Phonology Yearbook 2 (1985) 85–138
Printed in Great Britain

*Some consequences of Lexical Phonology**

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1 Principles of Lexical Phonology and their interaction

1.1 Introductory remarks

Phonological theory in recent years can be said to have undergone a 'modularisation' in several respects. The formal theory is no longer expected to explain everything about phonology by itself: generalisations about phonological change which previously were used to motivate constraints on abstractness or opacity have turned out to make more sense as effects of real-time language acquisition and use. Secondly, phonological representations have become multi-tiered arrays, and much that seemed problematic about the application of rules has resolved itself in terms of properties of these arrays. Lastly, phonology itself is seen as applying both within the lexicon to the output of each morphological process, and to the output of the syntactic component. The lexicon, moreover, may itself be organised into a hierarchy of levels, each constituting a quasi-autonomous morphological and phonological domain. In this paper I propose to investigate some consequences of this third kind of modularisation, the approach which has come to be known as LEXICAL PHONOLOGY.

Lexical Phonology raises certain questions concerning learnability. Given the evidence for a phonological rule, how does the child determine whether it applies lexically or postlexically, and if lexically, at what level? In part, surely, from the direct evidence of forms in which the rule is applicable. But the more interesting part of the answer is that the application of rules at different points in the grammar is subject to different regulative principles, such as the Strict Cycle Condition and Structure Preservation. They probably do not suffice to determine outright where and how a rule is to apply, but they do significantly restrict the range of arbitrariness. The test of the proposed principles is whether they correctly account for the domain and mode of application of rules and allow them to be formulated in a simpler and more general way. In this paper I examine a number of cases where the same rule, or similar rules, apply both lexically and postlexically, and argue that the domain and mode of application are indeed to a considerable extent predictable. In non-lexical treatments these cases appear as duplications of rules or other unexplained complications of the phonological system.

The paper is organised into three sections. The first section presents a version of Lexical Phonology and demonstrates the role of the Strict Cycle Condition, Structure Preservation, and underspecification by means of relatively unproblematic examples. In the remainder of the paper the theory is applied to more challenging material, Russian voicing assimilation (§2) and a series of harmony systems (§3).

Aside from supporting the approach of Lexical Phonology, the results bear more particularly on two issues. One is the issue of 'local *vs.* global or large-scale transmission of phonological information'. Both Russian voicing assimilation and the harmony systems to be examined in §3 have been adduced as arguments for extending hierarchical tree structure to certain processes which have hitherto been treated as 'segmental' or 'autosegmental'. The power of such metrical structure lies precisely in its capacity for global or large-scale transmission of phonological information, and I shall argue that Lexical Phonology eliminates the apparent need for this extra power in each case, paving the way for a return to the conception of unbounded processes as iterations of local applications of a rule.

The second issue is the nature of phonetic implementation rules, and the possibility that all 'postlexical rules' really belong in this category (Liberman & Pierrehumbert 1984). I argue that at least some postlexical processes are truly phonological, feature-changing rules. I further suggest that even gradient application might not suffice to ban a process from the phonology, on the grounds that such gradient postlexical processes are in a number of interesting cases the same as rules which apply categorically in the lexical phonology of the same language, and that their gradience might be predictable as a general property of the postlexical application of certain types of rules. However, I do not at this point have any idea about how representative this situation is and I put forward these preliminary explorations with some misgivings, simply in the hope of providing a basis for further discussion.

1.2 Lexical Phonology

In English, most phonological rules operate either at only one level of the lexicon or postlexically. Moreover, in the cases where there is overlap between the rules at different levels, or between lexical and postlexical rules, the rules are found to apply in somewhat different ways. For example, lexical assimilation of nasals in English is obligatory, confined to 'feet', and transfers major points of articulation only, while postlexical assimilation is optional, does not care about stress, and transfers the exact place of articulation of the following consonant. These considerations led me to suppose that the phonological rules at each level of the lexicon and in the postlexical component constitute essentially independent mini-phonologies (Kiparsky 1982). Impressed with the much greater overlap between the levels in Malayalam, Mohanan (1982) viewed the phonology as a single unitary system, where each rule is marked for the domain in which it is applicable, with the restriction that this domain must be a

continuous set of levels. More recent investigations suggest that severely restrictive principles govern the application of lexical rules. In many cases, it becomes possible to treat a lexical and a postlexical process as a single rule in spite of radical differences in mode and scope of application, because the differences are predicted by those principles. The picture that emerges is one in which the phonology – lexical and postlexical – is a single system of rules, which however requires much less marking of domains than was supposed. It may, in fact, be possible to restrict the marking of domains to specifications of the form 'rule R does not apply after level *n*'. In general, when a rule is restricted to apply only at the word level or only postlexically this will be found to follow from general constraints on the lexical application of rules.

The specific constraints that will be important for us here involve three properties of lexical rules:

(a) cyclic application;
(b) restriction to 'derived environments';
(c) Structure Preservation.

Their close relationship has been recognised on empirical grounds for some time. As the theoretical link between (a) and (b), Mascaró (1976) proposed a form of the Strict Cycle Condition to the effect that cyclic rules apply only to things to which they have become applicable in the current cycle. He linked (a) and (c) by stipulating that a rule is cyclic if and only if it is a non-automatic neutralisation rule, i.e. a subclass of rules which is by definition structure preserving. Lexical Phonology suggests a more intrinsic connection between the three properties by virtue of the idea that phonological rules apply in the lexicon after every morphological operation, the output becoming a derived lexical item which can undergo a further layer of derivation. (a), (b) and (c) can be related under this assumption in the following way. Since the rules of Lexical Phonology are sandwiched between successive morphological operations, they are intrinsically 'cyclic'. Their restriction to derived environments can be seen as a special case of Blocking, understood in Aronoff's (1976) sense as a disjunctive relation between lexical entries. Thus the application of Vowel Shortening to *paint*, *pint*, *mount* is blocked by the existence of these very items specified in the lexicon with long vowels, while the rule does apply to *meant*, because the input /mēn+t/ is not a lexical item (though the output /mĕnt/ and the stem /mēn/ are). Structure Preservation is the result of constraints formulated over the entire lexicon. For example, if a certain feature is non-distinctive in a language we shall say that it may not be specified in the lexicon. This means that it may not figure in non-derived lexical items, nor be introduced by any lexical rule, and therefore may not play any role at all in the lexical phonology.

Besides replacing the earlier specially postulated connection between properties (a)–(c) by a principled one, we also achieve a truer picture of the facts. If neutralisation is no longer a criterion for cyclicity, then we predict that there can be postlexical neutralisation rules, which must apply across the board. In this way we admit just that class of 'absolute

neutralisation' rules which the facts appear to demand. Conversely, there can now be lexical – and therefore cyclic – non-neutralisation rules, such as metrical rules applying cyclically to metrically unstructured representations. The cyclic stress and syllabification rules of many languages (Hayes 1981; Harris 1983; Steriade 1982) are therefore no longer an embarrassment. Moreover, if 'strictness' is attributed to Blocking among distinct representations of a lexical entry, then such non-structure-changing applications of rules *should* apply in non-derived environments. The massive violations of the Strict Cycle Condition seen in those cases are exactly what is predicted by our new conception.

1.3 The Strict Cycle Condition

Because of its traditional connection with the abstractness controversy and the Alternation Condition, discussion and motivation of the Strict Cycle Condition (SCC) has tended to focus on the blocking of rules in non-derived lexical representations, such as the failure of Trisyllabic Shortening to apply morpheme-internally, as in *nightingale*. It must however be said with all possible emphasis that the SCC is essential to *any* cyclic phonology, irrespective of those cases, in order to permit counterfeeding order among cyclic rules. Suppose that A, B are cyclic rules, where B could feed A but in fact does not. We can block feeding on the same cycle by ordering A before B, but only the SCC can prevent the output of B from undergoing A on the *next* cycle. Rubach (1981) contains many examples of this point, of which I cite the following. Polish has a rule which primarily affects nouns and turns stem-final -*ś* into the prepalatal (high) fricative [ɕ]:

(1) *Nominal Strident Palatalisation* (NSP)

$$\begin{bmatrix} +\text{strident} \\ +\text{continuant} \\ -\text{anterior} \\ -\text{voiced} \end{bmatrix} \rightarrow [+\text{high}] \,/\, \text{—} \begin{bmatrix} +\text{syllabic} \\ -\text{back} \\ +\text{high} \end{bmatrix}$$

NSP accounts for the alternations seen in (2):

(2) kapelusz (-*ś*) 'hat', kapelus+ik [ɕ] 'little hat', kapelus+isk+o 'big hat'
grosz 'monetary unit', gros+ik (dim.), gros+iw+o (augment.)

Rubach also motivates a rule which turns underlying velars [k g x] into strident palatals [č ǰ š] before front vowels:

(3) *First Velar Palatalisation* (FVP)

$$\begin{bmatrix} +\text{obstr} \\ -\text{coronal} \\ +\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{high} \\ +\text{coronal} \\ +\text{strident} \end{bmatrix} / \text{—} \begin{bmatrix} -\text{cons} \\ -\text{back} \end{bmatrix}$$

This rule is involved in such alternations as:

(4) krzyk 'a shout', krzycz + e + ć [č] 'to shout'
strach [x] 'fear', strasz + y + ć [š] 'to tighten'
miazg + a 'squash', miażdż + y + c [ǰ] 'to squash', miażdż + e 'I squash'

That NSP precedes FVP is shown by the fact that [š] from FVP does not become [ɕ] by NSP:

(5) gmach [x] 'building', gmasz + ysk + o [š] 'big building' (by FVP, does not become *gmas + isk + o by NSP)

However, Rubach demonstrates that both rules are cyclic, and so the SCC is needed to block NSP from applying the second time around in derivations such as (6):

(6)	[kapeluš + isk]	[gmax + isk]
NSP	ɕ	–
FVP	–	š
	[kapeluɕ + isk + o]	[gmaš + isk + o]
NSP	–	BLOCKED
FVP	–	–

It is this type of case which constitutes the original and compelling motivation for the SCC, quite independent of the abstractness issue or of Lexical Phonology (cf. Chomsky 1973; Kean 1974).

Setting aside the problem of relating the SCC to morphological Blocking and to the Elsewhere Condition (Kiparsky 1982), let us reformulate it as follows:

(7) *Strict Cycle Condition* (SCC)
If W is derived from a lexical entry W′, where W′ is nondistinct from XPAQY and distinct from XPBQY, then a rule A → B / XP—QY cannot apply to W until the word level

Since the output of each cycle is a (derived) lexical entry, the cyclic application of NSP in (6) to $[[\text{gmaš} + \text{isk}]_{N}\text{o}]_{N}$ is blocked by the fact that $[\text{gmaš} + \text{isk}]_{N}$ is a lexical entry which satisfies (7) with respect to NSP. Such cases as the failure of Trisyllabic Shortening in non-derived words like *nightingale* work the same way.

Further, the SCC does not restrict word-level applications of rules. Hence lexical rules at the last level of the phonology apply 'across the board'. Rules such as Trisyllabic Shortening cannot apply at the word level because they are – on independent grounds – restricted to level 1, and therefore always observe the SCC. It seems that in English all rules which apply after level 1 can apply across the board, suggesting that level 2 is in fact the word level in English. A typical case is the simplification of final /mn/:[1]

(8) a. damn + ation, damn + able, damn + at + ory, hymn + al, hymn + ody, hymn + ology (*n* retained before level 1 suffixes)
b. damn/ # ing, damn/ # s, damn/, hymn/ # ing, hymn/ # # index (*n* deleted elsewhere)

This could be done by a phonological rule such as (9):

(9) $n \rightarrow \emptyset / [+\text{nasal}]—]$

Given Bracketing Erasure at the end of level 1 (9) will correctly fail to delete *n* in (8a) if applied anywhere after level 1. Because of the SCC, (9) can only apply at the word level. It will apply to (8b) if we assume either that level 2 is the last level, or, if there are more than two levels, that there is no Bracketing Erasure after level 1. Both alternatives seem plausible, and so there is no reason to believe that facts like those in (8) are inconsistent with the SCC.[2]

The most interesting cases are those where one and the same rule applies cyclically in derived environments and at the word level in non-derived environments, as dictated by the SCC. I shall summarise an example of this type from Icelandic (see Kiparsky 1984 for a more detailed presentation and justification of the analysis in the context of the rest of the phonology). The data of interest are typified by the partial paradigms of the nouns /dag/ 'day', /bylj/ 'snowstorm', /lifr/ 'liver', representing stems in /-C/, /-Cj/ and /-Cr/ respectively. Their composition with case endings at level 1, and with clitics at level 2, is illustrated with dat. pl. /um/, nom. masc. sg. /r/, acc. sg. (null), and the enclitic article /inn/, /ina/ (nom. and acc. sg.):

(10)

dag + um	→ dögum	bylj + um	→ byljum
dag + r	→ dagur	bylj + r	→ bylur
dag	→ dag	bylj	→ byl
dag + r # inn	→ dagurinn	bylj + r # inn	→ bylurinn
dag # inn	→ daginn	bylj # inn	→ bylinn

lifr + um → lifrum
(does not take -*r*)
lifr → lifur
(does not take -*r*)
lifr # ina → lifrina

We require the rules (11)–(13):

(11) σ
|
x
|
$j \rightarrow \emptyset$

(12) *Syllabification*

(13) σ
|
x
|
$\emptyset \rightarrow u$ / — r

Icelandic does not permit either [-Cj] or [-Cr] codas. It eliminates the first by deleting the unsyllabifiable [j] and the second by inserting a [u] into the cluster. As predicted by the SCC, *j*-deletion can only apply at the word level since its environment can never be 'derived', and, again as predicted by the SCC, *u*-epenthesis applies cyclically in derived environments (e.g. *dagur*, *dagurinn*) and at the word level in non-derived environments (e.g. *lifur*, *lifrina*). This is crucial for deriving the right forms; furthermore, it is essential that Syllabification follow *j*-deletion but precede *u*-epenthesis. See the def. acc. sg. *bylinn*, *lifrina* and def. nom. sg. *dagurinn*:

(14)	/bylj/	/lifr/	/dag/
level 1: morphology	—	—	dag + r
j-deletion	BLOCKED	—	—
syllabification	bylj	lifr	dag + r
u-epenthesis	—	BLOCKED	dagur
level 2: morphology	bylj inn	lifr ina	dagur inn
j-deletion	ø	—	—
syllabification	by linn	lif ri na	da gu rinn
u-epenthesis	—	—	—

Note that unlike the earlier formulation of the SCC in Kiparsky (1982), (7) does not allow the loophole of non-structure-changing applications creating 'derived environments' for lexical rules to apply in. Consequently we can no longer have stress and syllable structure feeding lexical rules on the first cycle. The earlier version clearly had unwanted effects anyway. For example, Trisyllabic Shortening is conditioned by stress, but why does stress assignment not create a derived environment allowing Trisyllabic Shortening to apply in *nightingale*? The 'stricter' SCC (7) now blocks the rule from applying, as desired. In the Spanish cases discussed by Harris (1983) (e.g. $[\text{desden}]_N\text{es}]_N$ *vs.* $[\text{desdeñ}+\text{oso}]_A$) this then entails that the rule:

(15) ñ → n in the syllable coda

is confined by the SCC to the word level. And this gives the right result if it is ordered before syllabification.

We have seen how a rule may apply at different places in different ways

as determined by the respectively applicable principles, in this case the SCC. Thus Icelandic *u*-epenthesis is restricted to derived environments cyclically and applies across the board at the word level, predicting the intricate pattern in (10). Considerably more spectacular divergences of this sort can be found in the lexical *vs.* postlexical application of rules. To pursue this point we turn to conditions that regulate the marking of features in the lexicon as a whole, and to the role of underspecification.

1.4 Structure Preservation and underspecification

The SCC now allows non-structure-changing applications of lexical rules even in non-derived environments. We have noted as one consequence that this correctly lets metrical structure be assigned on the first cycle. Actually we have here just a special case of a more general property of the SCC. It permits *any* lexical rule to fill in the values of lexically unspecified features. This eliminates the category of 'morpheme structure rules', together with the notorious problems that go along with it. We shall suppose that lexical representations are governed by two systems. The first is simply the set of rules of Lexical Phonology themselves, including both language-particular rules and universal rules such as those which supply the unmarked value for each feature. These supply the 'default' specifications for lexical entries. On this view, every feature specification entered in the lexical representation of a morpheme is really an instruction that some particular 'default' rule is not to apply. Thus the specification [+voiced] in the first segment of *bit* blocks the universal rule that makes obstruents [−voiced]. The *i* and *t* are lexically unspecified for voicing and receive their respective values by the universal default rules.

The second system governing lexical representations comprises CONDITIONS on what feature values may be marked. In English, for example, voicing is distinctive for obstruents but not for sonorants. We express this by a marking condition which prohibits voicing from being marked on sonorants in the lexicon:

(16) $*\begin{bmatrix} \alpha\text{voiced} \\ +\text{son} \end{bmatrix}$

A language in which voicing is entirely non-distinctive would have the marking condition:

(17) *[αvoiced]

By STRUCTURE PRESERVATION I mean that marking conditions such as (16) and (17) must be applicable not only to underived lexical representations but also to derived lexical representations, including the output of word-level rules.[3]

Structure Preservation implies that (16) not only blocks voiceless sonorants from appearing in underlying representations and lexical derivations but also blocks the redundant specification [+voiced] from being assigned to sonorants in lexical derivations. Only the former would result from the weaker formulation of the marking condition shown in (16′):

(16′)* $\begin{bmatrix} -\text{voiced} \\ +\text{son} \end{bmatrix}$

A language with (16′) would allow the default rule as well as language-specific rules to voice sonorants within the lexical phonology. We shall see in §2 that Russian clearly requires the stronger constraint (16), and it appears that the same is true of English. I will tentatively assume that conditions of the type (16) are the unmarked case but conditions of the type (16′) are also allowed, though the question obviously needs much more thought.

Structure Preservation contributes to the restrictiveness of phonological theory since it determines point-blank that any rule which introduces marked specifications of lexically non-distinctive features must be post-lexical. Thus the various rules for aspiration, glottalisation, intonational features, etc., in English could not be lexical. From the viewpoint of learnability this is an important constraint because it means that the learner does not have to fix the domain of these rules by checking their ordering or other properties.

Underspecification and Structure Preservation have considerable importance for the formulation of phonological rules. One theme of subsequent sections of this paper will be to pursue their implications and to demonstrate their explanatory power. First let us give a few simple examples of the general idea.

Going back to voicing in English, the marking condition (16) entails that voiced obstruents and sonorants form a natural class [+voiced] only in the postlexical phonology of English. In the lexical phonology sonorants remain unspecified for voicing and their union with voiced obstruents would require a disjunctive specification {[+son], [+voiced]}. By the same token, the class of voiced obstruents can be specified in the lexical phonology simply as [+voiced], but needs the additional specification [−sonorant] in the postlexical phonology.

In line with this we find that lexical voicing assimilation in English is triggered by, and applies to, obstruents (18a) but not sonorants (18b):

(18) a. a[d z], a[p s], (*a[tz], *a[bs]), wi[t + θ]

b. to[k n], a[p l], war[m + θ]

Postlexical voicing assimilations in English can both apply to sonorants (see (19a)) and be triggered by them (see (19b)):

(19) a. c[r̥]y, p[l̥]ay, sp[l̥]it
b. back[t], bagg[d], bann[d], kidd[id]
back[s], bag[z], bell[z], bush[iz]

The postlexical status of (19a) is evident. I take (19b) to be postlexical too, on account of its applicability to the reduced forms of the auxiliaries *is*, *has*. The point is that the final obstruent becomes voiced after *any* voiced segment, whether obstruent or sonorant.

It follows that if a rule applies both lexically and postlexically, it may operate on a different set of inputs and yield a different set of outputs because of Structure Preservation and underspecification. We shall be examining a series of cases of this type below.

There are two different types of postlexical rules, exemplified respectively by (19a) and (19b). The former is essentially phonetic in nature. Its output is gradient and variable. The devoicing is not necessarily complete; it may extend over only the initial portion of the sonorant, depending on such factors as the degree of aspiration on the preceding consonant and the rate and care of speech. This is a prime candidate for the status of phonetic implementation rule, as proposed by Liberman & Pierrehumbert (1984), Clements (1981) and Harms (1973). In contrast, the voicing of the final obstruents in (19b) seems phonological: it does not diminish in monitored speech but, on the contrary, extends more fully over the whole fricative: [bɛlz] (careful speech), [bɛlzz̥] (less careful speech). So the voicing is truly phonological but is in turn partially overlaid by a gradient *phonetic* process of 'final devoicing'.

However, the distinction between postlexical phonological and phonetic processes is by no means clear-cut. We shall find that gradient processes which propagate to form a 'cline' in many cases appear to be simply the postlexical applications of rules which in the lexicon function in strictly categorical fashion, suggesting that the distinction between 'phonology' and 'phonetic implementation' is to some extent at least a matter of how rules apply rather than their inherent content.

It is possible to make some tentative generalisations about *when* postlexical rules will function categorically and when they will function gradiently:

(i) Context-sensitive rules which override lexical marking conditions have gradient outputs (e.g. the devoicing of sonorants in (19a)).

(ii) Rules (usually context-free) which assign default values have categorical outputs (e.g. the default specification of voicing of sonorants, or the rules specifying labial fricatives as labiodental, coronals as alveolar, etc.).

(iii) Rules which assign lexically markable feature values are normally categorical (e.g. the voicing assimilation in (19b)). In some cases, though, there are indications that the process is really gradient articulatorily but is *perceived* as categorical – naturally enough if the output falls within the range of realisation, or reasonably close to it, of otherwise existing lexical segment types in the language. More on this below.

1.5 Catalan Nasal Assimilation

As a simple example of a rule functioning with different effects in the lexical and postlexical phonology, consider nasal assimilation in Catalan, as described by Mascaró (1976). Nasals assimilate in place of articulation to a following consonant. /n/ assimilates to all positions (but see note 10):

(20)	unassimilated alveolar:	so[n] amics	'they are friends'
	labial:	so[m] pocs	'they are few'
	labiodental:	so[ɱ] feliços	'they are happy'
	dental:	so[n̪] dos	'they are two'
	alveolar:	so[n] sincers	'they are sincere'
	postalveolar:	so[n̠] rics	'they are rich'
	laminopalatal:	so[n,] [ž]ermans	'they are brothers'
	palatal:	so[n,] [ʎ]iures	'they are free'
	velar:	so[ŋ] grans	'they are big'

The other three lexical nasals are /m/, /ŋ/, /ɲ/. Of these, /m/ assimilates only to a following labiodental, and the high nasals /ŋ/ and /ɲ/ do not assimilate at all:

(21)	/m/:	so[m] amics	'we are friends'
		so[m] pocs	'we are few'
		so[ɱ] feliços	'we are happy'
		so[m] dos	'we are two'
		etc.	
	/ŋ/, /ɲ/:	ti[ŋ] pa	'I have bread'
		a[ɲ] feliç	'happy year'
		etc.	

The second rule that concerns us here, Cluster Simplification, deletes stops in consonant clusters. At the end of a word, Cluster Simplification applies regardless of whether a vowel, a consonant, or a pause follows:

(22)	a.	[kámp] [és] → kám és	'the field is'
	b.	[kámp] [sígi] → kám sígi	'the field were (subj.)'
	c.	[kámp] → kám	'the field'

Inside words, Cluster Simplification takes place before consonants but not before vowels. This holds true both when a suffix follows (see (23)) and when a clitic follows (see (24)):

(23)	a.	/kamp + s/ → [káms]	'fields'
	b.	/kamp + ɛt/ → [kampét]	'little field'
(24)	a.	/súr̄t # li/ → [súr̄ li]	'go out to him'
	b.	/súr̄t # i/ → [súr̄t i]	'go out there'

We shall assume that both suffixes and clitics are added in the lexicon, at level 1 and level 2 respectively. Simplification is restricted to homorganic clusters:[4]

(25) a. subject to Cluster Simplification: mp, nt, lt, ŋk, rt, st
b. not subject to Cluster Simplification: lp, lk, rp, rk, sp, sk

Let us suppose that stops delete by being detached from their syllable slots in homorganic tautosyllabic clusters and then deleting by convention at word level:[5]

(26) *Cluster Simplification*

[place features]

The facts of (22)–(24) are derived if Cluster Simplification applies at the word level and is ordered after Syllabification. It does not apply cyclically in the lexicon, as shown by [[súr̄t] i] → [súr̄t i] (*[súr̄ i]); see (24b). It does not wait until the postlexical phonology since it would then be bled by resyllabification across word boundaries in cases like (22a). From our present point of view, nothing needs to be said about the domain of application of Cluster Simplification in order to derive this configuration of data. We can simply let the rule apply freely, subject to the principles of the theory. Its cyclic application is blocked by the Strict Cycle Condition, it does apply at the word level, and postlexically it will simply be vacuous for lack of inputs.

At this point a non-lexical phonology runs into an ordering problem. The Nasal Assimilation rule described above must precede Cluster Simplification, because it creates the homorganic clusters to which Cluster Simplification applies, and because a nasal before a deleted stop maintains its assimilated form:

(27) /kaNp/ → kámp → kám *camp* 'field'
/bɛNk/ → béŋk → béŋ *venc* 'I sell'
/biNt/ → bínt → bín *vint* 'twenty'

However, when the application of Cluster Simplification creates a word-final nasal, this nasal becomes subject to Nasal Assimilation before a following consonant:

(28) bint pans → bím páns 'twenty breads'

No single ordering of the two rules will give the right result, as shown by Mascaró's example *venc vint pans* [béŋ bím páns] 'I sell twenty loaves of bread':

(29)	/bɛNk	biNt	pan + s/
Nasal Assimilation	ŋ	n	n
Cluster Simplification	ø	ø	–
	béŋ	*bín	páns

(30)	/bɛNk	biNt	pan + s/
Cluster Simplification	ø	ø	–
Nasal Assimilation	m	m	–
	*bém	bím	páns

Rather, Cluster Simplification must apply between the word-internal and phrasal applications of Nasal Assimilation. Having previously established that Cluster Simplification is in the lexicon (where it can only apply at word

level as predicted by the SCC), we conclude further that Nasal Assimilation is both lexical and postlexical:

(31)	/bɛNk	biNt	pan+s/
lexical:			
Nasal Assimilation	ŋ	n	n
Cluster Simplification	ø	ø	–
postlexical:			
Nasal Assimilation	–	m	–
Cluster Simplification	–	–	–
	bɛ́ŋ	bím	páns

This means that Nasal Assimilation also has an unrestricted domain. The only thing that needs to be said in the grammar is that it precedes Cluster Simplification (feeding order).

There is, however, an apparent difficulty. We saw in (20) that coronal obstruent stops are dental, and preceding nasals assimilate to that position, both within words and in phrasal combinations:

(32) biN̪t̪+ɛ → bi[n̪t̪]ɛ 'twenty'
son d̪os → so[n̪ d̪]os 'they are two'

Therefore – a point that was suppressed in (27) above – the question is why we get /biNt/ → bi[n], and not /biNt/ → *bi[n̪], like /kaNp/ → ka[m].

The right forms are derived if the *lexical* application of Nasal Assimilation takes place at a point when the coronals are still *unspecified* with respect to dental *vs.* alveolar place of articulation. If the *-t* of /bint/ is merely a generalised coronal in the lexical phonology, and deletes at the word level as explained above, it never has a chance to acquire a dental specification, let alone pass it on to the preceding *n* by Nasal Assimilation. In fact, exactly this state of affairs is predicted by Structure Preservation. Being lexically non-distinctive, the dental/alveolar contrast should not play any role in the lexical phonology, and its specification will not take place until the postlexical phonology.

Turning to the Nasal Assimilation process itself, the outstanding question that we wish to answer is why only the coronals assimilate to all places of articulation, while the labials assimilate only in a limited way and the palatals and velars do not assimilate at all, as seen in the data of (20)–(21). The answer, again, is that the coronal nasals, being unmarked, are unspecified for place of articulation when Nasal Assimilation applies, and that Nasal Assimilation associates specified (and therefore marked) feature values or autosegments with segments that do not carry those feature values or autosegments.

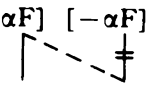
In order to accomplish this we must be able to do several things. We must keep the default rules at bay up to the point where Nasal Assimilation applies postlexically. On the assumptions of § 1.2 we cannot simply restrict rules to the postlexical domain. However, in this case the required effect can be obtained by means of the appropriate marking conditions in the lexicon, such as *[+coronal]. Secondly, we must be able to distinguish, even in the postlexical phonology, between two kinds of rules: rules which

only fill in values for unspecified features (both default rules and, on our proposed interpretation, Nasal Assimilation belong in this category), and rules which apply across the board (neutralisation rules). In Kiparsky (1982) I assumed that all postlexical rules are of the latter type, but some evidence that both types exist has meanwhile become available.[6] So, assuming, on the strength of the arguments of Halle & Vergnaud (1980), Steriade (1982), Harris (ms) and others, that assimilation is to be treated autosegmentally, we shall suppose that a rule of the form:

(33) 

is to be interpreted as associating the autosegment [αF] with slot B, provided that B is not already associated with [−αF]. (In addition, the association will of course be blocked if a marking condition applicable at that point prohibits the association of [αF] to B.)

This does not mean that we disallow 'feature changing' assimilation rules which spread [αF] in the place of an existing association to [−αF]. We shall, however, assume that such rules are the marked case and formulate them as delinking-cum-spread operations:

(34) 

in environment P

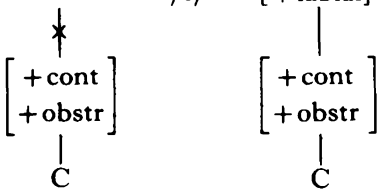
The interpretation of (34) is as follows: if B is in environment P and is linked to [−αF], delink [−αF]. If B follows A and A is linked to [αF], spread [αF] to B. The operations are independent in that [−αF] will be delinked even if A is not linked to [αF], and spread of [αF] from A to B will take place even if B is not originally linked to [−αF].

Behind this notation lie two basic generalisations about the relationship between assimilation and neutralisation. One is that assimilation processes tend to be paired with neutralisation processes which apply in corresponding contexts when there is no feature to assimilate to. For example, assimilation of syllable-final nasals to the place of articulation of a following sonorant is characteristically associated with neutralisation of syllable-final nasals when no consonant follows, i.e. at the end of a word. The other is the observation of Clements & Ford (1979) that when an association is destroyed, the element which conditions the delinking has precedence in reassociation.

The third requisite for our proposal to work out is some way to refer to unmarked segments such as coronals in the lexical phonology. By our assumption coronals are not associated with a [+coronal] melody in the lexical phonology, but surely there may be rules in which they must be singled out as a class. We shall assume that they can be referred to as consonants that have no specification on the tier of place features. This is

analogous to the way that toneless vowels can be referred to in tonological rules (Pulleyblank 1983). So /s/ and /f/, for example, can be singled out as in (35):

(35) /s/ /f/ [+labial]



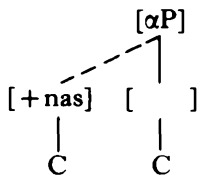
The Catalan facts can now be dealt with as follows. Catalan has four places of articulation. They can have several possible minimal lexical specifications, depending on which features are chosen as basic. I will suppose that the basic features are [high], [back], and [labial], on the grounds that they also figure in the vowel system:

(36)

	labials	coronals	palatals	velars
high			+	+
back			−	
labial	+			

The nasals in *camp*, *vint*, *venc* will thus be unspecified for place of articulation and will acquire their place features from the following consonant by the Nasal Assimilation rule, which we now formulate as in (37):

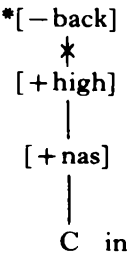
(37)



where P ranges over the place features. Being non-feature-changing, the lexical application of (37) in non-derived environments is permitted by the SCC. The nasals in *camp*, *vint*, *venc* thus get the specifications in (36) from the consonant to their right.

The velar nasal /ŋ/ only occurs before /k/ and /g/ lexically.[7] This restriction is reflected by a marking condition that restricts velar nasals to linked matrices:

(38)

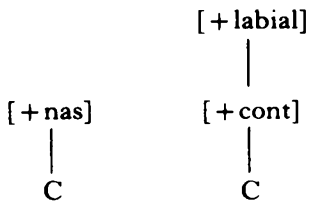


in an unlinked matrix

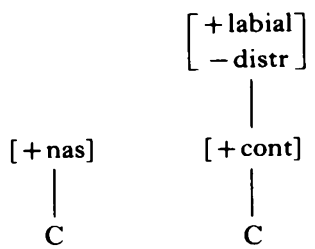
When not assimilated, unspecified nasals, like other consonants unspecified for place of articulation, are assigned the unmarked feature values [−labial], [−high], [−back], [+coronal], etc. If we block these default values from being assigned lexically, the Elsewhere Condition will guarantee that they will not be assigned in the postlexical phonology until after Nasal Assimilation has applied there. Being still unspecified for place of articulation when Nasal Assimilation applies, coronals at that point satisfy the structural description of (37). In this way we relate the unmarked status of the coronals to the fact that they alone assimilate to all other points of articulation.[8]

The detailed place of articulation features are determined postlexically by two sets of rules. The first set of rules determines the place of articulation for consonants having a particular manner of articulation. Among the coronals, the strident segments become laminopalatal ([š ž č ǰ]), *r* becomes postalveolar, *t* and *d* dental, and the rest alveolar; the labial fricative *f* becomes labiodental. The second set of rules determines the default values of the place features irrespective of manner of articulation. Nasal Assimilation applies *after* the first set and *before* the second.[9] The derivation of *son feliços* → *so[ŋ] feliços* 'they are happy' therefore runs as follows:

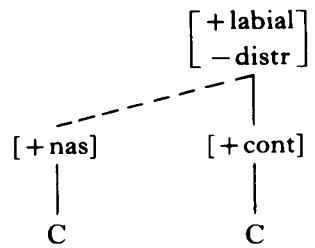
(39) output of postlexical phonology



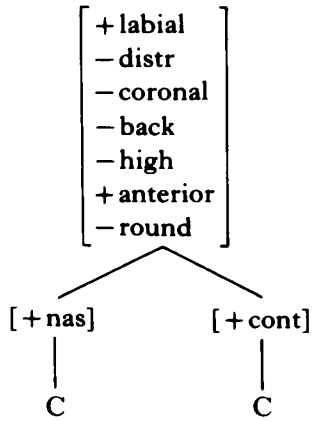
labiodental specification of *f*



Nasal Assimilation

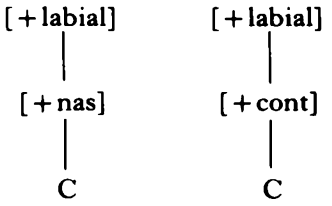


default rules

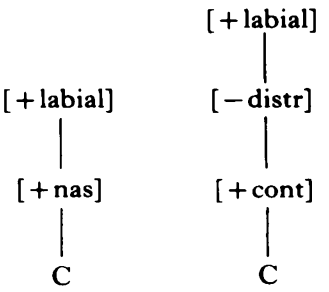


Assuming Steriade's (1982) Shared Features Convention (a version of the Obligatory Contour Principle) the derivation of *som feliços* → *so[m] feliços* 'we are happy' proceeds as shown in (40):

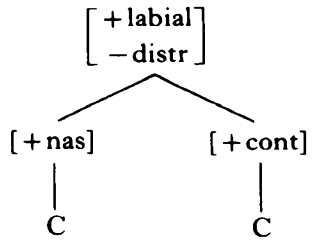
(40) output of postlexical phonology



labiodental specification of *f*

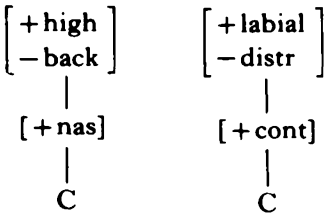


Nasal Assimilation and Shared Features Convention



followed by Default assignment as before. Assimilation cannot take place e.g. in *á[ɲ]feliç* 'happy year'. The relevant stage in the derivation is:

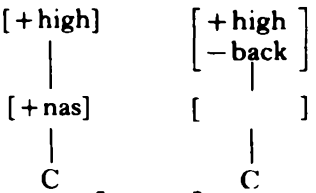
(41)



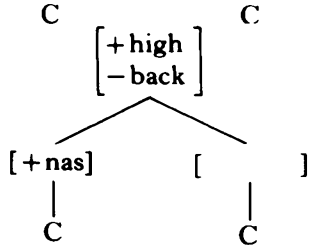
at which point (37) is blocked because the configuration [+high, + labial] is banned by a marking condition both lexically and postlexically.

Significantly, there is no assimilation in combinations of a velar nasal and a palatal such as [ɲ] or [ʎ].[10] Why does the configuration (42a) not end up as (42b) by the Shared Features Convention and Nasal Assimilation, as in the formally parallel (40)?

(42) a.

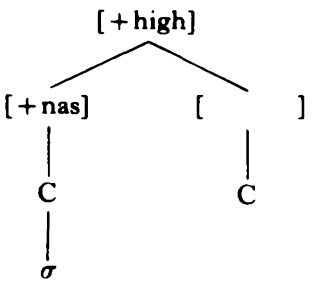


b.



The solution lies in the special status of [ŋ] in the system. Given the marking condition (38), Structure Preservation *prohibits* the [k] after [ŋ] from being deleted at word level. More precisely, given that Cluster Simplification is a dissociation of a final consonant from its syllabic slot, as formulated in (26), followed by its deletion by convention at word level, (38) and Structure Preservation entail that [-ŋk] may undergo the first step, but not the second. Then the initial postlexical representation for [-ŋ] is actually:

(43)



and Nasal Assimilation from a following [+high, −back] consonant is blocked.

There is still another piece of evidence for the floating velar stop after a final velar nasal. Final [-ŋk] is unique among all the clusters in (25a) in that the [k] may float on to a following word, contrary to the pattern of (22a). Thus we have:

(44) [kamp] [es] → kam es 'the field is'
[baŋk] [es] → baŋk es 'the bank is'

This floating is permitted within a phrase but not across a heavy syntactic boundary:

(45) el ba[ŋk] obre 'the bank opens'
si obre el ba[ŋ] obre la botiga 'if the bank opens, the shop opens'

Because of (38) and Structure Preservation, the [-k], though dissociated from its syllable slot by Cluster Simplification (26), may not be deleted at word level. Accordingly it may 'dock' as the onset of a following word-initial vowel by resyllabification in the postlexical phonology. If this does not happen, as when a syntactic boundary intervenes or the next word begins with a consonant, the [-k] is deleted by convention postlexically, where (38) no longer holds.

In conclusion, Catalan Nasal Assimilation can be stated in the minimal form (37) under the assumptions of Lexical Phonology, in particular the key principles sketched out in §§1.2–1.4 above: that rules may apply lexically and again postlexically, that structure-changing applications of lexical rules in non-derived environments are confined by the Strict Cycle Condition to the word level, that lexical phonology in its entirety is structure preserving, and that lexical representations are underspecified.

2 Russian voicing assimilation

In this section we shall apply the principles of § 1 to the notorious problem of voicing assimilation in Russian.

The basic facts are briefly as follows. Final obstruents are devoiced:[11]

(46) sad + a → sa[d]a 'garden' (gen. sg.)
sad → sa[t] (nom. sg.)

A sequence of obstruents assimilates in voicing to the last, word-internally as well as across clitic boundaries and full word boundaries:

(47) gorod + k + a → goro[tk]a 'little town'
mcensk # by → mcen[zg b]y 'if Mcensk'
mcensk # # byl → mcen[zg b]yl 'it was Mcensk'

Final Devoicing feeds Voicing Assimilation:

(48) mozg → mo[sk] 'brain'

Sonorants are 'transparent' to Voicing Assimilation:

(49) iz #mcensk+a → i[s mc]enska 'from Mcensk'
ot #mzd+y → o[d mzd]y 'from the bribe'

The labial fricative /v/ patterns as an obstruent in some ways and as a sonorant in others. Like other obstruents, it undergoes Final Devoicing and Voicing Assimilation:

(50) zdorov → zdoro[f] 'healthy'
krivd → kri[ft] 'justice' (gen. pl.)
korov+k+a → koro[fk]a 'little cow'

But like sonorants it does not trigger Voicing Assimilation:

(51) o[t v]raga 'from the enemy'
o[t n]auki 'from science'

even where it is itself devoiced to [f]:

(52) trezv → tre[zf] 'sober'

and like sonorants it is transparent to Voicing Assimilation:

(53) ot vdov+y → o[d vd]ovy 'from the widow'
ot vtor+ogo → o[t vt]orogo 'from another'

The phonology of Russian independently motivates deriving [v] from underlying /w/ (Jakobson 1948; Halle 1973; Lightner 1972). On this basis explanations for its special behaviour with regard to voicing have been proposed by Jakobson (1956, 1968, 1978), Coats & Harshenin (1971), Halle & Vergnaud (1981), and Hayes (1984). I shall summarise Hayes' proposal, since it is the most recent as well as the simplest and most complete in coverage.

The essence of Hayes' solution is that *all* sonorants – including /w/ – undergo Final Devoicing and Voicing Assimilation, but become revoiced by a late rule, in fact a rule of phonetic implementation. Only /w̥/ is not subject to this revoicing process, because it becomes an obstruent by the prior application of the rule /w̥/ → [f], /w/ → [v].

Hayes assumes, then, that all sonorants are specified as [+voiced] prior to the operation of the phonological rules, presumably by the redundancy rule in (54):

(54) [+son] → [+voiced]

He also assumes that Russian has no /v/, though /f/ is phonemic. Generalising this to */ɣ/ *vs.* /x/ we might then have the redundancy rule in (55):

(55) $\begin{bmatrix} +\text{obs} \\ -\text{cor} \\ +\text{cont} \end{bmatrix} \rightarrow [-\text{voiced}]$

Hayes proposes the following phonological rules:

(56) *Final Devoicing*
$C \rightarrow [-\text{voiced}] / \text{—}\ \#$

(57) *Sonorant Syllabification*
$\begin{bmatrix} +\text{son} \\ +\text{cons} \end{bmatrix} \rightarrow [+\text{syll}] / \ \# \text{—} C$

(58) *Voicing Assimilation*
Assimilate all consonants in a cluster to the voicing of its rightmost obstruent

(59) *Sonorant Assimilation*
$[+\text{son}] \rightarrow [+\text{voiced}] / \text{—}\ \#[+\text{son}]$

(60) *W Strengthening*
$\begin{bmatrix} C \\ -\text{cons} \\ +\text{labial} \end{bmatrix} \rightarrow [-\text{son}]$

(61) *Fast Speech Devoicing* (opt.)

$C \rightarrow [-\text{voiced}] / \text{—} \begin{bmatrix} C \\ -\text{voiced} \end{bmatrix}$

(62) *Sonorant Revoicing*
$[+\text{son}] \rightarrow [+\text{voiced}]$

The following illustrative derivations are taken from Hayes:

(63)	a. w skważine	b. tolst#li
Voicing Assimilation	w̥ skw	l̥st l
W Strengthening	f skv	—
Sonorant Revoicing	—	lst l
	c. s wami	d. jazw
Final Devoicing	—	zw̥
Voicing Assimilation	—	—
W Strengthening	s v	zf
	e. iz mcenska	f. bez wpuska
Voicing Assimilation	s n̥c	s w̥p
W Strengthening	—	s fp
Sonorant Revoicing	s mc	—

In support of his generalisation of Final Devoicing and Voicing Assimilation to sonorants, Hayes notes that sonorants may actually be pronounced as voiceless just where Final Devoicing or Voicing Assimilation would on his analysis have applied to them: *rta* [ɽt] 'mouth', *mysl'* [sl̥'] 'thought', *kontrfors* [ɽfoɽs] 'buttress'. If Avanesov (1972) is right, this option is available only in certain environments, particularly next to voiceless segments, and not, for example, in such cases as *byl* 'was'. So we should reformulate Sonorant Revoicing in something like the following way:

(62′) *Sonorant Revoicing*
[+son] → [+voiced]
Optional in fast speech under certain conditions, such as next to a voiceless segment. Obligatory elsewhere.

Hayes moreover argues plausibly that Sonorant Revoicing is not a phonological rule of Russian anyway, but a rule of phonetic implementation. That is, the sonorants devoiced by Final Devoicing and Voicing Assimilation are maintained as [−voiced] in phonetic representation and the phonetic realisation of [−voiced] specifies a laryngeal configuration which prohibits vocal cord vibration for obstruents but permits it for sonorants. Given that other languages have phonetically voiceless sonorants under different circumstances than Russian does, this means that the phonetic realisation rules for voicing may have to be in part language-particular. Language-particular rules of phonetic implementation have, however, been argued for on other grounds (Harms 1973; Liberman & Pierrehumbert 1984).

Hayes needs the rules of Sonorant Assimilation and Fast Speech Revoicing because of the following additional facts.

Word-finally, both original obstruents and /v/ are devoiced, and remain so before a following sonorant. Hence we have (after jer-deletion):

(64) zdorow	→ zdoro[f]	'healthy'
zdorow lew	→ zdoro[f l]e[f]	'Lev is healthy'
rad	→ ra[t]	'happy'
rad lew	→ ra[t l]e[f]	'Lev is happy'

Before sonorant clitics, however, /v/, like the other sonorants, shows up as voiced, while underlying obstruents are always voiceless:

(65) zdorow #li	→ zdoro[v l]i	'healthy?'
rad #li	→ ra[t l]i	'happy?'

Since the otherwise motivated rules in Hayes' system would predict *zdorofli*, he requires the further rule of Sonorant Assimilation – given as (59) above. If this is ordered between Voicing Assimilation and W Strengthening, we get the right forms, as in (66):

(66) Final Devoicing	zdorow̥ #li
Voicing Assimilation	–
Sonorant Assimilation	w
W Strengthening	v
	zdorovli

Hayes intimates that Sonorant Assimilation is independently motivated by the fact that *other* final sonorants do not exhibit voiceless variants before sonorant clitics either. Thus we presumably have:

(67) mir #li → mi[r l]i (*mi[r̥ l]i) 'is it peace?'
bobr #li → bo[br l]i (*bo[br̥ l]i) 'is it a beaver?'

But in view of the above discussion concerning the conditions on Sonorant Revoicing (62) and its status as a phonetic implementation rule, it is entirely possible that the obligatory voicing of the sonorants in contexts such as (67) follows from the proper formulation of that rule and does *not* require a special rule of Sonorant Assimilation. The latter rule would then have to be added to Hayes' system solely for the sake of /v/. To settle this point we require more detailed phonetic information.

A further fact to be covered is that regressive Voicing Assimilation in fast speech is sometimes triggered by devoiced sonorants:

(68) jazw → ja[zf] ~ ja[sf] 'wound'
žizn' → ži[zn'] ~ ži[sn'] 'life'
bobr → bo[br] ~ bo[b̥r] ~ bo[p̥r] ~ bo[pr] 'beaver'

As shown by [žisn'], this can happen even when the sonorants themselves are implemented with vibration of the vocal cords, confirming Hayes' contention that they are 'really' [−voiced] phonetically in the positions predicted by Final Devoicing and Voicing Assimilation. (The four forms for *bobr* are implied by Hayes' rules, but again there may be more detailed conditions on the implementation of voicing in sonorants.) To derive these forms, Hayes cannot simply extend Voicing Assimilation to be triggered by sonorants as well as obstruents, on pain of overapplication:

(69) knjaz' → *[g]njaz' 'prince'
prokljast' → *[b]ro[g]ljast' 'to curse'

He therefore adds the rule of Fast Speech Devoicing ((60) above), which must be ordered before Sonorant Revoicing:

(70)

	jazw
Final Devoicing	w̥
Voicing Assimilation	–
W Strengthening	f
Fast Speech Devoicing	s
	jasf

Finally, there is a similar stylistic option when Voicing Assimilation operates across a sonorant:

(71) i[s mc]enska ~ i[z mc]enska
o[d mzd]y ~ o[t mzd]y

Hayes suggests that this is due to the optional syllabification of the intervening sonorant (by (57)) applying crucially before Voicing Assimilation. This concludes our summary of Hayes' analysis.

Within Lexical Phonology, two assumptions in particular are crucial to the analysis of these facts. The first is that phonological rules apply in the lexicon as well as postlexically to combinations of words. The second is that lexical applications of rules are governed by certain principles which do not apply to postlexical applications. These principles include the Strict Cycle Condition and Structure Preservation. The cases of the latter that

are relevant here concern the lexical neutralisation of voicing in sonorants and noncoronals. The Russian lexicon is subject to the conditions on marking given in (72):

(72) a. * $\begin{bmatrix} \alpha\text{voiced} \\ +\text{son} \end{bmatrix}$ (cf. (16))

b. * $\begin{bmatrix} +\text{voiced} \\ -\text{cor} \\ +\text{cont} \end{bmatrix}$

which are binding both on underlying representations and on each step in lexical phonological derivations, including the output of the lexicon.

With these assumptions, the rules can be reduced to the following:

(73) *Final Devoicing*
$C \rightarrow [-\text{voiced}] / —]$

(74) *Voicing Assimilation*
Assimilate all consonants in a cluster to the voicing of its rightmost consonant

(75) *Default Voicing*
$[\alpha\text{son}] \rightarrow [\alpha\text{voiced}]$

(76) *W Strengthening*
$\begin{bmatrix} +\text{labial} \\ -\text{cons} \end{bmatrix} \rightarrow [-\text{son}]$

I have purposely left (74) unformalised for the time being and will return to it in a more general context below.

I shall assume that the Russian lexicon contains at least two levels, level 1 containing derivation and inflection and level 2 containing clitics. The above rules are not restricted to apply either postlexically or lexically, or at any particular level of the lexicon. They are free to apply wherever they can, provided the principles of the theory allow it. These principles will constrain their application in the following way.

Final Devoicing can apply at the word level only. The cyclic application of Final Devoicing is blocked by the Strict Cycle Condition. Its word-level application is allowed because the SCC does not extend to word-level applications of rules. This is clearly correct since we have [gorod] → *goro[t]* but [[gorod]a] → *goro[d]a*, not **goro[t]a*. Final Devoicing is blocked at level 1 by the SCC and is no longer applicable at the word level to *goroda* because Bracketing Erasure has removed the stem brackets at the end of level 1.

Lexical applications of Devoicing and Voicing Assimilation affect obstruents only and are triggered by obstruents only. This follows from Structure Preservation, since voicing may not be specified on sonorants anywhere in the lexicon. Postlexically, both rules affect and are triggered by sonorants as well as obstruents. Even though they apply quite differently in the lexicon and postlexically, they are the same rules, and can be stated

identically, because the differences follow from general principles which govern the two domains.

Default Voicing is the 'elsewhere' case to Voicing Assimilation and Final Devoicing. It supplies the values [−voiced] and [+voiced] respectively to those obstruents and sonorants which have not been already specified as [+voiced] or [−voiced], either lexically or by the application of these earlier lexical rules. By Structure Preservation, it applies lexically only to obstruents, postlexically to sonorants. Lexically it assigns the unmarked value [−voiced] to all obstruents which are not either marked [+voiced] in the lexicon or become [+voiced] by Voicing Assimilation, and postlexically it assigns the unmarked value [+voiced] to all sonorants which have not undergone Voicing Assimilation or Final Devoicing. Default Voicing is a universal rule that is part of the grammar of every language. Not only the rule itself but also its order is fixed given the rest of the system. Being the 'elsewhere' case it must apply directly after the special rules of Voicing Assimilation and Final Devoicing, which assign values of voicing in particular contexts.

Our rule of Default Voicing, then, does *not* correspond to Hayes' Sonorant Revoicing rule, but to the segment structure rule which in his solution would assign redundant voicing to all sonorants *prior* to the application of his rules (56)–(61). Like Hayes I view 'Sonorant Revoicing' not as a feature-changing rule of phonology but as a rule of phonetic implementation, albeit with Russian-particular conditions as noted above.

Finally, W Strengthening can only apply postlexically. For the voiced case ([w] → [v]) this follows from Structure Preservation (no/v/'s in the lexicon, and more generally no non-coronal voiced continuants, cf. (55)); for the voiceless case [ʍ] → [f] it follows because the input [ʍ] only arises postlexically, as explained above.

Since we do not have the rules of Sonorant Assimilation and Fast Speech Devoicing, how do we account for the relevant data? The contrast of [zdoro[v]]li] *vs.* [[ra[t]]li] (see (65)) is already predicted by rules (72)–(75). The nominative singular forms are underlying /SdOROW+Ŭ/, /RAd+Ŭ/. The Strict Cycle Condition restricts the rule of jer-deletion:

(77) ĭ, ŭ → ø

to the word level. On level 1 nothing happens except for Voicing Assimilation. The derivation then continues:

(78) *level 2*

morphology: clitics	[zdOROWŬ]LI]	[[RAdŬ]LI]
phonology (word level):		
jer-deletion	ø	ø
Final Devoicing	–	t
Voicing Assimilation	–	–
Default Voicing	–	–
W Strengthening	–	–

Bracketing Erasure	[zdOROWLI]	[RAt LI]
postlexical phonology:		
Final Devoicing	–	–
Voicing Assimilation	–	–
Default Voicing	[zdorowli]	[ratli]
W Strengthening	v	–
	zdorovli	*ratli*

Final Devoicing in *zdorovli* is blocked lexically by Structure Preservation and postlexically because Bracketing Erasure at the end of the lexicon has eliminated its context. Contrast the phrase:

(79) [SdOROW] [LEW] → zdorof lef 'Lev is well'

where the final /w/'s of both words are devoiced postlexically before the external word bracket (which of course is not touched by Bracketing Erasure).

There is also a variant *zdoro[f] li*, with devoicing of /w/ before the clitic. For many speakers this is the preferred pronunciation. It can be derived by treating the clitic as a syntactic entity in its own right, a possibility which exists also for other clitics (see (84)–(85) below).

We noted in § 1.4 that postlexical rules may apply in gradient fashion, particularly when they contravene the lexical marking conditions. Although I know of no relevant instrumental evidence, both the impressionistic phonetic reports in the literature and certain phonological facts suggest that exactly this is the case for Russian voicing. Jakobson (1968) gives a very explicit discussion of how *f* is pronounced when it undergoes Voicing Assimilation (recall that by Structure Preservation *f* can only be voiced postlexically). Contradicting earlier reports that voiced *f* is simply always identical with *v*, Jakobson maintains that 'in explicit style' *f* does not undergo full Voicing Assimilation, but rather is subject to one of two types of *partial* assimilation: (1) 'lenition' or (2) extension of vocal cord vibration to the final portion of the *f*. He reports that many Moscow speakers whom he consulted clearly distinguished, in this style, between such minimal pairs as (80):

(80) drof by 'if bustards' (gen. pl.) ~ drov by 'if firewood' (gen. pl.)
Lef by 'if LEF (the Left Front)' ~ lev by 'if the lion'

In the 'elliptic subcode' the difference is suppressed, and both are pronounced with [v]. Other writers have reported partial voicing for other consonants as well. Isačenko (1955) states: 'The pronunciation of the sequence *rež' bulku* with [žb] is unusual. Before [b] there appears a sound whose beginning is voiceless, but which towards its end may become voiced as a result of the vibration (*Exkursionstätigkeit*) of the vocal cords in preparation for the phonation of [b].' Halle (1959: 64) comments: 'my own observations include cases like the one described by Isačenko, but these appear to be no more common than cases with entirely voiced clusters'.

If postlexical Voicing Assimilation establishes a 'cline' within the assimilated segment, which can extend part way into it or penetrate the whole segment, as these remarks indicate, then *a fortiori* there should be such a cline in a string of successively assimilated consonants. That is, the degree of (de)voicing should decrease in proportion to the distance from the triggering (rightmost) consonant. In the light of this we can account for the option between *tre[zf]* and *tre[sf]* (from /trezw/) without any special rule such as Fast Speech Devoicing. Voicing Assimilation simply extends further to the left in the consonant cluster in fast speech:

(81) a. dro[v b]y dro[f͡v by]

b. tre[s w̥] tre[z͡s w̥]

We can easily extend this interpretation to the variation in (82), so that the Sonorant Syllabification rule also becomes otiose:

(82) a. i[s m̩c]enska i[z m̩c]enska

b. o[d mzd]y o[t mzd]y

This predicts a parallel variation before /w/:

(83) i[s fk]lada i[z v͡fk]lada

o[d vd]ovy o[t vd]ovy

If this is correct, then a syllabification rule could certainly not be involved, as we would derive **uklad*, **udova* for *vklad*, *vdova*.

Finally, for some clitics there is yet another stylistic option, more grammatical in nature, namely of treating them as full words by themselves. Jakobson (1956) and Halle (1959: 64) observe that proclitics have non-palatalised final consonants and lack a stress of their own, properties which correlate with the absence of final devoicing:

(84) clitic:	[bez[okná]]	→ be[z] okná	'without the window'
independent word:	[blíz'] [okná]	→ blí[s'] okná	'near the window'

A preposition like *čerez* works both ways:

(85) clitic:	[čeriz [oknó]]	→ čeri[z] oknó	'through the window'
independent word:	[čériz'] [oknó]	→ čéri[s'] oknó	'through the window'

Given the bracketing option the phonology follows. The analogous option for the enclitic *-li* was mentioned above (*zdoro[v~f]li*).

Our lexical analysis makes a further interesting prediction. Suppose there were lexical exceptions to Voicing Assimilation. Since postlexical rules cannot have lexical exceptions (Mohanan 1982), and since postlexical Voicing Assimilation applies in gradient fashion, it ought to be the case that those words surface with the kind of fluctuation seen in (81) and (82). It seems that there is indeed one type of word that fits the bill, namely truncated abbreviations like *Mosgazproekt* 'Moscow gas works', *politbjuro* 'politbureau'. As Shapiro (1966) summarises:

> Alekseev (1963: 24–26) records pronunciations like *mosgazproekt* [-sg-] 'Moscow gas works' and *kožgalanterejnyj* [-šg-] 'leather goods', but reports that the expected assimilation also occurs in these examples; i.e. there is some vacillation. Further, Alekseev attests the greater frequency of *Mosbank* [-zb-] 'Moscow bank', *politbjuro* [-db,-] 'Politburo', *speczadanie* [-3z-] 'special assignment', etc., as compared to pronunciations without assimilative voicing. This vacillation is also indirectly reflected by Avanesov *et al.* (1959).

To summarise, we can eliminate the rules of Sonorant Syllabification, Sonorant Assimilation, and Fast Speech Devoicing from the phonology, obtaining their effects from independently given facts about how Voicing Assimilation applies postlexically, which moreover fits well into the general picture that is emerging of postlexical rules. Like Hayes, we assume that Sonorant Devoicing is also a matter of phonetic implementation.

In addition to eliminating these rules, our lexical formulation allows a simpler version of Voicing Assimilation. It need no longer be restricted to a string of consonants whose last member is an obstruent, but can apply to any string of consonants whatever. The operation of Voicing Assimilation is shown in (86):

(86) *level 1*

phonology:	[MCENSK]	
Final Devoicing[12]	MCENSk	
Voicing Assimilation	MCENsk	
Default Voicing	McENsk	
W Strengthening	–	
morphology: inflection	[[McENsk]A]	[[McENsk]Ŭ]
phonology	–	–
Bracketing Erasure	[McENskA]	[McENskŬ]

level 2		
morphology: clitics	[Iz[McEnskA]]	[[McENskŬ]bY]
phonology:		
jer-deletion		
Voicing Assimilation	[Is[mcEnskA]]	[[mcEnzg]bY]
Bracketing Erasure	[IsmcEnska]	[mcEnzgby]
postlexical		
phonology:		
Default Voicing	[ismcenska]	[mcenzgby]

More important than this simplification of Voicing Assimilation, however, is the fact that our version of the rule is fully compatible with the interpretation of unbounded processes as *iterations of local processes*. This view of long-distance propagation is supported by the well-known observation that processes only propagate when the target is itself a trigger of the rule (Anderson 1974; Howard 1972; Jensen & Stong-Jensen 1976; Johnson 1972; Kenstowicz & Kisseberth 1977; Vago & Battistella 1982; etc.). That is, we require a theory which predicts that by a rule such as Sanskrit *n*-retroflexion:

(87) n → ṇ / r — (on the [+coronal] projection)

/r...n...n/ necessarily becomes [r...ṇ...n] and not [r...ṇ...ṇ]:

(88) /varn + anā + nām/ → varṇanānām (*varṇaṇāṇām) 'descriptions' (gen. pl.)

If we allow rules such as:

(89) n* → ṇ / r —

not to speak of the metrical trees proposed by Halle & Vergnaud (1982) for harmony rules, we simply cannot have this prediction.

Russian Voicing Assimilation has been the main thorn in the side of proponents of the iterative view of long-distance propagation, since it actually seemed to show that the prediction is false in at least one instance. But Russian now submits to be a strictly local iterative formulation of the rule. The importance of the analysis offered above is therefore that it clears the empirical way for reinstating this more restrictive, and therefore *a priori* more desirable theory of unbounded rule application in phonology.

Since Russian Voicing Assimilation has figured so prominently in the debate on the phonemic level, a final remark on the relationship between our lexical representations and structuralist phonemic representations may be appropriate. With regard to the classic point of contention itself, our position should satisfy both parties. The output of the lexical phonology contains of course the voiced obstruents /b d g ž.../, but it does *not* contain the voiced allophones of the phonemes that lack a phonemic voiced counterpart, namely /č/, /c/, /x/, and in our analysis also /f/.[13] But neither

do we require two separate Voicing Assimilation rules: we have a single rule which applies both lexically and postlexically with different results as dictated by the principles of the theory. Thus we obtain a level of representation where the lexically distinctive properties are encoded without compromising the simplicity and generality of the description.

However, our lexical representations do differ from standard post-Bloomfieldian phonemic representations. In the first place, they do not show the application of Voicing Assimilation across word boundaries, even in those cases where this effects a neutralisation. Secondly, they show *v* as a glide /w/. This is perhaps not something that classical phonemics would expressly forbid, but it is motivated by considerations which were not supposed to play a role in establishing the phonemic level. Thirdly, we view features not as distinctive or non-distinctive *tout court* but as distinctive or non-distinctive in classes of phonemes defined by other features. For example, voicing is non-distinctive in sonorants. Therefore lexical representations do not show voicing for sonorants. Fourthly, since Structure Preservation forces Vowel Reduction (e.g. unstressed /a o/ → [ʌ] or [ə] depending on the context, as in [zdʌróf]) into the post-lexical phonology, the reduced vowels [ʌ ə] do not show up in lexical representations. In taxonomic phonemics, biuniqueness forces [ʌ ə] either to be assigned to a separate phoneme or to be identified with *one* of the source vowels, either /a/ or /o/.

These similarities and differences between lexical representations and phonemic representations are illustrated in the following examples (where capitalisation indicates unspecified voicing):

(90)	underlying	lexical	phonemic	phonetic
	[[SdOROW]U̍]	[zdORÓW]	/zdaróf/	[zdʌróf]
	[[[SdOROW]U̍]bY]	[zdORÓWbY]	/zdaróvby/	[zdʌróvby]
	[[MOSg]U̍]	[MÓsk]	/mósk/	[mósk]
	[[[žEg]tI̍]bY]	[žÉčbY]	/žéčby/	[žéǯby]
	[[[dA]tI̍]bY]	[dÁt'bY]	/dád'by/	[dád'by]

Our lexical representations are closer to 'naive' phonemics as it developed prior to the period when the insistence on discovery procedures led to the imposition of requirements such as biuniqueness. In any case their theoretical status is quite different, since they are motivated not by intuition or *a priori* considerations but by the abstract principles that govern the application of phonological rules in the lexical and postlexical components of the grammar.

3 Some harmony systems

Vowel harmony and related unbounded harmony phenomena are interesting test cases for Structure Preservation. Harmony commonly applies in systems with phonemic inventories that are skewed in that the harmonising feature is lexically distinctive for some of the segments and non-distinctive

for others. By Structure Preservation the latter type of segment should not undergo harmony lexically. An example will make this point clear. Finnish has [±back] vowel harmony operating in a vowel system containing three distinctively [+back] vowels *a*, *o*, *u*, three distinctively [−back] vowels *ä*, *ö*, *y*, and two redundantly [−back] vowels *i*, *e*. The prediction is that lexical Vowel Harmony in Finnish may not apply to *i*, *e* to create the ninth and tenth vowels *[i], *[ɤ]. Logically there is no reason why such harmony systems should not exist, and so it is certainly remarkable that no clear instance of them is known.[14]

In this section I shall examine some instances of *pairs* of harmony processes which look as if they might be the lexical and postlexical applications of the same rule. Here too our approach will obviate the need for the metrical treatment of harmony which some of these processes have previously been claimed to require. We shall find as before that some kinds of postlexical processes are firmly phonological, feature-changing operations, while others function as rules of phonetic implementation, the crucial difference apparently being whether they respect or break the lexical marking conditions of the language.

Kaye (1982) endorses the position that some harmony processes are metrical in nature, while others are autosegmental. In support he cites Vata, a language of the Ivory Coast, as an example of a language in which *both* kinds of vowel harmony are separately instantiated. I shall attempt to show that both processes can very well be stated autosegmentally, and may even be the lexical and postlexical versions of the same rule. For this I draw exclusively on the data in Kaye's article; space does not permit a full reworking of the wealth of interesting material that it contains, however, and the reader is urged to consult it at first hand.

Vata has ten vowels, five [+Advanced Tongue Root] and five [−Advanced Tongue Root]:

(91)

[+ATR]			[−ATR]	
i	u		ɪ	ʊ
e	o		ɛ	ɔ
	ʌ			ə

All vowels in a word must be either [+ATR] or [−ATR]. Each member of a compound is a separate harmonic domain. Kaye takes [+ATR] as the spreading autosegment and assumes that every vowel on the segmental tier is specified as [−ATR], which will be realised unless the vowel becomes associated with [+ATR], which by convention overrides the segmental specification [−ATR]. In line with our approach we shall assume that [−ATR] is itself an autosegment, but one which is not subject to spreading and which is added as the 'default' value to vowels which have not received [+ATR]. Lexically, stems may be associated with [+ATR]; this is spread bidirectionally on to all stem vowels and associated affixes, which may not carry lexical [+ATR].

Thus we assume the following rules:

(92) *Vowel harmony*
Spread [+ATR]

(93) *Default rule*
Associate [−ATR]

Both rules apply maximally and only to vowels not already associated with [αATR]. To illustrate, the instrumental–locative suffix /lɛ̄/ materialises as [lē] by spreading after [+ATR] stems and as [lɛ̄] by the default rule after non-[+ATR] stems, as in (94), where 'A' denotes [Advanced Tongue Root]:

(94) a. +A +A

pI + lɛ̄ → pɪ̄ + lɛ̄ = [pīlē] 'prepare with'

b. −A

ɓlɪ̄ + lɛ̄ → ɓlɪ̄ + lɛ̄ = [ɓlīlɛ̄] 'sing in'

In addition to this word-bounded harmony of the familiar type, Vata has a process which optionally spreads [+ATR] leftwards across word boundaries. Observe the variants with [a] and [ʌ] in (95a) and (95b):

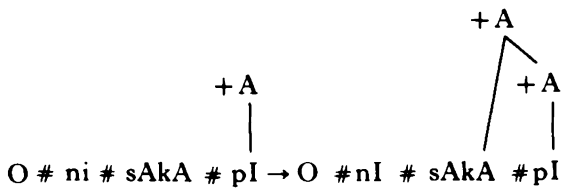
(95) a. ɔ̀ nɪ sàká pì 'he didn't cook rice'
b. ɔ̀ nɪ sàkʌ́ pì
c. *ɔ̀ nɪ sʌ́kʌ́ pì

The [−ATR] word *sàká* 'rice' may assimilate its second vowel to the following [+ATR] word *pì*. Only word-final syllables undergo this process (see (95c)). However, in a sequence of monosyllabic [−ATR] words the assimilation may propagate arbitrarily far to the left:

(96) a. ɔ̀ ká zā pī 'he will cook food'
b. ɔ̀ ká zʌ̄ pī
c. ɔ̀ kʌ́ zʌ̄ pī
d. ɔ̀ kʌ́ zʌ̄ pī

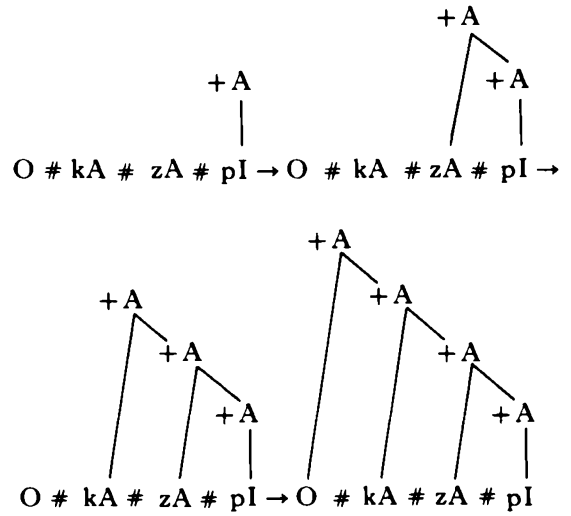
Kaye proposes to deal with this process, following Halle & Vergnaud's (1981) treatment of directional harmony, by constructing binary right-dominant metrical trees. The right branch of the trees dominates a floating [+ATR] autosegment and the left branch dominates a V slot which is not associated with [ATR]. The feature [+ATR] percolates up from the right branch to the root and down again to the left branch. In order to account for the local spreading to polysyllables (95) *vs.* the iteration in monosyllables (96), Kaye further supposes that these trees may only be constructed across a word boundary, but that given this condition the construction of trees may be iterated. Each step in this iteration is optional:

(97) a.



(no further tree construction possible)

b.



This metrical account can be directly reformulated in autosegmental terms if we recognise the distinction between the two types of spread shown in §1.5 in (33) and (34). The postlexical spread of [+ATR] would then be an optional delinking-cum-spread rule of type (34), applying iteratively from right to left. The distinction between (96) and (97) would be reflected by a condition restricting the rule to applying across a word boundary. We can identify this rule with Vowel Harmony itself by allowing the postlexical application of this rule to delink [−ATR].

Though this suffices for the point I shall be making, let us consider in passing another variant of the autosegmental account, which makes use of the idea that peripheral syllables may remain unassociated with suprasegmental structure. In the domain of stress and syllabification, extrametricality has been amply justified by Hayes (1981), Harris (1983), and others. Pulleyblank (1983) has already pointed out that it is required for tone as well. He shows that word-initial and/or word-final tone-bearing elements in some languages do not accept a tone by spreading in the lexicon, but receive it postlexically from a neighbouring word or by a default rule. In Vata, then, word-final syllables are analogously 'extraharmonic' and receive [+ATR] from the next word by postlexical application of Vowel Harmony or, failing that, receive [−ATR] by the Default Rule.

I shall refer to 'extrametrical', 'extratonal', and 'extraharmonic' elements by the more neutral and general term EXTRAPROSODIC. I further

make the following assumptions, which (except perhaps for (d)) are standard and well supported in the theory of stress, syllable structure, and tone:

(98) a. Only single units (syllables, segments) may be designated as extraprosodic.
b. An element may be marked as extraprosodic inherently in a lexical entry or by a rule in the phonology.
c. Such marking is only permitted in peripheral positions. An element automatically loses its extraprosodic status when it ceases to be peripheral, as for example by affixation.
d. An element automatically loses its extraprosodic status at the end of the lexicon. (It may, however, be marked again as extraprosodic postlexically if the rule applies there and if it is peripheral in its phrasal domain.)

The leftward spreading of [+ATR] across word boundaries is then achieved by adding to the lexical phonology, between Vowel Harmony and the Default Rule, a rule that marks final vowels as extraprosodic. We then have the derivations in (99), where parentheses show that a vowel is extraprosodic:

(99) *Lexical phonology*

				+A
Vowel Harmony	O	nI	sAkA	pI
				+A
Extraprosodicity	(O)	n(I)	sAk(A)	p(I)
			−A	+A
Default rule	(O)	n(I)	sAk(A)	p(I)
			−A	+A
(by convention (98d))	O	nI	sAkA	pI
Postlexical phonology			−A	+A
Vowel Harmony	O	nI	sAkA	pI
	−A	−A	−A	+A
Default Rule	O	nI	sAkA	pI
	[ɔ	nɪ	sakʌ	pī] (95b, 97a)

The optional status of spreading can be obtained in two ways. We can either suppose that the rule which makes final vowels extraprosodic is optional, or that it is obligatory but the convention removing Extraprosodicity at the word level (98d) is itself optional, or perhaps is dependent on some prosodic conditions which may themselves hold optionally (such as close contact between adjoining words). If the option of applying (or retaining) Extraprosodicity is not taken, we derive the other variant [ɔ nɪ saka pī] (95a). The impossible form (95c) *[ɔ nɪ sʌkʌ pī] is excluded because only final syllables are extraprosodic.

All variants in (96) are directly predicted. Each of the monosyllabic words [ɔ], [ka], [za] may optionally be extraprosodic, and the extent of the leftward spread of [+ATR] depends on which of them actually are. The derivations of (96a) and (96d) (assuming the first option mentioned in the last paragraph) are shown in (100):

(100) a. *Lexical phonology*

				+A
Vowel Harmony	O	kA	zA	pI
Extraprosodicity		—		
	−A	−A	−A	+A
Default rule	O	kA	zA	pI

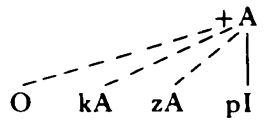
Postlexical phonology (no rule applies)

[ɔ ka za pi] (96a)

b. *Lexical phonology*

				+A
Vowel harmony	O	kA	zA	pI
				+A
Extraprosodicity	(O)	(ka)	(za)	pI
Default rule		—		
				+A
(by convention (98d))	O	kA	zA	pI

Postlexical phonology



Vowel Harmony

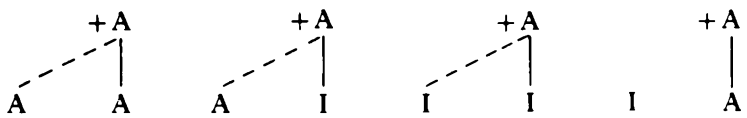
Default rule —

[o kʌ zʌ pi] (96b)

Thus extraprosodicity replaces both the stipulation that postlexical applications of (92) may delink [−ATR], and that they must cross a word boundary. What must be stated in all versions of the postlexical rule is that they only apply leftwards.

One problem which I cannot resolve with the data at hand is that [+ATR] does not spread across word boundaries from nonhigh vowels to high vowels. Denoting these by A and I respectively, we have the pattern:

(101)



Steriade (1981) found the reverse pattern in rounding harmony (spreading from A to I but not from I to A) and argued that given the greater sonority of A relative to I it constituted support for a metrical treatment. The Vata pattern confounds her argument and suggests that sonority and metrical trees are in any case not responsible. As for Vata, the simplest system would result if (101) were a general condition on Vata Vowel Harmony. I cannot find examples of high vowel prefixes in Kaye's article; if none exists, the height constraint can of course be vacuously extended to lexical leftward spreading of [+ATR] by (92).

In Vata, the set of harmony-bearing elements is apparently the same lexically and postlexically, namely all and only the vowels. If the set of harmony-bearing elements differs in the two components, a rule applying in both would have different results in each, as in the case of Russian, where only obstruents may be lexically marked for voicing but any consonant may be marked for voicing postlexically. A simple case of this type involving vowel harmony would be Diola-Fogny. This language has a 5+5 vowel system, with [ATR] ('tenseness') harmony in all relevant respects like that of Vata (Sapir 1965). However, harmony extends allophonically also to consonants:

(102) All consonants are tense in the presence of tense vowels, otherwise they are lax (Sapir 1965: 5)

Let us suppose that the marking condition:

(103) *[αATR]
|
C

holds lexically in Diola-Fogny, but is suspended postlexically. Then the harmony rule, which spreads [+ATR] to any available unassociated segments, will apply as desired lexically to vowels and postlexically to consonants. A consequence is that the consonant harmony might apply across word boundaries; unfortunately, Sapir gives no information on this point.

One could reasonably claim that the tense allophones of consonants are a matter of coarticulation rather than phonology. However, the tensing of consonants is apparently quite marked for some of the consonants. Thus tense *b* is described as having 'a breathy quality that is particularly distinct when *b* is under stress'. This shows at least that there is a language-particular rule involved, and there is no reason not to relate it to the harmonic process that functions in the language anyway.

The problem of delimiting phonetic implementation from phonology proper arises in a particularly sharp form where a lexical rule also operates postlexically, and its postlexical applications show the gradient, non-categorical properties associated with coarticulation. If this kind of case is typical, we might conclude that such gradient processes are also to be considered part of the phonology, especially if we can show that their language-particular idiosyncrasies are replicated in their postlexical applications and if we can discover principles which predict *when* a postlexical rule will apply in gradient rather than in categorical fashion.

An interesting case in point is provided by the vowel harmony system of Akan, a Kwa language of Niger-Congo, which has been studied by Clements (1981).

Phonemically, Akan has nine vowels, grouped into two sets according to their specification for the feature [ATR]:

(104)

[+ATR]	[−ATR]
i u	ɪ ʊ
e o	ɛ ɔ
	a

In words containing no low vowel, all vowels must be either [+ATR] or [−ATR], e.g. [e-bu-o] 'nest', [ɛ-bʊ-ɔ] 'stone'. The low vowel [a] co-occurs with either set, e.g. [bisa] 'to ask', [pɪra] 'to sweep'. Moreover, vowels of the two sets freely co-occur if [a] intervenes, e.g. [fuŋanɪ] 'to search', and only exceptionally co-occur otherwise, e.g. [ɲinsɛŋ] 'to be pregnant'. Prefix and suffix harmony are controlled by the first and last root vowel, respectively, e.g. [o-bisa-ɪ] 'he asked (if)', [o-ɲinsɛŋɪ-ɪ] 'she became pregnant'.

Akan, then, has a vowel harmony system similar to that of Vata except that [a] is opaque. The feature [ATR] is autosegmental and affixes are inherently unspecified for this feature. In order to exclude the tenth vowel *[ʌ] (the [+ATR] counterpart of [a]) from lexical representations and from being derived by vowel harmony, we assume that it is inherently associated with [−ATR]:

(105) [−ATR]
|
[+low]

Since consonants do not participate in harmony, Akan is also subject to (103) in its entire phonology. Nonlow [−ATR] stem vowels, and all suffix vowels, can be left lexically unmarked, and Vowel Harmony taken as the bidirectional spread of [+ATR]:

(106) *Vowel Harmony*
Spread [+ATR]

We again assume a Default Rule:

(107) [ ] → [−ATR]

by which vowels not subject to (106) receive their correct phonetic specifications.

According to Clements, Akan disallows sequences of [+ATR] and nonlow [−ATR] vowels, with the exception of the two roots [pɪɲcɛ] and [ɲinsɛɲ]. We may then ask why [+ATR] vowels *can* abut the *low* [−ATR] vowel [ɑ] with impunity. If [ɑ] is opaque, this distribution follows from the assumption that [+ATR] spreads maximally within words. This admits (108a–b) as harmonically regular roots (and words) but renders (108c) exceptional, as desired, since association is maximal in (a–b) but not in (c):

(108) a. + A − A
| |
b i s ɑ

b. + A – A
| |
fuɲɑn

c. + A
|
ɲin(sɛɲ)

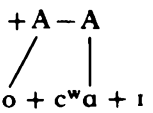
The two exceptional roots could then be treated by marking their final syllable as idiosyncratically extraprosodic, or opaque. We then have derivations as follows:

(109)

	+A		+A − A
	|		| |
Vowel Harmony	bU	bU	b I s A
	+A		+A − A
	/ | \		/ |
Morphology	E bU O	E bU O	O b I s A I
	[ebuo]	[ɛbʊɔ]	[obisɑɪ]
	'nest'	'stone'	'he asked (it)'

Clements observes that roots beginning with $C^{j}a$, $C^{w}a$ (a palatalised or labialised consonant) unexpectedly take [+ATR] prefixes, e.g. [o-cʷɑ-ɪ] 'he cut it'. He proposes that they carry a floating autosegment [+ATR], so that their lexical representation is as in (110a). If a prefix is added, the floating [+ATR] 'docks' on to it (110b); otherwise it remains unassociated and is deleted by convention at the end of the derivation (110c):

(110) a. 

b. 

c. 

The restriction noticed by Clements that the floating autosegment occurs *only when the root vowel is [ɑ]* follows from the Vowel Harmony rule (104) and the opaque nature of [ɑ].

We now come to what is for our present concerns the most interesting aspect of Akan vowel harmony. The [+ATR] counterpart of [ɑ], missing from the lexical inventory, does occur phonetically in the environment before [+ATR]. Cf. the examples in (111), where [ạ] denotes this vowel:

(111) kạri	'to weigh'
ạ+furumɑ	'navel'
pirạko	'pig'
wạ+sʲɑnɪ	'he has descended'

Syllables further to the left are also affected to a lesser degree. According to some descriptions (Schachter & Fromkin 1968) an [ɑ] to the right of a [+ATR] vowel is also affected, e.g. [bisə] 'to ask', but this was not the case in the dialect studied by Clements. Moreover, the process of Vowel Raising, which introduces [ạ], applies also across word boundaries, when a [+high, +ATR] vowel follows. This environment reveals that Vowel Raising applies not just to [ɑ], but to all other [−ATR] vowels as well:

(112) a.	ŋŋʷɑ		'snail'	b. ɔwɔ		'snake'
	ŋŋʷɑ	nʊ	'the snail'	ɔwɔ	nʊ	'the snake'
	ŋŋʷạ	bi	'a snail'	ɔwọ	bi	'a snake'

Inside words the process is detectable only for [ɑ] because [ɑ] is the only [−ATR] vowel that occurs before [+ATR] vowels.

What is especially interesting is that the process applies also in the context of the floating [+ATR] before words in $C^{j}a$, $C^{w}a$:

(113) kʷɑɑmɪ	jʷɑrɪ	'Kwame bathes'
ɔsʊnʊ	jʷɑrɪ	'an elephant bathes'
pɛtɛ	jʷɑrɪ	'a vulture bathes'
ɔwɔ	jʷɑrɪ	'a snake bathes'
ɑmɑ	jʷɑrɪ	'Amma bathes'

The phonetic realisation of [ɪ̣], [ʊ̣] is identical to the lexically [+ATR] vowels [i], [u]. For these nothing need be said beyond that [+ATR] spreads postlexically. The vowels [ɛ̣] and [ɔ̣] are described as 'acoustically

intermediate' between the usual norms for [ɛ], [ɔ] and [e], [o]. Still supposing that they are derived by spreading the feature [+ATR], we specify:

(114) $[\text{e o}] = \begin{bmatrix} +\text{ATR} \\ -\text{low} \end{bmatrix}$ $[\text{ɛ ɔ}] = \begin{bmatrix} -\text{ATR} \\ +\text{low} \end{bmatrix}$ $[\text{ɛ̣ ɔ̣}] = \begin{bmatrix} +\text{ATR} \\ +\text{low} \end{bmatrix}$

and add before Vowel Harmony a rule:

(115) [+ATR] → [−low]

which by Structure Preservation can only apply postlexically. Word-internally and before clitics, [ạ] is pronounced as a fronted vowel 'approaching [ɛ] in quality'. Word-finally, [ạ] is usually slightly raised, but remains back for most speakers. This contrast is accounted for by adding prior to Vowel Harmony a rule which fronts [ɑ] before [+ATR], again necessarily postlexically:

(116)

$$[+\text{low}] \rightarrow [-\text{back}] \;/\; -\!\!-\; X \begin{bmatrix} [+\text{ATR}] \\ | \\ \quad\quad] \end{bmatrix}$$

Have we already gone beyond phonology? What is suspect, of course, is the GRADIENT character of the postlexical spread of [+ATR]. How are we to account for the fact that it is neither binary nor unbounded in the usual sense, but rather causes preceding syllables to acquire 'increasingly raised variants in a gradual "crescendo" as the conditioning syllable is approached', as Clements puts it?

At this point it is instructive to compare the postlexical application of Vowel Harmony in Vata and Akan:

(117) *Vata*	*Akan*
Categorical	Gradient
Local	Propagates as a 'cline'
Applies to unspecified segments?	Applies to specified segments
Structure preserving	Creates new segment types

It is of course possible that closer phonetic investigation of Vata will reveal unsuspected gradience there too. But taken at face value, postlexical harmony in Vata seems indisputably phonological. The reason one might wish to consider it phonological also in Akan is that it matches the lexical harmony rule. Do we want to say that the relationship between the lexical and postlexical processes is entirely accidental? Is it merely historical, in that the lexical harmony rule is a phonologisation of a phonetic process which still subsists in the shadow of its lexical offspring? Or is there an intrinsic synchronic connection between them? The latter assumption might be tenable if we could state general conditions under which postlexical rules operate in gradient fashion as opposed to categorically.

As suggested in § 1.4, one hypothesis would be that postlexical rules which spread features in violation of lexical marking conditions, i.e. which create new segment types, are intrinsically gradient.

Guaraní nasal harmony raises many of the same issues. I shall try to show that the problems encountered by previous approaches receive a natural resolution in a lexical phonological analysis.

The Guaraní facts have been described in Gregores & Suárez (1967), Lunt (1973), and Rivas (1974a, b). An autosegmental account has been developed by Rivas, Goldsmith (1976a, b) and Poser (1981). There have also been attempts to analyse it segmentally (Barratt 1981) and metrically (Sportiche 1977); see Poser for a critical assessment.

According to Rivas, Guaraní has the following phoneme inventory:

(118)	p	t		k	k^w	ʔ
		s	š	x		
	^{m}b/m	^{n}d/n	y/ñ	^{ŋ}g/ŋ	^{ŋ}g^w/ŋ$^{\tilde{w}}$	
	v/ṽ	l/l̃	r/r̃	ɣ/ɣ̃	ɣ^w/ɣ̃$^{\tilde{w}}$	
	i/ĩ	ɨ/ɨ̃	u/ũ			
	e/ẽ		o/õ			
		a/ã				

All voiced segments – stops, continuant sonorants, and vowels – have an oral and a nasal variant, shown by slashes above. The oral variant occurs only in ORAL SPANS and the nasal variant occurs only in NASAL SPANS, as defined by the harmonic spread of the nasal feature. The voiceless obstruents are always oral and are transparent to nasal harmony.

Nasality is distinctive in stressed vowels and the feature [nasal] spreads from them in both directions within a word:

(119)	tupá	'bed'
	tũpã́	'God'
	ãtĩ́ã	'to sneeze'
	but not:	*tũpá, *tupã́, *atĩ́a, *ãtĩ́a, *atĩ́ã

The voiced stops are inherently nasal. They are realised as prenasalised when a stressed [–nasal] vowel occurs to their right (with no nasals or stressed vowels intervening) and as full nasals otherwise:

(120)	^{m}baʔé	'thing'
	ɲã^{n}dé	'we (incl.)'
	nõ + r̃õ + xẽ^{n}dú + i	'I don't hear you'
	nẽ + pẽtĩ́	'your tobacco'

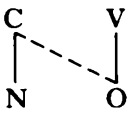
A prenasalised stop spreads nasality to the left exactly like a stressed nasal vowel:

(121)	pãnã^{m}bɨ́	'butterfly' (*pana^{m}bɨ́, *pãna^{m}bɨ́, *panã^{m}bɨ́)
	tẽnĩ^{m}bé + ɣ^{w}i	'from the bed'

but it does not spread nasality to the right:

(122) ^{n}do + ro + xaɨxú + i 'I don't love you'
^{n}de + rivɨ́ 'thy brother'

Poser proposes that the autosegment [nasal] is lexically associated with stressed vowels and that voiced stops are inherently [+nasal]. The autosegment [nasal] spreads bidirectionally from these segments to any unstressed vowels and sonorants, skipping any voiceless obstruents in its way, up to the next segment associated with its own [nasal] autosegment. The prenasalised stops are then derived by a rule of Post-oralisation which links nasal consonants to an oral autosegment on their right. Representing [+nasal] as N, and [−nasal] as O, the rule is:

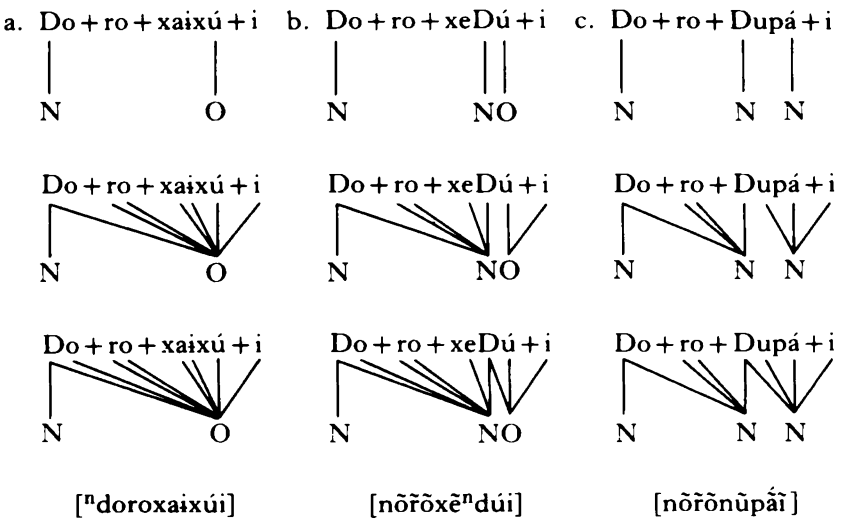
(123) 

In this autosegmental account, some principle is required to resolve which autosegment spreads in ambiguous cases. Poser suggests that the correct principle is the following PRIORITY CLAUSE:

(124) In case of an ambiguity in fulfilling the Well-formedness Condition the right-hand autosegment takes precedence

I quote some derivations from Poser to illustrate the working of this system:

(125)



[^{n}doroxaɨxúi] [nõr̃õxẽ^{n}dúi] [nõr̃õnũpa̋ĩ]

This straightforward autosegmental solution severely violates Structure Preservation because it spreads nasality on to segments which cannot bear it lexically, namely unstressed continuants. In fact, it was already considered

in Rivas' careful study and rejected – for entirely different reasons – in favour of a solution with *two* nasal spreading rules, Deep Spreading and Surface Spreading. Poser also, for different reasons, arrives at a two-stage analysis with three nasal spreading rules.

Rivas' rule of Deep Spreading spreads nasality to voiced stops and operates between word boundaries. The rule of Surface Spreading applies after Deep Spreading, assigning degrees of nasalisation to sonorants which decrease with their distance from 'deeply' nasalised segments (nasal stops and nasal stressed vowels).

Rivas gave three reasons for adopting this two-stage spreading solution. First, Deep Spreading is categorical while Surface Spreading establishes a cline of decreasing nasality in both directions from a fully nasal segment, or 'nasal centre'. Indeed, Rivas remarks that 'if the word is long enough, such that there are voiced segments far away from the nasal center, then these segments may be completely oral':

(126) [nõɾoipɨtĩ̃ṽõĩ] 'I didn't help you'

In this finer transcription, successively weaker degrees of nasalisation are marked as [ṽ], [ṽ], [ɣ], and complete lack of nasality is indicated by absence of any diacritic. Thus [...oi...] in the above word is actually fully oral. Yet 'this decrease of nasalisation does not affect the alternation $^{m}b/m$. That is, it does not matter how far a prenasalised stop is from a trigger of nasalisation; it will always become completely nasal, that is, *m*. Furthermore, this derived *m* will become a center of nasalisation, and cause the decreasing of nasality in both directions.' Rivas' derivation of (126) works as follows:

(127)

Deep spreading	N Doroipitivói	(+N spreads from the nasal vowel to the stop)
Surface Spreading	N nõɾoipɨtĩ̃ṽõĩ	(nasality fans out locally from the two +N segments)

Suppose now that there was only a single process of nasal spreading applying at the same time to stops and continuants. Then the problem would be the following. Nasality must spread from the stressed vowel all the way up to the initial stop in order for it to surface as [n] rather than [^{n}d] as it would in an oral span. Therefore it would also have to spread to the intervening continuant sonorants, just as in the examples of (125):

(128)

To get from here to the actual pronunciation shown in (126) we would somehow have to weaken the nasality of unstressed vowels and continuant sonorants in proportion to their distance from stressed nasal vowels or nasal stops. But stressed nasal vowels and nasal stops, the fixed 'nasal centres' which must be singled out in representations like (128), are precisely the segments for which nasality is *lexically* relevant and which initiate nasal spans of their own. This information is lost after spreading has taken place, as in (128). So the single-spreading account loses the generalisation that nasalisation is categorical in segments where it is distinctive and gradient in segments where it is allophonic. Two-stage spreading makes immediate sense of it, since we can say that Deep Spreading is categorical and Surface Spreading is gradient.

Rivas' second argument is the phenomenon he calls 'leakage of nasalisation'. Nasality may optionally spread across a word boundary, both rightward (129a) and leftward (129b) (Rivas 1974a: 23; Lunt 1973: 135; Gregores & Suárez 1967: 69; Poser 1981: 38):

(129) a. amã́ # sapiʔá → [ãmã́sãpiʔá] 'sudden downpour'
b. še # na+yeʔẽ́+i → [šẹnãnẽʔẽ́i] 'I did not speak'

This spread has the gradient character described above and extends just a short distance into the next word (one syllable only, *fide* Poser). If we have a single process of nasal spreading, we cannot let it freely cross word boundaries, since it is unbounded. But then we need a separate rule for the spreading in (129), which exhibits the same gradient characteristics as that in (126) but cannot now be related to it.[15] On the two-stage solution there is no problem because Deep Spreading can apply strictly within words while Surface Spreading may cross word boundaries.

Rivas' third piece of evidence for distinguishing Deep Spreading and Surface Spreading is that there is a rule which must apply between them. This is a rule that deletes a secondary stress in rapid speech whenever this vowel is followed by a stressed syllable:

(130) /ai+k^{w}aà+sé/ → [aik^{w}aàsé] (slow speech)
[aik^{w}aasé] (rapid speech)

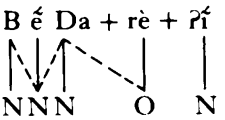
(131) Destress a syllable before a stressed syllable

To derive the correct form [mẽ́^{n}daɾẽʔĩ́] from /BẽDa+rè+ʔĩ́/, this rule must apply between Deep Spreading and Surface Spreading.

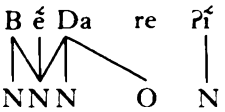
Adapted to the specific version of the autosegmental solution under discussion, the argument goes like this. As we learned from (126), nasality spreads arbitrarily far from a stressed vowel over unspecified segments to induce the fully nasalised realisation of a nasal stop to its left. The configuration $^{n}d \ldots \acute{V} \ldots \acute{\tilde{V}}$ (not $^{*}n \ldots \acute{V} \ldots \acute{\tilde{V}}$) shows that this spread is

blocked by an intervening stressed oral vowel. What a form such as [mḗⁿdaɽẽ + ʔí] shows is that those oral vowels which have undergone Destressing block Deep Spreading (hence [ⁿd]) but are themselves receptive to Surface Spreading (hence [ɽẽ]). The right results are obtained if we order Destressing between Deep Spreading and Surface Spreading and furthermore let Destressing delink an associated [−nasal] autosegment:

(132) Deep Spreading



Destressing



Surface Spreading

[mḗⁿda ɽẽ ʔí]

Notice that the oral autosegment must get delinked, but it cannot be deleted because it is responsible for the realisation of *D* as [ⁿd]. There is still another reason why the oral autosegment cannot be deleted. Gregores & Suárez (1967: 68, esp. n. 3) are quite explicit on the point that nasality in cases like (132) spreads leftward maximally one syllable, and optionally at that. Thus we have /xaɨxupɨ̀rã́/ → [xaɨxupɨ̃ɾ̃ã́], or optionally [xaɨxupɨrã́], [xaɨxupɨ̀rã́], never *[xaɨxũpɨ̃ɾ̃ã́] or the like. This contrasts, then, with a configuration where there is no oral autosegment to the left of the first nasal vowel, and the nasal cline extends several syllables to the left, e.g. (126) above.

It is not entirely clear what happens in the reverse configuration ...V̀CV́..., but judging from the fact that Gregores & Suárez make no special mention of it they apparently go by the general rules, i.e. a word like /oi + kɨti + xã̀ + pé/ 'he cut that + acc.' (Gregores & Suárez 1967: 205) is pronounced something like [oikɨtĩxãpé]. This means that a [+nasal] autosegment must *not* be delinked by Destressing.

From a descriptive point of view, Rivas has clearly justified his view of Guaraní nasal harmony as a two-stage process. Yet his solution leaves him with an unsatisfactory duplication: *why* should there be two nasal harmony processes in the language?

Lexical Phonology reconciles the two harmony processes with a unitary harmony rule. It allows us to treat Deep Spreading and Surface Spreading as the lexical and postlexical operations of a single rule of Nasal Spreading, which operates in different ways in the two components by virtue of the different principles that apply in them.

Suppose that stops and stressed vowels may be associated with the autosegment [αN] in the lexicon. Then the underlying manner features for the nasal stops ([^{m}b/m],[^{n}d/n],...) will be:

(133) [+nasal]
|
[ ]

and for the other obstruents:

(134) [ ]

Prior to nasal harmony, the former will be assigned the feature value [+voiced] and the latter, as the default case, [−voiced]. We assume that nasality may not be specified at any stage on unvoiced segments, and that lexically it may be specified only on stops and stressed vowels:

(135) a. *[αnasal] | [−voiced] b. *[αnasal] | [−stressed, +continuant] in the lexicon

To account for nasal harmony we then require the following rule:

(136) Spread [αnasal]

Consider now how rule (136) applies. It cannot apply to unstressed vowels or sonorants because of (135b). Neither can it apply to voiceless obstruents, because of (135a). Rule (136) spreads [−nasal] (O) and [+nasal] (N) to the only available landing sites, the nasal stops (here we have to specify that multiple association of [+nasal] on C-slots is permitted, in order to allow for prenasalised consonants).

Thus, a nasal stop with a stressed [−nasal] vowel to its right will be linked to the [−nasal] feature and surface as prenasalised:

(137) N O N O N O
P a ʔ é → b a ʔ é → b a ʔ é = [^{m}baʔé] 'thing'

Otherwise it will surface as an ordinary nasal:

(138) a. N N N N N N N N N
T o r o Tu P ã́ i → d o r o d u p ã́ i → d o r o d u p ã́ i
= [noronupãi] (→ [nõrõnũpãĩ])

b. NNN NNN NNN
P é̃ T a → b é̃ d a → b é̃ d a = [mé̃na] (→ [mé̃nã])

I have assumed that both O and N spread, but clearly only the spread of O is crucial here; stressed nasal vowels might just as well receive their specification by a default rule after spreading.

There are a number of clitics (postpositions) and suffixes whose initial consonant alternates depending on whether they follow an oral or nasal span. The first group begins with a voiceless stop after an oral span and with a nasal stop after a nasal span, with the latter variant phonetically realised, according to the normal rules, as prenasalised before a stressed oral vowel and as fully nasal before an unstressed vowel:

(139)		in oral environments	in nasal environments
	a.	-pá	-^{m}bá
		-potá	-^{m}botá
		-tɨ́	-^{n}dɨ́
		-pɨ́	-^{m}bɨ́
		-pe	-me
	b.	-pukú	-^{m}bukú/-pukú
		-k^{w}é(ra)	-^{ŋ}g^{w}é(ra)/-k^{w}é(ra)

The nasal form is obligatory for the suffixes in (139a) and optional in (139b). In another group of suffixes, allomorphs in [-ɣ^{w}] alternate – always optionally – with allomorphs in [-^{ŋ}g^{w}] depending on whether the stem is oral or nasal:

(140) in oral environments	in nasal environments
-ɣ^{w}á	-^{ŋ}g^{w}á/-ɣ^{w}á
-ɣ^{w}aré	-^{ŋ}g^{w}aré/-ɣ^{w}aré
-ɣ^{w}ivé	-^{ŋ}g^{w}ivé/-ɣ^{w}ivé
-ɣ^{w}asú	-^{ŋ}g^{w}asú/-ɣ^{w}asú

These affixes are referred to in the literature as irregular affixes, but actually it seems from the data in Gregores & Suárez that *all* affixes beginning with nasal consonants undergo the alternation in (139) and *all* affixes beginning with voiced labiovelars undergo the alternation in (140). The only possible outcome when a nasal consonant is added to an oral stem is just the denasalisation seen in the left-hand column of (139). We therefore set up rule (141):

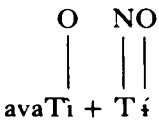
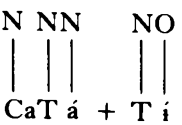
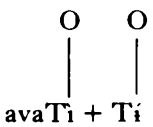
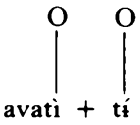
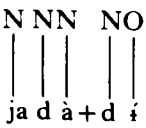
$$(141)\quad \begin{array}{l} N \rightarrow \emptyset \;/\; O\ — \\ \quad\ \ | \\ \quad\ \ C \end{array}$$

which has to apply *before* voicing.

The functioning of (141) is illustrated in (142b) by the derivations of [avatitɨ́] 'cornfield' ([avatí] 'corn') and [ɲãnã^{n}dɨ́]' 'place full of weeds' ([ɲãnã́] 'weed'), with the 'collective' suffix shown in (142a):

(142) a.

b.

		
Rule (141)		—
Voicing		
Nasal Spread (136)	—	
Destressing, post-lexical Nasal Spread	avati + ti	ɲãnãⁿdi

The variant forms of the two suffixes in (139b) can be ascribed to variant

lexical representations, viz. /PuKú/, /PuKú/.

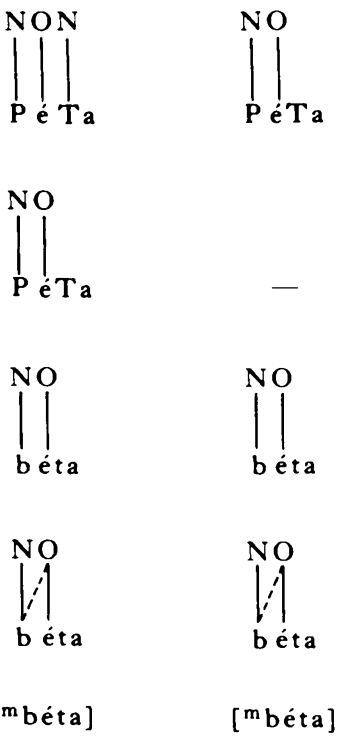
Rule (141) also sheds light on a gap in the distribution of [+nasal] within simple morphemes. Theoretically there should be four possible combinations of stress and nasality in a morpheme of the form /CVCV/, where the two Cs are associated with an autosegment N. In fact, there are three:

(143) /MeNã́/ [mẽnã́]
/MeNá/ [mẽⁿdá]
/MéNa/ [mén̄ã]
*/MéNa/ *[ᵐbénⁿda], *[ᵐbénã]

(where M and N denote  and  respectively).

The fourth combination does not exist and our analysis explains why. /MV́NV/ would be indistinguishable from /MV́TV/ because of rule (141):

(144)



Rule (141) neutralises nasality in consonants after a [−nasal] vowel. Given that (141) applies at word level, as surely it must, since it applies even to postpositions as in (139), the SCC does not block it in non-derived environments, and hence neutralisation is correctly predicted for the morpheme-internal case as well.

As for the optional alternation in (140), it is apparently characteristic of all affixes beginning with [ɣʷ], but affixes beginning with other voiced continuants maintain them as continuants in nasal environments, e.g. /umí̃+va/ → [ũmí̃vã] 'those'. So minimally we have to say something special about [ɣʷ]. We shall say that [ɣʷ] may be optionally unspecified for [continuant] at the point when Nasal Spread applies. Let us suppose that the default values of the feature [continuant] are assigned by rule (145):

$$(145)\ [\quad] \rightarrow \begin{cases} [+\text{continuant}] \\ [-\text{continuant}] \end{cases}$$

That is, the default value is [+continuant] where possible and [−continuant] otherwise. In the general case, (145) must apply before Nasal Spread (136) because it bleeds Nasal Spread via condition (135b). Suppose that the cyclic application of (145) were optionally blocked for labiovelars. Then

Nasal Spread could associate [±nasal] with them. If (145) applies to them *after* Nasal Spread (at word level), condition (135b) dictates that (145) will assign them the specification [−continuant] if they are associated with [+nasal], and [+continuant] otherwise. This accounts for the distribution in (140).

In this solution there is no need for any language-particular 'priority clause' such as (124). Lexically, Nasal Spread simply applies wherever it can; the only case where an ambiguity arises is the configuration C...C, where each C is associated with an N, and there it is immaterial which way the association line is drawn. Thus we may simply go by the *general* principle proposed by Clements (1981) which gives priority to the left autosegment in such cases. Postlexically there is no need to establish priority either. As Gregores & Suárez explain (1967: 66–69), the unstressed sonorants intervening between N and O or O and N are neither all fully nasal nor all fully oral but show a 'cline' from fully nasal to fully oral or vice versa. Thus Nasal Spreading shows the correlation between non-Structure Preservation and gradient application that we found in the previous examples as well. Whether or not it is ultimately correct to view 'Surface Spreading' as the postlexical application of the same Nasal Spreading rule whose lexical application gives 'Deep Spreading' is a question which can only be decided by further investigation of the properties of postlexical rules.

Our conclusion about vowel harmony and nasal harmony is the same as about Russian Voicing Assimilation: the autosegmental theory is correct and requires no metrical supplement for harmony processes.[16] The distinction between 'directional' and 'dominant' harmony has already lost some of its importance with the realisation that autosegments spread by rules and not by virtue of well-formedness conditions (Halle & Vergnaud 1982; Pulleyblank 1983). From the present point of view the distinction breaks down into two independent parameters. Harmony is directional or bidirectional, depending on whether the spreading rule goes in one direction or both. Harmony is 'dominant' (in the Halle & Vergnaud sense) if it is non-feature-changing, i.e. spreads an autosegment only to segments which are not already linked to a contradictory autosegment, and 'non-dominant' if it delinks existing associations. Catalan Nasal Assimilation is directional and dominant, Russian Voicing Assimilation is directional and non-dominant, vowel harmony as in Vata and Akan is bidirectional and dominant.

NOTES

* This is a lightly revised version of a paper prepared for the Amherst phonology conference of April 1983. Thanks to Toni Borowsky, Morris Halle and Bill Poser for comments.

[1] This and other similar cases have been discussed by Mohanan (1983).

[2] I know of no systematic phonological differences between inflectional affixes and level 2 derivational affixes. For example, the syllabification facts are apparently the same: *hinder # ing*, *centre # ing* are trisyllabic (*vs.* disyllabic level 1 *hindr + ance*,

centr + *al*) to exactly the same extent as noun-forming derivational *-ing* and as the present participle suffix (*John's hindering of* NP and *he was hindering* NP). Some speakers distinguish obligatorily disyllabic *crackling* 'pork fat' from optionally trisyllabic *crackle # ing* (noted by Nigel Fabb) but here again the abstract noun and inflectional *-ing* both work the same way and the disyllabic concrete noun in *-ing* is best regarded as an unproductive level 1 derivative. Compound and affix boundaries do of course differ phonologically, but since they are structurally distinct (...] [... *vs.* ...]...) this does not suffice to show a level distinction. On the morphological side, as is well known, the arguments for more than two levels in English are weak. The possibilities that have been considered include splitting level 2 into derivation/inflection, into compounding/affixation, and three ways into derivational affixation/compounding/inflectional affixation, but none of these has so far carried conviction.

[3] We may wish to weaken this in various ways, e.g. by allowing marking conditions to 'turn off' at some level of the lexicon, like phonological rules, but I shall not investigate this possibility further here.

By assuming marking conditions I do not mean to claim that the learner assumes that all features are available for marking unless the language has specific evidence to the contrary. The reverse would be closer to the truth: the learner begins with the maximal restrictions and relaxes them only when he has to. Moreover, universal grammar will constrain this process by a hierarchy of features which defines their accessibility to marking (Jakobson 1941; Kean 1975).

[4] In some of the clusters the deletion is optional. For the facts see Mascaró (1976: 77 ff.).

[5] In marked cases we must be able to provide for retention of 'floating segments' at word edges, e.g. for French liaison.

[6] See Pulleyblank (1983).

[7] It also arises in /gn/ → [ŋn] (e.g. *ma[ŋ]nífic* 'magnificent' by what Mascaró argues is a postcyclic rule.

[8] We might further suppose that coronals have an empty slot on the tier of place features, as opposed to [h ʔ], which are entirely invisible on that tier (and hence transparent to assimilation of place, see e.g. Keyser & Kiparsky 1984). Analogously, the unmarked vowel *i* would have an empty slot on the place tier while schwa would be invisible there.

[9] The details are as follows. From the initial specifications where the four basic places of articulation are specified as in (36), the eight surface places of articulation branch out by the rules given in (A) below:

(A) i. $\begin{bmatrix}+\text{son}\\-\text{nas}\\-\text{lat}\end{bmatrix} \rightarrow \begin{bmatrix}+\text{high}\\-\text{back}\\+\text{anterior}\end{bmatrix}$

ii. $\begin{bmatrix}-\text{cont}\\-\text{nasal}\end{bmatrix} \rightarrow [+\text{distr}]$

iii. $\begin{bmatrix}+\text{labial}\\+\text{cont}\end{bmatrix} \rightarrow [-\text{distr}]$

(This assumes that /š ž/ are distinguished from /s z/ as [−anterior] underlyingly.) At this point Nasal Assimilation applies. The default values are then filled in by (B. i–vii):

(B) i. [ ] → [−high, −labial]

ii. [+high] → [−anterior, +back]

iii. [ ] → [+anterior, −back]

iv. $\left\{\begin{bmatrix}+\text{back}\\+\text{high}\end{bmatrix}, [+\text{labial}]\right\} \rightarrow [-\text{coronal}]$

v. [ ] → [+coronal]

vi. [−anterior] → [+distr]

vii. [ ] → [−distr]

The place features in the final fully specified matrix are shown in (C):

(C)	labial	labio-dental	dental	alveolar	post-alveolar	lamino-palatal	palatal	velar
high	−	−	−	−	+	−	+	+
back	−	−	−	−	−	−	−	+
labial	+	+	−	−	−	−	−	−
anterior	+	+	+	+	+	−	−	−
coronal	−	−	+	+	+	+	+	−
distributed	+	−	+	−	−	+	+	+

[10] It is also not clear why *n* preceding [ɲ] and [ʎ] becomes a laminopalatal rather than a palatal (see (20)). Unless this is really to be interpreted as testimony of gradient application, as might be expected in non-structure-preserving applications of postlexical rules, it requires an ad hoc restriction on Nasal Assimilation.

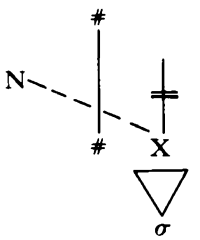
[11] Some of the 'deeper' phonology is suppressed in (46) and subsequent displays. Following Halle (1973) and Lightner (1972) I assume that the masc. nom. sg. ending is a 'jer', phonologically a reduced high vowel *-ŭ*. This vowel may surface by a cyclic 'jer-lowering' rule, and otherwise deletes by a word-level rule (Pesetsky 1979; Rubach 1981).

[12] Final Devoicing does apply cyclically to fill in the value [−voiced] for stem-final voiceless obstruents, which, like all voiceless obstruents, are lexically represented as unspecified for voicing. In this case, Final Devoicing is not feature-changing and the Strict Cycle Condition does not apply. This is only a technical point since the value [−voiced] would be assigned by Default Voicing anyway.

[13] These unpaired obstruents are, however, marked as [−voiced] lexically by Default Voicing. It was in order to allow this that (72b) was stated as restricting [+voiced] rather than [α voiced]. The motivation is provided by forms such as /molod + ĭc + a/ → *molotca*, pointed out to me by M. Halle.

[14] Examples of non-trivially structure-preserving vowel harmony are: Finnish, Hungarian, Ostyak, Vogul, Mongolian ([±back]), Warlpiri, Djingili, Telugu, Yokuts ([±round]), Akan, Tangale, Dho-Luo ([±ATR]), Chukchi, Nez Perce (possibly [±ATR]).

[15] This is the solution of Poser, who gives a rule:



(mirror image)

[16] There is of course no reason to preclude the possibility of harmony within an *independently* given genuinely metrical domain, such as a syllable or foot.

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