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The Syllable in Optimality Theory

Edited by

CAROLINE FÉRY

University of Potsdam, Germany

RUBEN VAN DE VIJVER

University of Potsdam, Germany

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Sympathy, Cumulativity, and the Duke-of-York Gambit

John J. McCarthy

Oh, the grand old Duke of York,
He had ten thousand men;
He marched them up to the top of the hill,
And he marched them down again.
An English Nursery Rhyme

2.1. Introduction

Serial derivations have been a central idea in the theory of generative phonology throughout its history, but scant attention has been paid to a key question: is any serial derivation possible in human languages? More precisely, can any independently licit rule coexist with any other licit rule, and can the rules apply in any order? The rule coexistence question has, to my knowledge, never been raised in the literature. The rule ordering question was investigated intensively during the early 1970s (see Iverson 1995 for a review), but often just a pair of rules was studied in isolation from the broader derivational context. Since about 1975, research in generative phonology has mostly dealt with the form of rules and the nature of representations – subjects that are interesting in themselves but do not help advance the theory of derivations.

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A rare contribution to this neglected topic is Pullum's (1976) study of the "Duke-of-York gambit." Duke-of-York (DY) derivations have the general form A → B → A, where underlying A passes through a B stage before returning to surface A again. For example, in some analyses of *r*-dropping and *r*-intrusion in various English dialects, final *r* is first deleted and then reinserted before a vowel: *Homer is* → *Hom[ə] is* → *Homer is* (cf. *Hom[ə] saw*). Pullum addresses this case and others like it, asking whether DY derivations are required by the facts and how they might be ruled out generally.

Optimality Theory (OT – Prince and Smolensky 1993) offers a novel perspective on process coexistence and interaction. It is to be expected, therefore, that OT can yield new insights into DY derivations and, by extension, into the questions posed at the outset of this chapter. I propose to revisit the topic of DY derivations within the context of OT.

There are two main types of DY derivations, and they turn out to have very different implications for linguistic theory. In the first type, which I call *vacuous*, the intermediate stage of the A → B → A derivation has a somewhat artifactual status, as in the hypothetical example in (1).

(1) Vacuous DY derivation

	Underlying	/CAD/	cf.	/ZAD/	/CBW/
⇨	A → B/__D	CBD		ZBD	–
⇨	B → A/C__	CAD		–	CAW

The last two columns show that both rules are independently motivated; the focus is on the column headed by /CAD/. The DY derivation /CAD/ → *CBD* → *CAD* is vacuous because nothing else depends on the intermediate stage CBD. The theory-internal assumptions of strict serialism, rather than some empirical argument, motivate this intermediate stage.[1]

In *feeding* DY derivations like (2), the intermediate stage is crucial for conditioning some further process. That is, the rule changing A to B feeds some other rule, which applies before B changes back into A.

(2) Feeding DY derivation

	Underlying	/CAD/	
⇨	A → B/__D	CBD	A → B sets up environment for next rule.
	C → E/__B	EBD	Now B conditions C → E change.
⇨	B → A/__D	EAD	B → A, undoing effect of first rule.

In derivations like this, the intermediate stage is independently motivated, since it supplies the context for the change from C to E.

Vacuous DY derivations like (1) are abundantly attested; in fact, all of Pullum's examples are like this, as are many others in the literature. As the vacuity of the intermediate stage suggests, there is no need here for a serial derivation. Rather, the vacuous DY case involves blocking under constraint domination, a well-understood mode of interaction in OT (Prince and Smolensky 1993: chapter 4). The goal of section 2.2 is to demonstrate this result.

In contrast, feeding DY derivations have scarcely ever been reported in the literature, and Pullum cites no actual examples. Several possible cases are discussed and reanalyzed in section 2.3, with a particular concentration on the best-documented example, the interactions of syllabic and metrical processes in Bedouin Arabic. The conclusion I reach is that, in general, feeding DY derivations do not exist. This typological result demands an explanation, and in the following sections of this chapter I offer one.

One element of the explanation is sympathy theory (McCarthy 1999b), which is summarized in section 2.4. Sympathy is a general model of opaque interactions within OT. It assumes that, in addition to the actual output form, there may be a sympathetic candidate, which is the most harmonic candidate that obeys some specified faithfulness constraint. The output form is required to resemble the sympathetic candidate in some respect, and in this way the sympathetic candidate, even if not the winner itself, may exercise an indirect influence over the outcome.

The other element of the explanation is a refinement of sympathy theory, called *cumulativity*. In a DY derivation, later steps do not accumulate the results of earlier steps, since some later step literally undoes the effect of an earlier step. In non-DY derivations, later steps do reliably accumulate the mappings made earlier. A definition of cumulativity in terms of shared unfaithful mappings is proposed in section 2.5, and this definition is incorporated into the theory of sympathy, replacing an earlier approach based on intercandidate faithfulness constraints. The resulting theory is one that can deal with opaque interactions generally but that cannot accommodate the unattested feeding DY type.

The cumulativity property has implications for the theory of syllabification, and these are explored in section 2.6. It is not uncommon to find serial derivations in which a segment is syllabified one way, triggers some phonology, and then is resyllabified another way – a seemingly noncumulative derivational path. The hypothetical example in (3) is a good illustration, closely paralleling the feeding DY case in (2).

(3) Derivation with resyllabification

	Underlying	/apia/	
⇨	Syllabification	a.pi.a	One syllable for each vocoid.
	a → i/__.	i.pi.a	Raise *a* to *i* in nonfinal open syllable.
⇨	Resyllabification	ip.ya	Resolve hiatus by devocalizing and resyllabifying.

I claim that cumulativity is defined in terms of faithfulness, and so any property that is not governed by faithfulness – arguably including syllabification – is irrelevant to determining whether a derivation is cumulative. Therefore, mappings like (3) are cumulative, appearances to the contrary, and so they can be simulated with the revised theory of sympathy.

2.2. Vacuous Duke-of-York Derivations

2.2.1 The Core Cases

There is no shortage of real DY derivations of the vacuous type. Some examples, most of which were originally collected by Pullum (1976), appear in (4).

(4) Vacuous DY cases
  a. Nootka rounding/unrounding (Campbell 1973, Sapir and Swadesh 1978).
  b. Vedic Sanskrit glide/vowel alternations (Kiparsky 1973a).
  c. Dutch devoicing/voicing assimilation interactions (Lombardi 1991, Booij 1995).
  d. English *r*-deletion/intrusion (McCarthy 1991, 1993, Halle and Idsardi 1997, Bakovic 1998).
  e. English trisyllabic shortening/C*i*V lengthening (Kenstowicz 1994, Halle 1995, Prince 1996).
  f. Bedouin Arabic vowel raising/lowering (Al-Mozainy 1981, Irshied and Kenstowicz 1984).
  g. Anglian breaking/smoothing (Hogg 1978, Dresher 1993).

These cases share certain characteristic properties: there are two (or more) rules that produce opposite mappings (A → B and B → A); these rules apply in environments that sometimes overlap; and the rules are ordered with the A → B rule applying before the B → A rule. This constellation of properties will yield a DY derivation in any word that happens to match the environment of both rules. I am using the term *vacuous* to describe these cases because the intermediate stage serves no independent function, beyond its obvious role in negotiating a path between the two contradictory rules.

Nootka nicely illustrates these observations. In Nootka, dorsal consonants (velars and uvulars) become labialized after round vowels ((5a)). Nootka also has underlying labiodorsal consonants, and these delabialize syllable-finally ((5b)). Now consider the situation where a dorsal consonant is both preceded by a round vowel and followed by a syllable boundary (indicated by "."), so it meets the structural conditions of both rules. In fact, Delabialization takes precedence ((5c)).

(5) Nootka Labialization and Delabialization
  a. Dorsals become labialized after round vowels
    K → K^w / *o*__   ʔo.**k^w**i:ɬ   'making it'
    cf. **k**i:ɬ   'making'
  b. Syllable-final labiodorsals delabialize
    K^w → K / __.   ɬa:**k**.šiƛ   'to take pity on'
    cf. ɬa:.**k^w**iqnak   'pitiful'
  c. Interaction: Delabialization wins
    m̓o:**q**.   'throwing off sparks'
    cf. m̓o.**q^w**ak   'phosphorescent'

The problem, then, is to account for the interaction of these two processes in situations where their environments intersect.

Under the assumptions of strict serialism, the only way to ensure that Delabialization takes precedence is to order it after Labialization. The result is a DY derivation in just those cases where the ordering matters, such as the input /m̓o:q/ in (6).

(6) Serial derivation for Nootka

	Underlying	/m̓o:q/	cf.	/ʔoki:ɬ/	/ɬa:k^wšiƛ/
⇨	Labialization	m̓o:q^w.		ʔo.k^wi:ɬ	–
⇨	Delabialization	m̓o:q.		–	ɬa:k.šiƛ

Nootka, then, has exactly the characteristics of a vacuous DY derivation: two rules that produce contradictory mappings in overlapping environments are ordered so that one undoes the effect of the other.

Cases like Nootka have a straightforward nonderivational interpretation in OT, with no need for the vacuous intermediate stage. The interaction between the labialization and delabialization processes is a matter of conflicting markedness constraints, and this conflict is resolved, like all constraint conflicts, by ranking. The constraints themselves are universal; their interaction through ranking is language particular and learned. Here I will focus on just the interaction, glossing over details of constraint formulation that are not relevant in this context.

Two markedness constraints are visibly active in Nootka. One asserts that plain dorsals cannot occur after round vowels, as in (7a). The other prohibits rounded dorsals syllable-finally, as in (7b).

(7) Markedness constraints for Nootka
  a. ROUNDING
    **o*K
  b. UNROUNDING
    *K^w.

These markedness constraints dominate the faithfulness constraint IDENT(round), as shown in the tableaux (8)–(9).[2]

(8) ROUNDING >> IDENT(round)

/ʔokiːɬ/	ROUNDING	IDENT(round)
a. ☞ ʔo.k^{w}iːɬ		*
b. ʔo.kiːɬ	*!	

(9) UNROUNDING >> IDENT(round)

/ɬaːk^{w}ši(ƛ)/	UNROUNDING	IDENT(round)
a. ☞ ɬaːk.ši(ƛ)		*
b. ɬaːk^{w}.ši(ƛ)	*!	

This much is the basic phonology of (de)labialization in Nootka.

Now we turn to the cases of interest, where the ranking between the two markedness constraints is decisive. If UNROUNDING dominates ROUNDING, then the output will be unrounded in situations of conflict like /m̓oːq/ (see (10)).

(10) UNROUNDING >> ROUNDING >> IDENT(round)

/m̓oːq/	UNROUNDING	ROUNDING	IDENT(round)
a. ☞ m̓oːq.		*	
b. m̓oːq^{w}.	*!		*

Obviously, there is no need for an intermediate derivational stage or kindred notion. (See Dresher 1993: 238, where a similar point is made for a mixed rule-and-constraint theory.) As usual in OT, ranking permutation predicts a range of permitted interlinguistic variation. So, if the ranking of the two markedness constraints were reversed, then *m̓oːq^{w}* would be the output.

Before we continue, it is necessary to consider and dismiss two alternatives that might seem like reasonable ways to sidestep the DY problem within a rule-based derivational framework. One approach, advocated by Halle and Idsardi (Halle 1995, Halle and Idsardi 1997; cf. Prince 1996, 1997, Bakovic 1998), involves disjunctive ordering under the Elsewhere Condition (EC – Kiparsky 1973a, Anderson 1974, Hastings 1974, Koutsoudas et al. 1974, Sanders 1974). Halle and Idsardi propose to eliminate DY derivations by giving the B → A rule disjunctive precedence over the A → B rule. For example, Nootka would be analyzed by applying Delabialization before Labialization, as in (11), with Labialization blocked, in EC fashion, from applying to the output of Delabialization.

(11) Nootka with disjunctive ordering[3]

Underlying	/m̓oːq/	cf.	/ʔokiːɬ/	/ɬaːk^{w}šiƛ/
Delabialization	m̓oːq.		–	ɬaːk.šiƛ
Labialization	*blocked by EC*		ʔo.k^{w}iːɬ	–

This proposal, if successful, would eliminate the need for the vacuous intermediate stage in DY derivations.

There is, however, a significant problem with this idea: the characteristics of DY cases are not in general the same as the characteristics of EC cases, and so the EC does not always have the desired effect. All versions of the EC require that the two rules stand in a specific/general relation in order for them to be disjunctively ordered. But to produce a DY derivation, the two rules only need to overlap in their applicability. Therefore, the conditions that trigger the EC are more stringent than the conditions that produce a DY derivation. This means that the EC can address only a proper subset of DY derivations. Nootka illustrates this point, since Delabialization and Labialization are not in a specific/general relation. (To be at the end of a syllable is not in any way more specific than to be after a round vowel.) This observation means that the EC does not produce disjunctive application in Nootka, and so this DY case is not eliminated, nor is the more general problem solved.[4]

The second way to avoid the DY problem in Nootka involves skirting the intermediate stage of the /m̓oːq/ → *m̓oːq^{w}* → *m̓oːq* derivation by enforcing the effect of Labialization in the underlying representation: /m̓oːq^{w}/ → *m̓oːq*. But this means that Labialization must function as a morpheme structure constraint ruling out */m̓oːq/ and as a regular rule heteromorphemically, as in (5a). This is an instance of the Duplication Problem (Clayton 1976, Kenstowicz and Kisseberth 1977): the same rule appears twice in the grammar, in both static and dynamic roles. OT solves the Duplication Problem by denying the existence of morpheme structure constraints or other language-particular restrictions on underlying forms. OT derives all linguistically significant patterns from constraints on outputs interacting with faithfulness constraints ("Richness of the Base" in Prince and Smolensky 1993). Because faithfulness is bottom ranked in (10), the choice of input – /m̓oːq/, /m̓oːq^{w}/, or archisegmental /m̓oːQ/ – does not matter, since all map to surface *m̓oːq*. There is no need to restrict the inputs and no Duplication Problem.[5]

All of the vacuous DY cases cited in (4) can be understood, as Nootka is, in terms of conflict among markedness constraints resolved by ranking. The purely artifactual status of the intermediate derivational stage is revealed by this analysis. In serial theories, precedence relations among processes must be analyzed in terms of rule ordering (unless auxiliary principles like the EC intervene); the last rule to get its hands on the representation has precedence, in the sense that it reliably states a surface-true generalization. If two rules perform contradictory mappings in overlapping environments, some DY derivations are unavoidable, since there is no other way to specify the precedence relation between them. In OT, however, precedence relations among constraints are accounted for by ranking: the highest-ranking constraint has precedence, in the same sense that it reliably states a surface-true generalization.[6] By decoupling precedence from serial ordering, OT permits vacuous DY derivations to be analyzed without positing a spurious intermediate stage.

2.2.2 Variations

Certain other examples of DY derivations, though not strictly of the vacuous type, are also reanalyzable in terms of conflicting constraints. Consider first the interaction of coda devoicing and voicing assimilation in Harris's (1993) analysis of Catalan:

(12) Catalan (after Harris 1993: 185f.)

From lexical stratum	sub.lu.nar	
Devoicing	sup.lu.nar	
Spirantization	*does not apply*	
Voicing Assimilation	sub.lu.nar	'sublunar'

This is a *bleeding* DY derivation: Devoicing bleeds Spirantization, which only affects voiced stops, but then the intermediate *p* is re-voiced by Voicing Assimilation. (Compare *su.[β]lim* 'sublime', where Spirantization applies, as expected, to onset *b*.)

A more direct analysis is possible, however, in terms of constraint conflict. Language typology shows that Universal Grammar (UG) contains a constraint barring continuants from codas – Korean is a well-known example where this constraint is undominated and produces alternations; similar facts in Kiowa lead Zec (1995: 111f.) to posit precisely this constraint. In Catalan, its activity is more limited: it dominates the markedness constraint responsible for the spirantization process, blocking spirantization of codas. (This is similar to Mascaró's [1984] account of Catalan.) With the markedness constraint responsible for voicing assimilation ranked above the constraint responsible for devoicing, the Catalan DY derivation reduces to vacuous status.[7]

This discussion of Catalan suggests a general approach to bleeding DY derivations, where the intermediate stage waits out a third rule. The general form of such derivations is shown in (13).

(13) Bleeding DY derivation

	Underlying	/CAD/	
⇨	A → B/__D	CBD	A → B to escape next rule.
	C → E/__A	*does not apply*	No A there to condition C → E change.
⇨	B → A/__D	CAD	B → A, undoing effect of first rule.

Descriptively, the effect of this derivation is to change /C/ into *E* before *A*, except when *A* is followed by *D*. This is just the familiar blocking pattern obtained by ranking markedness constraints, as in Nootka or Catalan. The constraint *CA can compel the unfaithful mapping of /C/ to *E*, but *CA is crucially dominated by another markedness constraint, *EAD, which effectively blocks that mapping. So, in the general case, bleeding DY derivations can be reduced to vacuous status.[8]

Another variation on the DY theme can be found in Rubach's (1993: 266ff.) analysis of depalatalization in Slovak (or Polish [Rubach 1984: 101ff., 199f.]). The rule of Anterior Depalatalization affects palatalized *t'*, *d'*, and *n'* when they precede coronals: *kost'* 'bone', *kostný* 'bony'. In addition, Anterior Depalatalization "undoes the effect of Coronal Palatalization whenever Coronal Palatalization has applied before a yer-initial suffix containing a coronal consonant and the yer has not been vocalized" (Rubach 1993: 267):

(14) Palatalization and Depalatalization in Slovak

Underlying	/let+En+ý/	
Palatalization	let'Ený	
Yer Vocalization	*does not apply*	
Yer Deletion	let'ný	
Depalatalization	letný	'summer-like'

The yers *E* and *O* are abstract vowels posited in most analyses of Slavic languages. When followed by another yer in the next syllable, a yer "vocalizes" to *e* or *o*; otherwise, as in (14), it deletes. Before it deletes, the front yer *E* causes palatalization of a preceding consonant (cf. *mliek/mliečný* 'milk'/'milky'). Once the yer has deleted, though, the *t'* in (14) is followed by a coronal, and so it must depalatalize.

This too is a vacuous DY derivation, though with the added complication of an opaque interaction between Palatalization and Yer Deletion. In OT, the opaque interaction can be accounted for using sympathy theory (as in Łubowicz's [1999] analysis of similar facts in Polish). The sympathy constraint is, however, crucially dominated by a constraint against clusters like *t'n*. Schematically, except for the opacity, the interaction here is no different than in Nootka or Catalan.

2.2.3 Summary

I have now reviewed vacuous DY derivation and variations on it. I have shown that the vacuous DY pattern is an expected consequence of the core premises of OT, constraint ranking and constraint violation under domination. Significantly, cases of this type are well attested and uncontroversial, indicating that the typological claim implicit in OT fits the facts. But when we turn to the feeding DY interaction in the next section, the situation is quite different.

2.3. Feeding Duke-of-York Derivations

2.3.1 Introduction

In feeding DY derivations like (2), the intermediate stage is crucial. A rule changing A into B feeds some process that applies at the intermediate stage, before a rule changing B back into A wipes out its environment.

Plausible-looking examples are not difficult to concoct. The first, given in (15), is modeled after a postvocalic spirantization process in Tiberian Hebrew, but with a twist. In this hypothetical case, rules epenthesizing and later deleting ə are wrapped around a process of postvocalic spirantization:

(15) Quasi-Hebrew (hypothetical feeding DY derivation)

	Underlying	/qarbi/	
⇨	Epenthesis	qarəbi	Insert ə after any syllable coda.
	Spirantization	qarəvi	Stops become fricatives postvocalically.
⇨	Syncope	qarvi	Delete ə in two-sided open syllable (VC__CV).

In feeding DY fashion, the ə is inserted, hangs around long enough to cause spirantization, and then deletes, leaving a fricative behind as evidence of its passage.

A more complex hypothetical example, shown in (16), was brought to my attention by Paul Kiparsky (e-mail, July 7, 1998). At the first step, trimoraic CVːC syllables are repaired by *i* epenthesis (cf. Mekkan Arabic in Abu-Mansour 1987). The vowel *i*, whether underlying or epenthetic, then triggers palatalization of a preceding coronal. A process of apocope deletes final vowels, including epenthetic *i*, and finally the CVːC syllable is re-repaired by shortening. Because it shares some rules with the real Yokuts language, I call this hypothetical system quasi-Yokuts.

(16) Quasi-Yokuts (hypothetical feeding DY derivation)

	Underlying	/maːt/	
⇨	Epenthesis	maːti	To repair trimoraic syllable.
	Palatalization	maːči	*ti* → *či* generally.
⇨	Apocope	maːč	Final vowels delete.
	Shortening	mač	To repair trimoraic syllable.

The vowel *i* is epenthesized, triggers palatalization, and later deletes. The condition that originally produced *i* epenthesis, a trimoraic syllable, is subsequently repaired by other means.

In quasi-Hebrew and quasi-Yokuts, some crucial phonological business occurs at the intermediate stage of the derivation – unlike the vacuous DY cases of section 2.2. In quasi-Hebrew, the intermediate stage allows the temporary ə to condition postvocalic spirantization, and in quasi-Yokuts, the intermediate stage is the point at which temporary final *i* triggers palatalization. These cases are particularly interesting because each process individually is quite plausible and natural. The peculiar thing is not the rules themselves but their coexistence and interaction in a single system.

2.3.2 Review of Putative Examples

Examples of feeding DY derivations are not exactly thick on the ground, or even thin. Pullum's (1976) survey contains none, and I am aware of just four putative cases:

(i) Insertion and removal of coda moras in Tübatulabal (Crowhurst 1991).
(ii) Harmony and disharmony of neutral vowels in, for example, Finnish (Bach 1968 and others).
(iii) Epenthesis and syncope of ə in (real) Tiberian Hebrew (Prince 1975).
(iv) Syncope and epenthesis in Bedouin Arabic (Al-Mozainy 1981).

I will pass over (i) and (ii) fairly quickly, since there are equally good and possibly superior alternatives to the DY derivations. I will then show that Hebrew involves an output-output faithfulness effect (iii). Finally, I will turn to a close examination of the Bedouin Arabic case (iv) in section 2.3.3, asking whether it is an authentic instance of the feeding DY type. I will argue that it is not, concluding that feeding DY interactions do not in general occur – an observation for which linguistic theory needs to supply an explanation.

(i) Coda moras in Tübatulabal. Crowhurst (1991) argues that an early rule, Reduplication, treats CVC syllables as bimoraic, while a later rule, Stress Assignment, treats CVC syllables as monomoraic. A feeding DY derivation is apparently required: codas are assigned a mora by Weight-by-Position (Hayes 1989), Reduplication applies, coda moras are deleted, and then Stress Assignment applies. Reduplication crucially relies on the intermediate stage where coda moras are temporarily present.

This chain of reasoning relies on the assumption (which Crowhurst shares with several contributors to this volume) that stress assignment processes are reliably diagnostic of the mora count of CVC syllables. That assumption has been called into question in recent years. Research on syllable weight (e.g., Hayes 1995, de Lacy 1997, Gordon 1999) has shown that stress is also conditioned by factors, such as sonority, that are not reified in the moraic representation. Arguably, Tübatulabal is just such a case: stress is attracted to certain syllables because they contain prominent long vowels, not because they are the only bimoraic syllables at the derivational instant when stress is assigned. On the strength of the reduplicative evidence, then, and with no remaining impediments from the stress evidence, it is reasonable to suppose the CVC syllables in Tübatulabal are bimoraic *tout court.*

(ii) Neutral vowels in harmony systems. Ever since Bach (1968), a common analytic strategy for dealing with neutral vowels has been to assume that they temporarily undergo the harmony process: for example, Finnish /tuoli-llA/ → *tuolılla* → *tuolilla* 'on the chair'. (See Ní Chiosáin and Padgett 1997 and Walker 1998 for a similar approach within OT.) This too is a feeding DY interaction, since the intermediate stage is required to support a strictly local, iterative harmony process.

This idea is not lightly dismissed. There is a concern, however: the principal motivation for strict locality in current thinking (see also Archangeli and Pulleyblank 1994, Gafos 1996, 1998, Pulleyblank 1996) is a kind of phonetic realism, and this is difficult to reconcile with the fact that the phonetically real representations like *tuolilla* do not actually respect strict locality. There are alternatives to strict locality, summarized with references in Bakovic 2000: 266ff., including an approach, proposed by Bakovic, that is strictly local but without DY derivations, based on an extension of Wilson's (1999) "targeted constraints."

(iii) Spirantization in Tiberian Hebrew. A process of postvocalic spirantization in Hebrew is rendered opaque by syncope: /katab(+uː)/ → *kaː θaβ*/*kaː θβuː* 'he/they wrote'. According to Prince (1975), there is one particular morphological situation where a vowel is inserted, remains around long enough to trigger spirantization, and then is syncopated. This happens when the infinitival stem /ktob/ bears a prepositional prefix like /bi#/ 'in':[9]

(17) Tiberian Hebrew feeding DY derivation (after Prince 1975)

	Underlying	/bi#ktob/
⇨	Epenthesis	bi#kətob
	Spirantization	bi#xəθoβ
⇨	Syncope	bi#xθoβ
	Other rules	bixθoːβ

Unlike the invented example in (15), though, real Hebrew has no general process epenthesizing schwa in a context that will later trigger syncope. In fact, the infinitive *lixtoːβ* 'to write' supplies a near-minimal pair, with the expected stop *t* and no ghost of a prior epenthesis process. Derivations like (17) are limited to words that bear the syntactically independent prefixes /bi#/ and /ki#/ 'like', as Prince indicates with the # boundary. With ordinary inflectional prefixes (*lixtoːβ*) or morpheme-internally (*malkiː* 'my king'), there is no Ø → ə → Ø DY derivation.

The morphology is obviously the key to understanding this restricted DY effect. In the theory of Lexical Phonology, one would say that Epenthesis and Spirantization apply to /ktob/ at a stratum when /bi/ is not yet present, producing the freestanding word *kə.θoːβ* 'writing'. Only later is /bi/ added, triggering syncope of ə. Words with inflectional prefixes like *lixtoːβ* and tautomorphemic cases like *malkiː* are derived in the earlier stratum, so Epenthesis never applies.

In OT, an approximation to the Lexical Phonology analysis is possible using output-output correspondence. The spirantized *θ* in *bixθoːβ* is faithful to its correspondent in the freestanding word *kə.θoːβ* in obedience to OO-IDENT(cont). The difference in strata is modeled by allowing different affixes to assign different output-output correspondence relations (Benua 1997a, 1997b). In this way, a restricted feeding DY effect – limited to circumstances where the intermediate stage is another independent word – can and should be reconstructed in OT. Of course, standard serial phonology is subject to no such restriction; it allows feeding DY derivations even morpheme-internally, where there is no evidence for cyclic or stratal organization.

2.3.3 A Feeding Duke-of-York Interaction in Bedouin Arabic

The standard analysis of Bedouin Arabic incorporates a feeding DY interaction between stress and syllabically conditioned rules of vowel deletion and epenthesis. Words like /ʔakal-at/ 'she ate' are said to get initial stress *ʔákalat*, followed by deletion of the stressed vowel with concomitant shift of the stress to the following syllable *ʔkálat*, and later epenthesis to restore the deleted vowel *ʔakálat*. As we will see in section 2.3.3.1, the evidence in support of this DY derivation is quite compelling.

Nevertheless, there is a better analysis that avoids the need for the stress → deletion → stress-shift → epenthesis DY derivation. The problem in traditional accounts lies with the deletion rule, which purportedly deletes a vowel in a light syllable that is itself followed by a nonfinal light syllable (section 2.3.3.2). This rule's complex, nonlocal environment amounts to nothing more than a redescription of the facts. But an explanation is possible in terms of prosodic theory. This deletion process, I will argue, is an instance of the well-documented tendency of iambic feet to maximize quantitative differences between their head and dependent syllables. This analysis, in common with several other contributions to this volume, relies on positing moraless semisyllables in the output of vowel deletion. The analysis explains all properties of the deletion process, and it eliminates the need for the DY derivation.

In section 2.3.3.3, this analysis is formalized within OT. One aspect of stress/deletion interaction turns out to involve phonological opacity. Opacity is intimately connected with the DY problem, because DY derivations are by their very nature opaque (*pace* Pullum 1976: 89–90). Sections 2.4–2.6 then go on to address the general problem of opacity and DY in OT.

2.3.3.1 Overview of Traditional Analysis

To understand the DY derivation, it is first necessary to have a good deal of background in Bedouin Arabic phonology. The plan is first to present the core processes of vowel raising and deletion, and then turn to their interaction with stress, which has DY character.

The partial paradigms in (18) illustrate the main points.[10]

(18) Bedouin Arabic core data

	/katab/ 'wrote'	/samiʕ/ 'heard'	/kitib/ 'was written'
'he_' + Ø	kítab	símiʕ	ktíb
'we_' +*na*	kitábna	simíʕna	ktíbna
'she_' +*at*	ktíbat	sámʕat	kítbat

Descriptively, underlying /a/ raises to *i* in an open syllable, while underlying /i/ deletes in the same environment – a typical chain-shift. But observe that even underlying /a/ has deleted in the form *k_tíbat* (from /katab-at/).[11]

Starting with Al-Mozainy (1976, 1981) and continuing through Al-Mozainy et al. (1985), Hayes (1995), and Irshied and Kenstowicz (1984), most analysts have agreed on approximately the rule system in (19) to deal with the data in (18).

(19) Core rules for Bedouin Arabic

a. Syncope
   i → Ø /_. σ Delete short *i* in a nonfinal light syllable.
b. Trisyllabic Deletion
   V → Ø /_. L σ Delete a short vowel from an open syllable that is followed by a nonfinal light syllable.
c. Raising
   a → i /_. σ Raise short *a* to *i* in a nonfinal open syllable.

The rule of Syncope is necessary to account for alternations like *samiʕ* / *sam_ʕat*. Raising is exemplified by forms like *kitab*. Trisyllabic Deletion will be discussed in detail in section 2.3.3.2.

These rules have several crucial ordering relations, which are illustrated by the derivations in (20).

(20) Rule interaction

Underlying	/katab/	/katab-at/	/samiʕ/	/samiʕ-at/	/kitib/	/kitib-at/
Initial syllabification	ka.tab	ka.ta.bat	sa.miʕ	sa.mi.ʕat	ki.tib	ki.ti.bat
Syncope				sam.ʕat	ktib	kit.bat
i→ Ø / C_ σ						
Trisyllabic Deletion		kta.bat				
V → Ø / C_ L σ						
Raising	ki.tab	ki.tab	kti.bat	si.miʕ		
a → i / C_ σ						

After an initial round of syllabification, Syncope first applies, deleting all *i*s that occur in open syllables. (To handle /kitib-at/, right-to-left iteration of Syncope has to be assumed.) Syncope crucially precedes Trisyllabic Deletion, since otherwise the first vowel of /samiʕ-at/ would be deleted. Syncope must also precede Raising, since otherwise the first vowel of /samiʕ-at/ would raise to *i*. This ordering – Syncope, then Raising – is responsible for the /a/ → *i*, /i/ → Ø chain-shift that can be observed in these examples.

The interaction of Trisyllabic Deletion with Stress is the source of the DY derivation. Standard accounts posit a Latin-type stress rule, as in the sedentary Arabic dialects discussed by Kiparsky (this volume) and Wiltshire (this volume): stress the penult if heavy, otherwise the antepenult.[12] Formally, a moraic trochee is assigned right to left, subject to extrametricality of the final syllable: *kítab, sámʕat, kitábna, maktú:fah* 'tied (f. sg.)', *má:lana* 'our property', *ðarábtukum* 'I hit you (m. pl.)', *yšu:fú:nukum* 'they (m.) see you (f. pl.)'. But in words that are subject to Trisyllabic Deletion, the traditional analysis posits an early stress rule followed by stress shift when the stressed vowel deletes (Al-Mozainy 1981, Al-Mozainy et al. 1985, Hayes 1995: 228–238):

(21) Interaction of Stress and Trisyllabic Deletion in standard analysis

		a. /katab-at/	b. /ʔinkasar-at/	c. /ʔakal-at/
	Stress	(káta)bat	ʔin(kása)rat	(ʔáka)lat
⇨	Trisyllabic Deletion	(kta)bat	ʔin(ksa)rat	(ʔka)lat
	Stress Shift	(ktá)bat	ʔin(ksá)rat	(ʔká)lat
⇨	Epenthesis (#ʔ_C)			(ʔaká)lat
	Other rules	ktíbat	ʔinksárat	ʔakálat

Deletion of a vowel out from under the stress forces stress to shift to the other syllable of the foot. The derivation in (21a) is provided for comparison purposes; the interesting cases are (21b) and (21c). In (21b), Latin-type trochaic stress is applied at an early stage of the derivation, but then it is obscured by the subsequent effects of Trisyllabic Deletion and concomitant stress shift. In (21c), this much also happens, plus the effect of Trisyllabic Deletion is undone, in classic DY fashion, by an epenthesis rule that repairs the initial #ʔC cluster.

This is a perfect exemplar of a feeding DY derivation, because the intermediate stage is crucial to obtaining the stress-shift effect.

2.3.3.2 The Prosodic Basis of Trisyllabic Deletion

There is good reason to be skeptical of Trisyllabic Deletion and the DY derivation based on it. Trisyllabic Deletion has a complex, nonlocal, and highly arbitrary environment – why should deletion be limited to a light syllable that is followed by a light syllable that is itself nonfinal? The conditioning factors don't seem to make sense.

This situation is strongly reminiscent of trisyllabic shortening in English. Pairs like *serene/serenity*, *grateful/gratitude*, and *derive/derivative* show that, descriptively, a long vowel is shortened when followed by an unstressed syllable that is itself nonfinal. The standard analysis (Chomsky and Halle 1968) uses a rule with a complex, nonlocal environment, much like Trisyllabic Deletion. Again, the conditiong factors don't seem to make sense.

The explanation for the English case (and its Arabic counterpart) comes from higher-level prosodic structure. According to Myers (1987) and Prince (1990), trisyllabic shortening is conditioned by foot structure, in top-down fashion. The typical English pattern is a trochaic foot over penult and antepenult, with final syllable extrametricality: *se* $(réni)_{Ft}$ *⟨ty⟩*. Shortening improves the well-formedness of the trochaic foot, replacing a HL (heavy-light) trochee with a more harmonic LL (light-light) trochee (Prince 1990). This approach has answers to the *why*s of trisyllabic shortening, as Prince (1996) emphasizes. Why shortening and not, say, lengthening? Because shortening improves the match with the preferred bimoraic foot. Why a following unstressed syllable? Because a following unstressed syllable is a descriptive artifact of the real foot-based condition. And why, in nonlocal fashion, must there be another syllable after that? Because of the regular extrametricality rule. The answers to these questions emerge once the role of trochaic foot structure in English is properly understood, while they remain mysteries under the standard analysis.

Similarly, I propose that the key to understanding trisyllabic deletion in Bedouin Arabic is to place it in the context of an *iambic* stress system. Iambic feet are subject to strong quantitative requirements. According to the Iambic/Trochaic Law (Hayes 1987, 1995: 80) or Grouping Harmony (Prince 1990) (cf. also McCarthy and Prince 1986, Kager 1993), iambic feet tend to favor quantitative reinforcement of the prominential contrast, so a LH (light-heavy) iamb is better than a LL one. For concreteness, I will assume the formulation of Grouping Harmony in (22).

(22) GRPHARM

In an iambic foot (x ′y), |y| > |x|. (|α| ≡ weight of α in moras)

Because of GRPHARM, many languages have iambic lengthening processes, which improve LL iambs by lengthening the second syllable. Another logically possible consequence of GRPHARM is reduction of unstressed syllables in iambic feet, enhancing the quantitative contrast by weakening the weak rather than strengthening the strong. Hayes (1995: 213) reports that this occurs in Delaware, and it is an element of Kager's (1997) analysis of Macushi Carib. Trisyllabic deletion, I will show, is exactly this: reduction of the unstressed syllable in a LL iambic foot to enhance the quantitative contrast.

First, though, we must establish that the stress system of Bedouin Arabic is indeed iambic. Traditionally, the Arabian Bedouin Arabic dialects have been assumed to have trochaic stress, like all sedentary dialects, and Al-Mozainy, among others, adopts that assumption. But Hayes (1995) shows that two non-Arabian Bedouin dialects, one spoken in eastern Libya and the other in the Negev, are actually iambic. I will now show that Al-Mozainy's Arabian dialect is also iambic.

The analysis of words like *ʔakálat* is tortuous under trochaic assumptions, but if stress is left-to-right iambic, then the analysis is straightforward: *(ʔaká)lat*. Moreover, the examples usually cited in support of the trochaic analysis – *kítab*, *sámʕat*, *kitábna*, *maktú:fah*, *má:lana*, *ð̣arábtukum*, *yšu:fú:nukum* – are also compatible with left-to-right iambic feet. In words with heavy penults like *kitábna*, trochaic footing *(ki(táb)na)* and iambic footing *((kitáb)na)* produce descriptively equivalent results. In disyllables like *kítab*, iambic FT-FORM yields to NONFINALITY, which is a near-universal accompaniment to iambic stress (Prince and Smolensky 1993, Hung 1994). Thus, disyllables do indeed have trochaic stress – as in *(kítab)* – but only when higher-ranking NONFINALITY compels violation of FT-FORM(IAMBIC). Words with heavy antepenults and light penults, such as *ð̣arábtukum*, follow the "foot extrametricality" pattern identified by Hayes (1995: 232). The actual output form is *(ð̣aráb)tukum*, and its most important competing candidate is **ð̣arab(túkum)*, which also satisfies NONFINALITY but violates FT-FORM. In contrast, the actual output form satisfies NONFINALITY and FT-FORM at the price of inferior rightward alignment of its main stress (ALIGN-HEAD-R [McCarthy and Prince 1993a]). We, therefore, have the ranking NONFINALITY >> FT-FORM >> ALIGN-HEAD-R, as the tableau in (23) certifies.

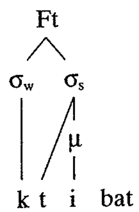
(23) Iambic stress in *(ð̣aráb)tukum*

	NONFINALITY	FT-FORM	ALIGN-HEAD-R
a. ☞ (ð̣aráb)tukum			**
b. ð̣arab(túkum)		*!	*
c. ð̣a(rábtu)kum		*!	**
d. ð̣arab(tukúm)	*!		

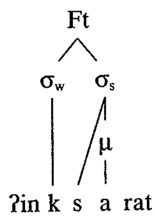
The two threads of analysis, GRPHARM and iambic stress, can now be combined to supply an explanation for the trisyllabic deletion process. Without trisyllabic deletion, a word like /ʔinkasar-at/ would be parsed with a LL iambic foot: **ʔin(kisá)rat*. Trisyllabic deletion improves the quantitative structure of this iamb. According to GRPHARM, iambic feet optimally match their weak-strong prominence with short-long quantity. Many languages have iambic lengthening, where a LL iambic foot becomes LH by lengthening the vowel of the second syllable. In Bedouin Arabic, I claim, a LL iamb becomes ΔL, where Δ denotes a moraless syllable, called a *semisyllable*.

(24) The ΔL iamb in trisyllabic deletion cases

a. ktíbat



b. ʔinksárat



The idea, then, is that loss of the pre-stress vowel in *ʔin(k.sá)rat* brings this word into conformity with GRPHARM, in a way that closely parallels iambic lengthening effects in other languages.

There are several reasons to think that this account of trisyllabic deletion is essentially correct.

First, it offers a complete, strictly local explanation for the peculiar contextual conditions on trisyllabic deletion:

(25)

Observation	Explanation
a. Trisyllabic deletion only affects a light syllable.	Only a light syllable can be the weak branch of an iambic foot.
b. The affected syllable must be followed by another light syllable.	If the following syllable is heavy, then the iamb is already LH, satisfying GRPHARM without further ado: *(ki.táb)na*, *(ðaráb)tukum*.
c. The syllable following the affected syllable must itself be nonfinal.	If the following syllable is final, then the foot is trochaic, not iambic, because NONFINALITY dominates FT-FORM ((23)): /rama/ → *(ríma)* 'he threw'.

Second, this analysis explains a significant correlation in the history of Arabic dialects. The sedentary dialects have trochaic stress, and they never have trisyllabic deletion. The Bedouin dialects have iambic stress, and many (though not all) have trisyllabic deletion. Historically, then, trisyllabic deletion appears to be a secondary development in those dialects that first changed to iambic stress – exactly as the synchronic analysis predicts.

Third, this analysis also accords well with processes affecting iambic feet in other languages, as documented by Hayes (1995) and Kager (1997). Kager's analysis of Macushi Carib is a close parallel in many respects.

Fourth, this analysis makes sense syllabically. What appear to be tautosyllabic clusters arise only as a result of vowel deletion, supporting the claim that they actually involve semisyllables: *(k.tí).bat, ʔin.(k.sá).rat.*[13] This too is closely paralleled in Kager's analysis of Macushi Carib. And overall, there is ample precedent for semisyllables or similar notions in Arabic (Aoun 1979, Selkirk 1981, McCarthy and Prince 1990a, 1990b, Broselow 1992, Farwaneh 1995, Kiparsky, this volume), in other languages (e.g., Cho and King, this volume, Féry, this volume), and in analyses of epenthesis (Hyman 1985, Piggott 1995).

Finally, this analysis accounts for words like *ʔinksárat* without the problematic stress-shift process. There is instead iambic stress, with optimization of the quantitative relations in the iambic foot.

In short, trisyllabic deletion is actually iambic deletion – a local process, motivated by foot well-formedness, much like the Myers-Prince approach to trisyllabic shortening in English.

2.3.3.3 OT Analysis of Bedouin Arabic

These ideas can be incorporated into a fuller OT analysis of Bedouin Arabic, which also deals with the reduction and syncope processes. The first order of analytic business is to dispose of the /a/ → *i*, /i/ → Ø chain-shift. The insight behind the analysis of chain-shifts in OT is relative faithfulness (Kirchner 1996, Gnanadesikan 1997): if /A/ → B and /B/ → C in the same environment, but /A/ ↛ C, then the prohibited /A/ → C mapping must be categorically less faithful than the permitted /A/ → B and /B/ → C mappings.[14] Then the markedness constraint that drives these alternations can be ranked so that it can compel the "shorter" mappings but not the "longer" one.

Gnanadesikan (1997) proposes that this distinction in relative faithfulness is defined on universal phonological scales, such as consonantal stricture, voicing and sonorancy, or vowel height.[15] All scales are ternary, by her hypothesis, and positions on a scale can be referenced by markedness and faithfulness constraints. The key is to recognize two distinct faithfulness constraints, one that precludes any movement on a scale and another that prohibits only longer movements on the scale:

(26) STAY(S) and STAY-ADJ(S)

a. STAY(S)

Input and output have the same position on the scale S.

b. STAY-ADJ(S)

Input and output have the same or adjacent positions on the scale S.

If there is a universal phonological scale S = A > B > C, then the mappings /A/ → B, /B/ → C, and /A/ → C all incur violations of STAY(S). But the mapping /A/ → C also incurs a violation of STAY-ADJ(S), and so it is categorically less faithful than the other two mappings.

Following Kirchner (1996), I assume that the scalar dimension relevant to the Bedouin Arabic *a*/*i*/Ø alternations is intrinsic duration (Lehiste 1970): the low vowel is longest, the high vowel is intermediate, and, of course, Ø is shortest:

(27) The Duration Scale *Dur*

a > *i* > Ø

Kirchner proposes that the markedness constraint driving the chain-shift is REDUCE:

(28) REDUCE (after Kirchner 1996: 347)

A short vowel in an open syllable has zero duration. Assign one violation mark for each increment of duration above Ø on the scale *Dur*.

So the vowel *i* receives one mark from REDUCE, while *a* gets two. Ranked between STAY-ADJ(Dur) and STAY(Dur), REDUCE is responsible for the /a/ → *i* and /i/ → Ø chain-shift, and it is correctly unable to compel the /a/ → Ø mapping:

(29) Raising: /a/ → *i* in open syllable

/katab/	STAY-ADJ(Dur)	REDUCE	STAY(Dur)
a. ☞ ki.tab		*	*
b. ka.tab		**!	
c. k.tab	*!		*

(30) Syncope: /i/ → Ø in open syllable

/kitib/	STAY-ADJ(Dur)	REDUCE	STAY(Dur)
a. ☞ k.tib			*
b. ki.tib		*!	
c. ka.tib		**!	*

In (29), the candidate with raising of /a/ to *i* triumphs over the faithful candidate by virtue of its better performance on the markedness constraint REDUCE. Perfect performance on REDUCE is available from the remaining candidate, (29c), but the cost is too high: fatal violation of top-ranked STAY-ADJ(Dur), which bars the /a/ → Ø mapping. In (30), however, perfect performance on REDUCE is possible: the /i/ → Ø mapping only violates the low-ranking faithfulness constraint STAY(Dur), since *i* and Ø are adjacent on the Dur scale. In this way, the shorter mappings (/a/ → *i*, /i/ → Ø) are permitted, but the longer mapping (/a/ → Ø) is not.

Of course, /a/ does delete when GRPHARM is at stake. To compel deletion of underlying /a/, GRPHARM must therefore be ranked above STAY-ADJ(Dur):

(31) Application to trisyllabic deletion case

/kata-at/	GRPHARM	STAY-ADJ(Dur)	REDUCE	STAY(Dur)
a. ☞ (k.tí).bat		*	*	**
b. (ki.tí).bat	*!		**	**

The failed candidate (31b) contains a LL iambic foot, violating GRPHARM. The alternative in (31a) contains an iamb of properly unequal weight, obtained by deleting the first vowel, leaving only a weightless semisyllable behind. Alternative candidates like **(ktí).bat* (with a complex onset), **(tí).bat* (with consonant deletion), or **(kitá:).bat* (with lengthening instead of shortening) violate undominated constraints, so they need not distract us further.

The DY case *(ʔaká)lat* is analyzed in much the same way, except that it shows the effect of an undominated constraint against a semisyllable with onset *ʔ*. (This replaces the special post-*ʔ* epenthesis rule of the traditional analysis.) Ranked above GRPHARM, that constraint effectively blocks trisyllabic deletion in words with initial *ʔ*.

(32) Application to /ʔakal-at/

/ʔakal-at/	*ʔΔ	GRPHARM	STAY-ADJ(Dur)
a. ☞ (ʔa.ká).lat		*	
b. (ʔ.ká).lat	*!		*

In short, this DY case is analyzed in terms of conflicting markedness constraints, just like the vacuous DY examples discussed in section 2.2. There is no need for stress shift under deletion; stress is iambic in conformity with the general pattern of the language.

We now have a reasonably complete picture of the trisyllabic deletion phenomenon. Trisyllabic deletion can be explained in terms of known quantitative properties of iambic stress systems. There is no evidence for a DY derivation; instead, there is a blocking effect by virtue of one markedness constraint dominating another, as in Nootka.

One detail remains, and it introduces the issue of opacity, which intersects in important ways with the analysis of DY derivations. Consider the effect, shown in (33), of adding the candidate **(kát).bat* to the tableau in (31):

(33) Tableau in (31) with **(kát).bat* Added

/katab-at/		GrpHarm	Stay-Adj(Dur)	Reduce	Stay(Dur)
Opaque	a. ☞ (k.tí).bat		*	*!	**
	b. (ki.tí).bat	*!		**	**
Transparent	c. ☜ (kát).bat		*		*

This additional candidate harmonically bounds the intended output *(k.tí).bat*, a problematic condition I have indicated with the reversed pointing hand.[16] To get the right result here, there must be some further constraint, ranked above Reduce, that *(k.tí).bat* satisfies better than **(kát).bat* does.[17]

This is a case of *opacity*. Two phonological processes interact opaquely if one hides the results or environment of the other:

(34) Opacity (after Kiparsky 1973b)

A phonological rule ℘ of the form *A* → *B* / *C*_*D* is *opaque* if there are surface structures with any of the following characteristics:

a. instances of *A* in the environment *C*_*D*.

b. instances of *B* derived by ℘ that occur in environments other than *C*_*D*.

Intuitively, the idea is that a rule is opaque if there are surface forms that look like they should have undergone it but did not ((34a)) or surface forms that underwent the rule but look like they should not have ((34b)). In rule-based phonology, the output of Trisyllabic Deletion, *(k.tí).bat*, is opaque with respect to Syncope, because it contains surface *i* in an open syllable ((34a)-type opacity). In OT, the hallmark of opacity is unexplained markedness or faithfulness violation by the actual output form (McCarthy 1999b). In (33), as was already noted, the intended output *(k.tí).bat* has unexplained violations of both the markedness constraint Reduce and the faithfulness constraint Stay(Dur). These violations are unexplained because there is another candidate, **(kát).bat*, that fares better on both of these constraints and equally well on all higher-ranking constraints. Opaque interactions demand some revision of the basic theory, and that is the subject of the next section.

2.4. Sympathy and Opacity

The problem identified in (33) is that the actual output form *(k.tí).bat* has all of the violation marks of the failed candidate **(kát).bat*, and more. Some higher-ranking constraint must compel these violations. According to sympathy theory (McCarthy 1999b), the responsible constraint is one that is sensitive to relations between candidates – specifically, the relation between all other candidates and one particular candidate, called the sympathetic candidate (which is notated with the symbol ❀). The sympathetic candidate is chosen by faithfulness to the input: it is the most harmonic candidate that obeys some designated faithfulness constraint, called the selector (which is notated by the symbol ✯). A ranked, violable sympathy constraint (also notated by ❀) assesses candidates for their similarity, in a sense to be made precise in section 2.5, to the sympathetic candidate. A sympathy constraint is responsible for compelling *(k.tí).bat*'s seemingly supererogatory constraint violations.

Even without the details of how the sympathy constraint works, we can still get a reasonably good picture of sympathy theory in action. A little bit of the logic of sympathy starts the ball rolling. If the effects of sympathy are to be nonvacuous, the sympathetic candidate must be distinct from both the actual output *(k.tí).bat* and its transparent competitor **(kát).bat*. And since the sympathetic candidate is chosen for obedience to a faithfulness constraint (the selector), it follows that it must be more faithful, on some dimension, than either *(k.tí).bat* or **(kát).bat*. This reasoning leads to Stay-Adj(Dur) as the selector, since it is the only faithfulness constraint violated by both *(k.tí).bat* and **(kát).bat*. The most harmonic candidate that obeys ✯Stay-Adj(Dur) is ❀*(ki.tí).bat*. It obeys the selector because no /a/s have been deleted. It is the most harmonic candidate, given this restriction, because the /a/s in open syllables have reduced to *i*, maximally satisfying Reduce.

The sympathy constraint, here temporarily designated by ❀Sym, evaluates candidates for similarity to the sympathetic candidate. The actual output form *(k.tí).bat* ((35a)) is more similar to ❀*(ki.tí).bat* than **(kát).bat* ((35b)) is, and so *(k.tí).bat* performs better on ❀Sym. Obviously, ❀*(ki.tí).bat* is maximally similar to itself, and so it performs perfectly on ❀Sym, but it is not optimal because of its fatal GrpHarm violation. The tableau in (35) adds the sympathy constraint to (33).

(35) Sympathy applied to /katab-at/ → *(k.tí).bat*, **(kát).bat*

/katab-at/	GrpHarm	❀Sym	★Stay-Adj(Dur)	Reduce	Stay(Dur)
Opaque a. ☞ (k.tí).bat		*	*	*	**
Sympathetic b. ❀ (ki.tí).bat	*!		✓	**	**
Transparent c. ☜ (kát).bat		**!	*		*
Faithful d. (ka.tá).bat	*!		✓	****	

The numbers of violation marks in the ❀Sym column should not be taken literally, but the relative harmony of candidates with respect to this constraint should be. It is **(kát).bat*'s inferior resemblance to the sympathetic candidate that explains why it is not optimal, thereby accounting for *(k.tí).bat*'s otherwise unexplained violations of Reduce and Stay(Dur).[18]

To complete this sketch, we need to check that sympathy has no untoward consequences for the rest of the language. No effects of sympathy are expected if the actual output form obeys the selector constraint, because in that case the selector and normal harmonic evaluation will converge on the same candidate, and so ❀Sym will be vacuously satisfied by a candidate that would have been optimal in any case. Some perusal of the core data in (18) shows that deletion of /a/, which translates into violation of ★Stay-Adj(Dur), only occurs in derivations like /katab-at/ → *(k.tí).bat*, and so that is the only circumstance where sympathy is relevevant.[19]

2.5. Sympathy and Cumulativity

2.5.1 The Problem

The issue to be addressed now is the nature of the sympathy constraint ❀Sym. In the earliest, unpublished work on sympathy theory (McCarthy 1998), the role of ❀Sym is fulfilled by a family of intercandidate faithfulness constraints, specifying the exact way in which the candidate under evaluation must match the sympathetic candidate. For instance, intercandidate faithfulness constraints requiring corresponding vowels to match in height or stress would correctly favor *(k.tí).bat* over **(kát).bat* in (35), since the former better matches ❀*(ki.tí).bat*'s vowel height and stress than the latter does.

This framework of sympathetic intercandidate faithfulness constraints is very rich, because it brings with it the full expressive power of correspondence theory (McCarthy and Prince 1995). In fact, it is too rich, because it permits unattested patterns of opacity to be described, such as the feeding DY type. In this section, I will argue against intercandidate faithfulness constraints and in favor of an alternative that is based on comparing the unfaithful mappings that produce candidates.

Perhaps the clearest example of the excessive descriptive power of intercandidate faithfulness is the quasi-Yokuts example in (16).

This DY case reflects an unattested and presumably impossible type of rule interaction. Yet, as Kiparsky (e-mail, July 7, 1998) points out and as I will now show, quasi-Yokuts is analyzable in sympathy theory, if information is transmitted from the sympathetic candidate to the rest of the candidate set by intercandidate faithfulness constraints.

The basic phonology of quasi-Yokuts is given by the rankings in (36).

(36) Constraint rankings for Quasi-Yokuts
- a. $*[\mu\mu\mu]_\sigma$ >> Dep-V — Trimoraic syllables are repairable by epenthesis.[20]
- b. $*[\mu\mu\mu]_\sigma$ >> Max-μ — Trimoraic syllables are repairable by shortening.
- c. Dep-V >> Max-μ — Shortening is preferred to epenthesis.
- d. **ti* >> Ident(high) — There is palatalization.

Under the assumption that codas contribute to weight, CVVC syllables run afoul of $*[\mu\mu\mu]_\sigma$. This constraint is able in principle to compel both epenthesis and shortening; which one actually occurs is determined by the ranking in (36c), which favors shortening over epenthesis. The last ranking, by deploying the ad hoc constraint **ti* above Ident(high), accounts for the palatalization process.

To simulate the feeding DY pattern, the sympathetic candidate must be ❀*maːči*, like the intermediate stage of the serial derivation in (16). This sympathetic candidate is chosen if the selector constraint is ★Max-μ, favoring the most harmonic candidate that does not show the effects of vowel shortening. And to transmit the effects of palatalization from the sympathetic candidate to the actual output form, we can call on the correspondence-based sympathy constraint ❀Ident(high). By dominating its input-output counterpart Ident(high), the sympathy constraint ❀Ident(high) ensures that palatalization in the sympathetic candidate is repeated in the actual output form, even if not present in the input.

The tableau in (37) confirms the details of the analysis.

(37) Quasi-Yokuts in Sympathy Theory with intercandidate faithfulness constraints

/maːt/	$*[\mu\mu\mu]_\sigma$	**ti*	❀Ident (high)	Ident (high)	Dep-V	★Max-μ
Transparent a. ☜ mat			*!			*
Sympathetic b. ❀ maːči				*	*!	✓
Opaque c. ☞ mač				*		*
d. maːt	*!		*!			✓
e. maːti		*!	*!		*	✓
f. maːč	*!			*		✓

The actual output form is *mač*. Its transparent competitor *mat lacks the sympathetic effect of palatalization, and it is not optimal, because of high-ranking ❀IDENT(high). The sympathetic candidate ❀*maːči* is chosen for its obedience to the selector ★MAX-μ; of all the candidates that obey the selector, it is the most harmonic, since it contains no trimoraic syllables and has palatalization before *i*. Other candidates incur fatal violations of undominated markedness constraints, so they require no further attention.

This analysis pretty effectively simulates a feeding DY derivation. The input /maːt/ is mapped onto the output *mač* through sympathetic attraction to ❀*maːči*. On the assumption that such cases are not merely nonexistent but actually impossible, we have to conclude that the original faithfulness-based theory of sympathy is too powerful.

What is the source of this problem? The theory's excessive richness comes from the existence of intercandidate faithfulness constraints like ❀IDENT(high). These constraints allow essentially any information about the sympathetic candidate to be transmitted to the actual output form. Palatalization in quasi-Yokuts is a mere side effect of a spurious epenthesis process, yet sympathetic faithfulness constraints have no difficulty in transmitting the result of palatalization from the sympathetic candidate to the actual output form. I therefore reject the whole notion of intercandidate faithfulness constraints and here propose a more restrictive alternative.

2.5.2 The Solution

As the earlier discussion of ❀SYM emphasized, the point of sympathy theory is to require some sort of resemblance between the output form and the sympathetic candidate. The flawed approach based on intercandidate faithfulness involves checking this resemblance directly, using specific constraints on candidate-to-candidate correspondence. The alternative I explore here compares candidates indirectly, in terms of the unfaithful input → output mappings that created them.[21] If a candidate C has a superset of the sympathetic candidate ❀C's unfaithful mappings, then C and ❀C stand in a relation of *cumulativity*: C accumulates all of ❀C's unfaithful mappings and may add some more of its own. DY derivations, including quasi-Yokuts, are noncumulative – *mač* does not have a superset of ❀*maːči*'s unfaithful mappings.

To implement this idea formally, we require a definition of what an "unfaithful mapping" is, and we need a metric for comparing the sets of unfaithful mappings incurred by two candidates (one of which is the sympathetic candidate) derived from the same input. Each of these prerequisites will be addressed in turn.

Unfaithful mappings are a tokenized version of faithfulness, specifying the type and locus of unfaithfulness more precisely than constraints do. In some

cases, faithfulness constraints may disregard differences in type of unfaithfulness. For example, the epenthetic mappings from /ai/ to *a.ʔi* versus *a.ti* are distinct, but both simply incur a violation of DEP. And except for certain prominent positions (Beckman 1997, 1998), faithfulness constraints are indifferent to the locus of violation. For example, the same type of faithfulness violation – deletion of a segment, a violation of MAX – is involved in mapping /pap/ to *pa* or *ap*, but the loci of violation are different.

Unlike faithfulness per se, a fully characterized unfaithful mapping specifies exactly how input and output differ, resolving all potential ambiguities. In the case of constraints like DEP, the resolution is obvious: DEP(*ʔ*) and DEP(*t*) are two distinct unfaithful mappings, but they are presumably not distinct constraints. To distinguish the locus of each unfaithful mapping, I will index elements of the input. We can therefore talk about two distinct unfaithful mappings affecting $/p_1a_2p_3/$: MAX@1, which yields *ap*, and MAX@3, which yields *pa*. In this way, the locus of faithfulness violation is always relativized to the input, and thus it is commensurable across candidates.[22]

The locus of epenthesis is usually defined on the output; to keep things simple, it would be convenient to have a way of talking about the locus of epenthesis relative to the input. Assume that the input XY is equivalent to XεY, where "ε" is the null character. An output epenthetic segment stands in correspondence with an input ε, with one or more εs supplied as needed for epenthetic correspondence to a set of input-equivalents. The ε symbols will be indexed relative to the segment on their left, if any: for example, input /a/ is equivalent to $/\varepsilon_{0\text{-}1}a_1\varepsilon_{1\text{-}1}\varepsilon_{1\text{-}2}/$, which underlies the output candidate $ʔ_{0\text{-}1}a_1ʔ_{1\text{-}1}i_{1\text{-}2}$.

Any output candidate from a given input is almost fully characterized by the set of unfaithful mappings that yield it. "Almost" fully characterized, because candidates can differ in properties that are not governed by faithfulness and thus do not involve unfaithful mappings. The most obvious such property is syllabification, discussed in section 2.6. Apart from this, though, Gen could be thought of as emitting various sets of unfaithful mappings qua candidates. Distinct candidates will be associated with distinct sets of unfaithful mappings, and these sets provide the basis for a metric of similarity between candidates – a metric that can replace intercandidate faithfulness constraints in sympathy theory.

Let U_{Cand} stand for the set of unfaithful mappings that relate some input to the output candidate *Cand*. We are interested in comparing the sets of unfaithful mappings U_{Cand1} and U_{Cand2} associated with the candidates Cand1 and Cand2, respectively. There are four situations to consider:

- $U_{Cand1} = U_{Cand2}$. In this case, Cand1 = Cand2 (except for properties like syllabification, as noted). Each is trivially cumulative with respect to the other.
- $U_{Cand1} \subsetneq U_{Cand2}$. In this case, Cand1 and Cand2 are different but compara-

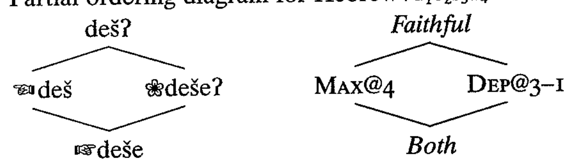
ble.[23] Cand2 is nontrivially cumulative with respect to Cand1; that is, Cand2 accumulates Cand1's unfaithful mappings and adds some more of its own.

- $U_{Cand1} \supsetneq U_{Cand2}$. Cand1 and Cand2 are likewise comparable, and, symmetrically, Cand1 is cumulative with respect to Cand2.
- $U_{Cand1} \not\subset U_{Cand2}$ and $U_{Cand1} \not\supset U_{Cand2}$. Then Cand1 and Cand2 are noncomparable, and there is no relationship of cumulativity between them.

In short, cumulativity is defined in terms of a subset relation over unfaithful mappings.

The theory of partial orderings provides a more perspicuous way of looking at these intercandidate relations. The candidate that is most faithfully mapped – identical to the input – stands at the top of a partial ordering, and below it is a rank of candidates each of which has a single unfaithful mapping. Below that is a rank of candidates each of which combines two of the unfaithful mappings from the first row, and so on. Partial orderings are best seen diagrammatically, as in (38), a fragment of the Hebrew *deše* example from McCarthy 1999b. Underlying /dešʔ/ is mapped onto surface *deše* by two unfaithful mappings, epenthesis of *e* and deletion of *ʔ*. Interesting candidates include sympathetic ❀*dešeʔ* and the transparent competitor *deš*, where *ʔ* was deleted without the seemingly superfluous epenthesis process.

(38) Partial ordering diagram for Hebrew /$d_1e_2š_3ʔ_4$/



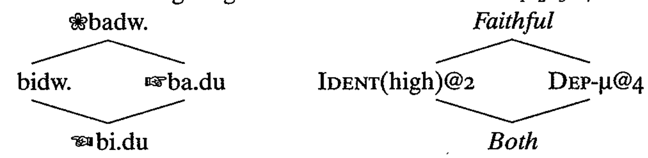
Obviously, this is just a tiny portion of the candidate set. Standing at the top of the partial ordering is the most faithful candidate (see Moreton 1996/1999 on why such a candidate must exist). Below it, on the first tier, are candidates with a single unfaithful mapping, including deletion of /ʔ/ or epenthesis of /e/. At the next level down is the candidate *deše*, the actual output, which has suffered both of these unfaithful mappings.

The candidate standing at the top, *dešʔ*, is comparable with all other candidates, and all other candidates accumulate its unfaithful mappings. (That is because the fully faithful candidate has no unfaithful mappings, and every set is a superset of the null set.) The actual output *deše* is comparable with all of the candidates shown (though not with all possible candidates), and so it is cumulative with respect to the sympathetic candidate ❀*dešeʔ*. Significantly, *deše*'s transparent competitor **deš* is not cumulative with respect to the sympathetic candidate ❀*dešeʔ*. This noncumulativity proves to be fatal.

A similar diagram can be constructed for another of the examples in

McCarthy 1999b, the failure of open-syllable vowel raising to occur in Bedouin Arabic words like *ba.du*, derived by glide vocalization from underlying /badw/:

(39) Partial ordering diagram for Bedouin Arabic /$b_1a_2d_3w_4$/



The sympathetic candidate is one in which the underlying glide has not vocalized, and so raising, which occurs in an open syllable, is not motivated. In this case, then, the sympathetic candidate is faithfully mapped from the input. The actual output form has glide vocalization but not raising; it competes with **bi.du*, which transparently has both.

As usual, the faithfully mapped candidate ❀*badw* is comparable with all other candidates, and moreover, all other candidates vacuously accumulate its empty set of unfaithful mappings. The difference between the actual output *badu* and its transparent competitor **bidu* is that *badu* is closer, in terms of shared unfaithful mappings, to the sympathetic candidate.

These examples give a pretty good idea of how the revised sympathy system will work: only candidates that accumulate the unfaithful mappings of the sympathetic candidate are in sympathy with it, and among those candidates it is best to be closest, in terms of shared unfaithful mappings, to the sympathetic candidate. There are various ways to implement this system formally, and here I will take an approach suggested to me by Alan Prince. Replacing the diverse intercandidate correspondence constraints in the earlier theory, there are just two sympathy constraints per selector. They compare a candidate's accumulated unfaithful mappings to those of the sympathetic candidate:

(40) Cumulativity[24]

Given a sympathetic candidate ❀-Cand from a selector ★F, to evaluate a candidate E-Cand:

a. ❀Cumul$_F$
   E-Cand is cumulative with respect to ❀-Cand. That is, $U_{❀\text{-Cand}} \subseteq U_{\text{E-Cand}}$.

b. ❀Diff$_F$[25]
   Every unfaithful mapping incurred by E-Cand is also incurred by ❀-Cand. That is, assign one violation mark for every member of the set $U_{\text{E-Cand}} \backslash U_{❀\text{-Cand}}$.

c. Fixed universal ranking
   ❀Cumul$_F$ >> ❀Diff$_F$

❀Cumul evaluates each candidate categorically for whether it accumulates all of the sympathetic candidate's faithfulness violations. (See the appendix of this chapter for a refinement of this definition.) ❀DIFF evaluates candidates gradiently for how far they are from the sympathetic candidate in terms of unshared faithfulness violations. The fixed ranking places the more stringent test universally higher. Because of this fixed ranking, evaluation by ❀DIFF will only be relevant when ❀CUMUL is not decisive, thereby ensuring that only comparable candidates (in the technical sense) are actually compared by ❀DIFF.

Here is a shortcut that uses a diagram like (38) or (39). If there is a purely downward path from ❀-Cand to E-Cand, then E-Cand satisfies ❀CUMUL, and the number of links in that path is the number of marks on ❀DIFF that E-Cand incurs. If there is no purely downward path from ❀-Cand to E-Cand, then E-Cand violates ❀CUMUL, and so its performance on ❀DIFF is of no consequence. In (38), ❀CUMUL correctly favors *deše* over its transparent competitor **deš*, relative to the sympathetic candidate *❀deše?*. And in (39), both *ba.du* and **bi.du* are cumulative with respect to the sympathetic candidate *❀badw*, but *ba.du* is closer, in terms of shared unfaithful mappings, so *ba.du* receives one "*" from ❀DIFF to **bi.du*'s two "*"s.

Intuitively, these two notions, cumulativity and distance in terms of shared faithfulness violations, are analogous to criteria that have sometimes been imposed on serial derivations. The requirement that derivations be monotonic (as in Declarative Phonology; see Scobbie 1993, and references there), meaning that they take a steady path away from the input, never backtracking, is roughly equivalent to saying that later steps of the derivation are cumulative, in the sense just described, with respect to earlier steps. And derivational economy, meaning that the length of the derivational path is minimized (Chomsky 1995: 138ff.), approximates the effect of checking the number of unshared faithfulness violations. The difference, of course, is that these notions have not previously been couched in terms of faithfulness, which is unique to OT.

Back to Bedouin Arabic. Recall that sympathy must favor *(k.tí).bat* over transparent **(kát).bat* relative to the sympathetic candidate *❀(ki.tí).bat*. The definition of ❀CUMUL in (40) does exactly that. Consider the sets of unfaithful mappings associated with these three candidates:[26]

(41) Unfaithful mappings relative to input /$k_1a_2t_3a_4b_5a_6t_7$/

	Candidate	U_{Cand}		
☞	(k.tí).bat	{STAY-ADJ(Dur)@2,	STAY(Dur)@2,	STAY(Dur)@4}
❀	(ki.tí).bat	{	STAY(Dur)@2,	STAY(Dur)@4}
☜	(kát).bat	{STAY-ADJ(Dur)@4,		STAY(Dur)@4}

The desired output form *(k.tí).bat* has a proper superset of the sympathetic

candidate's unfaithful mappings, so it obeys ❀CUMUL. The transparent competitor **(kát).bat* has a partly disjoint set of unfaithful mappings from the ❀-candidate's. They are noncomparable or, equivalently, noncumulative, and so **(kát).bat* violates ❀CUMUL. The tableau in (42) updates (35) to reflect these developments.

(42) ❀CUMUL applied to /katab-at/ → *(k.tí).bat*, **(kát).bat*

	/katab-at/	GRPHARM	❀CUMUL	★STAY-ADJ(Dur)	REDUCE	STAY(Dur)
Opaque	a. ☞ (k.tí).bat			*	*	**
Sympathetic	b. ❀ (ki.tí).bat	*!		✓	**	**
Transparent	c. ☜ (kát).bat		*!	*		*

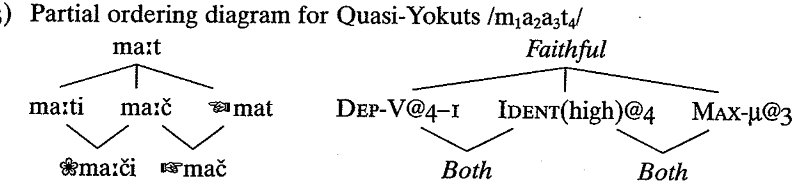
Because ❀CUMUL is decisive, performance on ❀DIFF is irrelevant, and so the latter constraint is not shown in the tableau.

This is a good point at which to summarize the discussion. The original implementation of sympathy theory posited a set of intercandidate faithfulness constraints that permit any property (as long as it can be named in a correspondence constraint) to be transmitted from the sympathetic candidate to the actual output form. Here I have proposed a more restrictive alternative, in which the only information that can be transmitted from the sympathetic candidate is the set of its unfaithful mappings.

The central role of cumulativity in this revised theory of sympathy is the key to explaining the impossibility of DY derivations, particularly the quasi-Yokuts case in (37). DY serial derivations are, by their very nature, noncumulative; rather than monotonically increasing the unfaithful mappings relative to the input, they proceed nonmonotonically, introducing an unfaithful mapping at one stage and then undoing it at a later stage, as in (16). Noncumulativity makes a simulation in terms of the revised sympathy theory impossible – a welcome result, since the need for DY derivations is not supported empirically, as I argued in sections 2.2 and 2.3.

To see this concretely, consider the diagram in (43), which organizes the quasi-Yokuts candidates in (37) according to their unfaithful mappings.

(43) Partial ordering diagram for Quasi-Yokuts /$m_1a_2a_3t_4$/



It is immediately evident that the intended output *mač* does not accumulate the unfaithful mappings of the sympathetic candidate ❀*maːči*. Top-ranked ❀CUMUL extinguishes all noncumulative candidates, leaving only ❀*maːči* as a viable candidate. Thus, ❀CUMUL is equally fatal to *mač* and its transparent competitor **mat*. This means that the quasi-Yokuts DY derivation cannot be simulated under the revised sympathy theory.

The quasi-Yokuts example highlights a general result. Under the revised theory of sympathy, the relation between the output and the sympathetic candidate is one of cumulative unfaithful mappings. DY derivations, whether implemented serially or simulated with an underlying–sympathetic–surface triplet, are inherently noncumulative. The revisions to sympathy theory have made it more restrictive, by limiting the kinds of information that can be extracted from the sympathetic candidate. One indication of this greater restrictiveness is the impossibility of reproducing DY derivations; others, no doubt, remain to be discovered.

2.6. Cumulativity, Faithfulness, and Syllable Structure

2.6.1 Overview of the Issue

Cumulativity is defined in terms of shared unfaithful mappings. In fact, the candidates themselves can be described in terms of the unfaithful mappings that produced them – up to a point. Candidates may also differ in properties that are phonologically relevant but not governed by faithfulness constraints. Here's the difference. Any phonological property that is independently contrastive in the phonology of some language must be protected by faithfulness constraints provided by UG, and each breach of a faithfulness constraint will count as an unfaithful mapping for the purposes of assessing cumulativity. But properties that are never contrastive in the phonology of any language are not subject to faithfulness constraints. For example, Keer (1999) argues, from the observation that tautomorphemic true and fake geminates are never contrastive (Hayes 1986, McCarthy 1986), that fusion of two adjacent identical segments exacts no cost in faithfulness. Any such faithfulness-free mappings will be irrelevant to determining how well a candidate performs on ❀CUMUL and ❀DIFF.

It is virtually a truism that syllabification is never contrastive in any language. (This claim has some subtleties, to be discussed later, involving juncture effects and distinctions of quantity or syllabicity.) No language is known to contrast tautomorphemic *pa.ta* with *pat.a* or *pa.kla* with *pak.la* (though see van Oostendorp, this volume, for a possible counterexample.) This observation is usually taken to mean that syllabification is absent from underlying representations (e.g., Clements 1986b: 318, Hayes 1989: 260, Blevins 1995: 221). It is, however, more in keeping with OT's thesis of richness of the base (Prince and Smolensky 1993) to assume that underlying representations may be syllabified or not and in diverse ways – freely but pointlessly, since no constraints of UG lobby for the conservation of underlying syllabification:

(44) Faithfulness-free syllabification
No constraints of UG demand faithfulness to syllables per se.

This section explores the implications of (44) for cumulativity and opacity.

A derivation is cumulative if it monotonically increases its unfaithful mappings. Cumulative derivations are in general permitted, but noncumulative derivations are not, for the reasons given in section 2.5. If the thesis of faithfulness-free syllabification is correct, then syllabification is irrelevant to cumulativity, and so it should be possible to find real derivations where syllabification changes, nonmonotonically. These derivations will have something of the look and feel of the unattested feeding DY derivations, but they will involve nonmonotonicity *only* in faithfulness-free syllabification.[27]

The example back in (3) is a hypothetical, though undoubtedly authentic-appearing, instance of this. A genuine case comes from Clements's (1986a) analysis of quantity in Luganda (cf. Wiltshire 1992, Rosenthall 1994). In Luganda, vowels are always long before prenasalized consonants: *ku-liːnda* 'to wait', *mu-leːnzi* 'boy', *muː-ntu* 'person', *baː-ntu* 'people'. Clements argues that this is an effect of compensatory lengthening: the nasal is first syllabified as a weight-bearing coda and then is joined to the following consonant, leaving a stray weight-unit to be filled by spreading from the preceding vowel. Here is a derivation, substituting moras for the CV weight-units that Clements uses:

(45) Luganda derivation with resyllabification

⇨	Syllabification	μ μ | | mun.tu
	Weight-by-position	μμ μ || | mun.tu
⇨	Prenasalization	μμ μ | | mu.ⁿtu
	Spreading	μμ μ |/ | mu.ⁿtu

Just like the feeding DY cases, the intermediate stage plays a crucial role, since it supplies the context for Weight-by-Position (Hayes 1989), which assigns a mora to the nasal.

This derivation is cumulative, even though it has the DY-like step of Prenasalization undoing the effects of earlier Syllabification. To show that formally, it is necessary to sketch a partial account of Luganda within OT, using the revised theory of sympathy to deal with the opaque interaction between the process assigning positional weight and the process creating prenasalized consonants.[28]

There are no (nongeminate) codas in Luganda. Potential nasal codas, such as the *n* in /muntu/, are disposed of by coalescence with a following consonant, in violation of the faithfulness constraint UNIFORMITY (McCarthy and Prince 1995; but cf. Keer 1999). These observations motivate the ranking in (46).

(46) NOCODA, MAX >> UNIFORMITY

/muntu/	NO-CODA	MAX	UNIF
a. ☞ muː.^{n}tu			*
b. mun.tu	*!		
c. muː.tu		*!	

Rankings like this, where a markedness constraint and MAX together dominate UNIFORMITY, are typical of coalescence phenomena (Gnanadesikan 1995, 1997, Lamontagne and Rice 1995, McCarthy and Prince 1995, Causley 1997, Pater 1999, McCarthy 2000b).

This analysis is not sufficient, however, because there is an element of opacity in Luganda coalescence, as I have noted. The mapping /muntu/ → *muː.^{n}tu* involves a seemingly gratuitous violation of DEP-μ, a violation that the transparent output form **mu.^{n}tu* would have avoided. This is a sympathy effect, induced by the sympathetic candidate ❀*muN.tu* (where capitalization marks the *N* as moraic). The selector constraint is ★UNIFORMITY, which is obeyed by ❀*muN.tu* and violated by the actual output form *muː.^{n}tu*. And to ensure that the sympathetic form is the most harmonic candidate among those that obey the selector, certain additional rankings among as-yet unranked constraints are necessary. One of these is MAX >> NOCODA, so that ❀*muN.tu* is more harmonic than **mu.tu*. Another deploys Weight-by-Position (WxP) above DEP-μ, so that ❀*muN.tu*, with a moraic coda, is more harmonic than **mun.tu*, with a nonmoraic coda.

This much establishes the essential background for discussing the sympathy effect. Sympathy must favor opaque *muː.^{n}tu* over transparent **mu.^{n}tu* relative to the sympathetic candidate ❀*muN.tu*. To check whether it does, the first step is to assemble the sets of unfaithful mappings for these candidates:[29]

(47) Unfaithful mappings relative to input /$m_1u_2n_3t_4u_5$/

	Candidate		$U_{Candidate}$
☞	muː.^{n}tu	{DEP-μ@1–1,	UNIF@3&4}
❀	muN.tu	{DEP-μ@1–1	}
☜	mu.^{n}tu	{	UNIF@3&4}

The intended output form has a superset of the sympathetic candidate's unfaithful mappings; they are therefore in a relationship of cumulativity. But the transparent competitor does not accumulate the sympathetic candidate's unfaithful mappings. Therefore, ❀CUMUL will favor *muː.^{n}tu* over **mu.^{n}tu*, exactly as desired. The tableau in (48) completes the argument at the level of formal detail.

(48) Luganda /muntu/ → *muː.^{n}tu*

/muntu/	MAX	WxP	NOCODA	❀CUMUL	★UNIF	DEP-μ
a. ☞ muː.^{n}tu					*	*
b. ❀ muN.tu			*!		✓	*
c. ☜ mu.^{n}tu				*!	*	
d. muː.tu	*!				✓	*
e. mu.tu	*!				✓	
f. mun.tu		*!	*	*	✓	

Several candidates obey the selector constraint ★UNIFORMITY; of those, ❀*muN.tu* is most harmonic, so it is chosen as the sympathetic candidate. Through the constraint ❀CUMUL, the sympathetic candidate bestows its favor on *muː.^{n}tu*, which accumulates its unfaithful mappings, over **mu.^{n}tu*, which does not.[30]

This analysis succeeds under the assumptions that (i) cumulativity is defined in terms of shared unfaithful mappings and (ii) syllabification is not an unfaithful mapping – that is, (44). If syllabification were to be counted as an unfaithful mapping, then the record of unfaithful mappings for each candidate would have to be augmented as shown in (49). (Ons, Nuc, and Cod stand for the mappings that assign segments to syllabic positions.)

(49) Unfaithful mappings relative to /$m_1u_2n_3t_4u_5$/ under wrong assumption about syllabification

	Candidate	$U_{Candidate}$
☞	muː.^{n}tu	{Ons@1, DEP-μ@1–1, Nuc@2, UNIF@3&4, Ons@3, Ons@4, Nuc@5}
❀	muN.tu	{Ons@1, DEP-μ@1–1, Nuc@2, Cod@3, Ons@4, Nuc@5}
☜	mu.^{n}tu	{Ons@1, Nuc@2, UNIF@3&4, Ons@3, Ons@4, Nuc@5}

Observe that the sympathetic candidate and the intended output differ on the syllabification of /n/: Cod@3 versus Ons@3. Thus, there is no cumulativity relation between these candidates, if syllabification is reckoned in the determination of cumulativity. This means that the intended output and its transparent competitor **mu.^{n}tu* both violate ❀CUMUL. This tie is disastrous; since they also tie on ❀DIFF (each incurs two marks), the decision falls to low-ranking DEP-μ (see (48)), which *muː."tu* fatally violates. That is the wrong result.

This argument shows why, as a matter of descriptive necessity, syllabification cannot be reckoned as an unfaithful mapping. What remains is to fill in the details, hinted at earlier, of how this premise fits into phonology generally. As I noted, saying that syllabification is not governed by faithfulness constraints entails that no contrast in syllabification can be preserved in the mapping from underlying to surface representations. The main challenges to noncontrastive syllabification are these:

Grammatically conditioned contrast. Morphemic juncture can produce syllabificational contrasts, as in well-known examples like *lightning/lightening* or *nitrate/night-rate.*

Phonologically derived contrast. In Barra Gaelic, CV sequences derived by epenthesis are syllabified differently from underlying CV sequences.

Contrast in quantity or syllabicity. Consonant gemination has obvious consequences for syllabification. And contrasts between glides and vowels have been reported for Berber, Ilokano, and Spanish, inter alia (Levin 1985, Guerssel 1986, Harris 1987, Hayes 1989, Rosenthall 1994).

When none of these conditions obtain, syllabification does appear to be reliably noncontrastive, as in the examples of tautomorphemic *pa.ta/pat.a* and *pa.kla/pak.la* that were cited earlier. I will take each of these conditions in turn, briefly showing how they are compatible with the thesis in (44) that syllabification is not regulated by faithfulness constraints.

2.6.2 Grammatically Conditioned Contrast

Grammatically conditioned contrasts in syllabification have been extensively studied within OT. One important source of grammatically conditioned syllabification contrast is alignment (McCarthy and Prince 1993a). Alignment constraints can require that a segment standing at the edge of a morphological constituent, such as the stem, also stand at the edge of a prosodic constituent, such as the syllable. In English, for example, ALIGN-LEFT dominates NOCODA, to ensure that the stem-initial *r* of *rate* is also word- and syllable-initial in *night-rate*. Where ALIGN-LEFT is irrelevant, though, as in tautomorphemic *nitrate*, the ranking of NOCODA above *COMPLEX-ONSET will force onset maximization. A surface syllabification contrast is the result, but it does not require constraints demanding faithfulness to syllabification.

Output-output faithfulness constraints need to be considered as another potential source of grammatically conditioned contrasts in syllabification. A central thesis of Transderivational Correspondence Theory (Benua 1997b) is that output-output faithfulness constraints have the same formal properties as input-output (or base-reduplicant) faithfulness constraints. So if there are no constraints enforcing faithfulness to syllabification in input → output mappings, then there can be no such constraints on output → output mappings either.

English phonology is a good place to look for potential counterexamples to this thesis. The challenge comes from syllabic "closure" cases like *lightning/lightening* or *siren/siring*, where the sonorant is syllabic only before a Level II suffix (see, among others, Mohanan 1985, Harris 1990, Borowsky 1993, Benua 1997b). But even in these cases, it does not seem to be necessary to invoke faithfulness constraints on syllabification per se. Alignment constraints are one possible line of attack; another is moraic faithfulness. In section 2.6.4, I argue that faithfulness to moras, rather than syllables, is the basis of contrasts in syllabicity. The syllabic *n* of *lighten* bears a mora, under one view of syllabification. Faithfulness to this mora in the output-output dimension (i.e., OO-MAX-μ) will ensure its preservation in the derived form *lightening*. Moraic faithfulness is here a partial surrogate for syllabic faithfulness, and surrogacy appears to be enough for known cases. Of course, this surrogate also opens the possibility of introducing illegitimate syllabic contrasts through the moraic back door; that issue is also discussed in section 2.6.4.

A final grammatical circumstance that is relevant to syllabic faithfulness is reduplication. Reduplication never copies syllables (Moravcsik 1978, Marantz 1982, McCarthy and Prince 1986, 1990a). That is to say, no known language has a single reduplicative morpheme that copies the initial *ta* of *ta.pi* and the initial *tak* of *tak.pi.* A necessary (but not sufficient) condition for excluding this possibility is that UG contains no constraints enforcing faithfulness to syllables on the base-reduplication dimension. Again, this correlation between base-reduplicant faithfulness and input-output faithfulness is expected under correspondence theory (McCarthy and Prince 1995, 1999).

2.6.3 Phonologically Conditioned Contrast

In Barra Gaelic, the sequence $\breve{V}_1CV_2$ is said to be syllabified differently depending on the provenance of V_2 (Borgstrøm 1937, 1940, Kenstowicz and Kisseberth 1979, Clements 1986b, Bosch 1991, Bosch and de Jong 1997, 1998, Green 1997: 230–231, Beckman 1998): if V_2 is underlying, then the syllable boundary falls after C, but if V_2 is epenthetic, then the syllable boundary falls before C. As a consequence there are surface near-minimal pairs differing in syllabification, like *ar.an* 'bread' (from /aran/) and *a.ram* 'army' (from /arm/).

Following Clements, Blevins sketches a plausible derivational analysis:

(50) Derivational analysis of Barra Gaelic (after Blevins 1995: 231)

Underlying	/aran/	/arm/
Syllabification	a.ran	a.rm
Attraction	ar.an	–
Epenthesis	–	a.ram

The source of the surface contrast is the counterfeeding order between Attraction and Epenthesis. Attraction makes the stressed initial syllable heavy by drawing in the following consonant as a moraic coda. Because Epenthesis applies later, the onset of the epenthetic syllable cannot be attracted away. A surface contrast in syllabification is the result.

Clearly, Barra Gaelic does not depend on syllabic faithfulness in the input → output mapping, so it presents no difficulties for my main premise. And in any case, there is good reason to doubt that the story in (50) is correct and complete. New phonetic evidence developed by Bosch and de Jong (1997, 1998) shows that epenthesis leads to a difference in stress: *ár.an* versus *a.rám*. It may be that this difference in stress is directly responsible for the reported syllabification difference (see also Beckman 1998).

2.6.4 Contrasts in Quantity and Syllabicity

It is widely though not universally accepted that contrasts of quantity and syllabicity are represented by deploying moras in underlying representation (see McCarthy and Prince 1988, Hayes 1989, Rosenthall 1994, Sherer 1994, Davis, this volume). Faithfulness to underlying moras, thanks to constraints like Dep-μ and Max-μ, ensures that these underlying distinctions are maintained faithfully at the surface. Indeed, the analysis of Luganda in section 2.6.1 shows that insertion of a mora does constitute an unfaithful mapping, a result that is consistent with the role of moras in representing contrasts.

To complete the picture, though, it is necessary to show that faithfulness to underlying moras does not offer a back door into the nonoccurring *pa.ta/pat.a* or *pa.kla/pak.la* contrasts. This is not an easy undertaking: in its most general form, the claim is that no arrangement of underlying moras on the tautomorphemic string /pata/ will map onto a surface *pa.ta/pat.a* distinction under any permutation of the constraints of UG (and likewise for *pa.kla/pak.la*). Rather than solve this problem in its most general form, I propose here to address a modest-sized piece of it: the impossibility of having a language with the mappings in (51).

(51) Moraic faithfulness as surrogate for syllabic faithfulness
a. /pata/ → *pa.ta*
b. /paTa/ → *paT.a*

(Recall that capital *T* stands for *t* associated with a mora.) A language with mappings like these would be one in which faithfulness to moras in underlying representation produces contrast in syllables in surface representation. To account for the impossibility of tautomorphemic syllabic contrast, it is necessary (though not sufficient) to universally rule out the system with these mappings.

In OT, with Richness of the Base, the way to rule out a mapping is to find a more harmonic mapping. The way to rule out a mapping universally is to make sure that there is *always* a more harmonic mapping, under *any* permutation of the constraints of UG. Suppose that UG consists of only the constraints in (52).

(52) A limited UG constraint set
a. Onset
 $*[_\sigma V$
b. NoCoda
 *C.
c. $*\mu_{Cons}$ (Sherer 1994: 26)
 $*[C]_\mu$ (Consonants may not be parsed as moraic.)
d. WxP
 If C_i., then $[C_i]_\mu$ (Coda consonants must be parsed as moraic.)
e. Faithfulness constraints
 Max
 Max-μ
 Dep-μ

This constraint set will map input /pata/ onto output *pa.ta* under any ranking (cf. Prince and Smolensky 1993). But it will also map input /paTa/ onto geminate *paT.ta* or simplex *pa.ta*, depending on the disposition of Max-μ relative to the structural constraints. No permutation will produce *paT.a* or *pat.a* from input /paTa/, because there is no antagonistic constraint to offset their violations of Onset. Therefore, the illicit syllable structure contrast is not obtainable from these inputs under this theory of UG.[31]

Other theories of UG may have other consequences. For instance, if UG contains a constraint that specifically militates against geminate or ambisyllabic consonants (as in Rosenthall 1994 or Beckman 1998), then the illicit contrast is easily obtained simply by ranking the antigeminate constraint above Onset. But the absence of geminates from some phonemic inventories does not necessarily mean that UG has a constraint against geminates specifically. The theory in (52) can rule out geminates indirectly, under the ranking permutations in (53).[32]

(53) Some geminateless permutations of (52)
   a. No geminates, no codas whatsoever
      All others >> MAX, MAX-μ
   b. Moraic codas, but no geminates
      ONSET, WxP, MAX >> *μ_{Cons}, DEP-μ, NOCODA >> MAX-μ
   c. Nonmoraic codas and no geminates
      ONSET, MAX, *μ_{Cons}, DEP-μ, >> MAX-μ, NOCODA, WxP

The source of geminatelessness under (52) is the ranking *μ_{Cons} >> MAX-μ, and this ranking will never aid and abet the illicit mapping /paTa/ → *paT.a.* For further discussion, see Keer 1999: 48ff.

2.6.5 Summary

To summarize the results of this section, I have argued that there are no constraints enforcing faithfulness to syllables per se. A theory-internal argument, based on applying revised sympathy to cases like Luganda, was supported by theory-external observations about nonoccurring contrasts and impossible reduplicative patterns. Several challenges to this thesis were also addressed: grammatically conditioned and phonologically derived contrasts, and distinctions of quantity and syllabicity. Finally, I showed that moraic faithfulness, which is necessary to maintain contrasts in quantity and syllabicity, need not lead to illicit syllabification contrasts.

2.7. Conclusion

The serial derivation, although it is a central concept of generative phonology, has been little studied. A rare exception is Pullum's (1976) work on the Duke-of-York gambit, a type of derivation where the output returns to the same place as the input. Though serial rule-based phonology predicts the existence of DY derivations, they do not seem to occur, except as descriptive artifacts of serialism's commitment to rule prioritization through ordering.

The principal goal of this chapter has been to explain the impossibility of DY derivations in their most general form. The argument here is embedded within OT, and more specifically within the extension to OT called sympathy, which addresses opaque interactions among processes. The key is a revision of sympathy theory, changing the means by which information is transmitted from the sympathetic candidate to the output form. Instead of intercandidate faithfulness constraints, I have argued for a considerably more restrictive hypothesis: candidates are compared for their faithfulness violations. The actual output must accumulate the faithfulness violations of the sympathetic candidate. This notion of cumulativity is what separates real derivations from nonexistent DY derivations.

The chapter concluded with an examination of the role of syllabification in derivations. Syllabification, I argued, is not governed by faithfulness, and so it does not figure in the reckoning of cumulativity. Theoretical and empirical consequences of this view were presented.

The results presented here suggest that familiar notions like the serial derivation, which might seem to have little or nothing left to offer, bear close study. It is perhaps significant that the questions raised by Pullum have not been much studied in the intervening decades; it is certainly significant that these questions still claim our attention.

APPENDIX: SYMPATHY, CUMULATIVITY, AND HARMONIC ASCENT

Classic OT grammars share a property of *harmonic ascent* (Moreton 1996/1999). A classic OT grammar, following Prince and Smolensky (1993), is a ranking of markedness and faithfulness constraints, and nothing else. Because violation is minimal, unfaithfulness is only possible to achieve markedness improvement relative to some language-particular ranking of the markedness constraints in UG. So, if a language has an unfaithful mapping /A/ → B, then B must be less marked, relative to that language's hierarchy, than the fully faithful candidate A. (See Moreton 1996/1999 for a formal proof of this result and discussion of its empirical consequences, such as the impossibility of circular chain-shifts.)[33]

Elliott Moreton (personal communication, May 5, 1998) has shown that the harmonic ascent property also holds of classic OT grammars to which a single sympathy constraint has been added. To see why, assume that this claim is not true – that is, assume that input /A/ maps onto output *B* even though *B* is more marked than (output) *A*. *Ex hypothesi*, this mapping occurs by virtue of sympathy to some third candidate *C*, which is selected by the faithfulness constraint ✯F. The tableau in (54) shows the imagined situation, where *A* is less marked than *B*, yet *B* is the output. Observe too that *C* must be even less marked than *A*; since *C* and *A* both obey the selector ✯F, *C* must be less marked than *A* if it is to be the *most* harmonic candidate that obeys the selector.

(54) Harmonic descent with one sympathy constraint (partial tableau)

	/A/	M	✯F
Faithful	a. A	*	✓
Harmonic Descent	b. ☞ B	**	*
Sympathetic	c. ❀ C		✓

Any sympathy constraint that will ensure *B*'s victory must be ranked above M. It must also choose *B* over both *A* and *C*, since *B* is harmonically bounded by both. But no sympathy constraint can possibly do this: how could sympathetic resemblance to *C* somehow disfavor *C* itself? There is an obvious contradiction here, and so harmonic descent is impossible with a single sympathy constraint. This is a desirable result, since harmonic ascent is arguably a welcome consequence of OT.

Moreton goes on to show, however, that harmonic descent is possible if there are two sympathy constraints with two sympathetic candidates and two selectors (for a worked-out example of opacity with two selectors, see McCarthy 1999b). The trick is that each sympathy constraint is called on to exclude the other's sympathetic candidate, as in the schematic tableau in (55).

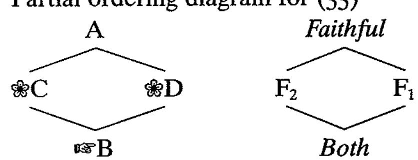
(55) Harmonic descent with two sympathy constraints

/A/	❀S_{F1}	❀S_{F2}	M	★F_1	★F_2
Faithful a. A	*!		*	✓	✓
Harmonic Descent b. ☞ B			**	*	*
Sympathetic c. ❀$_{F1}$ C		*!		✓	*
Symapthetic d. ❀$_{F2}$ D	*!			*	✓

The sympathy constraints ❀S_{F1} and ❀S_{F2} are indexed to the faithfulness constraints that serve as their selectors. Each rules out the other's sympathetic candidate, and in addition ❀S_{F1} ensures that *B* is more harmonic than *A*, despite *B*'s worse performance on the markedness constraint M.

The undesirable result in (55) cannot be avoided in the correspondence-based sympathy theory of McCarthy (1998), but it can be eliminated by refining the definition of cumulativity in (40). The faithfulness relationships among the various candidates are given by the diagram in (56) (cf. (38), (39), and (43)).

(56) Partial ordering diagram for (55)



Under the definition in (40), only *B* accumulates all of the unfaithful mappings incurred by both ❀C and ❀D, so only *B* satisfies both ❀CUMUL$_{F1}$ and ❀CUMUL$_{F2}$. But suppose (40) is modified as in (57).

(57) Cumulativity (revised)

a. ❀CUMUL$_F$

E-Cand and ❀-Cand$_F$ are comparable. That is, $U_{❀\text{-Cand}} \subseteq U_{\text{E-Cand}}$ or $U_{❀\text{-Cand}} \supseteq U_{\text{E-Cand}}$.

b. ❀DIFF$_F$

Every unfaithful mapping incurred by E-Cand is also incurred by ❀-Cand$_F$, and vice versa. That is, assign one violation mark for every member of the set $U_{\text{E-Cand}} \backslash U_{❀\text{-Cand}}$ and every member of the set $U_{❀\text{-Cand}} \backslash U_{\text{E-Cand}}$.

Revised in this way, ❀CUMUL and ❀DIFF will evaluate *A* and *B* in (56) as equally harmonic, since both stand in a super- or subset relation to the sympathetic candidates, and both are equidistant from the sympathetic candidates. This will leave the decision up to the markedness constraint M, which rules out candidate *B*. As a consequence of this revised definition, harmonic descent is impossible in OT with sympathy theory, just as it is in classic OT.

NOTES

1. *Bleeding* DY interactions, where the intermediate stage waits out another process, may be reducible to the vacuous type. See section 2.2.
2. To complete the analysis, it is also necessary to dispose of candidates where the vowel loses its rounding or the dorsal shifts to another place of articulation. I assume that such candidates are dealt with by high-ranking faithfulness constraints.
3. If the underlying form /m̓oːq/ is assumed, the Delabialization rule applies only vacuously. Vacuous application is generally regarded as sufficient to trigger the EC, however.
4. The Bedouin Arabic vowel-height alternations present the same problem: a rule raising *a* to *i* when the next syllable contains *i* must take precedence over a rule lowering *i* to *a* after a guttural consonant (see note 11). Clearly, there is no specific/general relation between these rules either.
5. According to Klokeid (1977), the word that Campbell (1973) writes as *m̓oːq* in (5c) is actually pronounced *m̓oːq^w*. This is unlikely to be correct – Campbell refers to his own fieldwork with Nootka, but Klokeid evidently does not. In any case, it does not matter. Suppose the output is indeed *m̓oːq^w*. It is then necessary to supply a grammar that will map both /m̓oːq/ and /m̓oːq^w/ onto this output. From input /m̓oːq/, there is a DY derivation: /m̓oːq^w/ → *m̓oːq* → *m̓oːq^w*. In OT, the ranking ROUNDING >> UNROUNDING >> IDENT(round) accomplishes the same thing.
6. Even the highest-ranking constraint will be violated if Gen supplies no candidates that obey it. That situation probably never arises in phonology, where Gen meets the requirements of Inclusiveness (McCarthy and Prince 1993b: 5).
7. Merchant (1997) takes a different tack, reinterpreting the Catalan DY derivation $\alpha \rightarrow \beta \rightarrow \alpha$ as $\alpha \rightarrow \beta \rightarrow \gamma$, where α and γ are phonetically identical but structurally different. In his account, output *sublunar* has a single [+voice] specification shared by the *bl* cluster, but input /sublunar/ does not.

   Joan Mascaró (e-mail, February 24, 2000) informs me that Harris's Catalan example *sublunar* in (12) is problematic. Except for the orthographic [b], there is evidently no reason to assume that the final consonant of the prefix *sub-* is underlying voiced, since it also shows up as voiceless before a vowel. (The prevocalic behavior is analogous to compounds like *sud-est.*) Hence, it never occurs in a position where it could show a voicing contrast.

8. This line of attack on bleeding DY derivations would be foreclosed in any case where either UG does not supply the equivalent of the constraint *EAD or where independent evidence proves that *CA dominates *EAD. The derivation *puš* → *piš* → *puš* 'push' in Chomsky and Halle 1968: 294 is perhaps such a case, but the analysis is not worked out and seems dubious on its face (Zwicky 1974: 216).

9. I am grateful to Morris Halle, Harry van der Hulst, and Bill Idsardi for bringing up the Hebrew example. Compare Idsardi 1998 for an approach to these alternations based on different assumptions about the underlying representation.

10. The transcription has been simplified by suppressing indications of velar palatalization and contextual effects on the raised vowel. The data are drawn from the Ħarbi dialect carefully described and analyzed by Al-Mozainy (1976, 1981) (see also Al-Mozainy et al. 1985). (A text dictated by Al-Mozainy has been published in Ingham 1982: 112–115.) Similar data can be found in other Saudi Bedouin dialects, such as those in Johnstone 1967a, 1967b, Abboud 1979, and Prochazka 1988. The Levantine and North African Bedouin dialects described in Mitchell 1960, Blanc 1970, Irshied 1984, and Irshied and Kenstowicz 1984, differ significantly. The more familiar sedentary dialects of Arabic, such as those discussed by Kiparsky (this volume) and Wiltshire (this volume), are even more different, reflecting an ancient split between two dialect groups.

11. Al-Mozainy (1981) takes considerable care in establishing that the underlying forms given in (18) are correct. His most controversial claim is the vowel posited in the first syllable of /katab/ – underlying /a/, but always *i* or *Ø* on the surface. Three arguments support underlying /a/. First, a distinction between /a/ and /i/ is necessary to account for the different paradigms of /katab/ and its passive /kitib/. Observe that the presence or absence of a surface vowel between *k* and *t* is exactly complementary in these two paradigms. Second, there are paradigms where the initial *a* posited in /katab/ does show up, because there are conditions where raising is blocked (Al-Mozainy 1981, Irshied and Kenstowicz 1984, Gafos and Lombardi 1999, McCarthy 1999a):

(i) Conditions that block raising
Raising occurs in nonfinal light syllable:
/katab/ → *kitab*
Except
a. Before a guttural consonant (*ʔ, h, ʕ, ħ, ʁ, X*) or coronal sonorant (*r, l, n*) followed by *a*:

	/saħab/	saħab	'he pulled'
	/daras/	daras	'he studied'
cf.	/taʕib/	tiʕib	'he got tired'
	/šarib/	širib	'he drank'

b. After a guttural consonant:

/ʔakal/	ʔakal	'he ate'

Except before a high vowel:

/Xasir/	Xisir	'he lost'

Third, secret-language data demonstrate that the raising rule applies completely productively, with *a* or *i* in an open syllable depending on the blocking conditions just mentioned:

(ii) External evidence for raising and conditions on it
a. Root-consonant-permuting secret language:

difaʕ	'he pushed'	daʕaf, ʕadaf, faʕad, fidaʕ, . . .
ðarab	'he beat'	ðibar, ribað, barað, . . .
ðribat	'she beat'	rbiðat, bðarat, rðibat, . . .

b. Invented ħar-inserting secret language:
kitab 'he wrote' → kaħartab

12. As usual in Arabic, final superheavy syllables act like heavy penults and so receive stress: *maktú:b* 'written', *saħábt* 'I pulled'. See Kiparsky, this volume, and Wiltshire, this volume, for discussion.

13. Al-Mozainy (1981) reports syllabifications like *kti.bat* and *yak.tbin*, based on his own intuitions. Since surface degenerate syllables were not an option in the theory of the time, he had no choice but to assign the extra consonant to one of the visible syllables.

14. "Categorically less faithful" means that there must be a distinct high-ranking faithfulness constraint against the /A/ → C mapping. It is not enough for /A/ → C simply to accumulate more violations of the same faithfulness constraint that /A/ → B and /B/ → C violate.

15. According to Kirchner (1996), relative faithfulness is established by locally conjoining faithfulness constraints (in the sense of Smolensky 1995). Since any two faithfulness constraints can in principle be conjoined, this is an inherently richer theory than Gnanadesikan's scales.

16. See Morelli, this volume, for a fuller explanation of harmonic bounding under the rubric of "The Subset Strategy." Harmonic bounding was introduced in Samek-Lodovici 1992 and also figures prominently in Prince and Smolensky 1993: chapter 9 and Samek-Lodovici and Prince 1999.

17. A natural idea is to attempt some sort of reformulation of GrpHarm to prefer the ΔL foot of *(k.tí).bat* over the monosyllabic H foot of **(kát).bat* (cf. Black 1991). The problem is that any such move will interfere with the syncope process. Recall that the high vowel of /samiʕ-at/ deletes to yield *(sám).ʕat*. This speculative reformulation of GrpHarm would instead favor **(s.mí).ʕat*. The table in (i) makes this problem clear.

(i) Summary of the **(kát).bat* problem

Input:	/katab-at/	Input:	/samiʕ-at/
Actual output:	*(k.tí).bat*	Actual output:	*(sám).ʕat*
Failed candidate:	**(kát).bat*	Failed candidate:	**(s.mí).ʕat*

The failed candidate from /katab-at/ has exactly the shape of the actual output from /samiʕ-at/, and vice versa. This means that no markedness constraint(s) can successfully sort out these candidate comparisons. And the faithfulness system is not helpful either – the failed candidate **(kát).bat* is in fact more faithful (because it preserves /a/) than the actual output *(k.tí).bat*.

18. Because sympathy allows a nonsurface candidate to influence the outcome, it is sometimes suggested that sympathy is basically a restatement of the rule-based serial derivation. The differences between sympathy and rule-based serialism are the topic of sections 3.2 and 7 of McCarthy 1999b, and the treatment of opacity in serialized OT ("harmonic serialism") is covered in section 4 of McCarthy 2000a.

19. Other approaches to opacity in OT include local constraint conjunction (Kirchner 1996, Ito and Mester, this volume) and serially ordered levels (McCarthy and Prince

1993b: appendix, Cohn and McCarthy 1994, Potter 1994, Kenstowicz 1995, Booij 1996, 1997, Clements 1997, Kiparsky 1997a, 1997b, 2000, Noyer 1997, Paradis 1997, Roca 1997, Rubach 1997, 2000, Hale and Kissock 1998, Hale et al. 1998, Bermúdez-Otero 1999, Kiparsky, this volume). For discussion of these and other alternatives to sympathy, see sections 6.2 and 8 of McCarthy 1999b.

20. This ranking is introduced solely to pick out the right ❀-candidate; it is otherwise unmotivated.
21. I am greatly indebted to Alan Prince for discussion of this material.
22. Though described here in segmental terms, this approach can be generalized in obvious ways to handle moras, tones, and other nonsegmental structure.
23. The terms "comparable" and "noncomparable" come from the theory of partial orderings (see, e.g., Davey and Priestley 1990).
24. These constraints are relativized to the selector constraint, to allow for systems with multiple sympathetic candidates. See McCarthy 1999b on opacity in Yokuts, for example.
25. The notation A\B (or A–B) denotes the *relative complement* of B in A. It is the set of all elements of A that do not also belong to B.
26. I have suppressed the violations of the faithfulness constraint IDENT(stress), which are incurred when a vowel receives (or loses) a stress. Though stress is fully predictable in Bedouin Arabic, it is contrastive in some languages, and so there must be faithfulness constraints conserving it (McCarthy 1995, Pater 1995, Bye 1996, Ito et al. 1996, Alderete 1998, 1999, Inkelas 1999). Violations of IDENT(stress), although they do not affect the outcome in (41), are part of the package of unfaithful mappings that each candidate brings with it.
27. In fact, one can construct cases that have not only the look and feel but even the actual form of DY derivations. Under Richness of the Base, underlying representations may contain syllabic structure, allowing for the possibility of derivations like /pak.la/ → *pa.kla* → *pak.la*.
28. For a comprehensive analysis of Luganda within OT, see Rosenthall 1994.
29. In (47), I assume that epenthesis on the moraic tier is treated for indexation purposes like epenthesis on the segmental tier.
30. Since **mu.ⁿtu* is literally impossible in Luganda, it is necessary to show that it cannot be attained from any input, not just /muntu/. Of particular interest is the fully faithful mapping /mu.ⁿtu/ → **mu.ⁿtu*, which must somehow be excluded.

    In OT, prohibiting one mapping is a matter of ensuring that some other mapping from the same input is more harmonic. The more harmonic mapping then "occults" (Prince and Smolensky 1993) the less harmonic one. The seemingly easy task of occulting /muⁿtu/ → **mu.ⁿtu* with /muⁿtu/ → *muː.ⁿtu* is actually the wrong way to go, though, since the lengthening of the vowel cannot be explained. Rather, the right move is to map /muⁿtu/ unfaithfully onto *mu.tu*, simplifying the underlying prenasalized consonant. This reduces Luganda to a kind of chain-shift, with side effects on vowel length: /nt/ → *ⁿt* and /ⁿt/ → *t*. It is then a straightforward matter to apply the theories of chain-shifts reviewed in section 2.3.3.3. In fact, Gnanadesikan (1997: 139ff.) analyzes an exactly parallel case from Sanskrit, which she calls a coalescence "paradox."
31. These results were checked using the OTSoft package created by Bruce Hayes. It is available for download via http://www.linguistics.ucla.edu/people/hayes/otsoft.

32. This system does have some odd properties. Under some permutations, it will allow a contrast between moraic and nonmoraic preconsonantal consonants to emerge on the surface: /paTka/ → *paTka* versus /patka/ → *pat.ka*. Lexical contrasts like this do not seem to occur, perhaps because the evidence for them is so very indirect. And under some permutations, this system will map (only) nonmoraic preconsonantal consonants onto zero: /paTka/ → *paTka* versus /patka/ → *pa.ka*. This might offer a mora-based approach to certain kinds of ghost-segment behavior (cf. Clements and Keyser 1983, Zoll 1993).
33. I am greatly indebted to Elliott Moreton for discussion of this material.

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3

The Controversy over Geminates and Syllable Weight

Stuart Davis

3.1. Introduction

One of the major areas of research in syllable phonology is syllable weight; specifically, what types of syllables can function as heavy and how weight is represented. The moraic view of the syllable is a widely accepted approach for encoding syllable weight. Within this approach, it is generally agreed that a short vowel constitutes a single mora while a long vowel is bimoraic. With respect to consonants, however, there is a controversy over whether the difference between a single consonant and a geminate (long) consonant is one of inherent weight or of featural or other type of representation. On the one hand, Hayes (1989) posits the moraic theory of geminates whereby a geminate consonant is underlyingly moraic but a single consonant is not. On the other hand, Selkirk (1990) posits the two-root node theory of geminates whereby a geminate consonant is represented underlyingly as a consonant linked to two root nodes while a single consonant is linked to only one root node. In an earlier view of geminates, developed in Clements and Keyser (1983) and Hayes (1986), a geminate is represented as a consonant linked to two skeletal slots, but a nongeminate is represented as a consonant linked to a single skeletal slot. These three views are illustrated in (1)–(3), respectively. (The following abbreviations are used: UR = underlying representation, μ = mora, c = consonant, RN = root node, X = skeletal slot.)

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