

persede those of a lower category have a further consequence: the whole of prosodic structure must be present when phonological rules apply. Therefore, phonology is not taking place in tandem with prosodic structure building, either in a strong form (the cyclic application that McHugh (this volume) has advocated) or in a weaker form (category to category as, for example, Rice (this volume) presupposes). As we saw in the discussion of focus in Greek, not only is vowel degemination blocked in the presence of a *U* break, but so are the sandhi rules. An analysis assuming interspersing of prosodic structure formation with phonological rule application would consistently make the wrong predictions with respect to these facts. The reason is that, in reconciling the top-down effects in phrasing with phonological rules having access to intermediate prosodic representations, the wrong domains are identified for the application of rules. For example, if such an analysis is to capture top-down effects in Greek by resorting to restructuring—that is, if *z* and  $\phi$  are to be built according to the regular edge-based specifications and later split apart in the presence of a *U* break—it would predict that the *w* juncture and *z* juncture sandhi rules should apply between an unfocused and a focused word. Or, if it is to specify a *z* and a  $\phi$  break before a focused word, then it would predict that the *z* juncture and the  $\phi$  juncture sandhi rules should apply between a focused and an unfocused word.

While much of this section was devoted to demonstrating the existence of top-down effects, we still have not addressed the question: why do top-down effects arise? The perspective on phrasing that I consider in this section suggests that top-down effects are in essence repair mechanisms. The configurations in which such repair mechanisms are needed have two possible sources: they arise from special mapping requirements of particular elements in a language, *and* from the way prosodic parsing is organized, namely the separation between primary and mop-up parsing operations.

## 5

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# Precompiled Phrasal Phonology

BRUCE HAYES

WHAT IS THE MECHANISM by which syntax affects phonological rule application? A very restrictive hypothesis is the following:

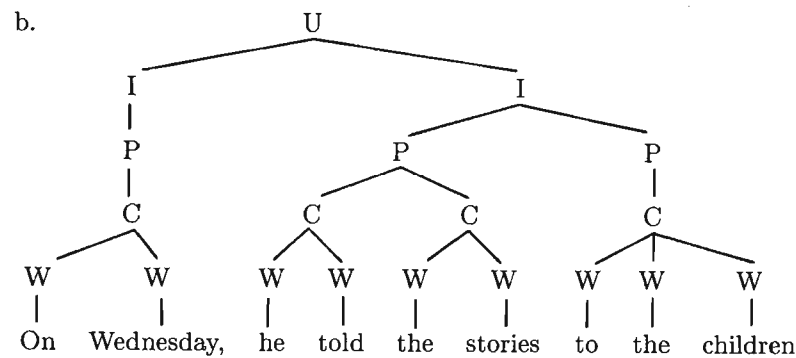
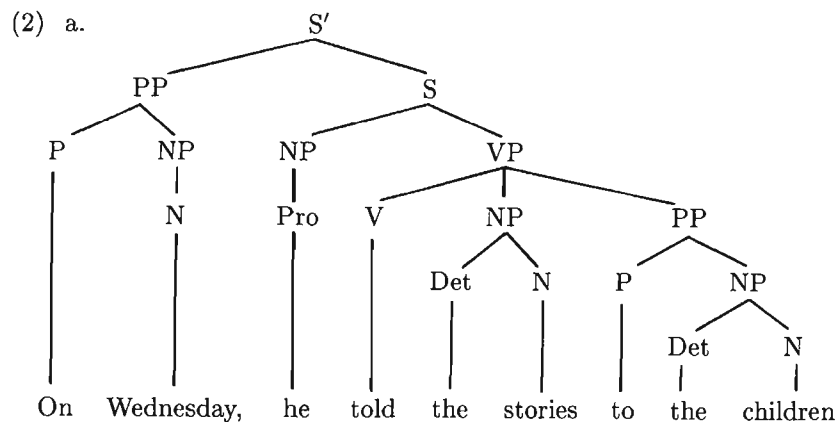
- (1) Syntax has phonological effects only insofar as it determines phonological phrasing.

By phonological phrasing I mean the theory of the prosodic domains developed in work by Selkirk 1980a, 1981a, 1986; Nespor and Vogel 1982, 1986; Hayes 1989; and others. The basic idea is that the output of the syntactic component is submitted to a set of phonological phrasing rules, which rebracket and relabel the structure to form a new, purely phonological bracketing which I will refer to as the 'prosodic hierarchy.' To give an example, the sentence whose syntactic structure is given in (2a) would be assigned the prosodic structure under (2b).

Phonological rules may refer to the prosodic hierarchy in three ways (Selkirk 1980a): they may be *bounded* by a particular domain, they may refer to the right or left edge of a domain in their structural descriptions, and they may refer to domain-internal junctures of the form  $[[$ . A crucial element of the theory is the Strict Layer Hypothesis (Selkirk 1981a): each non-terminal category in the hierarchy dominates only categories of the immediately lower level. Thus *U* dominates only *I*, *I* only *P*, and so on.

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W = Word C = Clitic Group P = Phonological Phrase  
I = Intonational Phrase U = Utterance

When combined with a requirement that the string be parsed exhaustively at all levels, this means that all expressions have exactly the same number of levels of embedding.

The basic support for the prosodic hierarchy lies in the fact that there are many phonological rules that refer to phrasal domains that are not syntactic constituents. This and other arguments are presented in a growing body of research; cf. *Phonology Yearbook 4*, several of the papers in this volume, and the references cited therein. I review some of the arguments below in section 8. Although problems and possible counterexamples exist in various languages, my view is that prosodic hierarchy theory has had enough descriptive and explanatory success so far that it constitutes the most promising research program for the study of phrasal phonology.

## 1 Shortcomings of Prosodic Hierarchy Theory, and a Proposal

It is clear, however, that the prosodic hierarchy cannot serve as a complete theory of the phonological phenomena that are syntax-dependent. That

is, the slogan under (1) has been clearly shown not to be true. I give some counterexamples below.

- (3) a. *Ewe* (Clements 1978): A High tone verb acquires Rising tone following High or Rising tone if the immediately following noun root bears Mid or Low tone on its first syllable.
- b. *French* (Selkirk 1972): In colloquial style (*conversation familière*), liaison occurs between an adjective or quantifier and a following noun, but not between an adverb and a following verb or adjective.
- c. *Hausa* (Kraft and Kirk-Green 1973): A verb-final long vowel is shortened immediately before an object NP.

Rules like these refer to very specific syntactic information, and do not generalize across X' categories as phonological phrasing characteristically does. Thus it is unlikely that a successful account of such rules based on phonological phrasing could be maintained. I will refer to rules like (3a-c) as 'direct-syntax rules.' Selkirk 1980a and Nespor and Vogel 1986:32-3 note the existence of such rules, and observe that they fall outside the scope of prosodic hierarchy theory.

The existence of direct-syntax rules is a problem for prosodic hierarchy theory, since when a rule doesn't fit the predictions of the theory, we can usually reclassify it as a direct-syntax rule. This seriously reduces the falsifiability, hence the predictive value, of the theory.

An option that may be workable here is to develop a theory of the *residue* left unaccounted for by prosodic hierarchy theory. That is, the phenomena that elude successful treatment in prosodic hierarchy theory may have their own regularities that can be insightfully accounted for under a completely different theory.

In this paper I propose a theory of this sort, based in part on work by Zwicky 1985d, 1987a; Pullum and Zwicky 1988 (forthcoming); and Spencer 1988. My claim is that all phonological rules fall into one of two classes: (a) truly phrasal rules, which apply postsyntactically and may refer only to the levels of the prosodic hierarchy; (b) lexical rules, which apply presyntactically within the lexicon. Of the latter, a subset are 'precompiled rules,' which derive multiple diacritically-marked allomorphs for certain classes of words. At the interface of syntax and phrasal phonology, the appropriate diacritically-marked allomorphs are inserted in the relevant syntactic contexts.

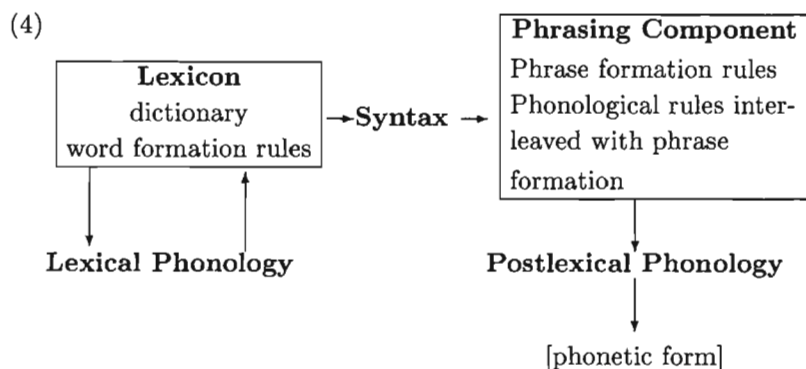
A central claim of the theory is that direct-syntax rules do not exist. The theory reanalyzes most such rules as precompiled rules. The reanalysis is not just a notational translation, because the conditions under which rules may be precompiled are limited in specific ways. Thus my proposal makes empirical predictions that are not made by a theory under which direct-syntax rules are allowed.

I will refer to my proposal as precompilation theory. My conjecture is that precompilation theory and prosodic hierarchy theory together form most of an adequate account of syntactic effects in phonology.<sup>1</sup>

The outline of this paper is as follows. I first discuss some proposals made earlier in the literature that serve as ingredients of precompilation theory, then the theory itself, then arguments in favor of it. Finally, I discuss the role of the prosodic hierarchy in the general theory of phrasal alternations, and diagnostics that indicate whether a rule is precompiled or truly phrasal.

## 2 An Example of Precompilation: Inflection

I assume the following outline of grammatical structure, which indicates the directions in which representations flow through the various components. Semantics is excluded here, since there is little agreement as to where it belongs (cf. Woodbury 1987).



The configuration above leads to an ordering paradox concerning inflectional morphology. I will suggest that a frequently-proposed answer to this paradox (Lieber 1980, Williams 1981, and Lapointe 1981) can be extended as the answer to the problem of direct-syntax phonological rules.

The inflectional ordering paradox is as follows. The distribution of inflection is determined syntactically, through processes such as agreement and concord. Nonetheless, in its morphological manifestation inflection can involve the kinds of irregularity and idiosyncrasy that we associate

<sup>1</sup>The quibble "most of" appears in the preceding sentence because some direct-syntax rules in the literature must be reanalyzed by other means than precompilation theory. Two such cases are: (a) rules triggered by particular morphemes, such as the vowel merger process triggered by the Puerto Rican Spanish future marker *-á*, documented in Mercado 1981 and Kaisse 1985; (b) rules that are analyzable as syntactically-distributed floating morphemes. An example of the latter is Odden's 1987:21-6 rule of Phrasal Tone Insertion in Kimatuumbi: the data he describes suggest that no such rule exists; rather, Kimatuumbi has a floating High tone particle, which is distributed syntactically and whose meaning corresponds to a grammaticized version of the English continuation rise intonation.

with lexical phonology and morphology. A good example here is the case of Slavic languages, in which inflection can be manifested by fully abstract jer vowels, can be involved in cyclic rule application, and can involve suppletion or even paradigm gaps (Lightner 1972, Halle 1973, Pesetsky 1985, Kenstowicz and Rubach 1987).

The paradox resolves itself under a precompilation theory of inflection. The basic idea here (cf. Robins 1959, Matthews 1972) is that inflectional systems involve a finite, predetermined structure, with a specific and limited set of inflectional categories; i.e., of cross-classified 'slots' arranged in paradigms, which are filled by individual inflected words. Anderson 1982 formalizes this idea with the device of a 'morphosyntactic representation,' a (possibly layered) set of inflectional features that indicates the inflectional category of each word.<sup>2</sup>

Assuming morphosyntactic representation, the paradox is resolved as follows: morphosyntactic representations are created in the lexicon, and the lexical morphology and phonology create the word forms that fill the paradigm slots that morphosyntactic representations define. Because inflection is carried out lexically, all of the phenomena that we associate with the lexicon (irregularity, suppletion, cyclic rule application, etc.) can be associated with inflection as well as with derivation.

In the syntax, feature values are assigned to terminal nodes by rules such as agreement. At the stage of lexical insertion, inflected words are inserted into frames such that their morphosyntactic representations are featurally non-distinct from the values borne by the terminal nodes into which they are inserted. Thus the choice of inflected form used is determined syntactically, while the phonological form of the inflected word is determined by the morphological and phonological rules of the lexicon.

At first glance, this looks like a cheat; the morphosyntactic representations are being used solely to allow us to order lexical operations before syntactic ones. But more careful thought suggests that it is correct. In particular, it correctly predicts that inflectional categories, unlike syntactic structures, are bounded in scope. Individual languages may include colossal numbers of inflected forms (Odden 1981b estimates 16 trillion forms for the Shona verb), but they do not have an *infinite* number; the large numbers are due to the geometric combinatorial possibilities of independent inflectional categories. If inflection had direct access to syntax, with its essentially unbounded character, we would expect to find unbounded inflectional systems, such as an affix that is added to a Wh-word each time it crosses a bounding node. By invoking the admittedly global device of morphosyntactic representation, we correctly predict the non-existence of such cases. Moreover, we are able to characterize both morphology and syntax by the rather distinct principles that each requires.

<sup>2</sup>However, Anderson would not subscribe to the notion of precompiled inflection, described below.

I have dealt with this idea at some length because it illustrates the mechanism of *precompilation*: inflectional morphology may precede syntax because each inflected form is precompiled in the lexicon, accompanied by a frame indicating where it may be inserted. It is the same strategy I will suggest for direct-syntax rules in phonology.

The notion of precompilation should not be confused with the notion of lexical listing. As Aronoff 1976 has made clear, lexical rules have two functions, that of generating new words and that of expressing the pattern of existing words. It is quite possible that a lexically precompiled inflected form could be generated 'on line' as a neologism; in fact, in languages with rich morphologies this will very often be the case. The crucial point is that inflected forms are *derived in the lexicon*, which allows us to account for forms that show classically lexical behavior.

### 3 Allomorphy Rules

As is well known, there exist cases of morphological alternation that are not insightfully derivable by phonological rules. For example, in Yidj, an Australian language (Dixon 1977), the ergative suffix appears as *-ŋgu* after vowel-final stems and as *-du* after consonant-final stems. There is no justification anywhere else in the grammar of Yidj for a phonological rule having the effects of either (5a) or (5b):

- (5) a.  $d \rightarrow \eta g / V \_$   
 b.  $\eta g \rightarrow d / C \_$

Moreover, neither rule can be construed as a general phonological process in Yidj, as both */Vd/* and */Cŋg/* sequences exist. In fact, neither (5a) nor (5b) was ever a phonological rule at any stage in the history of the language (Dixon 1980:318–20, Hale 1976).

If we wish to distinguish regularities that are properties of individual morphemes from general properties of a sound system, then the most reasonable account would be to characterize the Yidj ergative not with phonological rules but with rules of allomorphy (Aronoff 1976). Schematic rules would be as follows:

- (6) a. Insert */ŋgu/* / *V \\_* <sub>[+Ergative]</sub>  
 b. Insert */du/* / *C \\_* <sub>[+Ergative]</sub>

Cross-linguistically, rules of allomorphy have diverse structural conditions: they may refer to phonological environments, to inflectional features, and to the identity of individual morphemes (as in cases where a given affix appears on an arbitrary subset of stems).

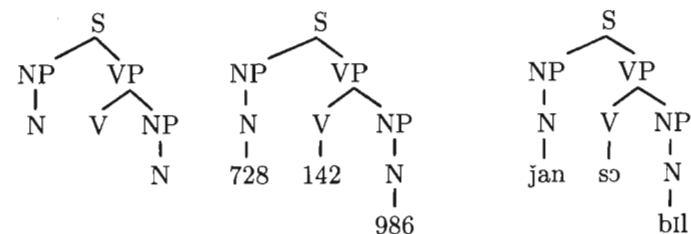
### 4 Phonological Instantiation

Pullum and Zwicky (forthcoming) argue that syntactic rules may not make reference to phonological properties. That is, we do not expect to find rules that front noun phrases consisting of two heavy syllables, that delete resumptive pronouns if they contain a coronal, that enforce a verb-second constraint for high-voweled verbs, and so on.<sup>3</sup>

What is striking about Pullum and Zwicky's principle is the following: syntactic rules clearly can make reference to properties of particular words. For instance, in various languages only certain verbs permit long-distance dependencies to extend into their complement clauses, only certain verbs permit clause union in causative constructions, and only certain verb-preposition sequences permit preposition stranding in cases of Wh-movement. Although treatments vary, I believe that reference by rules to individual morphemes would be required in some form in all syntactic frameworks.

What this suggests is that words appear in syntactic representations in rather abstract form, consisting of a kind of place marker, lacking in phonological content. More specifically, we can posit that what we think of as 'lexical insertion' is actually two processes: (a) insertion into syntactic trees of abstract place markers, indicating the identity of a word and its syntactic properties; (b) post-syntactic *phonological instantiation* of abstract markers with phonemic material. The following is a crude example of this scheme:

- (7) a. Abstract Phrase Marker  
 b. Index Insertion  
 728 = index of *John*  
 142 = index of *saw*  
 986 = index of *Bill*  
 c. Phonological Instantiation (Postsyntactic)



<sup>3</sup>The work of Zec and Inkelas (this volume) is a serious challenge to this principle. A line of reasoning that preserves the principle is as follows. The phonological properties to which syntax apparently makes reference are precisely the properties to which rules of phonological phrasing may refer; i.e., branchingness, heaviness, and the like. This suggests that Zec and Inkelas's ill-formed examples should not be ruled out in the syntactic component, but rather are ill-formed because the rules of phonological phrasing are unable to assign them a well-formed structure. This predicts, correctly I think, that for phonological properties that cannot be accessed by rules of phrasing (e.g., [high] or [coronal]), there will be no cases in which syntactic rules give the appearance of referring to this property.

The intent of this proposal should be clear: to allow syntactic rules to refer to lexical information, with the exception of phonological content.

## 5 Precompilation Theory

With this background, my proposal can be stated more precisely: there are no true phonological rules that make reference to syntactic representations. Rather, most of the rules that have in the past been analyzed as such should be characterized as 'phrasal allomorphy'; that is, as the selection of the appropriate precompiled allomorph for phonological instantiation. The idea of phrasal allomorphy has been developed and argued for in earlier work by Zwicky 1985d, 1987a and by Pullum and Zwicky 1988 (forthcoming).

The more novel aspect of my proposal will be as follows: phrasal allomorphs may be derived by phonological rule within the lexical phonology, so that whole classes of words will have multiple precompiled allomorphs.

I begin with a very simple example, the alternation of the indefinite article *a/an* in English, as in (8):

- (8) a pear    an apple    an edible pear    an apparently ripe pear

Although this alternation may have originally been due to a phrasal phonological rule (responsible for other alternations like *thine eyes ~ thy face*), synchronically it is completely isolated. Since only one morpheme alternates, it makes little sense to analyze the alternation in phonological terms; an account positing allomorphy is more accurate. The notion of phonological instantiation provides a straightforward account, as follows:

- (9) 999 → ən / \_\_\_V                    where 999 = index of the indefinite article  
           ə / elsewhere

In what follows, it will be useful to regard the environments for phonological instantiation as similar in form to syntactic subcategorization frames. Under such a view, the lexical entry for the indefinite article would appear as follows:

- (10) 
$$\left[ \begin{array}{l} 999 \\ \text{(syntactic and semantic} \\ \text{specifications)} \\ \text{Phonological instantiation:} \\ \text{/ən/ in the context / ___V} \\ \text{/ə/} \end{array} \right]$$

To ensure the selection of the *ən* allomorph over *ə* in prevocalic position, I posit that phonological instantiation is governed by the Elsewhere Condition (cf. Pāṇini, Anderson 1969, Kiparsky 1973b), which insures

that the most specific insertion context that is applicable in any particular environment takes precedence over more general insertion contexts.

A more interesting case, because it refers to syntax, is the alternation in the Spanish feminine definite article *la* (Pullum and Zwicky 1988), which appears as *el* before certain nouns beginning in stressed /á/ (see Posner 1987 for details).

- (11) *la* tórre            'the tower'  
       *el* água            'the water'            (N.B. *águ*a is feminine)  
       *la* álta tórre    'the high tower'

The interesting example here is *la álta tórre*, which shows that the conditioning environment is partly syntactic. I express the allomorphs and their environments for phonological instantiation as follows:

- (12) 
$$\left[ \begin{array}{l} \text{/el/ / } \text{---[N á]} \\ \text{/la/} \end{array} \right]$$

The next step in the analysis proposed here is the crucial one: to allow for whole classes of words to acquire precompiled alternants. In this case, mere lexical listing will not suffice, since the form of the allomorphs is largely or completely predictable.

To illustrate the mechanism I will propose, it will be useful to go through a concrete example, namely the rule of Hausa noted under (3c). In Hausa, final long vowels of verbs appear as short when the verb precedes a full NP direct object. Here are sample data, taken from Kraft and Kirk-Green 1973:

- (13) ná: ká:mà:            'I have caught (it)'                    (no object)  
       ná: ká:mà: sí        'I have caught it'                    (pronominal object)  
       ná: ká:mà kífí:      'I have caught a fish'                (full NP object)  
       ná: ká:mà: wà        'I have caught                        (object does not  
       Mú:sá: kífí:        Musa a fish'                            directly follow)

My proposal is as follows. A language's lexicon may include a set of 'phonological instantiation frames,' which serve as standardized contexts for the phonological instantiation of words. For instance, the following phonological instantiation frame is available in Hausa:

- (14) *Frame 1*: / [v<sub>P</sub> \_\_\_ NP ...], NP non-pronominal

This indicates that Hausa words (here necessarily verbs, given the frame) may have an extra allomorph marked to appear in this particular context.<sup>4</sup>

Second, I assume that for every word, the grammar automatically generates allomorphs marked for every applicable phonological instantiation frame. Thus for every Hausa verb there is generated a variant marked [Frame 1]. In the case of *ká:mà:*, the two variants are generated as follows:

<sup>4</sup>Hausa also has a Frame 2, for verbs preceding dative objects, and possibly a Frame 3, for verbs preceding pronominal clitics.

- (15) *ká:mà:* input  
*ká:mà:, ká:mà:[Frame 1]* outputs

Similar variants would be created for all other verbs of Hausa.

Third, I assume that lexical phonological rules may include phonological instantiation frames in their structural descriptions. The Hausa Shortening rule refers to [Frame 1]:

- (16) Hausa Shortening  
 $V: \rightarrow V / [ \dots \_ ]_{[Frame\ 1]}$

Shortening would apply to the forms of (15) as follows:

- (17) *ká:mà:* *ká:mà:[Frame 1]* inputs (from (15))  
*ká:mà:* *ká:mà:[Frame 1]* outputs

Since Shortening is a lexical rule, its outputs count as lexical entries; both are available for phonological instantiation. When phonological instantiation takes place, the appropriate allomorph is inserted in each syntactic environment. Thus *ká:mà* will be inserted before lexical objects (following the Elsewhere Condition), and *ká:mà:* will be inserted elsewhere. This completes the analysis.

Two points are worth emphasizing. First, there is no loss of generality in treating the shortening alternation in the lexicon rather than at the phrasal level. Shortening has essentially the same environment that it would have if it were expressed as a direct-syntax rule, but this environment is expressed as a phonological instantiation frame rather than as a syntactic context. Second, the analysis does not commit us to the claim that Hausa speakers memorize two allomorphs for every verb. As Aronoff 1976 notes, lexical rules can apply productively as well as relating memorized forms. The situation is quite parallel to what is posited in lexical accounts of inflection (section 3), which likewise can be agnostic about the extent to which lexically derived forms are memorized.

Some additional facts about Hausa further illustrate the precompilation analysis. In particular, Shortening is not the only lexical rule of Hausa that is triggered by [Frame 1]. A particular lexical class of verbs (the 'Grade II' verbs of Parsons 1960) also undergo a change in vowel quality, as exemplified below:

- (18) a. *ná: sà:yá:* 'I bought (it)'  
 b. *ná: sà:yí àbínčí* 'I bought food'

I would account for this by positing a second rule that includes [Frame 1] in its structural description:

- (19) Hausa Raising  
 $a \rightarrow i / [ \dots \_ ] \left[ \begin{array}{l} \text{Grade II} \\ \text{Frame 1} \end{array} \right]$

The fact that this rule is restricted to a particular diacritic lexical class supports the claim that it is lexical, since such restrictions are characteristic of lexical rules, but not of true phrasal phonology.

In fact, [Frame 1] governs alternations in Hausa that are almost completely isolated in the grammar. In particular, a handful of verbs show irregular allomorphs in the [Frame 1] environment:

- (20) a. *ná: gání:* 'I see'  
*ná: gá Áúdù* 'I see Audu'  
 b. *sáni:* 'know (isolation)'  
*sán* 'know (pre-object)'  
 c. *bári:* 'permit (isolation)'  
*bár* 'permit (pre-object)'  
 d. *bá:* 'give (isolation)'  
*bá:* 'give (pre-object)'

These would plausibly be listed in the lexicon, along the following lines:

- (21) 'see': /gá/[Frame 1] /gání/

The overall picture is that [Frame 1] serves as an organizing principle for the Hausa lexicon, determining in part the verbal allomorphs that the lexical rules derive.

I would add that this account of Hausa Shortening is largely a formalization of what appears in the Hausa literature (e.g., Parsons 1960, Leben 1971, Newman 1973, McHugh 1981). Hausaists typically treat the verbal allomorphs as members of a paradigm, isolated from their phrasal context.<sup>5</sup>

At this point I summarize the general claim I am making: there are no rules of true phrasal phonology that refer directly to syntax. Instead, most apparent cases of syntax-sensitive phonology are appropriately analyzed as cases of precompilation. Precompilation sometimes takes the form of lexical listing, as in English *a/an*. Where it involves a more general alternation, the alternants are derived by lexical rules, which make reference to phonological instantiation frames. In phonological instantiation, which intervenes between syntax and true phrasal phonology, the appropriate allomorph is selected for insertion, following the Elsewhere Principle.

To give further examples, here are the other two apparent direct-syntax rules of (3), reanalyzed as precompiled.

<sup>5</sup>A reviewer notes two further complications in the Hausa data: (a) Frame 1 must be modified to allow for certain particles to intervene optionally between verb and object; (b) as one might expect in a lexical rule, Shortening has exceptions, i.e. verbs which have final long vowels across the board. The same reviewer's suggestion that we replace Shortening with a Lengthening rule (applying before object pronouns) seems unworkable, since it fails to account for vowel length in isolation forms.

- (22) a. *Ewe* (Clements 1978): A High tone verb acquires Rising tone following High or Rising tone if the immediately following noun root bears Mid or Low tone on its first syllable.

$$H \rightarrow R / [v \text{ [-Lopitch] } \_ ]_{[\text{Frame } 1]}$$

Frame 1: /  $\_ [N \text{ [-Hipitch] } \dots]$

- b. *French* (Selkirk 1972): In colloquial style (*conversation familière*), liaison occurs between adjectives and quantifiers and a following noun, but not between an adverb and a following verb or adjective.

$$C \rightarrow [+extrasyllabic] / [_{\{A,Q\}} \dots \_ ]_{[\text{Frame } 1]}$$

Frame 1: /  $[x^i \_ X^0 \dots]$

For the theoretical background to (22b), see Clements and Keyser 1983:96–114.

## 6 Arguments for Precompilation Theory

So far, I have proposed that precompilation theory provides a workable alternative to a theory that allows direct-syntax rules. In this section, I argue that there are explanatory advantages in treating the relevant phenomena with precompilation rather than with direct-syntax rules.

### 6.1 Structure Preservation

Precompilation theory derives phrasal alternations with lexical rules, whereas in a direct-syntax approach, the rules must be postlexical. If precompilation theory is correct, then the conditions that are met by ordinary lexical rules should hold for precompiled rules as well.

It is widely believed that lexical rules are subject to a requirement of ‘structure preservation’ (Kiparsky 1985b): their outputs must be segments that already exist in the phonemic inventory of the language. Mohanan and Mohanan 1984 weaken this requirement somewhat, arguing on the basis of Malayalam for a ‘lexical alphabet’ that contains a few sounds not present in the underlying alphabet. Nonetheless, the basic spirit of structure preservation is maintained in their proposal, in that lexical rules may have as their outputs only segments from a strictly limited inventory. This is obviously not the case with postlexical rules, which in every language derive a vast array of phonetic segments on the surface.

The crucial point is this: to my knowledge, all the rules that have been argued to require direct reference to syntax share the property of structure preservation, deriving segments that exist independently in the phonemic inventory of the language. This is predicted by precompilation theory: rules previously described as direct-syntax rules are treated as precompiled rules in the lexicon, where structure preservation holds. The

predictions of precompilation theory would be falsified if, for example, the rules of English that assign shades of vowel length, or which nasalize vowels in the neighborhood of nasals, or which front velars near front vowels, etc., were shown to refer to particular syntactic environments rather than to phonological phrasing.

I am aware of one potential counterexample to the prediction of structure preservation for precompiled rules. Tateishi 1987 suggests that the Consonant Mutation rule of Mende, which I argue below is precompiled, violates structure preservation. Tateishi’s contention is that the segments [b], [g], and [gb] are derived only by Mutation and are not in the lexical alphabet of Mende. The references on Mende I have read, however, suggest that this is quite unlikely. The sections in Innes’s 1969 Mende dictionary for words beginning with non-derived *b*, *g*, and *gb* are very ample, forming about 8% of the total vocabulary. Non-alternating /b/, /g/, and /gb/ occur in commonplace expressions of greeting and thanks (Innes 1967:9); and as the entries in Innes 1969 indicate, words with non-alternating /b/, /g/, and /gb/ freely participate in Mende affixational processes. Etymologically, no /b/, /g/, or /gb/ is of ancient origin, but synchronically this is irrelevant: through borrowing and other mechanisms, these originally allophonic sounds have been restructured as phonemes of Mende.

### 6.2 Rule Ordering: Precompiled Precedes Postlexical

Precompilation theory divides phrasal phonology (broadly construed) into two very separate parts: precompiled phrasal phonology, which resides in the lexicon, and true phrasal phonology, which follows syntax and respects the prosodic hierarchy. Necessarily, the two lie in a rigid ordering relation: true phrasal phonology may refer to information derived by precompiled phonology, but not vice versa. To my knowledge, this expectation is confirmed.

A possible exception is the interesting situation in Turkish described by Kaisse 1986, (this volume). For many speakers of Turkish, there are three distinct categories of voicing in stops: invariantly voiceless, invariantly voiced, and alternating. The latter are voiced in surface syllable-initial position, voiceless syllable-finally. The interest of this case lies in the fact that that Turkish surface syllabification is determined in part by a clearly postlexical rule that resyllabifies consonants across word boundaries.

Kaisse’s example presents an ordering paradox if we assume that the distribution of voicing in stops must be carried out by lexical rules; i.e., that the voicing alternations are precompiled. This is not clear, however. I believe that any adequate analysis of the facts would require us to adopt the following assumption or some notational equivalent of it: the Turkish stops group into three phonemic categories, [+voice], [–voice], and [0 voice], with the rule for voicing applying only to the third, alternating

category. Given this, the distribution of voicing could just as well be carried out by an exceptionless postlexical rule. Such an analysis involves no precompiled rules, so that the ordering paradox disappears.

The kind of ternary distinction on which the analysis depends is disallowed under a number of theories, but nonetheless appears to be widely attested in vowel harmony, tone, and elsewhere; for further defense of ternarity, see Goldsmith 1987b.

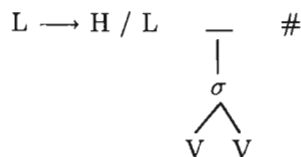
### 6.3 Rule Ordering: Precompiled May Precede Lexical

Precompilation theory makes another, rather striking prediction about rule ordering: that certain phonological rules that have heretofore been considered phrasal, namely the precompiled ones, can actually apply before lexical phonological rules. Three cases of this sort have been pointed out in the literature.

#### Hausa

In Hausa, the rule that shortens final vowels before a full NP object ((3c) above) interacts with the rule of Low Tone Raising (Leben 1971), which raises Low tone to High when it occupies a long final vowel and immediately follows another Low tone:

#### (23) Hausa Low Tone Raising



Low Tone Raising is arguably a lexical rule. It has a fair number of exceptions (McHugh 1981:18), and native speakers seem clearly aware of its effects. However, Low Tone Raising must be ordered after Shortening, because Low-toned vowels that are shortened are not raised. Under standard views, this should not be a possible ordering, since lexicon-internal processes must precede the concatenation of words into phrases. However, we noted above that Hausa Shortening would necessarily be a precompiled rule in our framework, owing to the quite explicit syntactic conditions on its application. If Shortening applies in the lexicon, then the fact that it precedes a lexical rule is not contradictory. Sample derivations, showing how this works, are shown below:

(24) /káràntà:/	/káràntà:/	'read' (underlying form)
káràntà:	káràntà: <sub>[Frame 1]</sub>	Free assignment of phonological instantiation frames
—	káràntà <sub>[Frame 1]</sub>	Shortening
káràntà:	—	Low Tone Raising

The form *káràntà* will be inserted before NP objects, *káràntà:* elsewhere.

#### Mende

In Mende (Cowper and Rice 1987), there is a phrasal rule of Mutation, which lenites various word-initial consonants in certain syntactic environments. Cowper and Rice argue that the rule refers to the prosodic hierarchy. However, several facts cast doubt on this claim. First, the rule appears to be sensitive to certain empty syntactic categories (Cowper and Rice 1987, Tateishi 1988). Among others, Berendsen 1985 and McHugh 1987 have argued that true phrasal phonology is never trace-sensitive.<sup>6</sup> Second, Mutation has a fair number of lexical exceptions, found in borrowings, proper names, and certain kinship terms (Innes 1967:45–6). Such exceptions are characteristic of lexical rules, but typically not of true phrasal rules. Third, Innes 1962:8 mentions that in a few words, the mutated allomorph is different from what the phonological mutation rule would predict, requiring such forms to be lexically listed. For these reasons, I will assume that Mende Mutation is precompiled.

In this respect it is striking that Mutation must be ordered before reduplication, which is generally agreed to be a lexical process. The following data illustrate this (Innes 1967:108):

- (25) a. *táa fembé-ma*  
 he shake-prog.  
 'He is shaking (it)'  
 (base form of verb)
- b. *táa mbomeí vembé-ma*  
 he hammock shake-prog.  
 'He is shaking the hammock'  
 (initial consonant of verb mutated)
- c. *táa fembe-fémbe-ma*  
 he redup.-shake-prog.  
 'He is repeatedly shaking (it)'  
 (reduplicated form)
- d. *táa mbomeí vembe-vémbe-ma*  
 he hammock redup.-shake-prog.  
 'He is repeatedly shaking the hammock'  
 (mutated consonant copied in reduplication)

The crucial datum here is the verb *vembe-vémbe-ma* in (25d), where the initial /f/ must first be mutated to /v/, then copied to yield the surface form.

Under precompilation theory, this result can be derived. Mutation is a precompiled rule, which applies lexically to words marked for [Frame 1], as in (26).

<sup>6</sup>It is possible to analyze Mende Mutation without the use of empty elements, but only at the cost of referring to very specific syntactic or morphological categories, such as unaccusative verbs and inalienably possessed nouns (Tateishi 1987). The argument against a prosodic hierarchy account holds under either analysis.

- (26) a. *Mende Mutation*:  $C \rightarrow [+mutated] / [ \_ \dots ]_{[Frame\ 1]}$   
 b. *Frame 1*:  $[ N^X [ \_ ]_{X^0} \dots ]_{X'}$ , where  $N^X$  is some projection of  $N$

Justification for the formulation of Frame 1 can be found in the work of Tateishi 1988, who has independently made the argument from reduplication for the lexical status of mutation. The ad hoc feature [+mutated] stands for a rather heterogeneous set of phonological changes, described in the work cited above.

Being lexical, Mutation may precede the lexical process of reduplication. Schematic derivations for the verbs of (25c) and (25d) are as follows:

- |                                 |            |   |
|---------------------------------|------------|---|
| (27) a. /fembɛ/                 | b. /fembɛ/ | underlying form of stem 'shake'         |
| fembɛ <sub>[Frame 1]</sub>      | fembɛ      | free assignment of instantiation frames |
| vembɛ <sub>[Frame 1]</sub>      | —          | Mutation                                |
| vembɛvembɛ <sub>[Frame 1]</sub> | fembɛfembɛ | Reduplication                           |

The outputs that result are inserted following an NP object (27a), and elsewhere (27b). The upshot of the analysis is that there is no ordering paradox, since both Mutation and Reduplication are lexical processes.<sup>7</sup>

### Kimatuumbi

The most striking case of precompiled phrasal rules preceding lexical rules is that provided by Odden 1986b, this volume (see also Odden 1981a, 1987). The data involve the well-known rule of Shortening in Kimatuumbi, which Odden 1986b states as being directly sensitive to syntax:

- (28) a. Kimatuumbi Shortening  
 $VV \rightarrow V / [ [ \_ ]_X Y ]_{X'}$ , where  $Y$  contains phonetic material
- b. kjkóloombe 'cleaning shell'  
 kjkólombe chaángu 'my cleaning shell'

Shortening interacts with a rule of Glide Formation, which converts a prevocalic high tense vowel (transcribed /i, ɥ/) to a glide, at the same time lengthening the following vowel:

- (29) a. Kimatuumbi Glide Formation  
 $/i, \text{ɥ}/ + V \rightarrow [y, w] VV$
- b. /ɥ-até/ → lw-aaté 'banana hand'  
 cf. ɥ-toóna 'star'

<sup>7</sup>Innes 1962 notes that some speakers produce forms derivable by applying Mutation after Reduplication: *vembɛ-fembɛ*. Such forms are neutral with respect to the issues at stake. A precompilation account would assume that for these speakers, Reduplication precedes Mutation within the lexicon, since the ordering of lexical rules appears to be largely idiosyncratic.

Odden notes that this rule is word-bounded, citing cases like *ɪláatú ɪtúymbwɪkke* (\**ɪláatwɪtúymbwɪkke*) 'the shoes fell.' He also shows that Glide Formation does not affect long vowels, so long vowels may occur freely in prevocalic position.

Odden next shows that Glide Formation interacts in an interesting way with morphological levels. The levels he assumes for Kimatuumbi are shown schematically as follows (Odden 1986b, (3)):

- (30) a. Levels for Kimatuumbi Verbs  
 $[ \text{subord.} [ \text{subject} - \text{tense} - \text{object} [ \text{ROOT} - \text{derivation} ]_1 ]_2 ]_3$   
 markers marker marker  
 e.g., [ pa [ n - áa - kɪ [ kalaang - ɪté ]\_1 ]\_2 ]\_3  
 when I past it fried perfective  
 'when I fried it'
- b. Levels for Kimatuumbi Nouns  
 $[ \text{locative} [ \text{Class 5} [ \text{noun class} [ \text{ROOT} - \text{derivation} ]_1 ]_2 ]_3 ]_4$   
 e.g., [ kɥ [ [ mw [ aák - ɪ ]\_1 ]\_2 ]\_3 ]\_4  
 to Cl. 1 hunt er  
 'to the hunter'

Within a given morphological level, Glide Formation applies level-finally, left-to-right. However, Glide Formation is also cyclic, in the sense that it applies successively at the end of each of the four morphological levels. As a result, the same underlying sequence of vowels can surface differently, depending on the morphological structure involved. For example, the form [ mɥ i [ ɥtɪ ]\_1 ]\_2 'you should pull it' surfaces as *mɥɪtɪ* (i.e., /ɥiV/ → [wɪiV]); whereas the form [ mɥ [ [ i [ úlá ]\_1 ]\_2 ]\_3 ]\_4 'in the frog' surfaces as *mɥyúlá* (i.e., /ɥiV/ → [ɥyV]). These forms are taken from Odden 1986b, (9–11); for full derivations, see this and other references by Odden cited above. The crucial point for present purposes is that Kimatuumbi Glide Formation shows the classical properties of a lexical rule: interleaving with morphology (i.e., cyclicity) and sensitivity to morphological levels.

Consider now the interaction of Glide Formation and Shortening. Odden's crucial observation is the following: the rule of Shortening, which is obviously phrasal, must be ordered right in the middle of the lexical phonology. In particular, it applies only at Level 1, ordered after Glide Formation. Therefore, it is *fed* by Level 1 applications of Glide Formation, but is *counterfed* by applications of Glide Formation at levels 2, 3, and 4.<sup>8</sup> In the derivation below (Odden 1986b, (23–4)) the vowel /aa/ derived at Level 1 from /i+a/ undergoes phrasal Shortening, but the vowel /aa/ derived at Level 2 from /ɥ+a/ does not.

<sup>8</sup>An additional fact noted in Odden 1981a is probably also relevant here: as a Level 1 rule, Shortening does not apply to underlying long vowels that occur in prefixes attached at levels 2, 3, and 4.

(31)	[ tɥ [ ak-j-an-a ] <sub>1</sub> ] <sub>2</sub> ɪtúumbili	'inf.-net hunt-for-recipr.-final vowel # monkeys' = 'to net-hunt monkeys for each other'
	[ ak-j-an-a ] <sub>1</sub>	Level 1: affixation
	[ akyana ] <sub>1</sub>	Glide Formation
	[ akyana ] <sub>1</sub>	Shortening (triggered by phrasal context, <i>ɪtúumbili</i> )
	[ tɥ akyana ] <sub>2</sub>	Level 2: affixation
	[ twaakyana ] <sub>2</sub>	Glide Formation
	—	(Shortening is Level 1 only)
	twaakyana ɪtúumbili	output

The lesson that Odden draws from these remarkable facts is that lexical rules and phrasal rules do not always interact in the expected fashion, and that grammatical theory must be revised so that the lexical phonology can apply after the syntax.

I agree fully with Odden's general point that the Kimatuumbi facts require us to revise our conceptions of how lexical and phrasal phonology are related. But there are problems with his specific account. Odden's theory doesn't just reshuffle the components of the grammar, but it also radically extends our notion of the phonological cycle. In particular, the theory claims that in course of Level 1, the phonological rules have the power to look *completely outside the word* to the phrasal context, in order to establish whether Shortening is applicable. Once this is done, the cycle returns to the word-internal context, applying to levels 2, 3, and 4. This procedure violates the notion of cyclic rule application in the most fundamental way: the rules on a given cycle may refer to information that does not actually appear in the representation until several cycles later in the derivation. If this is allowed, the whole notion of the cycle becomes a much weaker one, allowing the grammar to access larger and smaller domains in arbitrary order. Given what it entails, Odden's idea of ordering the lexical phonology to follow the syntax is less appealing.

I believe that the Kimatuumbi facts should be taken instead to argue for precompilation theory. Specifically, if we suppose that Shortening is a precompiled rule, then its intimate ordering relations with the lexical rule of Glide Formation immediately become unremarkable. The specific analysis goes as follows. Kimatuumbi permits the phonological instantiation frame under (32).

$$(32) \text{ Frame 1: } [ \dots [ \_ ]_X Y ]_{X'} \quad Y \neq \emptyset$$

That is, special allomorphs are derived for insertion in head positions that precede an overt complement.

Shortening is a lexical rule, which applies only at Level 1:

(33) Kimatuumbi Shortening (precompiled version)

$$VV \rightarrow V / [ \dots \_ \dots ]_{[\text{Frame 1}]}$$

The derivation for the form *twaakyana ɪtúumbili* 'to net-hunt monkeys for each other' (from (31)) would proceed as follows. At Level 1, the stem *akjana* generates two allomorphs, one marked for [Frame 1], the other serving as the elsewhere case. The lexical derivation for the specially marked form proceeds essentially as Odden has it, with the exception that Shortening does not refer to a phrasal context (indeed, no such context yet exists, since we are still in the lexicon). Rather, Shortening refers to the phonological instantiation frame of (32), which restricts the output form to head positions followed by an overt complement. After phonological instantiation, this yields the correct result.

The upshot is that the basic idea of the cycle is maintained: no rule refers to information that is not yet present on the cycle on which the rule applies. The universal ordering of lexical before syntactic rules is also preserved.<sup>9</sup>

To summarize this section: a basic claim of precompilation theory is that many rules that have been called 'syntax sensitive' are actually lexical rules, which precompile allomorphs for insertion in particular phrasal contexts. A prediction of this is that this class of rules, being lexical, may apply before ordinary lexical rules. The prediction is confirmed by the facts of Hausa, Mende, and Kimatuumbi.

#### 6.4 Summary of the Arguments

My overall argument is closely related to a proposal made by Kaisse 1985. Kaisse suggests that postlexical phonology is divisible into two rule components, called P1 and P2. P1 rules have all the properties of lexical rules other than confinement within word boundaries: they exhibit structure preservation, are subject to morphological restrictions, have lexical exceptions, and may apply cyclically. P2 rules are the classical postlexical rules, and lack all of these properties.

Precompilation theory accepts this bifurcation, but attempts to give it a principled basis by actually placing the P1 rules in the lexicon. My view is that the simplest explanation for why P1 rules act as if they were lexical is to assume that they *are* lexical.

### 7 Whither the Prosodic Hierarchy?

Since precompilation theory and prosodic hierarchy theory are both theories of phonological alternation at the phrasal level, one wonders whether

<sup>9</sup>Odden notes that Shortening has exceptions in borrowings: cf. *boóksj yaángu* 'my box' and *bakteélijya yaángu* 'my bacteria' (Odden 1986b, (25)). Since lexical rules often fail to apply to borrowed forms, these data support the claim (common to Odden's account and mine) that Shortening is a lexical rule.

the adoption of the former impinges on the validity of the latter. I believe this is not so, although admittedly a number of supporting cases for prosodic hierarchy theory disappear when reanalyzed as precompiled. Below, I briefly review the basic arguments for prosodic hierarchy theory, drawing on Selkirk 1980a, 1986; Nespor and Vogel 1982, 1986; and Hayes 1989.

- a. In a number of languages, more than one rule refers to the same phrasal domains, where the domains are not equivalent to syntactic constituents. This suggests that syntactic effects in phonology can be mediated by a *structure*, for which the prosodic hierarchy appears to be an appropriate representation.
- b. Typological patterns about junctural strength emerge naturally from the hierarchy. In particular, rules that apply before a juncture of a certain strength apply before all junctures of greater strength; and rules that apply across a given juncture strength apply across all junctures of weaker strength. These fall out under prosodic hierarchy theory from Strict Layering and from the ways rules are allowed to refer to edges (Selkirk 1980a).
- c. Shih 1985 and McHugh (this volume, forthcoming) argue for Mandarin and Chaga respectively that phonological rules can apply cyclically at the level of the phrase. But the cycle that we find is not the cycle predicted by SPE, with rules reapplying on ever-larger syntactic constituents. Rather, the phrasal cycle is apparently the result of an interleaving of phonological rules with phrase formation rules, just as the word-internal cycle results in lexical phonology from the interleaving of phonological rules with rules of word formation.
- d. The rules of phrase formation found in the world's languages show an encouraging family resemblance, suggesting that the theory is on the right track in isolating phrase formation as a level of abstraction at which valid generalizations can be made.

There are a number of cases in which adopting precompilation theory actually provides additional support for prosodic hierarchy theory, by removing apparent violations of the Strict Layer Hypothesis. For example, Chen 1987c points out that the domains required by Xiamen tone sandhi overlap with intonational phrases. Xiamen tone sandhi has two properties that suggest it is a precompiled rule (see below for discussion of these diagnostics): it may apply across pause, and it must have recourse to fairly rich syntactic information, in particular, the argument/adjunct distinction. A plausible precompilation analysis for Xiamen would insert 'basic' allomorphs at the right edges of non-adjunct maximal projections, 'sandhi' allomorphs elsewhere. These purely syntactic environments have

no necessary connection with the prosodic principles that determine intonational phrasing in Xiamen. Thus the overlap of the tone sandhi 'domains' with intonational phrasing says nothing about the Strict Layer Hypothesis, because tone sandhi does not refer to a prosodic domain.

As S. Inkelas has pointed out to me, Hausa Shortening (16) is a similar case. The phonological phrases that would be diagnosed by Shortening if we regarded it as a true phrasal rule would contradict the phonological phrases diagnosed by other means, in particular by the distribution of the clitic *fa* (Inkelas 1988). The contradiction disappears when we recognize that Shortening is precompiled, whereas the distribution of *fa* is genuinely sensitive to phonological phrasing.

A third example, from Tiberian Hebrew, is pointed out by Dresner 1983. Here, the phonology of the construct state, which would plausibly be analyzed as precompiled, applies in overlapping domains with the truly phrasal phonology.

If both precompilation theory and prosodic hierarchy theory are valid, the obvious question that arises is which theory is relevant for a given rule. To put it another way, how do we determine in which component of the grammar (lexical vs. postlexical phonology) a rule creating phrasal alternations resides? Before we consider this question, it is worth examining the issue from the viewpoint of historical change.

## 8 Historical Change and Reanalysis

Consider the characteristic historical evolution of phonological rules (Anderson 1985:73–9), interpreted from the viewpoint of lexical phonology (Kiparsky 1982b:56–8). Typically rules originate phonetically, then crystallize as categorial, exceptionless postlexical rules. With the passage of time, they accumulate exceptions and irregularity, until at some critical point they are *restructured* by a new generation as lexical rules. Ultimately, through leveling and other processes, lexical rules disappear from the grammar.

The above account of restructuring is normally regarded as valid only for rules that apply within words, since phrasal alternations are held to be exclusively postlexical. But if precompilation theory is correct, then phrasal rules can be viewed as having essentially the same history: they originate phonetically, crystallize into categorial postlexical rules, acquire exceptions and irregularities, and at some crucial stage *restructure* as lexical rules—that is, as precompiled. Later, through leveling and other processes, they die out. The gradual death of precompiled rules can be seen in progress in the case of French liaison and the Celtic mutations.

### Excursus: Inflectional Restructuring

Moribund precompiled alternations sometimes undergo a *second* restructuring: they become rules of inflectional morphology, which mark partic-

ular inflectional categories by phonological means. This is demonstrated clearly by Rotenberg 1978 for Modern Irish. In this language, certain tense-marking pre-verbal particles have dropped, so that the mutation they leave behind becomes the sole marker of verbal tense. Similarly, cases in which a noun in a particular case and gender triggers mutation on a following adjective get reanalyzed as adjective agreement, so that the adjective no longer has to immediately follow the noun to get mutated. Other cases of inflectional restructuring can be found in French liaison (Morin and Kaye 1982), English *n't* (Zwicky and Pullum 1983), and Italian inflected prepositions (Napoli and Nevis 1987).

E. Selkirk has suggested to me the possibility of treating *all* precompiled phonology as inflection. While this proposal has the merit of reducing the apparatus needed in the theory, I disagree with it because it would obscure important differences between precompiled phonology and inflection. First, inflectional morphology appears not to be influenced by the phonological form of nearby words in the string. Second, as Anderson 1988 and others have suggested, inflectional morphology is based on a fairly restricted set of syntactic structural relations, whereas precompiled phonology can involve rather haphazard environments that reflect its origins in true phrasal phonology. Third, precompiled phonology appears to be subject to a strict locality requirement: the triggering context for a precompiled allomorph must always lie in an adjacent word. Such a locality requirement clearly is not placed on inflection: for example, *wh*-words are often inflected according to the properties of a trace they bind elsewhere in the sentence.

The separation of inflection from precompiled phonology is supported by Rotenberg's 1978 work on Irish. His analysis suggests that the Irish mutations have been reanalyzed as inflection (hence as potentially non-local) in just those cases in which the data were amenable to syntactic reinterpretation as agreement or other inflectional processes. In the remaining contexts, mutation persists as a local process—in my terms, as precompiled phonology.

## 9 The Diagnosis Problem

To return to the main thread: the fact that precompiled phrasal rules originate historically as true phrasal phonology means that the diagnosis of a rule as precompiled or not is nontrivial. In particular, precompiled rules may look very much like they have prosodic environments, because they are restructured versions of older rules that did have prosodic environments.

Note that the diagnosis problem for phrasal rules is essentially parallel to the diagnosis problem (lexical vs. postlexical) for word-internal rules, itself a controversial and difficult topic.

As an initial attack on the problem, I suggest the following diagnostics

for whether a phrasal rule is precompiled or postlexical.

### Diagnostics for Precompiled Rules

- a. Only precompiled rules can precede rules of lexical phonology (cf. Hausa and Kimatuumbi above).
- b. Only precompiled rules can precede morphological rules (cf. Mende above, as well as the Leurbost Scots Gaelic case discussed in Thomas-Flinders 1981).
- c. Only precompiled rules can treat parallel *X'* categories differently (Hausa, French liaison).
- d. If we assume (following Berendsen 1985, McHugh 1987) that traces and other empty categories are deleted prior to true phrasal phonology, then sensitivity to empty categories diagnoses a precompiled rule. Berendsen notes several phonological rules whose sensitivity to trace can be predicted depending on whether they are 'P1' or 'P2,' or in our terms depending on whether they are precompiled or true phrasal phonology.

### Diagnostics for True Phrasal Phonology

- a. Only true phrasal rules may follow postlexical rules.
- b. Only true phrasal rules may violate structure preservation.
- c. Only true phrasal rules may involve phrasal cyclicity; i.e., the interleaving of phonology and phrase construction.
- d. Rules of phonological spreading, particularly spreading of autosegments over multiple syllables, would in many cases be impossible to treat as precompiled, and thus would have to be analyzed as true phrasal phonology. A good example is the tonal phonology of Chaga (McHugh (forthcoming)).
- e. Assuming that phonological instantiation is insensitive to pause, then any rule blocked by pause is a rule of true phrasal phonology (cf. Rotenberg 1978).
- f. Assuming that phonological instantiation is not sensitive to speaking rate, then rules that apply in larger domains at greater speaking rates must be true phrasal rules, and not precompiled.<sup>10</sup>

<sup>10</sup>Here it is worth noting the case of French liaison, which is highly unusual in that it expands its domain in slower, more careful speech styles. This is due, I believe, to the precompiled status of liaison: in careful speech, French speakers make use of largely obsolete phonological instantiation frames, which are artificially preserved by education and social pressure.

I am not sure if whether the converse of this diagnostic holds; i.e., whether if a rule applies in an invariant domain, it is precompiled. The phrasal rules of Chaga (McHugh (forthcoming)) cast doubt on this, in that they apply in invariant domains but by diagnostics (c) and (d) are true phrasal rules.

- g. Assuming that phonological instantiation cannot access phonological phrasing, any rule that refers to the prosodic hierarchy, or follows a rule that refers to the prosodic hierarchy, is a true phrasal rule. Note that the background assumption is not a necessary consequence of the theory: both phonological instantiation and phrase formation fall within the 'interface component' that lies between syntax and true phrasal phonology. In principle, some forms of phonological instantiation might follow phrase formation within this component, and thus be able to refer to prosodic domains.

The joint effect of the diagnostics proposed above is that the theory is quite testable empirically: ideally, all of the diagnostics should agree for all of the rules. Note, however, that many of the diagnostics depend on additional assumptions about precompilation theory and prosodic hierarchy theory. I have tried to make these assumptions explicit above. Counterevidence must therefore be considered carefully for just what it counterexamples.

## 10 Conclusion

To summarize: my proposal is that all phrasal phonological phenomena can be analyzed either under prosodic hierarchy theory or under precompilation theory. As a result, the class of rules that refer directly to syntax in their structural descriptions can be eliminated from phonological theory.

On the surface, this is hardly an earth-shaking result. After all, in order to eliminate one class of rules from phonological theory, we have had to introduce two others. The real point is that taken together, prosodic hierarchy theory and precompilation theory form a *structured* account of the data: every phrasal rule must fit into one theory or the other, and for a rule to fit into a theory, it must meet specific requirements, as I have tried to show in the preceding section. Thus the overall approach has the virtue of making falsifiable predictions. In contrast, it is hard to imagine an observation that would falsify a theory that simply said that phonological rules may refer to syntactic structure.

This kind of compartmentalization has already borne fruit for word-internal rules, as the theory of lexical phonology. By adding precompilation theory to prosodic hierarchy theory, my intent is to develop an equally articulated, hence predictive theory of alternations at the phrasal level.

# 6

## Boundary Tonology and the Prosodic Hierarchy

LARRY M. HYMAN

PHONOLOGISTS HAVE LONG BEEN interested in phonological rules that apply at the left or right edge of a constituent. The literature describes numerous processes affecting consonants and/or vowels at the beginning or end of a 'word,' 'phrase,' or other unit: 'initial' glottal stop insertion, 'final' devoicing, 'final' deletion and so forth. Selkirk 1980a,b; 1984, Nespor and Vogel 1986, and others have proposed that these constituents or 'prosodic domains' are organized into a phonological hierarchy which, going from smallest to largest domain, includes the phonological word (PW), clitic group (CG), phonological phrase (PP), intonational phrase (IP) and utterance (U).<sup>1</sup>

Processes which are restricted to the initial or final position of any such domain are termed 'domain-limit' rules. Instead of referring to the junctures or boundary symbols of earlier frameworks, domain-limit rules target the left or right edge of a constituent at any 'layer' of the above prosodic hierarchy.

Nowhere is the need for such domain-limit rules more evident than in the area of tone. Tone rules that apply at the beginning or end of a prosodic domain are extremely common and, as in the case of their segmental counterparts, tend to cluster around a few recurrent processes. In this study I shall refer collectively to such tonal domain-limit rules as 'boundary tonology.' Adopting the framework of Archangeli and Pulleyblank (to appear), some of the parameters of boundary tones are seen in (1).

<sup>1</sup>Though in this paper I am interested only in phrasal domains, it should be noted that the same authors propose that the hierarchy extends to the progressively smaller foot and syllable domains.