm</td><td></td><td></td><td></td><td>**</td></tr>
<tr><td>f. maːn</td><td></td><td></td><td>*!</td><td>*</td></tr>
<tr><td>/siːn–pə/</td><td colspan="4"></td></tr>
<tr><td>g. (FFC) ☞ siːnpə</td><td></td><td>*</td><td></td><td>*</td></tr>
<tr><td>h. siːmpə</td><td>*!</td><td></td><td>*</td><td>*</td></tr>
</table>

The first two candidate pairs (11a, b, c, d) establish that the basic ranking for place assimilation: AGREE(place) dominates IDENT(place). The constraint $_{\mathrm{N}}$*LAB|DORS is not active over these candidates because none introduces a new violation of *LAB|DORS. For example, *maːŋki* has three loci of violation of *LAB|DORS: *m, ŋ,* and *k*. For each locus, we check whether its t-correspondent in the FFC is also a locus of violation of *LAB|DORS. The t-correspondents are, respectively, *m, m,* and *k*. Although the t-correspondents *ŋ* and *m* differ in place of articulation, both violate *LAB|DORS, so there is no new violation to be reckoned with. Hence, $_{\mathrm{N}}$*LAB|DORS is not active on (11c, d), as promised.[9]

The candidate pair in (11e, f) is evidence of the grandfathering effect: dorsals and labials in coda position are not neutralized generally because $_{\mathrm{O}}$*LAB|DORS is ranked below faithfulness. The candidate *maːm* is the FFC and so, by definition, it shares a violation of *LAB|DORS with the FFC. So this candidate violates only low-ranking $_{\mathrm{O}}$*LAB|DORS; indeed, any violation incurred by the FFC must be an "old" one.

Finally, the pair of candidates in (11g, h) show how assimilation is blocked when it would change a coronal to a non-coronal. This follows from the ranking ⟦$_{\mathrm{N}}$*LAB|DORS ≫ AGREE⟧: avoidance of new violations of *LAB|DORS takes precedence over assimilation. Because of this ranking, only grandfathered labials and dorsals are permitted in coda position. A final detail:

[9]Paul de Lacy observes that this result requires that there be a constraint against both labials and velars. Separate constraints *LAB and *DORS won't do, because *maːŋki* would wrongly violate $_{\mathrm{N}}$*DORS. The existence of the unified constraint *LAB|DORS is in accordance with the findings of de Lacy (2002) and Prince (1987) that harmonic scales like place markedness must be expressed by stringency (i.e., inclusion) hierarchies of constraints.

candidates like *siːntə*, which satisfies Agree by changing the onset *p* into a coronal, are ruled out by the undominated positional faithfulness constraint Ident-Ons(place).

In Optimality Theory, permuted ranking is the source of differences among languages. One possibility predicted by ranking permutation is a reversal of the positions of Ident(place) and $_O$*Lab|Dors. If all else is held the same, then this predicted language should have the same medial clusters as Sri Lankan Portguese Creole, but only coronals word-finally.[10] The Australian languages Guugu-Yimidhirr and the Pintupi dialect of the Western Desert language are examples of this (Dixon 1980: 161-164) are examples. In common with many Australian languages, Guugu-Yimidhirr and Pintupi allow medial clusters that are homorganic or, if heterorganic, have a coronal as first member. Word-finally, unlike Sri Lankan Portuguese Creole, they permit only coronals. The following tableau shows how this pattern emerges by reversing the ranking of the two lowest constraints:

(12) Guugu-Yimidhirr and Pintupi: $_N$*Lab|Dors ≫ Agree(place) ≫ $_O$*Lab|Dors ≫ Ident(place)

/mt/	$_N$*Lab|Dors	Agree(place)	$_O$*Lab|Dors	Ident(place)
a. ☞ nt				*
b. (FFC) mt		*!	*	
/mp/				
c. (FFC) ☞ mp			**	
d. np		*!	*	*
/m#/				
e. ☞ n#				*
f. (FFC) m#			*!	
/np/				
e. (FFC) ☞ np		*	*	*
f. mp	*!		*	

As in the analysis of Sri Lankan Creole, I assume that Ident-Ons(place) is undominated.

A final remark. As I noted in §2, grandfathering effects are analyzed by Archangeli and Pulleyblank (1994) under the rubric of target conditions, which are specific restrictions on the segment targeted by a phonological rule. Their book is replete with examples; I will cite one here. In Yawelmani Yokuts, a certain suffix supplies a floating glottal feature that attempts to anchor onto the preceding root.

[10] I am grateful to Colin Wilson for pointing out this prediction of the theory.

(13) Yawelmani Glottal Association (Archangeli and Pulleyblank 1994: 346ff., Newman 1944)

a. Floating glottal feature anchors onto the second root consonant if it's a sonorant:

/caw/	caw'aahin	'shout'
/ʔilk/	ʔel'kaahin	'sing'

b. But not if second root consonant is an obstruent; in that case, the glottal feature must segmentalize or delete:

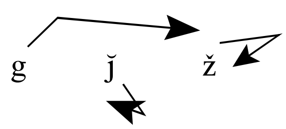
/max/	maxʔaahin	'procure'
/hogn/	hognaahin	'float'

Yawelmani has voiced obstruents generally, as shown by examples like *bok'en* 'will find' or *hiwt'iwlaxoʔ* 'becomes very happy'. There is, then, no general prohibition on glottalized obstruents, but rather the process that docks the floating feature is prohibited from creating them. This shows that the markedness constraint against new instances of [–son, +glott] segments is ranked high, though its old alter ego is ranked too low to matter. It seems plausible that all examples of target conditions can be reanalyzed in these terms, capturing Archangeli and Pulleyblank's insight without giving free license to process-specific constraints (cf. Davis 1995, McCarthy 1997, 2002: 103-6).

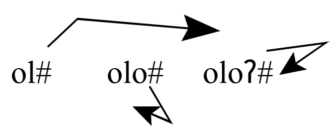
§4.2 Derived Environment Effects

Lubowicz (1999, to appear) draws our attention to the problem that phonologically derived environment effects (DEE's) present for classic OT.[11] Here are some examples of DEE mappings, using a perspicuous graphical format introduced by Lubowicz:

(14)

Polish: 

(Lubowicz to appear, Rubach 1984)

Makassarese: 

(Aronoff et al. 1987, McCarthy and Prince 1994)

In rule-based phonology, phenomena like these are understood as follows. Polish has a rule changing *ǰ* to *ž* (context-free). But this rule only affects *ǰ* derived by palatalization from /g/, as in /krogek/ → *kroǰek* → *krožek* 'xxx'. It does not affect underlying /ǰ/, as in /briǰek/ → *briǰek* 'xxx'. In Makassarese, a process epenthesizing *ʔ* after a word-final vowel affects words ending in epenthetic vowels, as in /botol/ → *botolo* → *botoloʔ* 'bottle'. But it does not affect words that already end in a vowel, such as /batu/ → *batu*, **batuʔ* 'xxx'. The graphical format in (14) brings the issue into focus: underlying /g/

[11] Comparative markedness is not applicable to *morphologically* derived environment effects. See Lubowicz (1999, to appear) for relevant discussion.

The study of DEE's originates with the work of Kiparsky (1973, 1982, 1993), who has analyzed them under various rubrics: the Alternation Condition, the Strict Cycle (following Mascaró 1976), and underspecification with structure-filling vs. structure-changing processes.

and /ol#/ are mapped onto surface forms *ž* and *oloʔ#* that are further away, faithfulness-wise, than /ǰ/ or /olo#/, which do not map onto those surface forms.

In comparative markedness theory, DEE's are a consequence of visible activity by $_{N}$M markedness constraints but not their $_{O}$M counterparts. The basic ranking schema responsible for a DEE is this:

(15) Ranking Schema for a Derived Environment Effect

$$_{N}M \gg \text{Faith} \gg {}_{O}M$$

Informally, this says that new violations of M are avoided, even at the expense of being unfaithful, but old violations are tolerated. For example, Polish /krogek/ maps to *krožek* because the alternative, **krojek*, would introduce a new instance of marked configuration (a *ǰ*) that is not present in the FFC *krogek*. But Polish also has /briǰek/ → *briǰek* because *briǰek*, which is itself the FFC, only has an old instance of the marked *ǰ* configuration.

Let NO-ǰ stand for the traditional markedness constraint responsible for the spirantization process in Polish. This constraint has two instantiations in comparative markedness theory, $_{N}$NO-ǰ and $_{O}$NO-ǰ. In accordance with the ranking schema in (15), these constraints are respectively ranked above and below the faithfulness constraint IDENT(cont):[12]

(16) Polish: $_{N}$NO-ǰ ≫ IDENT(cont) ≫ $_{O}$NO-ǰ

	$_{N}$NO-ǰ	IDENT(cont)	$_{O}$NO-ǰ
a. ☞ krožek		*	
b. krojek	*!		
cf. FFC *krogek*			
c. (FFC) ☞ briǰek			*
d. brižek		*!	

The mapping /krogek/ → **krojek* yields an output that contains a new instance of a marked *ǰ*, one that is not present in the FFC *krogek*. So $_{N}$NO-ǰ is violated. But the mapping /briǰek/ → *briǰek* exhibits only failure to improve relative to the FFC, not deterioration relative to the FFC. For this reason, it violates only low-ranking $_{O}$NO-ǰ.

In Makassarese, words ending in illicit codas (*r, l, s*) are supplied with an epenthetic copy of the preceding vowel. Seemingly gratuitously, though, these words also get a final *ʔ* (which is a licit coda):

[12]Following Lubowicz and Rubach, I assume that *ǰ* is a strident stop, differing in [continuant] from *ž*.

(17) DEE in Makassarese

/rantas/	rántasaʔ	‘dirty’
/tetter/	téttereʔ	‘quick’
/jamal/	jámalaʔ	‘naughty’

Epenthesis of *ʔ* is a response to the markedness constraint Final-C (McCarthy and Prince 1994): every PrWd is consonant-final (i.e., $*V]_{PrWd}$). This constraint is independently justified in the Makassarese reduplicative system and in other languages.

But Final-C is not universally obeyed in Makassarese; vowel-final words are permitted if they are also vowel-final in the FFC:

(18) Underlying Vowel-Final Words in Makassarese

/lompo/	lómpo	‘big’
	*lómpoʔ	

Epenthesis of *ʔ* is, then, a DEE: only *derived* vowel-final words receive epenthetic *ʔ*.

In comparative markedness theory, there are two instantiations of the markedness constraint Final-C: $_{O}$Final-C and $_{N}$Final-C. Substituting these constraints and Dep-C (no consonant epenthesis) into the DEE ranking schema (15), we obtain the ranking in (19).

(19) Ranking for Makassarese

$_{N}$Final-C $\gg$ Dep-C $\gg$ $_{O}$Final-C

This says, roughly, that Dep-C will be violated when necessary to avoid introducing new Final-C violations, but it will not be violated in order to remove existing Final-C violations. There is a threat of new Final-C violations because of final vowel epenthesis, which is compelled by undominated Coda-Cond.

(20) Makassarese: $_{N}$Final-C $\gg$ Dep-C $\gg$ $_{O}$Final-C

	$_{N}$Final-C	Dep-C	$_{O}$Final-C
a. ☞ rantasaʔ		*	
b. rantasa	*!		
cf. FFC *rantas*			
c. (FFC) ☞ lompo			*
d. lompoʔ		*!	

First, consider a consonant-final input. Candidate (20b) contains a locus of violation of Final-C, $a]_{PrWd}$. There is only one segment in this locus, the epenthetic vowel *a*. This vowel, precisely because it is epenthetic, does not t-correspond to any segment in the FFC *rantas*. This means that candidate (20b) violates $_{N}$FINAL-C — it contains a new FINAL-C violation, not shared with the FFC.

Now consider a vowel-final input. Candidate (20c) also contains a locus of violation of FINAL-C, $o]_{PrWd}$. Its competitor (20d) does not. But since (20c) is the FFC, its locus of violation of FINAL-C trivially t-corresponds to a locus in the FFC. This is a shared or old violation, which means that $_{N}$FINAL-C is satisfied by (20c), though $_{O}$FINAL-C is not. With this ranking, the faithful candidate triumphs over the candidate that satisfies low-ranking $_{O}$FINAL-C.

These examples show, incidentally, that comparative markedness comes fairly close to expressing Kiparsky's (1973) original conception of what it means for the environment of one process to be derived by another process. To paraphrase Kiparsky, rule A (palatalization in Polish, V-epenthesis in Makassarese) creates a derived environment for rule B (spirantization in Polish, C-epenthesis in Makassarese) if B's structural description would not have been met except for prior application of A. In other words, B is forced by something A does. A rough translation into comparative markedness theory goes something like this: Some new marked configuration is introduced by the unfaithful mapping that approximates process A. The unfaithful mapping that approximates process B occurs only when necessary to avoid the new instances of the marked configuration that A threatens to create. Comparative markedness theory obtains the "only when necessary" derived environment effect from its partition of traditional markedness constraints and standard OT constraint ranking. As I will show in the next section, approaches based on the conjunction of markedness and faithfulness constraints, though quite interesting, are somewhat more distant from Kiparsky's original idea, and this highlights some empirical differences between constraint conjunction and comparative markedness.

One last remark. Grandfathering effects and DEE's involve essentially the same ranking: $_{N}$M dominates some relevant faithfulness constraint, while its $_{O}$M counterpart is dominated by the same faithfulness constraint. This is not an accident. Though grandfathering and DEE's seem rather different when first encountered, they are really the same thing. The illusion of difference comes from looking at grandfathering effects as static restrictions — a process is blocked — and DEE's as dynamic processes — a process is triggered. This illusion is a holdover from rule-based phonology.[13] OT makes no distinction between static restrictions and dynamic processes; the same markedness constraints are responsible for both. Grandfathering and DEE's have similar rankings because the static and dynamic come from the same source.

§4.3 Grandfathering, DEE's, and Constraint Conjunction

The core of comparative markedness theory is the idea that markedness constraints can look simultaneously at the candidate under evaluation and at the fully faithful candidate. A similar notion is involved in another approach to DEE's, conjunction of markedness and faithfulness constraints. This section compares the two theories.

[13]The illusion can perhaps be overcome by thinking of grandfathering in DEE terms. For instance, Mekkan Arabic could be said to have a process of coda devoicing that applies only to derived voiced codas — that is, those derived by the assimilation process, which coda devoicing immediately reverses. Cf. McCarthy (2002: 149-41, to appear).

In the local conjunction approach to DEE's developed by Lubowicz (1999, to appear), markedness and faithfulness constraints can be locally conjoined in the sense of Smolensky (1995). (The local conjunction of constraints A and B, $[A\&B]_{\delta}$, is a constraint that is violated if and only if some constituent δ violates by A and B.) With the right ranking, it is then possible to ensure that the markedness constraint is active only when and where the faithfulness constraint is violated. In Polish, for instance, the markedness constraint NO-ǰ is active — that is, able to compel unfaithful analysis — only in segments that are themselves unfaithful to place of articulation. For example, /krogek/ maps to *krožek* and not **kroǰek* because /g/'s place of articulation has been changed by a palatalization process and so NO-ǰ is activated. But NO-ǰ is not active over candidates whose place of articulation is unchanged from the input, such as /briǰek/ → *briǰek.* The following tableau illustrates:

(21) Polish with Local Conjunction: $[\text{NO-ǰ\&IDENT(place)}]_{Seg}$ ≫ IDENT(cont) ≫ NO-ǰ

	$[\text{NO-ǰ\&IDENT(place)}]_{Seg}$	IDENT(cont)	NO-ǰ
a. ☞ *krožek*		*	
b. *kroǰek*	*!		
c. ☞ *briǰek*			*
d. *brižek*		*!	

In the (21a)/(21b) comparison, the conjoined constraint $[\text{NO-ǰ\&IDENT(Place)}]_{Seg}$ is decisive. By the logic of local conjunction, this constraint is violated by any candidate that simultaneously bears violation-marks from both constraints within the domain of conjunction (here, a segment). And **kroǰek* has exactly that problem: its *ǰ* is derived from /g/, so it bears a violation-mark from IDENT(Place). The conjoined constraint is not active over the (21c)/(21d) comparison because the *ǰ* of *briǰek* is underlying, so it is not in violation of IDENT(Place). In short, local conjunction of markedness with faithfulness allows the markedness constraint to be active only when the faithfulness constraint is violated.

The similarity between this model and comparative markedness theory should be apparent: both allow markedness constraints, indirectly or directly, to get some access to the input or something very much like it. But there are also important differences that emerge when we look more closely at how these two approaches deal with DEE's.

In comparative markedness theory, as I noted at the end of §4.2, the nature of a derived environment comes rather close to Kiparsky's (1973) original idea. For Kiparsky, process A (palatalization in Polish) creates a derived environment for process B (*ǰ* → *ž*) if B's structural description would not have been met except for prior application of A. That is, process B is made necessary because of something that process A did. The way this is understood in comparative markedness theory is that one unfaithful mapping (≈process A) has the potential to introduce some new marked configuration and another unfaithful mapping (≈process B) is necessary to avoid it.

The approach to derived environment effects via local conjunction is more remote from Kiparsky's original idea, and this is arguably to its detriment. The nearest thing to a derived environment is the domain of conjunction in which some faithfulness and some markedness constraint are both violated. Otherwise, there is no necessary connection between the faithfulness constraint and the conjoined markedness constraint that it activates. For this reason, local conjunction can produce some impossible-looking derived environment effects that comparative markedness cannot. Two examples are given in (22).

(22) Some Predicted Effects of Markedness and Faithfulness Local Conjunction

a. Conjunction of unrelated constraints

•Assume the ranking:

[IDENT(back)&NO-VOICE]$_{\sigma}$ ≫ IDENT(voice) ≫ NO-VOICE

and assume an umlaut process independently motivated.

•Then /boti/ → *pöti* but /beta/ → *beta*, /bota/ → *bota*, /böta/ → *böta*. Local conjunction captures a spurious generalization: obstruents are devoiced before fronted vowels.

b. Conjunction in wrong domain

•Assume ranking

[IDENT(Place)&NO-ǰ]$_{PrWd}$ ≫ IDENT(cont) ≫ NO-ǰ

This is the same as Polish, but with the *Seg* domain replaced by *PrWd*.

•Then hypothetical /ǰog+ek/ → *žožek*, but hypothetical /ǰob+ek/ → *ǰobek*. Local conjunction captures a spurious generalization: spirantize /ǰ/ if there's palatalization anywhere in the word.

Neither (22a) nor (22b) is a derived environment in Kiparsky's sense. In (22a), the process of umlaut does not produce conditions that encourage devoicing; rather, the process of umlaut is irrelevant to the process of devoicing. But local conjunction, in its most general form, does not impose any conditions of relevance or relatedness on the two constraints.[14] As for (22b), palatalization of /g/ should not have any effect on the /ǰ/ in the preceding syllable, since the derived environment created by the palatalization of /g/ should be local to the affected segment and not extend beyond that. But local conjunction, in its most general form, allows the domain of conjunction to be specified independently of the constraints conjoined in that domain, allowing for a domain that is too big, as in this case.

Lubowicz recognizes both of these issues and proposes to address them by imposing additional conditions on constraint conjunction. Nonetheless, the point is clear that local conjunction does not really capture Kiparsky's original idea of a derived environment and this may lead to unwanted empirical predictions. Comparative markedness, in contrast, comes closer to expressing the original derived environment notion. In fact, by its very nature, without the need for additional conditions, comparative markedness cannot express spurious generalizations like those in (22).

---

[14] Ito and Mester's (to appear) analysis of forms like *Honig* [honiç] 'honey' in standard German exploits this property of local conjunction. They argue that a constraint against dorsal stop codas is active only in segments that violate IDENT(voice), so final /g/ becomes the fricative [ç]/[x] but final /k/ does not. As they observe, this is a type of derived environment effect that does not come within the scope of Kiparsky's original idea. At present, this example seems to be unique, but if more cases emerge, then the argument in the text will not stand.

Recall the ranking schema for DEE's (15): ⟦$_N$M ≫ Faith ≫ $_O$M⟧. This schema says that new loci of M-violation are avoided at the expense of unfaithfulness, but "old" loci remain. In (22a), the mapping /boti/ → *böti* is not a new locus of NO-VOICE violation, so this more faithful mapping wins over /boti/ → **pöti*. And in (22b), the mapping /ǰog+ek/ → *ǰožek* beats /ǰog+ek/ → *žožek*, because the initial *ǰ* of *ǰožek* is not a new locus of NO-ǰ violation. (Formally, $ǰ_1$ of $ǰ_1o_2ž_3e_4k_5$ t-corresponds to $ǰ_1$ of the FFC $ǰ_1o_2g_3e_4k_5$.) Cases like these, where another process is occurring either irrelevantly (22a) or remotely (22b) should not come under the rubric of derived environment effects, and indeed they don't in comparative markedness theory.

Similar remarks can be made about grandfathering effects. Bakovic (2000) proposes to analyze dominant/recessive tongue-root harmony in Kalenjin as a kind of grandfathering effect: the vowels in a word should agree in their value of the feature [ATR], but harmony cannot create marked [–ATR] vowels. This perspective explains why only [+ATR] spreads, even from non-root morphemes. In the following examples, the root is indicated by √ and the source of the harmonizing [+ATR] feature is in boldface.

(23) Dominant/Recessive [ATR] Harmony in Kalenjin (Bakovic 2000, Hall and et al. 1974)

	/kɪ–ɑ –√**keːr**–ɪn/	kiɐgeːrin	'I saw you (sg.)'
	/kɪ–ɑ –√kɛr–**e**/	kiɐgere	'I was shutting it'
cf.	/kɪ–ɑ –√kɛr/	kɪɑgɛr	'I shut it'

[–ATR] doesn't spread, because it would create new instances of marked [–ATR] vowels. But there are marked [–ATR] vowels, though only in words like the last example that contain no underlying [+ATR] morphemes. There is a similar but more complex case in Lango (Archangeli and Pulleyblank 1994, Benua and Smolensky 2001, Prince and Smolensky 1991, Smolensky 1997).

Bakovic proposes to analyze this as a kind of DEE using local conjunction of markedness and faithfulness. The conjoined constraint $[\text{Ident(ATR)}\&\text{*–ATR}]_{\text{Seg}}$, ranked above IDENT(ATR), rules out the creation of [–ATR] vowels. The constraint AGREE(ATR), also ranked above IDENT, favors words with harmony. Together, $[\text{Ident(ATR)}\&\text{*–ATR}]_{\text{Seg}}$ and AGREE(ATR) ensure that harmony will be achieved by creating unmarked [+ATR] vowels rather than marked [–ATR] vowels. But IDENT(ATR) is ranked above unconjoined *–ATR, so that inputs containing only [–ATR] vowels will survive intact.

This case too is subject to reanalysis under the comparative markedness regime. The markedness-faithfulness conjunction is replaced by the comparative constraint $_N$*–ATR, which is violated by any new [–ATR] vowel. Its counterpart $_O$*–ATR is ranked below IDENT(ATR), so it cannot compel unfaithfulness to the input. It seems likely that all cases of markedness and faithfulness conjunction can be similarly reanalyzed (though see footnote 14).

Going the other way, it appears that there is at least one case of grandfathering that cannot be analyzed with local conjunction, although it submits to analysis with local conjunction. (Thanks to Paul de Lacy for pointing this out.) As shown in (11c, d), the mapping /maːm–ki/ → *maːŋki* does not violate the comparative constraint $_N$*LAB|DORS. Although *ŋ* is unfaithful to its underlying place specification, the /m/ → *ŋ* mapping does not introduce a new markedness violation because there is a single constraint against both labials and velars. But because *ŋ* is unfaithful to its underlying place specification, there is no way to translate this analysis into the local conjunction model. Conjunction of markedness and faithfulness activates the markedness constraint whenever a faithfulness violation is detected. This is fine when the mapping threatens to change a coronal into something else, as in /siːn–ki/ → **siːŋki*, but it is wrong when the mapping merely exchanges one marked element for another, as in /maːm–ki/ → *maːŋki*. Comparative markedness rules out /siːn–ki/ → **siːŋki* because it introduces a new marked thing; local conjunction wrongly rules out /maːm–ki/ → *maːŋki* because the output of an unfaithful mapping is a marked thing, even though the unfaithful mapping did not make it more marked.

To sum up, the local conjunction of markedness and faithfulness constraints, though it can treat DEE's and some kinds of grandfathering, is both too rich and too poor a theory. Markedness-faithfulness conjunction says, in essence, that an environment is derived if some process — some faithfulness violation — has occurred nearby. There is no requirement that the process be relevant (cf. (22a)) nor that it happen close enough to matter (cf. (22b)). The analyses of Polish and Kalenjin highlight this problem: the processes that create the derived environments in these languages are both relevant and near enough to interact, but the underlying theory treats this as an accident of stipulation. The Sri Lankan Portuguese Creole points toward the same problem: an unfaithful mapping creates a derived environment, but not always in a relevant way. Comparative markedness theory encounters no such difficulties (though it has plenty others of its own — see §5.4 and §6.1). Relevance and locality are assured by the nature of the comparison mechanism; matters could not be otherwise.

---

§5. Eliminating Old Marked Structures

Thus far, we have seen only hierarchies where $_{N}$M is ranked high and $_{O}$M low. The opposite is also possible. In this section, I document three situations where high $_{O}$M/low $_{N}$M is required: non-iterative processes, such as apocope and local tone spreading; coalescence paradoxes, where coalescence produces segments that are otherwise forbidden; and counter-feeding opacity, where the output of one process unexpectedly fails to undergo another process. All three cases involve the active elimination of old M-violating structures and tolerance for new ones.

§5.1 Non-iterating Processes

In the context of research on iterative rules in the 1970's (e.g., Kenstowicz and Kisseberth 1977: 155-229), a class of processes was identified that should be able to iterate but do not. For example, rules of apocope typically delete the final vowel mora, but they do not continue to nibble off additional vowel morae until they run into a consonant (Vago and Battistella 1982). The Siouan language Hidatsa forms the imperative in this way (Harris 1942):

(24) Hidatsa imperative

/cixi/	cix	'jump!'	cf. cixic 'jumped'
/kikua/	kiku	'set a trap!	cf. kikuac '(did) set a trap'
/ikaa/	ika	'look!	cf. ikaːc 'looked'

If the process fed itself, we would expect /kikua/ → *kiku* → **kik* instead. Similar examples can be found in Latvian (Halle and Zeps 1966), Lithuanian (Lightner 1972), Odawa (Piggott 1975), Ponapean (Howard 1972: 179-81), and Woleaian (Sohn 1975).

Perhaps the best-known case of this type, which has figured prominently in the OT literature, is Lardil (K. Hale 1973, Kenstowicz and Kisseberth 1979, Klokeid 1976, Prince and Smolensky 1993). In nominative-case nouns containing at least three morae, the final vowel of the root is apocopated. Apocope exposes consonants to word-final position, where some of them (the non-apicals) must also be deleted.

(25) Lardil Apocope

/pulŋarpa/	pulŋar	‘huge’	cf. pulŋarpan
/muŋkumuŋku/	muŋkumu	‘wooden axe’	cf. muŋkumuŋkun
/ʈipiʈipi/	ʈipiʈi	‘rock-cod’	cf. ʈipiʈipin
/pulumunitami/	pulumunita	‘young f. dugong’	cf. pulumunitamin

The rightmost column shows the final vowel protected by the non-future accusative suffix *–n*. In /pulumunitami/, for example, the final vowel *i* is apocopated and the preceding consonant, *m*, deletes also, since labials are prohibited word-finally.

Apocope does not feed itself; in terms of a serial derivation, we don’t find /pulumunitami/ → *pulumunitam* → *pulumunita* → **pulumunit* → **pulumuni* → **pulumun* → **pulumu* → **pulum* → **pulu*, as final vowels are successively truncated, each time exposing a new consonant that is prohibited word-finally. To prevent apocope from chewing its way through the word like this, Prince and Smolensky (1993: 101) derive it from a kind of anti-faithfulness constraint, FREE-V, that requires non-parsing of the word-final vowel.[15] By the representational assumptions of the PARSE/FILL faithfulness model current at that time, the unparsed final vowel was present but unpronounced in the output form *pulumunita⟨mi⟩*. FREE-V demands a final unparsed vowel, and that’s what it gets. Further vowel deletion is neither desired nor predicted.

This sort of analysis is not possible under the representational assumptions of correspondence theory (McCarthy and Prince 1995, 1999). Reanalysis of Lardil apocope must proceed either in the direction of a full-blown anti-faithfulness theory (Alderete 1998, 2001, Horwood 1999) or along the following lines. We have already seen that there is a markedness constraint prohibiting word-final vowels, FINAL-C (§4.2). According to the assumptions of comparative markedness theory, this constraint has two parallel forms, $_{\mathrm{O}}$FINAL-C and $_{\mathrm{N}}$FINAL-C. The constraint $_{\mathrm{O}}$FINAL-C is violated by any candidate that shares a locus of violation with the FFC. The constraint $_{\mathrm{N}}$FINAL-C is violated by any candidate that introduces a new locus of violation that is not present in the FFC. That is precisely the difference between the candidates **pulumunitami* and *pulumunita* in Lardil. The first candidate,

[15] Prince and Smolensky also describe FREE-V as morphologized because it is limited to nominative nouns. But Klokeid (1976) makes a fairly good case that apocope is not morphologized. The main problem for a fully general apocope process is the absence of apocope in verbs. Klokeid argues that all verbs end in an underlying final /t̪/, a kind of verb-marking morpheme, that protects the final vowel from apocope but itself deletes because it is not apical. This /t̪/ is overtly present with monomoraic roots, where it is followed by the usual Lardil augment *a*: *net̪a* ‘burn, cook’, *bet̪a* ‘bite’, *wut̪a* ‘give’.

pulumunitami*, shares a FINAL-C violation with the FFC — trivially, since it **is the FFC. The second candidate, *pulumunita*, also has a FINAL-C violation, but in a locus that is not shared with the locus of violation in the FFC, since the *a* of *ta* and the *i* of *mi* are not in t-correspondence. The following tableau tells the tale:

(26) Lardil: $_{O}$FINAL-C ≫ MAX ≫ $_{N}$FINAL-C

	$_{O}$FINAL-C	MAX	$_{N}$FINAL-C
a. (FFC) pulumunitami	*!		
b. ☞ pulumunita		**	*
c. pulumu		******	*

Apocope only affects underlying final vowels because the responsible markedness constraint, $_{O}$FINAL-C, only detects loci of violation that are shared with the FFC. The other markedness constraint, $_{N}$FINAL-C, detects the final vowels of *pulumunita* and *pulumu*, since these violation loci are not shared with the FFC. They are, moreover, irrelevant, because $_{N}$FINAL-C is ranked below MAX.

This analysis also explains why apocope does not affect words like *t̪ukuŋu* from underlying /t̪ukuŋuŋ/ 'lungs' (cf. *t̪ukuŋuŋin*). The root-final *ŋ* is deleted because it is non-apical, but the *u* that is thereby exposed to final position does not violate $_{O}$FINAL-C. The effect is like Prince and Smolensky's FREE-V, but comparative markedness gets this effect from an independently motivated markedness constraint, FINAL-C, rather than an ad hoc anti-faithfulness constraint.

Another situation where a process could in principle iterate but does not is local tone spreading. Research in OT on tone spreading, vowel harmony, and other assimilation processes has tended to focus on long-distance effects, which have been attributed to constraints of the Alignment family. Alignment is not of obvious help, though, in analyzing local spreading. Once the ranking ⟦Align(Tone, Edge) ≫ Faith⟧ has been established, there is no satisfactory way to limit the tone to spreading just one syllable toward the edge. For this reason, the sporadic mentions of local spreading in the literature (Bickmore 1996, Myers 1997) have required novel markedness or faithfulness constraints.

Comparative markedness provides a way to unify local and long-distance spreading processes. First the background. All spreading, local or long-distance, is a consequence of activity by the constraint AGREE. I assume that AGREE has left and right versions. For example, a high-tone-specific AGREE-R constraint is given in (27), with σ′ standing for a syllable head (or other tone-bearing unit).

(27) AGREE-R(H)

```
*H
 |   ǂ
 σ′  σ′
```

This constraint assigns a violation-mark to any pair of adjacent syllable heads (in the sense of Archangeli and Pulleyblank 1994), the first of which is linked to a high tone and the second of which is toneless (or low-toned, depending on one's representational assumptions).

In comparative markedness theory, there are two versions of the constraint in (27), $_{O}$AGREE-R(H) and $_{N}$AGREE-R(H). The constraint against old AGREE violations, $_{O}$AGREE-R(H), is violated by any disagreeing sequence that is shared with the FFC. The constraint against "new" violations, $_{N}$AGREE-R(H), is violated by any disagreeing sequence that is not shared with the FFC. Local tone spreading relieves old violations, thereby satisfying $_{O}$AGREE-R(H). Long-distance spreading relieves new violations — which local spreading may have introduced — thereby satisfying $_{N}$AGREE-R(H). We expect to see local spreading when only $_{O}$AGREE-R(H) dominates faithfulness, while long-distance spreading is the result of ranking both of these constraints above faithfulness.

For example, the Bantu language has a process of local tone spreading that spreads root-initial high tone one syllable to the right. The domain of spreading has been underlined in (28).

(28) Ekegusii verbal infinitive (Bickmore 1996: 18)

ó-go-kór-á	'to do'
ó-go-kór-ér-a	'to do for'
ó-go-káán-er-a	'to deny for'
ó-ge-símék-er-a	'to plant for'

I assume, following Bickmore and others, that syllables without high tone are toneless. To achieve this local spreading, we require a ranking where $_{O}$AGREE-R(H) can compel unfaithfulness but its counterpart $_{N}$AGREE-R(H) cannot, as in (29).

(29) Ekegusii: $_{O}$AGREE-R(H) ≫ Faith ≫ $_{N}$AGREE-R(H)

	$_{O}$AGREE-R(H)	Faith	$_{N}$AGREE-R(H)
a. (FFC) H linked to si: simekera	*!		
b. ☞ H linked to si, me: simekera		*	*
c. H linked to si, me, ke, ra: simekera		**! *	

As AGREE-R(H) is defined in (27), a locus of violation consists of a sequence of two syllable heads, the first of which is is high-toned and the second of which is toneless. The FFC (29a) has one locus of violation, the *í-e* sequence in the first two syllables. Since the FFC necessarily shares all of its own markedness violations, this means that (29a) is in defiance of $_{O}$AGREE-R(H). The next candidate, (29b), has a different locus of violation, the *é-e* sequence of the second and third syllables. This locus is different — that is, unshared — because it contains an element, the second *e*, that does not t-correspond to any elements in the FFC's locus. Observe that eliminating the violation of $_{O}$AGREE-

R(H) has caused (29b) to violate $_{N}$AGREE-R(H), precisely because of this unshared locus. The remaining candidate, (29c), shows that long-distance spreading on top of local spreading can eliminate both old and new AGREE-R(H) violations. This is a fool's bargain, though, because faithfulness is ranked above $_{N}$AGREE-R(H).

Permuting the ranking in (29) will produce other types of tone spreading. If $_{O}$AGREE-R(H) and $_{N}$AGREE-R(H) are both ranked above faithfulness, then candidate (29c) will win. This ranking, then, yields long-distance tone spreading. There is also a type of DEE to be found in tone spreading. The ranking schema for DEE's (15) puts $_{N}$M above faithfulness and $_{O}$M below faithfulness. The effect is that only new M-violations are treated unfaithfully. Substituting AGREE-R(H) for M in this schema, we obtain a system where new AGREE violations are eliminated but old ones are not.

Exactly this situation has long been recognized in the tonal literature, though under a different guise. Early autosegmental studies on tone often invoke a principle that says that floating tones spread in preference to linked tones, a requirement that is embodied in Clements and Ford's (1979: 185) tone spreading convention 2. (More ad hoc principles with similar effect can be found in other works.) Now, suppose there is a markedness constraint forcing the input floating tone to link to at least one syllable in the output, such as Myers' (1997: 867) *FLOAT. Unless the word is monosyllabic, linking a floating tone will create $_{N}$AGREE violations, and these can be avoided only by spreading the formerly unlinked tone. But tones that are already linked in the input violate only low-ranking $_{O}$AGREE, and so they will not spread. In this way, comparative markedness recovers an important but neglected insight about the spreading of floating tones.

One last remark about local tone spreading. Eric Bakovic (e-mail, 1/26/02) raises an interesting question: why don't we find processes of local vowel harmony that work like local tone spreading? Such a process would spread the harmonizing feature one syllable over, but no more, as in faux Finnish /talo-ssA-nsA-kAAn-kO/ → *talossansäkäänkö* (vs. real Finnish *talossansakaanko* 'not in his house either?'). This difference between tone and vowel harmony, I propose, follows from their fundamentally different phonetic character. Suppose we assume, in line with most recent thinking (Bakovic 2000, Gafos 1999, Ní Chiosáin and Padgett 2001, Walker 1998), that segmental features spread to immediately adjacent segments, with no skipping permitted. This assumption entails that harmony processes affect not only vowels but also the consonants between them, so the *ss* in *talossansäkäänkö* also bears the feature [back]. By nearly universal agreement dating back to the earliest generative work on suprasegmentals (Goldsmith 1976, Leben 1973, McCawley 1978, Williams 1976), tone is different: the tone-bearing elements are syllables, syllable heads, or moras, but not segments. Tone spreading is not segment-to-segment, then, but syllable-to-syllable or mora-to-mora.

Under the comparative markedness regime, this difference between segmental and tonal features automatically leads to a difference in the effects of the AGREE constraints. As we saw in Ekegusii, $_{N}$AGREE-R(H) is satisfied when the immediately following syllable becomes high-toned: /...sím-ek-er-a/ → *...símékera*. In a parallel fashion, $_{N}$AGREE-R([back]) is satisfied when the feature [back] spreads onto the immediately following **segment**. In vowel harmony, the immediately following segment is typically a consonant and not the next vowel: /talo-ssA-nsA-kAAn-kO/ → *taloss*^{ɰ}*änsäkäänkö*, with velarized *ss*. To get back to spread all the way onto the next vowel, as in hypothesized *talossansäkäänkö*, it is necessary for $_{O}$AGREE-R([back]) also to dominate faithfulness.

But then there is no way to stop spreading from chewing up the whole word, yielding *talossansakaanko*. In short, comparative markedness theory cannot produce the non-existent process of local, one-syllable-over vowel harmony — segmental features can be induced to spread onto the adjoining segment or unboundedly, just as tonal features can be induced to spread onto the adjoining syllable or unboundedly.

Is the constraint $_{\mathrm{N}}$AGREE([back]) ever active on its own, unbuttressed by $_{\mathrm{O}}$AGREE([back])? Yes, in processes that are limited to adjacent segments, such as in CV palatalization or harmony between pairs of contiguous vowels (e.g., **iw, *ew, *uj* in English).

§5.2 Coalescence Paradoxes

Gnanadesikan (1997) identifies a class of phenomena that she calls coalescence paradoxes. Coalescence is phonological fusion, where two input segments unite into a single output segment that shares characteristics of both its ancestors. In a coalescence paradox, the output segment derived by coalescence has no other source; when that segment appears in inputs, it is treated unfaithfully. The paradox is that coalescence is itself a product of faithfulness, and it is difficult to explain how being faithful can produce a type of segment that is normally treated unfaithfully.[16]

The best known example of a coalescence paradox comes from Sanskrit. Sequences of *a* followed by *i* or *u* merge into long *eː* or *uː*, respectively.

(30) Coalescence in Sanskrit

/a+i/ → eː

/ca_1+$i_2$ha/	→	$ce\!ː_{1,2}$ha	'and here'

/a+u/ → oː

/ca_1+$u_2$ktam/	→	$co\!ː_{1,2}$ktam	'and said'

The input-output correspondence relations are indicated by subscripts. The output vowel is mid because it is a result of fusing a low vowel with a high one; a mid vowel is a sort of compromise. The output vowel is long because it preserves the moras of both its input correspondents. Importantly, mid vowels have no other source in Sanskrit, so mid vowels in the input are mapped unfaithfully onto something else (presumably high vowels). This explains why there are no short mid vowels — input /e/ or /o/ never make it to the surface.

The Austronesian language Rotuman has a similar phenomenon involving vowel color rather than height.

(31) Umlaut in Rotuman (Churchward 1940, McCarthy 2000 and references there)

/mo_1se_2/	→	$\text{mö}_{1,2}$s	'to sleep'
/fu_1ti_2/	→	$\text{fü}_{1,2}$t	'to pull'

In the so-called incomplete phase, the final vowel is lost but can reemerge before the preceding consonant. Combinations of /o+e/ or /u+i/ fuse into a single segment that is front and rounded,

[16]On the analysis of coalescence in OT, see Causley (1997), Gnanadesikan (1995/to appear, 1997), Keer (1999), Lamontagne and Rice (1995), McCarthy (2000), McCarthy and Prince (1995), and Pater (1999).

compromising on the color of the two input vowels. Front rounded vowels are impossible in other circumstances in Rotuman. For example, there are no words like *füti* where the penult is *ü* and the ultima is an undeleted *i*.

Finally, the Bantu language Luganda supplies a case of consonant coalescence that is similarly paradoxical. Sequences of a nasal followed by a consonant fuse into a prenasalized stop with compensatory lengthening of the preceding vowel.

(32) Prenasalization in Luganda (Clements 1986a, McCarthy to appear, Rosenthall 1994, Wiltshire 1992)

/ku+lin$_1$d$_2$a/	→	kuliː^{n}d$_{1,2}$a	'to wait'
/mu+n$_1$t$_2$u/	→	muː^{n}t$_{1,2}$u	'person'

Prenasalized consonants have no other source in Luganda. For example, input /mu^{n}tu/ must map unfaithfully onto *mutu* or *munu* to explain why vowels are always long before a prenasalized consonant.

In all of these cases, then, we can be reasonably certain that the output of coalescence includes segments that, when present in the input, are not treated faithfully. The paradox is as follows. The output of coalescence shows the effect of being faithful to both of the input segments, compromising on their featural specifications. But when the same segment that is the output of coalescence is in the input, it is treated unfaithfully. The paradox can be illustrated formally with some ranking arguments from Sanskrit.

Coalescence in Sanskrit produces mid vowels. This means that the faithfulness constraints IDENT(–high) and IDENT(–low) are ranked above the markedness constraint NO-MID (≡*[–high, –low]). (See Pater (1999) on the role of IDENT constraints in coalescence.)

(33) Sanskrit: IDENT(–high), IDENT(–low) ≫ NO-MID

/a$_1$ + i$_2$/	IDENT(–high)	IDENT(–low)	NO-MID
a. ☞ e$_{1,2}$ː			*
b. i$_{1,2}$ː	*!		
c. a$_{1,2}$ː		*!	

The result of fusing two vowels is judged for its faithfulness to both of its input correspondents. Only one candidate, a mid vowel, satisfies both of the high-ranking IDENT constraints with respect to both of its input correspondents.

What about input /e/ or /o/, then? They must be treated unfaithfully, but mapping them to either high or low vowels leads to a ranking paradox.

(34) Sanskrit: NO-MID ≫ IDENT(–high) *or* IDENT(–low)

/e/	NO-MID	IDENT(–high)	IDENT(–low)
a. ☞ i			*
b. e	*!		
c. ☞ a		*	

Schematically, the rankings we have now derived include A ≫ C, B ≫ C, and C ≫ A or C ≫ B — a contradiction. Coalescence and unfaithfulness to input mid vowels make competing, contradictory demands on the analysis. Classic OT does not and cannot offer a general solution to this problem, since it emerges from fundamental properties of the theories of markedness and faithfulness constraints.

Comparative markedness theory allows constraints to be sensitive to the markedness consequences of unfaithful mappings. These constraints can therefore distinguish between a mid vowel (or front rounded vowel or prenasalized consonant) that is the product of coalescence and a mid vowel that is derived faithfully from the input. The latter is forbidden, showing that $_{O}$NO-MID is ranked high, above faithfulness (35c, d). But newly derived mid vowels are permitted, showing that faithfulness is ranked above $_{N}$NO-MID (35a, b).

(35) Sanskrit: $_{O}$NO-MID ≫ IDENT(–high) (*or* IDENT(–low)) ≫ $_{N}$NO-MID

$/a_1 + i_2/$	$_{O}$NO-MID	IDENT(–high)	$_{N}$NO-MID
a. ☞ $e_{1,2}$ː			*
b. $i_{1,2}$ː		*!	
cf. FFC a_1i_2			
/e/			
c. ☞ i		*	
d. (FFC) e	*!		

The ranking here is abstractly the same as the one seen in Lardil apocope and Ekegusii local tone spreading. In all of these situations, marked structures already present in the input are aggressively eliminated, even as other processes or even the same process create the same marked structures. The key to the analysis is a hierarchy where $_{O}$M is deployed above faithfulness and its $_{N}$M counterpart is ranked below it.

§5.3 Counter-feeding Opacity

In the literature of the 1970's, rules like apocope in Lardil or local tone assimilation in Ekegusii were sometimes said to counter-feed themselves. This conception, which derives from Kiparsky's (1965, 1968) ideas about rule ordering and historical change, sees a process as failing to create inputs to itself when in principle it could. Lopping off a final vowel exposes a new final vowel, ripe for the lopping. An apocope rule that fed itself would take advantage of this new opportunity to apply; when the rule counterfeeds itself, as in Lardil, it applies once and is denied further opportunities.

More generally, two different processes can also be in a counter-feeding relationship, which is one type of opacity (Kiparsky 1973). If a process P1 could in principle create inputs to a processs P2, but in fact does not, then P1 is said to counter-feed P2. For example, in Barrow Inupiaq (Archangeli and Pulleyblank 1994, Kaplan 1981), palatalization is triggered by an *i* derived from underlying /i/, as in (36a), but it is not triggered by a phonetically identical *i* derived from /ɨ/ (or perhaps archisegmental /I/), as in (36c):

(36) Barrow Inupiaq in Rule-based Phonology

a. Palatalization after *i* (can skip over consonants)

/savig–lu/ → savigʎu 'wound+be able'

b. Absolute neutralization: /ɨ/ → *i*

c. Serial Derivation: Palatalization Precedes Neutralization

/kamɨk–lu/ $\rightarrow_{\text{Pal}}$ DNA $\rightarrow_{\text{Neut}}$ kamiklu 'boot+be able'

This is counter-feeding opacity (CFO): /ɨ/ → *i* could in principle create additional inputs to palatalization, but doesn't. In derivational terms, the two rules are in counter-feeding order.

Counter-feeding opacity (CFO) cannot be accommodated in a fully general way in classic OT (McCarthy 1999). The reasoning goes like this. In OT, a process — that is, an unfaithful mapping — is compelled by some markedness constraint. But because markedness constraints evaluate outputs alone, the same markedness constraint responsible for making *savigʎu* more harmonic than **saviglu* would also make **kamikʎu* more harmonic than *kamiklu*. The fact that **kamikʎu* contains an *i* derived from underlying /ɨ/ can have no effect on how it performs on classic markedness constraints. In short, since markedness constraints evaluate outputs, why isn't the palatalization process triggered by all surface *i*'s, regardless of whether they are derived from /i/ or /ɨ/?

Comparative markedness theory offers a novel approach to CFO. Observe that Barrow Inupiaq has palatalization only when the FFC (e.g., *saviglu*) violates the operative markedness constraint, PAL-L. When the FFC satisfies this constraint (e.g., *kamɨklu*), then there is no palatalization. So the ranking for CFO should conform to the following schema:

(37) Ranking Schema for Counter-feeding Opacity

$_{\text{O}}\text{M} \gg \text{Faith} \gg {}_{\text{N}}\text{M}$

Informally, this says "be unfaithful only when it's necessary to eliminate an inherited locus of M violation". The mapping /kamɨk–lu/ → **kamikʎu* does not eliminate an inherited locus of violation because the FFC *kamɨklu* already satisfies PAL-L vacuously. High-ranking $_{\text{O}}$PAL-L is indifferent to the worsening palatalization situation created by the /kamɨk–lu/ → *kamiklu* map, though $_{\text{N}}$PAL-L cares about it greatly:

(38)

/savig–lu/	$_{O}$PAL-L	IDENT(Place)	$_{N}$PAL-L
a. ☞ savigʎu		*	
b. (FFC) saviglu	*!		
/kamɨk–lu/			
c. ☞ kamiklu			*
d. kamikʎu		*!	
cf. FFC *kamɨklu*			

In the first case, the input has underlying /iCl/. Candidate (38b) contains a locus of PAL-L violation — the string *igl* — that is shared with a locus of PAL-L violation in the FFC — trivially, since (38b) **is** the FFC. In candidate (38a), that violation is absent, so (38a) wins, in conformity with the ⟦$_{O}$PAL-L ≫ IDENT(place)⟧ ranking.

Next, consider an input with underlying /ɨCl/. Candidate (38c) contains a locus of PAL-L violation — the string *ikl* — that does not t-correspond to a locus of PAL-L violation in the FFC, because the t-corresponding segments in the FFC do not violate PAL-L. For this reason, (38c) does not violate $_{O}$PAL-L, and so it wins over candidate (38d), which satisfies low-ranking $_{N}$PAL-L but at the expense of a fatal faithfulness violation.

In CFO, a general phonological process P fails to apply to forms that meet P's conditions only by virtue of another process. For example, /kamɨklu/ → *kamiklu* shows no effect of palatalization because the conditions for palatalization — a preceding *i* — are only met by virtue of the /ɨ/ → *i* neutralization process. CFO, then, is the antithesis of a derived environment effect (a point made by Lubowicz 2002). In a derived environment effect, one process applies only when its conditions are met by virtue of another process. In CFO, one process fails to apply only when its conditions are met by virtue of another process. The analysis in terms of comparative markedness captures that antithetical quality formally: DEE's and CFO have opposite ranking schemata ((15) vs. (37)).

§5.4 Comparison with Alternatives

No alternative approaches to non-iterating processes and coalescence paradoxes are known to me that approach the generality of comparative markedness. The study of opacity in OT, however, is a relatively rich area, with several alternatives to consider: local conjunction of faithfulness constraints, stratal OT, sympathy theory, and targeted constraints. I will try to say something about each, commenting on differences from and similarities to comparative markedness.

Local conjunction of faithfulness constraints has been proposed as a theory of chain shifts and other forms of CFO (Ito and Mester to appear, Kirchner 1996). For example, Barrow Inupiaq (36) could be analyzed as follows:

(39) Barrow Inupiaq with Local Conjunction
[IDENT(back)&IDENT(Place)]$_{\text{Adj-}\sigma}$ ≫ PAL-L ≫ IDENT(Place)

That is, two adjacent syllables cannot contain segments that are unfaithful in both [back] and Place. By dominating PAL-L, this conjoined constraint blocks the otherwise expected /kamɨklu/ → *kamikʎu* mapping.

As in the local-conjunction analysis of DEE's, conjoining constraints in the wrong domain, or even what looks like the right one, can lead to unattested interactions (McCarthy 1999: 365-6). For example, the ranking in (39), because it posits "Adj-σ" as the domain of conjunction, predicts mappings like (hypothetical) /kɨmilku/ → *kimilku*, **kimiʎku*. Implausibly, /l/ has failed to palatalize in this example, even though it is preceded by underived *i*, because /ɨ/ has fronted in an adjacent syllable. This problem could be fixed by fine-tuning the domain of conjunction, but the global problem remains: this approach to CFO is predicting the wrong language typology.

Likewise, conjoining the wrong faithfulness constraints can produce equally implausible results. For example, assume a language with a general coda-devoicing process and the following ranking:

(40) [IDENT(voice)&IDENT(Place)]$_{\text{Adj-Seg}}$ ≫ PAL-L ≫ IDENT(Place)

This ranking prohibits adjacent segments from changing both [voice] and Place. It would produce mappings like these:

(41)	a.	/batiklu/	→	*batikʎu*
	b.	/batiglu/	→	*batiklu*

In (41b), the /l/ has failed to palatalize because it adjoins a devoiced segment. Again, this hypothetical example does not seem possible. The change in voicing is irrelevant to palatalization, and so coda devoicing should not block palatalization.

These unattested patterns of CFO are not attainable using comparative markedness. Recall the ranking schema (37): ⟦$_{\mathbf{O}}$M ≫ Faith ≫ $_{\mathrm{N}}$M⟧. This says that old loci of M-violation are eliminated at a cost in faithfulness, but new loci of M-violation may be created if necessary. The unattested and evidently impossible mapping /kɨmilku/ → *kimilku*, **kimiʎku* cannot be obtained with this schema because fronting of /ɨ/ in the first syllable does not create a new locus of PAL-L violation. Nor does devoicing of /g/ in (41b), since the voicing of the intervening consonant has no effect on whether or not PAL-L is satisfied. In the local-conjunction-based analysis of Barrow Inupiaq (39), it is really just an accident that the faithfulness constraint IDENT(back) is included in the conjunction rather than IDENT(voice). But this can be no accident: [back] in vowels is relevant to palatalization in a way that [voice] in consonants is not. It is hard to see how this problem with conjunction can be remedied, even with the aid of formal conditions on conjoinability (Fukazawa and Lombardi to appear, Fukazawa and Miglio 1998, Lubowicz to appear), because relevancy is determined only by interaction with other constraints in the hierarchy.

To sum up the results of this section and §4.3, approaches to DEE's and CFO based on local conjunction, though they offer interesting insights into these phenomena, do not seem to be leading us toward the right language typology. The problem is that locality and interaction are not the same thing. Local conjunction regulates the application of processes in segments that are close to each other. But in observed cases of DEE's and CFO, it is not closeness that matters — it is crucial interaction of the processes. Comparative markedness theory, by its nature, regards interaction as a sine qua non of DEE's and CFO.

Stratal OT is another approach to CFO. Stratal OT links several OT grammars serially, like the strata of the theory of Lexical Phonology.[17] Instead of rule ordering, as in *SPE*-style phonology, stratal OT attributes opaque interactions to the ordering between these strata. For example, the counter-feeding relationship between vowel neutralization and palatalization in Barrow Inupiaq is attributed to differences in the grammars of two strata and the ordering between them, as shown in (42).

(42) Barrow Inupiaq in Stratal OT

Lexical Stratum			
	Input	/savig–lu/	/kamɨk–lu/
	Output	*savigʎu*	*kamɨklu*
Word-level Stratum			
	Input	/savigʎu/	/kamɨklu/
	Output	*savigʎu*	*kamiklu*

The output of the lexical stratum becomes the input to the word-level stratum. The grammars of the different strata can and must differ — that is, they must rank the constraints of UG differently. Palatalization must occur before neutralization of /ɨ/ to *i* in order to explain the counter-feeding relationship between these two processes. If the lexical and word-level strata had the same grammar, then /kamɨk–lu/ would map directly to **kamikʎu* in the lexical stratum.

Stratal OT has much of the power of rule-ordering; its only limitation is that the depth of ordering cannot exceed the number of strata (which is presumably the same in every language). Concomitantly, stratal OT sheds no light on problems where rule ordering is of no help, such as grandfathering effects (§4.1), DEE's (§4.2), and rules that counter-feed themselves (§5.1).

Although comparative markedness does contribute to our understanding of these problems, it is a rather limited theory of counter-feeding opacity — probably too limited. Here I will present two limitations, one that may be right empirically and another that is surely wrong.

In comparative markedness theory, CFO is a property of whole grammars rather than specific processes. The basic ranking $[\![{}_{\mathrm{O}}\mathrm{M} \gg \mathrm{Faith} \gg {}_{\mathrm{N}}\mathrm{M}]\!]$ says that Faith will not be violated solely to

[17]Some version of stratal or cyclic OT can be found in the following works, among others: Black (1993), Bermúdez-Otero (1999), Cohn and McCarthy (1994/1998), Hale and Kissock (1998), Hale, Kissock, and Reiss (1998), Ito and Mester (2002), Kenstowicz (1995), Kiparsky (2002a, 2002b), McCarthy (2000), McCarthy and Prince (1993), Potter (1994), Rubach (2000), and many of the contributions to Hermans and van Oostendorp (1999) and Roca (1997).

eliminate new violations of M, no matter what their source. If several processes produce M-violating structures, then all of them will be in a counter-feeding relationship with the process defined by the $[\![{}_{\mathrm{O}}\mathrm{M} \gg \mathrm{Faith}]\!]$ ranking. For example, in Bedouin Arabic there is a process raising /a/ to *i* in an open syllable (43a). It is counter-fed by two other processes that create open syllables (43b), vocalization of high glides and epenthesis into rising-sonority clusters.

(43) Bedouin Arabic (Al-Mozainy 1981, Johnstone 1967)

a. The vowel /a/ is raised to *i* in an open syllable.

/katab/	→	kitab	'he wrote'

b. But not if the syllable is open by virtue of glide vocalization or epenthesis.

/badw/	→	badu	'Bedouin'
/gabr/	→	gabur	'grave'

If comparative markedness theory is right, then the situation observed in Bedouin Arabic could not be any different. Because the ranking $[\![\mathrm{Faith} \gg {}_{\mathrm{N}}\mathrm{M}]\!]$ appears in the grammar, new instances of *a*'s in open syllables, regardless of what process created them, are immune from the raising process. It would not be possible to construct the grammar so that, say, only glide vocalization and not vowel epenthesis was in a counter-feeding relationship with raising.

This is an interestingly strong claim, not obviously wrong but not obviously correct either. Certainly stratal OT, with its rich model of opacity, imposes no such restriction or anything like it. Another strong claim made by comparative markedness theory concerns the analysis of counter-feeding opacity involving basically allophonic processes. (This class of problems was first noted by Ito and Mester (to appear).) The claim is best explained with an example.

Processes of nasal harmony and simplification of nasal+voiced stop clusters interact opaquely in Sea Dayak to produce sequences of a nasal followed by an oral vowel, which are met with nowhere else in the language:

(44) Sea Dayak Nasal Harmony (Kenstowicz and Kisseberth 1979: 298, Scott 1957)

a. Rightward nasal harmony:

/naŋa/ → nãŋãʔ	'straighten'

b. Blocked by oral consonants:

/naŋga/ → nãŋgaʔ , *nãŋgãʔ	'set up a ladder'

c. Even if the blocker is optionally deleted:

/naŋga/ → nãŋgaʔ → nãŋaʔ, *nãŋãʔ	id.

Nasalized vowels have no other source in Sea Dayak. In other words, nasal harmony is a basically allophonic process except for its opaque interaction with deletion of voiced stops after nasals.

OT attributes linguistic generalizations to the grammar, not the lexicon (McCarthy 2002: 68-82, Prince and Smolensky 1993). This thesis is called "richness of the base": inputs are unrestricted, but the grammar is responsible for mapping all inputs onto pronounceable forms of the language. The grammar of Sea Dayak, then, must correctly dispose of inputs like /nãŋgã/, for example, with a nasalized vowel in a position where it would not be permitted at the surface.

The problem is that there is no ranking of the constraints supplied by comparative markedness theory— $_{O}$*V_{NAS}, $_{N}$*V_{NAS}, $_{O}$*NV_{ORAL}, $_{N}$*NV_{ORAL}, and IDENT(nasal) — that will map all of the rich-base inputs — /naŋga/, /nãŋga/, /naŋgã/, and /nãŋgã/ — onto the single output *nãŋa*. For example, to get the mapping /naŋga/ → *nãŋa*, it is necessary to rank $_{O}$*NV_{ORAL} above IDENT(nasal) and $_{N}$*NV_{ORAL} below IDENT(nasal). In this way, new instances of nasal+oral vowel sequences, derived by deletion of voiced stops, get a free pass. But the mapping /nãŋga/ → **naŋa* also produces a new instance of a nasal+oral vowel sequence, the initial *na*, which was obtained by denasalizing the first vowel of the input. This too gets a free pass, but wrongly, because **naŋa* is phonotactically impossible in Sea Dayak regardless of what the input is.

The Sea Dayak problem, more generally, is this. In cases of allophony, richness of the base entails that the input is relatively indeterminate. But comparative markedness theory relies on the input through its surrogate, the FFC, to evaluate markedness. The problem is much the same as in Ito and Mester's (2001, to appear) critique of sympathy theory. Indeed, opacity of basically allophonic processes presents the same challenge to comparative markedness or sympathy as it did to the structuralists (Chomsky and Halle 1965): it looks as if another level of representation is required. Stratal OT, for example, supplies that level in its account of facts like these.

Two other theories of opacity in OT, sympathy and targeted constraints, have a significant formal resemblance to comparative markedness theory. All three of these theories have constraints that use one output candidate to evaluate another output candidate. In comparative markedness theory, the basis for this comparison is the FFC. In sympathy theory (McCarthy 1999, to appear), it is the sympathetic candidate, which is defined as the most harmonic candidate among those that obey some designated faithfulness constraint. In the targeted constraints theory (Bakovic 2000, Bakovic and Wilson 2000, Wilson 2001), the basis for the comparison is determined on a constraint-by-constraint basis. For example, given the input /patka/, the constraint NO-CODA compares the candidate *paka* with its more faithful but otherwise identical counterpart *patka*:[18]

(45) NO-CODA (targeted version)

If candidate C1 contains a coda consonant *x*, and if candidate C2 is exactly like C1 except for the absence of *x*, then C2 is more harmonic than C1.

The "except for" clause will be different in other markedness constraints.

---

[18]In principle, there can be situations where a targeted constraint imposes an ordering on two candidates, neither of which is more faithful than the other. For instance, with input /patka/, targeted NO-CODA will say that *pa.ta* is more harmonic than metathetic *pak.ta*. Neither *pa.ta* nor *pak.ta* is more faithful, in a ranking-independent way, since they violate disjoint faithfulness constraints (MAX vs. LINEARITY).

These formal resemblances are important because the three theories have incompletely overlapping empirical coverage, suggesting that some broader synthesis is in order. Comparative markedness applies to grandfathering, DEE's, non-iterating processes, coalescence paradoxes, and some kinds of CFO. Sympathy theory is much more broadly applicable to opacity, including also counter-bleeding opacity, but it has nothing to contribute to the analysis of DEE's, grandfathering, or non-iterating processes. Targeted constraints are primarily relevant to the problem of explaining why some markedness constraints lead to certain repairs and not others, though they are also applicable to some cases of opacity. The hoped-for synthesis, though, is well outside my grasp at this point, though the similarities are intriguing.

§6 Further Issues

This section deals with topics that arise in and around comparative markedness theory. In §6.1, I discuss the theory's implications for harmonic ascent, an important consequence of OT that comparative markedness threatens. The problem of determining the FFC is addressed in §6.2 and a preliminary but workable proposal is made. Finally, §6.3 broaches the broad question of how language learning might proceed under the comparative regime. A goal of §6.3 is to suggest how comparative markedness theory might explain the existence of chain-shifts (i.e., counter-feeding opacity) in child phonology.

§6.1 Comparative Markedness and Harmonic Ascent

One of the most striking results of classic OT is *harmonic ascent* (Moreton 1996/1999). A classic OT grammar is a ranking of markedness constraints and faithfulness constraints — and nothing else. By definition, a classical markedness constraint evaluates output candidates without reference to the input, while a faithfulness constraint evaluates input-output disparity, favoring the candidate with the least disparity (i.e., none at all). From this fact, and from the further assumption that there always is a fully faithful candidate, Moreton proves the following result formally: For any OT grammar G and any input I, the output of G from I, G(I), is either identical to the FFC derived from I or less marked than the FFC according to the markedness constraints as ranked in G. The intuition behind this is clear: the only reason to violate a faithfulness constraint is if violation leads to improvement in markedness. For details of the proof, see Moreton's work; for a fuller summary than I have provided here, see McCarthy (2002: 101-3)

Harmonic ascent has several empirical consequences. For one thing, it means that no OT grammar can describe a process of unconditional augmentation, where every form grows in size (e.g., /ba/ → *baʔ*, /bat/ → *batə*, /bata/ → *bataʔ*, …). The reason: augmentation is an unfaithful mapping, and unfaithful mappings must improve markedness. Since classical markedness constraints evaluate output forms without reference to the input, and since "getting longer" is not evaluable on output forms alone, there can be no markedness constraint in CON that would compel unconditional augmentation.[19]

[19]Imagine a constraint ℂ that says "every word contains infinitely many syllables", under the usual assumption that gradient violation is reckoned by counting up the offenses. Ranked above DEP-V but below the local conjunction of DEP-V with itself, ℂ might seem to be able to force words to grow by one syllable. The problem with this line of analysis is ℂ itself. A markedness constraint of classic OT is a function from a candidate to zero or more violation-

Harmonic ascent also entails that no OT grammar can describe any process or set of processes that characterizes a circular chain shift, such as /a/ → … → *i* co-existing with /i/ → … → *a*. Circular shifts are impossible because the ranking in a grammar must be consistent: there is no way for both of the unfaithful mappings /A/ → *B*, **A* and /B/ → *A*, **B* to improve markedness relative to a single constraint hierarchy.

So far, we've only talked about classic OT. What are the implications of comparative markedness for harmonic ascent? Paul de Lacy observes that circular chain shifts are analyzable with comparative markedness constraints, and so harmonic ascent is not guaranteed under the comparative markedness regime. Consider the circular chain shift /e/ → *i* and /i/ → *e*. Assume that high-ranking faithfulness constraints rule out all other unfaithful mappings from these inputs and then apply the following ranking:

(46)

a. Input /e/

	$_{\mathrm{O}}$*HIGH	$_{\mathrm{O}}$*MID	IDENT(high)	$_{\mathrm{N}}$*HIGH	$_{\mathrm{N}}$*MID
i. ☞ i			*	*	
ii. (FFC) e		*!			

b. Input /i/

	$_{\mathrm{O}}$*HIGH	$_{\mathrm{O}}$*MID	IDENT(high)	$_{\mathrm{N}}$*HIGH	$_{\mathrm{N}}$*MID
i. (FFC) i	*!				
ii. ☞ e			*		*

The result is a circular chain shift, with /e/ mapping to *i* and /i/ mapping to *e*.

In classic OT, the /i/ → *e* and /e/ → *i* mappings cannot **both** improve on markedness because either high is more marked than mid ⟦*HIGH ≫ *MID⟧ or mid is more marked than high ⟦*MID ≫ *HIGH⟧. Classic OT says, then, that these mappings cannot co-exist in the same context within a single language. But by separating the old and new components of markedness, comparative markedness theory allows both of these mappings to register improvements with respect to different $_{\mathrm{O}}$M constraints, with the corresponding $_{\mathrm{N}}$M constraints tucked safely out of the way. The ranking here is the one for CFO, which is the same as the ranking for chain shifts generally. A circular chain shift, then, is possible with the CFO ranking if CON supplies markedness constraints that are opposed to one another in the same way that *HIGH and *MID are.[20]

marks. Present ℂ with *pataka* and it returns $\aleph_0$ violations. Present it with the supposedly improved candidate *pataka*ʔ*i* and it still returns $\aleph_0$ violations, because $\aleph_0 - 3 = \aleph_0 - 4 = \aleph_0$. With the faithful and augmented candidates tied on ℂ, the faithful candidate wins.

[20] *HIGH and *MID are not literally contradictory constraints — for example, they agree in their evaluation of segments that are neither high nor mid, such as *a* or *p*.

Elliott Moreton suggests an even more damaging example, involving just one ${}_{N}$M/${}_{O}$M pair. Imagine a language that, like Barrow Inupiaq, palatalizes *l* after *i*. Imagine too that it has a top-ranked OCP-like constraint that bans sequences of identical laterals, so **lVl* and **ʎVʎ* are prohibited but *lVʎ* and *ʎVl* are all right.[21] With the OCP constraint at the top and with ${}_{O}$PAL-L dominating ${}_{N}$PAL-L, underlying /iliʎ/ becomes surface *iʎil* and, contrariwise, underlying /iʎil/ becomes surface *iliʎ*. In other words, palatalization neatly flips from one lateral to the other. The following tableau delivers the bad news:

(47)

/iliʎ/	OCP	${}_{O}$PAL-L	${}_{N}$PAL-L	IDENT
a. ☞ iʎil			*	*
b. (FFC) iliʎ		*!		
c. iʎiʎ	*!			*
/iʎil/				
d. ☞ iliʎ			*	*
e. iʎil		*!		
f. iʎiʎ	*!			*

This too is a circular chain shift, though the circularity is reckoned over strings rather than individual segments. The crucial analytic move is to deploy the OCP constraint at the top, thereby excluding the possibility of satisfying both ${}_{O}$PAL-L and ${}_{N}$PAL-L. This allows ${}_{O}$PAL-L to force an alternation even when there is no net gain in terms of classic OT markedness.

This problem for comparative markedness theory is quite serious because harmonic ascent is a sound and empirically motivated deduction from classic OT. The problem also seems to be fundamental to comparative markedness theory. Circular chain shifts are unanalyzable in classic OT precisely because the classical markedness constraints cannot refer to the input, and so they are unable to make a distinction between new and inherited violations.

Here is the same reasoning somewhat more formally. One of the key results of Moreton's (1996/1999) work on harmonic ascent is the following lemma (paraphrased here):

(48) Assume that $\mathcal{H}$ is the constraint hierarchy of a language, and let $\mathcal{H}^M$ and $\mathcal{H}^F$ stand for the hierarchies of markedness and faithfulness constraints, respectively, in the same order that they have in $\mathcal{H}$. If a classic OT grammar maps /a/ to [b], then $\mathcal{H}^M$([a]) > $\mathcal{H}^M$([b]).

[21] The OCP constraint can, like all other markedness constraints, be subdivided into ${}_{O}$OCP and ${}_{N}$OCP. This does not change the result.

The expression "$\mathcal{H}^M([a]) > \mathcal{H}^M([b])$" says that [a]'s markedness violation profile is worse than [b]'s.[22] If some grammar maps /a/ to [b], then the markedness constraints as they are ranked in that grammar must favor output [b] over the FFC [a]. The markedness constraints must be doing this because the faithfulness constraints surely do not: they favor the FFC [a] over unfaithful [b]. Circular chain shifts are impossible because, for the same grammar to map input /b/ to output [a], $\mathcal{H}$ would also have to say that $\mathcal{H}^M([b]) > \mathcal{H}^M([a])$. This is an obvious contradiction.

Comparative markedness tosses a monkey wrench (i.e., a spanner) into this lemma. Expressions like $\mathcal{H}^M([a])$ are meaningless because markedness violations cannot be determined solely by reference to outputs because they need to have access to the input/FFC as well. So the existence of an /a/ → [b] mapping indicates that $\mathcal{H}^M(/a/,[a]) > \mathcal{H}^M(/a/,[b])$. The existence of a /b/ → [a] mapping indicates that $\mathcal{H}^M(/b/,[b]) > \mathcal{H}^M(/b/,[a])$. There is, then, no contradiction and so there is no proof that circular chain-shifts are impossible. In fact, the problematic grammar in (46) has exactly this property: $\mathcal{H}^M(/i/,[i]) > \mathcal{H}^M(/i/,[e])$ by top-ranked $_{\mathbf{O}}$*HIGH and $\mathcal{H}^M(/e/,[e]) > \mathcal{H}^M(/e/,[i])$ by top-ranked $_{\mathbf{O}}$*MID.

Though comparative markedness theory gives up classic OT's results about circular chain shifts, it preserves the result about the impossibility of unconditional augmentation. Unconditional augmentation is really an infinite chain-shift. Comparative markedness constraints cannot compel infinite chain-shifts for the same reason that classic OT markedness constraints cannot: movement toward an infinite limit will never follow from evaluating the markedness of an output structure, even if new and old violations are distinguished.

The impossibility of unconditional augmentation in comparative markedness theory is one important difference between comparative markedness and anti-faithfulness (Alderete 1998, 2001). Though both theories permit circular chain shifts, comparative markedness constraints demand that unfaithful outputs better obey some markedness constraint of UG, but anti-faithfulness constraints are indifferent to the markedness consequences of mappings. Consequently, anti-faithfulness constraints can produce unconditional augmentation (cf. Bakovic 1996).

Another difference between comparative markedness and anti-faithfulness is that only anti-faithfulness can map an input to an output that is unambiguously **more** marked than the FFC. Anti-faithfulness is simply the negation of faithfulness, and so an anti-faithful output is required only to differ from the FFC. For example, in Alderete's (1998) analysis of Luo, an underlying /t/ is mapped to a surface *d* to satisfy the anti-faithfulness constraint ¬IDENT(voice). There is no markedness constraint that is better satisfied by this mapping; on the contrary, markedness performance suffers. Comparative markedness theory cannot produce the /t/ to *d* map any more than classical OT can, and for the same reason: there is no markedness constraint that favors voiced obstruents over voiceless ones.[23]

---

[22] $\mathcal{H}^M([a])$ can be thought of as an *n*-tuple of strings of zero or more *'s, one for each constraint, ordered as ranked in $\mathcal{H}$: ⟨*, 0, **, ***, 0, ...⟩. Then $\mathcal{H}^M([a]) > \mathcal{H}^M([b])$ means that the violation profile $\mathcal{H}^M([a])$ has more *'s than $\mathcal{H}^M([b])$ in the leftmost member of the *n*-tuple where they differ.

[23] More precisely, there is no context-free markedness constraint favoring voiced obstruents over voiceless. In certain contexts, such as intervocalically or before another voiced obstruent, context-sensitive markedness constraints will favor voicing.

§6.2 What is the FFC?

Every candidate set emitted by GEN contains a fully faithful candidate (FFC). This assumption is more or less implicit in the basic statements of OT, and it is made explicit in Moreton (1996/1999). By definition, the FFC obeys every faithfulness constraint. If faithfulness is formalized using correspondence theory, then the relation 𝔑 between the input and the FFC is one-to-one, onto, and order-preserving (MAX, DEP, LINEARITY, INTEGRITY, and UNIFORMITY are all obeyed) with only identical elements standing in correspondence (all IDENT(feature) constraints are obeyed).

The existence of an FFC in every candidate set does not guarantee its uniqueness, however, and there lies a potential problem. A candidate is fully faithful if it obeys every faithfulness constraint. But if GEN can alter inputs in ways that faithfulness constraints will not detect, then candidate sets will contain several fully faithful candidates. To evaluate comparative markedness constraints, at least as I have defined them above, a unique FFC is required.

It seems likely that GEN does indeed alter inputs in ways that are invisible to faithfulness constraints. If richness of the base is understood in its strongest form, then this is the only way to account for the universal non-contrastiveness of certain phonological distinctions (Keer 1999, McCarthy 2002: 73-4). For example, it is frequently observed that syllabification of tautomorphemic sequences is never contrastive, so no language distinguishes two roots like *hab.la* and *ha.bla* (Blevins 1995: 221, Clements 1986b: 318, Hayes 1989: 260). A necessary condition for ensuring that syllabification is never contrastive is that syllabification is faithfulness-free, so an unsyllabified input like /maba/ or a syllabified input like /mab.a/ will be associated by GEN with all of the following fully faithful and fully syllabified candidates: *m.a.b.a*, *ma.b.a, m.a.ba, m.aba, m.ab.a, ma.ba*, *mab.a*, *maba*. Many of these candidates are sure losers for markedness reasons, such as the absurd monosyllable *maba*. But they are still fully faithful in the sense that they incur no faithfulness violations.

As this example shows, the existence of faithfulness-free mappings creates ambiguity in determining which candidate is **the** FFC. Simply to evaluate candidates using comparative markedness constraints, it is necessary to identify a unique FFC (presumably *ma.ba*) from the set of candidates that are fully faithful but diversely syllabified. The number of such candidates is finite and, indeed, not large,[24] but it is still greater than one, and one FFC is required for comparative markedness constraints to be evaluable.

---

[24]There are only 2^{N-1} ways to divide a word of *N* segments exhaustively into syllables. (For all segments in the word except the last, there are just two options: put it into the same syllable as the following segment or not.) The binary trees of prosodic theory afford richer possibilities, but still there are "only" $\frac{2*6*10...*(4N-10)}{(N-1)!}$ binary trees with *N* terminals. (This is Euler's formula for the *N*th term of the Catalan series. This series was discovered by the Belgian mathematician Eugene Catalan in 1838 (Gardner 1988).) The full candidate set in OT is (famously) infinite, but that's because there are infinitely many **unfaithful** candidates by virtue of epenthesis. Even then, the number of potential winners is finite (Samek-Lodovici and Prince 1999).

A natural idea is that the unique FFC is simply the most harmonic member of the set of fully faithful candidates — *ma.ba*, then.[25] On its face, though, this definition is circular: when choosing the most harmonic fully-faithful candidate, only markedness constraints are relevant. That seems reasonable: *ma.ba*, the presumptive FFC, is surely the least marked member of the set {*m.a.b.a*, *ma.ba*, *mab.a*, *m.ab.a*, ...}. But comparative markedness constraints themselves cannot be evaluated without already knowing what the FFC is. It is circular, then, to use comparative markedness constraints to find the FFC.

Here is an optimization procedure that unwinds the circularity. Take each of the fully faithful candidates {*m.a.b.a*, *ma.ba*, ...} with *itself* as temporary FFC, and then evaluate it using the constraint hierarchy of the language as a whole. The true FFC will be the most harmonic candidate that emerges from this operation.[26] That is, harmonic evaluation will optimize over the set {*m.a.b.a*, *ma.ba*, *mab.a*, *m.ab.a*, ...}, evaluating *m.a.b.a* as candidate relative to *m.a.b.a* as temporary FFC, *ma.ba* as candidate relative to *ma.ba* as temporary FFC, and so on. Because the candidates and their respective temporary FFC's are identical in all respects, neither the faithfulness constraints nor the "don't get worse" $_{\mathrm{N}}$M markedness constraints are relevant to this evaluation. The "get better" $_{\mathrm{O}}$M markedness constraints will carry the whole burden of selecting the true FFC. In the {*m.a.b.a*, *ma.ba*, ...} example, for instance, the markedness constraints $_{\mathrm{O}}$ONSET and $_{\mathrm{O}}$NO-CODA will favor *ma.ba* over the alternatives.

This procedure is somewhat reminiscent of lexicon optimization (Prince and Smolensky 1993) in using the language's independently required constraint hierarchy to select a unique member from a set of several seemingly equivalent alternatives. There are important differences, though. Lexicon optimization is charged with determining the underlying form of non-alternating forms — that is, it chooses underlying forms only in those circumstances where they make no difference empirically (McCarthy 2002: 76-80). Optimization of the FFC can make a difference empirically, however, as I will show shortly. Concomitant with its job of picking an underlying representation, lexicon optimization uses only faithfulness constraints, while optimization of the FFC, since it chooses among faithful candidates, uses only $_{\mathrm{O}}$M markedness constraints. Finally, lexicon optimization is relevant only during learning, whereas optimization of the FFC is part of harmonic evaluation.

To show that selection of the FFC has empirical consequences, I have constructed an example that, while hypothetical, is based on real-life cases like Yiddish and some German dialects (Lombardi 1991: 98fn.) or Isthmus Nahuatl (Kenstowicz and Kisseberth 1979: 298-9). Suppose a process of final devoicing is in a counter-feeding relationship with apocope. Underlying /kab/ maps to *kap*, but underlying /maba/ maps to *mab*, **map*. Suppose UG supplies a markedness constraint

---

[25] As I understand the proposal made in some handouts of talks of Ronald Sprouse (1997, 1998), his notion of an "enriched input" and the FFC may be the same thing.

[26] This procedure will provide a unique FFC to the same extent that OT grammars in general provide a unique output (cf. McCarthy 2002: 7, 200).

against voiced obstruents in coda position, NO-VOICE]$_\sigma$.[27] The ranking schema for CFO in (37) tells us how to rank the old and new versions of this constraint.

(49) $_{\mathbf{O}}$NO-VOICE]$_\sigma$ ≫ IDENT(voice) ≫ $_{\mathbf{N}}$NO-VOICE]$_\sigma$

This says that syllable-final voiced obstruents in the FFC must be devoiced, because they violate $_{\mathbf{O}}$NO-VOICE]$_\sigma$ and $_{\mathbf{O}}$NO-VOICE]$_\sigma$ dominates IDENT(voice). But syllable-final voiced obstruents derived by apocope are left alone, because they violate only low-ranking $_{\mathbf{N}}$NO-VOICE]$_\sigma$.

The identity of the FFC is crucial in this analysis. From the input /maba/, GEN derives the fully faithful candidates {*m.a.b.a*, *ma.ba*, *mab.a*, *m.ab.a*, ...}. (There are eight of them.) If the FFC is *ma.ba*, then the correct result is obtained, but if the FFC is *mab.a*, for instance, then the output is wrong:

(50) Correct Result with FFC *ma.ba*

	$_{\mathbf{O}}$NO-VOICE]$_\sigma$	IDENT(voice)	$_{\mathbf{N}}$NO-VOICE]$_\sigma$
a. ☞ *mab*			*
b. *map*		*!	
cf. FFC *ma.ba*			

(51) Wrong Result with FFC *mab.a*

	$_{\mathbf{O}}$NO-VOICE]$_\sigma$	IDENT(voice)	$_{\mathbf{N}}$NO-VOICE]$_\sigma$
a. *mab*	*		
b. ☞ *map*		*!	
cf. FFC *mab.a*			

If the FFC is *mab.a*, with the "wrong" syllabification, then high-ranking $_{\mathbf{O}}$*VOICE]$_\sigma$ is wrongly active and the wrong candidate wins. This shows that the FFC must be *ma.ba*, with the "right" syllabification — "right" in the sense that it is the most harmonic under optimization of the FFC.

§6.3 Learning[28]

Research on the acquisition of phonology has focused almost entirely on learning inventories and phonotactics. Although morphophonemic alternations are the bread and butter of phonological theorizing, there are few empirical studies of the acquisition of morphophonemics (v. Kiparsky and

[27] If there are no markedness constraints against voiced coda obstruents, as argued by Lombardi (2001), then a different process can be used. The argument in the text simply requires that there be **some** markedness constraint that refers to segmental features and syllabic position.

[28] Thanks to Joe Pater for pushing me into this and for indispensable guidance.

Menn 1977) and some preliminary results from the learnability side (M. Hale and Reiss 1997, 1998, Hayes to appear, McCarthy 1998, Tesar and Smolensky 2000: 77ff.). The phenomena that reveal differences between comparative markedness and classic OT are all morphophonemic, such as DEE's or opacity. Examining the consequences of comparative markedness for learning, then, would seem to be an unprofitable enterprise.

Nonetheless, it is possible to speculate about learning under comparative markedness, but first we need some background. Most research on the acquisition of phonology makes two basic assumptions, both of which I adopt here. First, the input to the early learner's grammar is not an adult-like underlying representation but rather the adult surface form exactly as the learner perceives it. If the adult says [but] *boot* and the learner produces [bu], then the learner's grammar has taken as input the expression [but], with its full prosodic structure, and emitted something different, [bu]. The goal of learning at this early stage, then, is to get the output of the nascent grammar to match its input.

That the output and input typically do not match is a consequence of the second assumption. To account for the phonotactic impoverishment of early child phonology, the initial state of the grammar, prior to any ranking, is taken to be ⟦M ≫ F⟧, with all markedness constraints ranked above all faithfulness constraints.[29] This assumption is also necessary to explain how phonotactics can be learned at all without access to negative data: M is demoted below F only in response to positive data evidencing violation of M. The natural translation of this assumption into comparative markedness theory is simply to recognize the splitting of M, making the initial state ⟦$_{O}$M, $_{N}$M ≫ F⟧. If we marry this hypothesis to learning by constraint demotion (Tesar 1995, 2000, Tesar and Smolensky 1994, 1996, 1998, 2000), then we expect to see $_{O}$M and $_{N}$M being demoted separately. If we also examine the path that learning takes from the initial state to the final adult grammar, we might expect to see stages in the acquisition process where $_{O}$M and $_{N}$M are ranked differently, even when they start out and end up in the same spot.

Concretely, suppose the learner at an early stage has the grammar ⟦$_{O}$NO-CODA, $_{N}$NO-CODA ≫ MAX⟧. Only CV syllables are produced and adult models like [but] come out as [bu]. Because input and output are not the same, the learner responds by demoting one of the NO-CODA constraints. Which one? Well, the FFC is just the same as the input/adult surface form [but], and it is [but]'s $_{O}$NO-CODA violation that is the problem. (The FFC only violates $_{O}$M constraints, never $_{N}$M. See §3.) Therefore, $_{O}$NO-CODA is demoted below MAX to ensure that [but] is optimal, as desired.

The action gets interesting when processes interact. Suppose the learner also truncates his/her early words, eliminating all unstressed syllables to satisfy a markedness constraint *σ̆ (an ad hoc substitute for the real prosodic constraints, for which see Pater 1997, Pater and Paradis 1996). The grammar of the initial state is given in (52a). It simplifies all words to CV, mapping adult [bˈut] to [bˈu] and adult [kˈu.ti] to [kˈu]. Constraint demotion, as standardly applied, will demote *σ̆ and $_{O}$NO-

[29]Arguments for the ⟦M ≫ F⟧ initial state can be found in the context of acquisition data and/or as a solution to learnability problems by Barlow (1997), Bernhardt and Stemberger (1998), Davidson, Juszcyk, and Smolensky (to appear), Demuth (1995), Gnanadesikan (1995/to appear), Goad (1997), Hayes (to appear), Levelt (1996), van Oostendorp (1997), Pater (1997), Pater and Paradis (1996), Smolensky (1996), Sherer (1994), and Tesar and Smolensky (2000: Chapt. 5).

CODA below MAX, since these constraints are violated by the intended winners. The resulting grammar is shown in (52b). Except for the presence of high-ranking (and innocuous — see below) $_{N}$NO-CODA, this is the same as the final state that would be expected in classic OT.

(52) Paths of Learning with Comparative Markedness

	Adult models	[b'ut]	[k'u.ti]
a. Initial state			
*σ̆, $_{O}$NO-CODA, $_{N}$NO-CODA ≫ MAX	Output	[b'u]	[k'u]
b. A possible final state			
$_{N}$NO-CODA ≫ MAX ≫ *σ̆, $_{O}$NO-CODA	Output	[b'ut]	[k'u.ti]
c. A possible intermediate state			
*σ̆, $_{O}$NO-CODA ≫ MAX ≫ $_{N}$NO-CODA	Output	[b'u]	[k'ut]
d. The final state after (52c)			
MAX ≫ *σ̆, $_{N}$NO-CODA, $_{O}$NO-CODA	Output	[b'ut]	[k'u.ti]

Comparative markedness theory allows for another possibility, however, and this is shown in (52c, d). Suppose that learners will demote $_{N}$M constraints merely to improve the resemblance between the output of the grammar and the adult target, without getting it exactly right. Since [k'ut] is a better match to adult [k'u.ti] than [k'u] is, such a learner may take the path of demoting $_{N}$NO-CODA as in (52c). Finally, this learner will end up with the ranking in (52d). Its effect is the same as (52b), but $_{N}$NO-CODA is differently ranked.

At the intermediate step (52c), the resulting grammar maps [b'ut] to [b'u], as it did in the initial state, but it also maps [k'u.ti] to [k'ut]. This is a case of CFO or, as it is usually referred to in the acquisition literature, a chain-shift (Dinnsen and Barlow 1998, Dinnsen, O'Connor, and Gierut 2001, Smith 1973) . Codas already present in adult forms are deleted, but the truncation process can create codas. The famous *puzzle-puddle-puggle* chain-shift involves this same kind of interaction. It may be, then, that comparative markedness offers a partial solution to the problem of how opacity — ostensibly a morphophonemic phenomenon — can intrude on the learning of inventories and phonotactics.

I do not see how classic OT with demotion can even begin to obtain results like this. In fact, demotions like (52c) must be strenuously avoided in the classic theory because they are a sure recipe for disaster. A learner who demotes NO-CODA on the strength of the datum [k'u.ti] has gone to a superset language without sufficient support. If the language turns out not to have codas after all, this learner is in a real pickle. On the other hand, demoting $_{N}$NO-CODA as in (52c) has no lasting consequences for phonotactic learning. Remember: the goal of phonotactic learning is a grammar that maps the inputs (the adult models) onto their respective FFC's. By definition, the FFC never violates any $_{N}$M constraints (§3). Therefore, at the end of phonotactic learning the placement of the $_{N}$M constraints in the hierarchy is completely irrelevant. Their place in the hierarchy might very well turn out to matter in the learning of morphophonemics, but with our present knowledge it cannot be said whether this is an advantage or disadvantage.

§7 Conclusion

I have examined a significantly different way of treating markedness constraints in Optimality Theory. Instead of evaluating output forms alone, comparative markedness constraints look at the markedness consequences of input→output mappings. The fully faithful candidate, which assumes the role of the input in this comparison, will have certain markedness violations. Every other output candidate will eliminate some of those violations, add others, or stay the same. Comparative markedness constraints are sensitive to this difference: $_{O}M$ constraints demand elimination of markedness violations, while $_{N}M$ constraints militate against addition of new markedness violations.

Taken together, $_{O}M$ and $_{N}M$ constraints assign exactly the same violation-marks as traditional markedness constraints. The interesting cases arise when $_{O}M$ and $_{N}M$ are ranked separately, with some faithfulness constraint ranked between them. If $_{O}M$ is higher ranked, then unfaithful mappings will be possible to eliminate pre-existing markedness violations, but not to prevent the introduction of new ones (by some other, independently motivated process). This is counter-feeding opacity: a process affects configurations present in the input, but not configurations that are produced by other processes. On the other hand, if $_{N}M$ is higher ranked, then unfaithful mappings will be possible to prevent the introduction of new markedness violations (as a result of some other process), but not to eliminate pre-existing ones. Derived environment effects are like this: a markedness constraint is visibly active only on configurations that are the result of some other process. These and other phenomena served as the basis for contrasting comparative markedness with classic OT, using differences between them to illuminate aspects of the comparative theory. Other enhancements to classic OT, such as local conjunction, were also considered in relation to comparative markedness. Finally, two further points of divergence between comparative markedness and classic OT were discussed: harmonic ascent, which appears to favor classic OT, and chain-shifts in acquisition, which tend to support comparative markedness.

John J. McCarthy
Department of Linguistics
University of Massachusetts
Amherst, MA 01003 USA
jmccarthy@linguist.umass.edu

Acknowledgments

I am grateful to Eric Bakovic, Andries Coetzee, Paul de Lacy, Maria Gouskova, Linda Lombardi, Elliott Moreton, Marc van Oostendorp, Joe Pater, Colin Wilson, and the participants in CONSOLE X at Leiden University for their comments on an earlier version of this article.

References

Abu-Mansour, Mahasen Hasan (1996) Voice as a privative feature. In *Perspectives on Arabic Linguistics VIII: Papers from the Eighth Annual Symposium on Arabic Linguistics*, ed. Mushira Eid. Amsterdam and Philadelphia: John Benjamins.

Alderete, John (1998) *Morphologically-Governed Accent in Optimality Theory*. Doctoral dissertation. Amherst, MA: University of Massachusetts, Amherst.

Alderete, John (2001) Dominance effects as transderivational anti-faithfulness. *Phonology* 18.

Al-Mozainy, Hamza Q. (1981) *Vowel Alternations in a Bedouin Hijazi Arabic Dialect: Abstractness and Stress*. Doctoral dissertation. Austin, TX: University of Texas, Austin.

Archangeli, Diana and Pulleyblank, Douglas (1994) *Grounded Phonology*. Cambridge, MA: MIT Press.

Aronoff, Mark, Arsyad, Azhar, Basri, Hassan, and Broselow, Ellen (1987) Tier configuration in Makassarese reduplication. In *CLS 23: Parasession on Autosegmental and Metrical Phonology*, ed. A. Bosch, E. Schiller, and B. Need, pp. 1-15. Chicago: Chicago Linguistic Society.

Bakalla, Mohammed (1973) *The Morphology and Phonology of Meccan Arabic*. Doctoral dissertation. London: School of Oriental and African Studies, University of London.

Bakovic, Eric (1996) Foot harmony and quantitative adjustments. Unpublished manuscript. New Brunswick, NJ: Rutgers University.

Bakovic, Eric (2000) *Harmony, Dominance, and Control*. Doctoral dissertation. New Brunswick, NJ: Rutgers University. [Available on Rutgers Optimality Archive.]

Bakovic, Eric and Wilson, Colin (2000) Transparency, strict locality, and targeted constraints. In *Proceedings of the 19th West Coast Conference on Formal Linguistics*, ed. Roger Billerey and Brook Danielle Lillehaugen, pp. 43-56. Somerville, MA: Cascadilla Press.

Barlow, Jessica A. (1997) *A Constraint-Based Account of Syllable Onsets: Evidence from Developing Systems*. Doctoral dissertation. Bloomington, IN: Indiana University.

Beckman, Jill (1998) *Positional Faithfulness*. Doctoral dissertation. Amherst, MA: University of Massachusetts, Amherst. [Available on Rutgers Optimality Archive.]

Benua, Laura and Smolensky, Paul (2001) Markedness and preconditions on vowel harmony. Unpublished manuscript. College Park and Baltimore, MD: University of Maryland and Johns Hopkins University. [Handout from talk presented at the University of Massachusetts, Amherst.]

Bermúdez-Otero, Ricardo (1999) *Constraint Interaction in Language Change: Quantity in English and Germanic*. Doctoral dissertation. Manchester, UK: University of Manchester.

Bernhardt, Barbara H. and Stemberger, Joseph P. (1998) *Handbook of Phonological Development from the Perspective of Constraint-Based Nonlinear Phonology*. San Diego: Academic Press.

Bickmore, Lee (1996) Bantu tone spreading and displacement as alignment and minimal misalignment. Albany, NY: University at Albany. [Available on Rutgers Optimality Archive.]

Blevins, Juliette (1995) The syllable in phonological theory. In *The Handbook of Phonological Theory*, ed. John A. Goldsmith, pp. 206-44. Cambridge, MA, and Oxford, UK: Blackwell.

Causley, Trisha (1997) Identity and featural correspondence: The Athapaskan case. In *Proceedings of the North East Linguistic Society 27*, ed. Kiyomi Kusumoto, pp. 93-105. Amherst, MA: GLSA Publications.

Chomsky, Noam and Halle, Morris (1965) Some controversial questions in phonological theory. *Journal of Linguistics* 1, 97-138.

Chomsky, Noam and Halle, Morris (1968) *The Sound Pattern of English*. New York: Harper & Row.

Churchward, C. M. (1940) *Rotuman Grammar and Dictionary*. Sydney: Australasia Medical Publishing Co. [Repr. 1978, AMS Press, New York.].

Clements, G. N. (1986a) Compensatory lengthening and consonant gemination in Luganda. In *Studies in Compensatory Lengthening*, ed. L. Wetzels and E. Sezer, pp. 37-77. Dordrecht: Foris.

Clements, G. N. (1986b) Syllabification and epenthesis in the Barra dialect of Gaelic. In *The Phonological Representation of Suprasegmentals*, ed. Koen Bogers, Harry van der Hulst, and Maarten Mous, pp. 317-36. Dordrecht: Foris.

Clements, G. N. and Ford, K. C. (1979) Kikuyu tone shift and its synchronic consequences. *Linguistic Inquiry* 10, 179-210.

Cohn, Abigail and McCarthy, John J. (1994/1998) Alignment and parallelism in Indonesian phonology. *Working Papers of the Cornell Phonetics Laboratory* 12, 53-137. [Available (1994) on Rutgers Optimality Archive.]

Davidson, Lisa, Juszcyk, Peter, and Smolensky, Paul (to appear) The initial state and the final state: Theoretical implications of Richness of the Base and empirical explorations. In *Fixing Priorities: Constraints in Phonological Acquisition*, ed. René Kager, Joe Pater, and Wim Zonneveld. Cambridge: Cambridge University Press.

Davis, Stuart (1995) Emphasis spread in Arabic and Grounded Phonology. *Linguistic Inquiry* 26, 465-98.

de Lacy, Paul (2002) *The Formal Expression of Scales*. Doctoral dissertation. Amherst, MA: University of Massachusetts, Amherst.

Demuth, Katherine (1995) Markedness and the development of prosodic structure. In *Proceedings of the North East Linguistic Society 25*, ed. Jill Beckman, pp. 13-25. Amherst, MA: GLSA Publications.

Dinnsen, Daniel A. and Barlow, Jessica A. (1998) On the characterization of a chain shift in normal and delayed phonological acquisition. *Journal of Child Language* 25, 61-94.

Dinnsen, Daniel A., O'Connor, Kathleen, and Gierut, Judith (2001) An optimality theoretic solution to the puzzle-puddle-pickle problem. Handout from Annual Meeting, Linguistic Society of America, Washington, DC.

Dixon, Robert M. W. (1980) *The Languages of Australia*. Cambridge: Cambridge University Press.

Fukazawa, Haruka and Lombardi, Linda (to appear) To be simple or not to be: Constraints in Optimality Theory. In *Proceedings of the First Tokyo Conference on Psycholinguistics*, ed. Yukio Otsu. Tokyo: Hitsuji-Shobo.

Fukazawa, Haruka and Miglio, Viola (1998) Restricting conjunction to constraint families. In *Proceedings of the Western Conference on Linguistics 9 (WECOL 96)*, ed. Vida Samiian, pp. 102-17. Fresno, CA: Department of Linguistics, California State University, Fresno.

Gafos, Adamantios (1999) *The Articulatory Basis of Locality in Phonology*. New York: Garland.

Gardner, Martin (1988) *Time Travel and Other Mathematical Bewilderments*. New York: W. H. Freeman and Co.

Gnanadesikan, Amalia (1995/to appear) Markedness and faithfulness constraints in child phonology. In *Fixing Priorities: Constraints in Phonological Acquisition*, ed. René Kager, Joe Pater, and

Wim Zonneveld. Cambridge: Cambridge University Press. [Available (1995) on Rutgers Optimality Archive.]
Gnanadesikan, Amalia (1997) *Phonology with Ternary Scales*. Doctoral dissertation. Amherst, MA: University of Massachusetts at Amherst.
Goad, Heather (1997) Consonant harmony in child language: An Optimality-Theoretic account. In *Focus on Phonological Acquisition*, ed. S.-J. Hannahs and Martha Young-Scholten, pp. 113-42. Amsterdam: John Benjamins.
Goldsmith, John (1976) *Autosegmental Phonology*. Doctoral dissertation. Cambridge, MA: MIT. [Published by Garland Press, New York , 1979.]
Hale, Kenneth (1973) Deep-surface canonical disparities in relation to analysis and change: An Australian example. In *Current Trends in Linguistics*, ed. Thomas Sebeok, pp. 401-58. The Hague: Mouton.
Hale, Mark and Kissock, Madelyn (1998) The phonology-syntax interface in Rotuman. In *Recent Papers in Austronesian Linguistics: Proceedings of the Third and Fourth Meetings of the Austronesian Formal Linguistics Society, UCLA Occasional Papers in Linguistics #21*, ed. Matthew Pearson, pp. 115-28. Los Angeles: UCLA Department of Linguistics.
Hale, Mark, Kissock, Madelyn, and Reiss, Charles (1998) Output-output correspondence in OT. In *The Proceedings of the West Coast Conference on Formal Linguistics 16*, ed. E. Curtis, J. Lyle, and G. Webster, pp. 223-36. Stanford, CA: CSLI.
Hale, Mark and Reiss, Charles (1997) Grammar optimization: The simultaneous acquisition of constraint ranking and a lexicon. Unpublished manuscript. Concordia University, Montreal. [Available on Rutgers Optimality Archive.]
Hale, Mark and Reiss, Charles (1998) Formal and empirical arguments concerning phonological acquisition. *Linguistic Inquiry* 29, 656-83. [Available on Rutgers Optimality Archive.]
Hall, Beatrice and et al. (1974) African vowel harmony systems from the vantage point of Kalenjin. *Afrika und Uebersee* 57, 241-67.
Halle, Morris and Zeps, Valdis (1966) A survey of Latvian morphophonemics. *Quarterly Progress Report of the Research Laboratory of Electronics* 83, 104-13.
Harris, Zellig (1942) Morpheme alternants in linguistic analysis. *Language* 18, 169-80.
Hayes, Bruce (1989) Compensatory Lengthening in moraic phonology. *Linguistic Inquiry* 20, 253-306.
Hayes, Bruce (to appear) Phonological acquisition in Optimality Theory: The early stages. In *Fixing Priorities: Constraints in Phonological Acquisition*, ed. René Kager, Joe Pater, and Wim Zonneveld. Cambridge: Cambridge University Press. [Available on Rutgers Optimality Archive.]
Hermans, Ben and van Oostendorp, Marc (eds.) (1999) *The Derivational Residue in Phonological Optimality Theory*. Amsterdam: John Benjamins.
Horwood, Graham (1999) Anti-faithfulness and subtractive morphology. Unpublished manuscript. New Brunswick, NJ: Rutgers University. [Available (9/9/00) for download from http://www.rci.rutgers.edu/~gvh/%7EF&subtr.pdf.]
Howard, Irwin (1972) *A Directional Theory of Rule Application in Phonology*. Doctoral dissertation. Cambridge, MA: MIT.
Hume, Elizabeth and Tserdanelis, Georgios (1999) Nasal place assimilation in Sri Lanka Portuguese Creole: Implications for markedness. Unpublished manuscript. Columbus, OH: The Ohio State University.
Idsardi, William (1992) *The Computation of Prosody*. Doctoral dissertation. Cambridge, MA: MIT.

Ito, Junko and Mester, Armin (2001) Structure preservation and stratal opacity in German. In *Segmental Phonology in Optimality Theory*, ed. Linda Lombardi, pp. 261-95. Cambridge: Cambridge University Press.

Ito, Junko and Mester, Armin (to appear) On the sources of opacity in OT: Coda processes in German. In *The Optimal Syllable*, ed. Caroline Féry and Ruben van de Vijver. Cambridge: Cambridge University Press.

Johnstone, T. M. (1967) Aspects of syllabication in the spoken Arabic of `Anaiza. *Bulletin of the School of Oriental and African Studies* 30(1), 1-16.

Kaplan, Lawrence (1981) *Phonological Issues in North Alaskan Inupiaq*. Fairbanks, AK: Alaska Native Language Center.

Keer, Edward (1999) *Geminates, the OCP, and Faithfulness*. Doctoral dissertation. New Brunswick, NJ: Rutgers University. [Available on Rutgers Optimality Archive.]

Kenstowicz, Michael (1995) Cyclic vs. non-cyclic constraint evaluation. *Phonology* 12, 397-436.

Kenstowicz, Michael and Kisseberth, Charles (1977) *Topics in Phonological Theory*. New York: Academic Press.

Kenstowicz, Michael and Kisseberth, Charles (1979) *Generative Phonology: Description and Theory*. New York: Academic Press.

Kiparsky, Paul (1965) *Phonological Change*. Doctoral dissertation. Cambridge, MA: MIT.

Kiparsky, Paul (1968) Linguistic universals and linguistic change. In *Universals in Linguistic Theory*, ed. Emmon Bach and Robert Harms, pp. 170-202. New York: Holt, Rinehart and Winston.

Kiparsky, Paul (1973) Phonological representations. In *Three Dimensions of Linguistic Theory*, ed. O. Fujimura, pp. 3-136. Tokyo: TEC.

Kiparsky, Paul (1982) Lexical phonology and morphology. In *Linguistics in the Morning Calm*, ed. I. S. Yang, pp. 3-91. Seoul: Hanshin.

Kiparsky, Paul (1993) Blocking in non-derived environments. In *Studies in Lexical Phonology*, ed. Sharon Hargus and Ellen Kaisse. San Diego: Academic Press.

Kiparsky, Paul (2002a) *Paradigmatic Effects*. Stanford, CA: CSLI.

Kiparsky, Paul (2002b) Syllables and moras in Arabic. In *The Optimal Syllable*, ed. Caroline Féry and Ruben van de Vijver. Cambridge: Cambridge University Press.

Kiparsky, Paul and Menn, Lise (1977) On the acquisition of phonology. In *Language Learning and Thought*, ed. J. Macnamara, pp. 47-78. New York: Academic Press.

Kirchner, Robert (1996) Synchronic chain shifts in Optimality Theory. *Linguistic Inquiry* 27, 341-50.

Klokeid, Terry (1976) *Topics in Lardil Grammar*. Doctoral dissertation. Cambridge, MA: MIT.

Kornai, Andras (1994) *Formal Phonology*. New York: Garland.

Lamontagne, Greg and Rice, Keren (1995) A correspondence account of coalescence. In *University of Massachusetts Occasional Papers in Linguistics 18*, ed. Jill Beckman, Laura Walsh Dickey, and Suzanne Urbanczyk, pp. 211-24. Amherst, MA: GLSA Publications.

Leben, Will (1973) *Suprasegmental Phonology*. Doctoral dissertation. Cambridge, MA: MIT.

Levelt, Clara C. (1996) Consonant-vowel interactions in child language. In *Proceedings of the UBC International Conference on Phonological Acquisition*, ed. Barbara H. Bernhardt, John Gilbert, and David Ingram, pp. 229-39. Somerville, MA: Cascadilla Press.

Lightner, Theodore (1972) *Problems in the Theory of Phonology*. Edmonton: Linguistic Research, Inc.

Lombardi, Linda (1991) *Laryngeal Features and Laryngeal Neutralization*. Doctoral dissertation: University of Massachusetts, Amherst.

Lombardi, Linda (1999) Positional faithfulness and voicing assimilation in Optimality Theory. *Natural Language and Linguistic Theory* 17, 267-302.

Lombardi, Linda (2001) Why Place and Voice are different: Constraint-specific alternations in Optimality Theory. In *Segmental Phonology in Optimality Theory: Constraints and Representations*, ed. Linda Lombardi, pp. 13-45. Cambridge: Cambridge University Press. [Available (1995) on Rutgers Optimality Archive.]

Lubowicz, Anna (1999) Derived environment effects in OT. In *The Proceedings of the West Coast Conference on Formal Linguistics 17*, ed. Kimary N. Shahin, Susan J. Blake, and Eun-Sook Kim, pp. 451-65. Stanford, CA: CSLI. [Available on Rutgers Optimality Archive.]

Lubowicz, Anna (2002) *Faithfulness as Contrast Preservation*. Doctoral dissertation. Amherst, MA: University of Massachusetts, Amherst.

Lubowicz, Anna (to appear) Derived Environment Effects in Optimality Theory. *Lingua* xxx, xxx-xxx.

Mascaró, Joan (1976) *Catalan Phonology and the Phonological Cycle*. Doctoral dissertation. Cambridge, MA: MIT.

Mascaró, Joan and Wetzels, Leo (2001) The typology of voicing and devoicing. *Language* 77, 207-44.

McCarthy, John J. (1997) Process-specific constraints in Optimality Theory. *Linguistic Inquiry* 28, 231-51.

McCarthy, John J. (1998) Morpheme structure constraints and paradigm occultation. In *CLS 32, Part 2: The Panels*, ed. M. Catherine Gruber, Derrick Higgins, Kenneth Olson, and Tamra Wysocki, pp. 123-50. Chicago, IL: Chicago Linguistic Society.

McCarthy, John J. (1999) Sympathy and phonological opacity. *Phonology* 16, 331-99.

McCarthy, John J. (2000) The prosody of phase in Rotuman. *Natural Language and Linguistic Theory* 18, 147-97.

McCarthy, John J. (2002) *A Thematic Guide to Optimality Theory*. Cambridge: Cambridge University Press.

McCarthy, John J. (to appear) Sympathy, cumulativity, and the Duke-of-York gambit. In *The Optimal Syllable*, ed. Caroline Féry and Ruben van de Vijver. Cambridge: Cambridge University Press.

McCarthy, John J. and Prince, Alan (1993) Prosodic Morphology I: Constraint Interaction and Satisfaction. Report no. RuCCS-TR-3. New Brunswick, NJ: Rutgers University Center for Cognitive Science. [Available on Rutgers Optimality Archive.]

McCarthy, John J. and Prince, Alan (1994) The emergence of the unmarked: Optimality in prosodic morphology. In *Proceedings of the North East Linguistic Society 24*, ed. Mercè Gonzàlez, pp. 333-79. Amherst, MA: GLSA Publications.

McCarthy, John J. and Prince, Alan (1995) Faithfulness and Reduplicative Identity. In *University of Massachusetts Occasional Papers in Linguistics 18*, ed. Jill Beckman, Laura Walsh Dickey, and Suzanne Urbanczyk, pp. 249-384. Amherst, MA: GLSA Publications.

McCarthy, John J. and Prince, Alan (1999) Faithfulness and identity in Prosodic Morphology. In *The Prosody-Morphology Interface*, ed. Rene Kager, Harry van der Hulst, and Wim Zonneveld, pp. 218-309. Cambridge: Cambridge University Press.

McCawley, James (1978) What is a tone language? In *Tone: A Linguistic Survey*, ed. Victoria Fromkin, pp. 113-31. New York: Academic Press.

Moreton, Elliott (1996/1999) Non-computable functions in Optimality Theory. Unpublished manuscript. Amherst, MA: University of Massachusetts, Amherst. [Written in 1996. Revised and placed on Rutgers Optimality Archive in 1999.]

Myers, Scott (1997) OCP effects in Optimality Theory. *Natural Language and Linguistic Theory* 15, 847-92.

Newman, Stanley (1944) *Yokuts Language of California*. New York: Viking Fund.

Ní Chiosáin, Máire and Padgett, Jaye (2001) Markedness, segment realization, and locality in spreading. In *Segmental Phonology in Optimality Theory: Constraints and Representations*, ed. Linda Lombardi. New York: Cambridge University Press.

Paradis, Carole and Prunet, Jean-François (eds.) (1991) *The Special Status of Coronals: Internal and External Evidence*. San Diego: Academic Press.

Pater, Joe (1997) Minimal Violation and Phonological Development. *Language Acquisition* 6, 201-53.

Pater, Joe (1999) Austronesian nasal substitution and other NC effects. In *The Prosody-Morphology Interface*, ed. Rene Kager, Harry van der Hulst, and Wim Zonneveld, pp. 310-43. Cambridge: Cambridge University Press.

Pater, Joe and Paradis, Johanne (1996) Truncation without templates in child phonology. In *Proceedings of the 20th Annual Boston University Conference on Language Development*, ed. A. Stringfellow, D. Cahana-Amitay, E. Hughes, and A. Zukowski, pp. 540-52. Somerville, MA: Cascadilla Press.

Piggott, G. L. (1975) More on the application of phonological rules. *Montreal Working Papers in Lingustics* 5, 113-50.

Potter, Brian (1994) Serial optimality in Mohawk prosody. In *Proceedings of the Thirtieth Annual Regional Meeting of the Chicago Linguistics Society*, ed. Katharine Beals, Jeannette Denton, Robert Knippen, Lynette Melmar, Hisami Suzuki, and Erica Zeinfeld, pp. 347-61. Chicago, IL: Chicago Linguistics Society.

Prince, Alan (1987) Paninian relations. Unpublished manuscript. New Brunswick, NJ: Rutgers University. [Handout from talk presented at the University of Massachusetts, Amherst.]

Prince, Alan and Smolensky, Paul (1991) Optimality. Handout from Arizona Phonology Conference, Tucson.

Prince, Alan and Smolensky, Paul (1993) Optimality Theory: Constraint interaction in generative grammar. Report no. RuCCS-TR-2. New Brunswick, NJ: Rutgers University Center for Cognitive Science.

Roca, Iggy (ed.) (1997) *Derivations and Constraints in Phonology*. Oxford: Oxford University Press.

Rosenthall, Sam (1994) *Vowel/Glide Alternation in a Theory of Constraint Interaction*. Doctoral dissertation. Amherst, MA: University of Massachusetts, Amherst.

Rubach, Jerzy (1984) *Cyclic and Lexical Phonology: The Structure of Polish*. Dordrecht: Foris.

Rubach, Jerzy (2000) Glide and glottal stop insertion in Slavic languages: A DOT analysis. *Linguistic Inquiry* 31, 271-317.

Samek-Lodovici, Vieri and Prince, Alan (1999) Optima. Unpublished manuscript. London and New Brunswick, NJ: University of London and Rutgers University. [Available on Rutgers Optimality Archive.]

Scott, N. C. (1957) Notes on the pronunciation of Sea Dayak. *Bulletin of the School of Oriental and African Studies* 20, 509-12.

Sherer, Tim (1994) *Prosodic Phonotactics*. Doctoral dissertation. Amherst, MA: University of Massachusetts, Amherst.

Smith, Neilson V. (1973) *The Acquisition of Phonology: A Case Study*. Cambridge: Cambridge University Press.

Smolensky, Paul (1995) On the internal structure of the constraint component Con of UG. Handout from talk, University of Arizona. [Available on Rutgers Optimality Archive.]

Smolensky, Paul (1996) The initial state and 'Richness of the Base' in Optimality Theory. Report no. JHU-CogSci-96-4. Baltimore, MD: Department of Cognitive Science, Johns Hopkins University. [Available on Rutgers Optimality Archive.]

Smolensky, Paul (1997) Constraint interaction in generative grammar II: local conjunction, or random rules in Universal Grammar. Handout from Hopkins Optimality Theory Workshop/Maryland Mayfest '97, Baltimore, MD.

Sohn, Ho-min (1975) *Woleaian Reference Grammar*. Honolulu: University of Hawaii Press.

Sprouse, Ronald (1997) A case for enriched inputs. Handout from TREND, Berkeley, CA.

Sprouse, Ronald (1998) Encriched input sets as a source of opacity in OT. Handout from GLOW, Tilburg.

Tesar, Bruce (1995) *Computational Optimality Theory*. Doctoral dissertation. Boulder, CO: University of Colorado. [Available on Rutgers Optimality Archive.]

Tesar, Bruce (2000) On the roles of Optimality and strict domination in language learning. In *Optimality Theory: Phonology, Syntax, and Acquisition*, ed. Joost Dekkers, Frank van der Leeuw, and Jeroen van de Weijer. Oxford: Oxford University Press.

Tesar, Bruce and Smolensky, Paul (1994) The learnability of Optimality Theory. In *Proceedings of the Thirteenth West Coast Conference on Formal Linguistics*, ed. Raul Aranovich, William Byrne, Susanne Preuss, and Martha Senturia, pp. 122-37. Stanford, CA: CSLI Publications.

Tesar, Bruce and Smolensky, Paul (1996) Learnability in Optimality Theory (long version). Report no. JHU_CogSci_96_3. Baltimore, MD: Johns Hopkins University.

Tesar, Bruce and Smolensky, Paul (1998) Learnability in Optimality Theory. *Linguistic Inquiry* 29, 229-68.

Tesar, Bruce and Smolensky, Paul (2000) *Learnability in Optimality Theory*. Cambridge, MA: MIT Press.

Vago, Robert and Battistella, Edward (1982) Rule application in phonology. Unpublished manuscript. New York: Graduate Center, City University of New York. [On cover: April, 1982, preliminary version.]

van Oostendorp, Marc (1997) *Vowel Quality and Phonological Projection*. Doctoral dissertation: Katolieke Universiteit Brabant.

Walker, Rachel (1998) *Nasalization, Neutral Segments, and Opacity Effects*. Doctoral dissertation. Santa Cruz, CA: University of California, Santa Cruz.

Williams, Edwin (1976) Underlying tone in Margi and Igbo. *Linguistic Inquiry* 7, 463-84.

Wilson, Colin (2001) Consonant cluster neutralization and targeted constraints. *Phonology* 18, 147-97.

Wiltshire, Caroline (1992) *Syllabification and Rule Application in Harmonic Phonology*. Doctoral dissertation: University of Chicago.