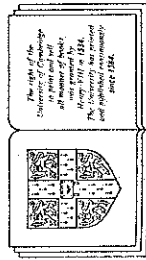


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Lexical Phonology and Prosodic Phonology*

Geert Booij

1 Introduction

Lexical Phonology and Prosodic Phonology are not two different components of the grammar. Rather, Lexical Phonology is a theory about the organization of the grammar, in particular about the way in which phonology and morphology interact, whereas Prosodic Phonology is a theory about the structure of phonological representations.¹

In this paper I will investigate the relations between these two theories. The main question is: (i) when, and (ii) how does the prosodification of words take place? It will become clear that an answer to the 'when?' question can only be given by investigating the role of prosodic structure in lexical phonological rules and in morphology. This will be done in Sections 2 and 3 respectively. Subsequently, I will deal with the 'how?' problem, in particular with the way in which the resyllabification effects of morphological and phonological operations should be accounted for (Section 4). Section 5 summarizes our findings.

2 Prosodic structure and Lexical Phonological rules

In most publications on Lexical Phonology (e.g. Kiparsky 1985) it is assumed that syllabification takes place as early as possible, i.e. on the first cycle. Although, as I will argue below, this is the correct view, it is by no means the a priori simplest and most natural one, because it forces us to redetermine the prosodic structure of a phonological string after each morphological and phonological operation. Why do we not postpone syllabification until at least the end of the lexicon, or even later, until the end of the postlexical phonological component, since the rules of sentence phonology may also affect the syllabification of words?

The answer to this question is that prosodic information concerning the input string is sometimes necessary for the proper application of cyclic phonological rules.

A well known class of cyclic lexical rules are the rules for the assignment of main stress in a number of languages. One of them is Spanish (Harris 1969: 125f), where the effect of main stress assignment to a syllable can still be seen in the diphthongized nature of the vowel of that syllable, even when the main stress has been shifted to another syllable on a following cycle, as illustrated in (1):

- (1) buenfssimo 'very good', pueblíto 'little town', adiestrár 'to train'

Since stress rules assign properties to syllables, it is clear that syllabification must take place before cyclic stress assignment. Hence, syllabification must already apply on the first cycle.

Classic examples of segmental rules which are cyclic because they are subject to the Strict Cycle Condition are a number of rules in Polish (Rubach 1984). Two of these are the palatalization rules of Coronal Palatalization and Iotation, which compete with respect to obstruents. The rule of Coronal Palatalization turns coronal consonants into prepalatals before front vowels and the glide [j]. Redundancy rules spell out /t' d' s' z' n' / as prepalatal consonants (stops become affricates): [č ž ś ź ń]. The dark ɾ is turned into a clear l and /r' / is spelled out as [ʒ]. The rule of Iotation creates a series of postalveolar obstruents before /j/.

- (2) *Coronal Palatalization*:
 $\{t \ d \ s \ r \ n \ ɾ\} \rightarrow [-\text{back}] / \text{---} \left[\begin{array}{c} -\text{cons} \\ -\text{back} \end{array} \right]$

- (3) *Iotation*:
 $\{t' \ d' \ s' \ z'\} \rightarrow \{\check{c} \ \check{z} \ \check{s} \ \check{z}'\} / \text{---} j$

Therefore, the distinction between /i/ and /j/ is crucial for the correct application of these two cyclic rules. However, in the recent phonological literature it has been argued that the distinction between high vowels and glides should not be expressed in terms of an inherent feature [syllabic], but as a difference of position in syllable structure: high [-cons] segments are vowels in nuclear position, but glides when occurring in onsets and codas. The syllabification and/or phonological rules will determine whether, for instance, an /i/ will surface as a vowel or a glide (cf. Levin 1985, Rubach & Booij 1990). Consequently, the syllabification rules will have to assign prosodic structure to a string before the cyclic phonological rules can apply. Hence, they have already to apply in the cyclic phonological component of the lexicon.

In conclusion, syllabification must be a cyclic process because cyclic phonological rules may presuppose prosodic structure.²

3 The role of prosody in morphological operations

In this section I will present a number of cases in which morphology requires prosodic information (see Booij 1988a for more examples). Since morphological rules apply in the lexicon, i.e., they are lexical rules, this implies that prosodic information must be available in the lexicon.

A first example comes from Anshen et al. (1986). They observe that the choice between the suffixes *-ify* and *-ize* in English is determined by the number of syllables of the base words: *-ify* is attached if the base word consists of at most two syllables, whereas *-ize* is attached if the base word contains at least two syllables.

Prosodic information also plays a role in certain reduplication processes. Marantz (1982: 453) has pointed out that in Yidin' the first two syllables of a stem are reduplicated regardless of the make up of these syllables, as the following examples of noun plural formation taken from Dixon (1977: 156) show:

- (4) (a) *dĩmurU* 'house' *dĩmudĩmurU* 'houses'
 (b) *gĩndalba* 'lizard' *gĩndalĩndalba* 'lizards'

In (4a) the reduplicated constituent has the form CVCV, because the /r/ of *dĩmurU* is the onset of the third syllable, whereas in (4b) a CVCVC string is added because the /l/ belongs to the second syllable.

Broselow & McCarthy (1983) argue that cases of so-called internal reduplication should be analysed as the prefixation of reduplicated constituents to phonological constituents. For instance, reduplication in Samoan can be characterized as follows (p. 53): 'CV is prefixed to the stressed syllable – or equivalently to the metrical foot – of the word.' Consequently, we get a CV-prefix for mono- and disyllabic words, but a CV-infix for trisyllabic words:

- (5) *input form:* *reduplicated form:*
 tá tata
 nófo nonofo
 alófa alolofa

Another situation that requires prosody to be present for morphology is that in which stress properties of base words condition morphological operations. In Dutch, the choice between the suffixes *-isch* and *-ief* which

both attach to words ending in *-ie* depends on the stress of the last syllable: if *-ie* is stressed, we get *-isch*, and otherwise *-ief* (Booij & Rubach 1987):

- (6) (a) hysterie 'hysteria' hysterisch 'hysterical'
 démocratie 'democracy' democratisch 'democratic'
 analogie 'analogy' analogisch 'analogical'
 (b) agressie 'aggression' agressief 'aggressive'
 indicatie 'indication' indicatief 'indicative'
 constitutie 'constitution' constitutief 'constitutive'

Note that it is impossible to avoid the necessity of prosodic information for morphology here by claiming that the nouns in *-ie* are derived from the corresponding adjectives. First, the meanings of the adjectives are compositional functions of the meanings of the nouns. Secondly, given a noun in *-ie*, native speakers of Dutch can always coin an adjective in *-isch* or *-ief* (i.e. these are productive suffixes). However, it is impossible to derive nouns in *-ie* from adjectives in *-isch* or *-ief*. For instance, it is impossible to derive *logie 'logic' from *logisch* 'logical' or *primitie 'primacy' from *primitief* 'primitive'.

An example from English can be found in Siegel (1974) who showed that the deverbal suffix *-al* only attaches to verbs with final stress:

- (7) try - trial versus organize - *organizational
 deny - denial encourage - *encourageal
 refuse - refusal compensate - *compensatal

Another example is given by Strauss (1982: 147) who points out that the adjectival suffix *-ic* requires non-final stress on X in X+*ist* bases (X bisyllabic):

- (8) (a) fatal-ist fatalistic
 modern-ist modernistic
 social-ist socialistic
 (b) defeat-ist *defeatistic
 escap-ist *escapist
 extrém-ist *extremistic

This type of interaction between morphology and phonology is precisely what we expect in the classic version of the theory of Lexical Phonology that claims that phonology and morphology are interspersed. Note, however, that these facts form a problem for the version of Lexical Phonology recently proposed in Halle & Vergnaud (1987: 278). In this version morphological rules form a block ordered before the block of lexical phonological rules. Consequently, morphology cannot use prosodic

information, counter to the facts presented above. The reason for Halle and Vergnaud's return to a kind of SPE model of morphology-phonology interaction is that, according to them, in this way the so-called bracketing paradoxes that arise in the standard version of Lexical Phonology can be avoided. For instance, it has been argued in the literature that *ungrammaticality* has the morphological structure

[un[grammat+ic+al]_A]_A+ity]_N

but the phonological structure

[un[[grammat+ic+al]_A+ity]_N]_N

(cf. Booij and Rubach 1984 for a survey of the issue). That is, from the morphological point of view the stress-neutral suffix *un-* is added before the stress-shifting suffix *-ity*, but for the proper assignment of stress the attachment of *-ity* would have to precede that of *un-*. Halle and Vergnaud now propose that there is only one structure for *ungrammaticality*, the morphological structure, which is derived before the application of phonology. The stress rules then apply to this structure starting with the string enclosed by the most inner brackets, as in *The Sound Pattern of English*.

In my opinion, this radical move back to SPE, based on bracketing paradoxes only, is not correct, given the observations concerning the role of phonology for morphology made above. Moreover, there are other well motivated solutions for the bracketing paradoxes, for instance that proposed by Booij & Rubach (1984). They argue that the stress rules apply to the - independently motivated - prosodic structure of *ungrammaticality*, which consists of two phonological words, *un* and *grammaticality*. A similar solution is proposed there for the Russian/Polish cases discussed by Halle & Vergnaud.

The conclusion of this section is again that syllabification is a cyclic operation, because morphology may need information about the prosodic structure of input words.

4 Resyllabification

A consequence of cyclic syllabification is that after each morphological operation the prosodic structure of the input string has to be redetermined. For instance, if the vowel-initial suffix *-er* is attached to the verb *eat*, the /t/, a coda in the input verb, has to become an onset in *eater*.

Resyllabification is also necessary after the application of phonological rules that delete or insert segments, i.e. change the x-tier.

This resyllabification can be conceived of in two ways. One logical possibility is to completely erase the existing prosodic structure of the input string, and to erect a completely new prosodic tree. This is, in fact, the suggestion made by Liberman & Prince (1977), who proposed to assume so-called 'Deforestation' of the input forms. The alternative is to minimally modify the prosodic structure of the input string by just changing the final coda of the input form. This is what I will defend below.

If in a certain language the stress patterns of derived words reflect those of their base words (i.e. stress assignment is cyclic), as has been claimed for English (cf. Chomsky & Halle 1968, Selkirk 1980: 597), Deforestation cannot be the right procedure, if, unlike Liberman & Prince's assumption, stress properties of words are solely represented by prosodic constituent structure and strong/weak labels assigned to these prosodic constituents. Therefore, Selkirk (1980: 598) suggested that restructuring should be minimal.

A requirement of minimality is also necessary for cases of affixation with stress-neutral affixes. For instance, the attachment of a stress-neutral suffix to a stem should leave the stress information expressed by the metrical tree intact. On the other hand, stress-neutral vowel-initial suffixes like English *-er* do require reprosodification in that the final consonant of a verbal stem becomes the onset of the next syllable: *con-táin/con-tái-ner, lín-ger/lín-ge-rer*. These two requirements are only compatible if syllabification as triggered by morphological operations does not affect nuclei, because nuclei are essential for keeping stressed syllables intact.

Stress is not the only phenomenon that forces us to exempt at least nuclei from resyllabification. In Kenstowicz & Rubach (1987: 474) it is argued that Slovak 'has a three-way distinction in the treatment of certain vocalic segments'. For instance, in the word *kliént* the *i* and the *e* constitute the nuclei of two separate syllables, in *tríed-a* 'class' *i+e* forms a diphthong, and in *jednáak* 'yet' it forms a glide-vowel sequence. At the lexical level, this difference can be represented as follows, assuming Levin's (1985) theory of syllable structure:

(9)	N	N	N	N	N	N	N	N	N
			/	/	/	/	/	/	/
	x	x	x	x	x	x	x	x	x
	k	l	i	e	n	t	r	i	e
									a
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The *e* of *kliént* will be assigned an N-node by the rule of N-placement for non-high [-cons] segments. The glide status of the /i/ in *jednáak* will then be predicted by the rule that assigns the segment before the nucleus to the onset. Clearly, then, resyllabification may not erase all existing prosodic structure, because otherwise the lexical information about the nuclear status of the *i* in *kliént* and *tríed-* would get lost.

Similarly, Guerssel (1986) argued that in Berber high vowels and glides should be treated as underlyingly identical segments, with the same feature specifications. However, some members of this set of high [-cons] segments must be lexically specified as being attached to a Nucleus-node.

A similar situation obtains for Polish. In this language, the glides [j] and [w] can be represented underlyingly as /i/ and /u/ respectively. The gliding rules will interpret /i/ as a glide before a [-cons] segment (Regressive Gliding) and both /i/ and /u/ as glides after a [-cons] segment (Progressive Gliding). The sequence /iu/ is interpreted as [ju] (cf. Rubach and Booij 1990):

- (10) kabriolet [kabrjolet] 'cabriolet'
- kraj [kraj] 'country'
- autor [awtor] 'author'
- situacja [sytuacja] 'situation'
- biuro [bjuro] 'office'

However, there are a few lexical exceptions to these generalizations concerning glides and vowels, borrowings such as those in (11):

- (11) kokaina [kokaina] 'cocaine', Ukraina [ukraina] 'Ukraine', muzeum [muzeum] 'museum', Pireus [pireus] 'Piraeus'

These exceptions must be lexically specified with N-nodes for the high [-cons] segments. Therefore, resyllabification in Polish must preserve nuclei, because otherwise crucial information would get lost.

A very interesting case which supports the principle of nucleus preservation is the rule of Lateral Vocalization of Polish which in certain contexts changes a dark /+ into a glide [w]. Since the [w] is an /u/ underlyingly, the rule changes the /+ into an /u/. Rubach & Booij (1988) now show that this rule must be subject to a principle of nucleus preservation. Normally, in Polish an /i/ before an /u/ is interpreted as a glide, as in *biuro* [bjuro] 'office'. However, in words like *pi-t* 'saw, gen. pl.' and *pi-t* + a 'saw' the /i/ must be kept a real vowel, even though Lateral Vocalization has turned the dark /+ into an /u/, since the pronunciation of these words is [piw] and [piwa] respectively. Clearly then, nuclei must be preserved in the process of resyllabification. Note that nuclei

preservation is not an independent principle, but follows from the principle that only coda structure may be erased after the application of a morphological or phonological rule.

The examples of resyllabification discussed so far were cases in which a constituent-final coda-consonant had to be resyllabified as onset of the next syllable.

Borowsky (1986:197) proposed to account for this by assuming that constituent-final consonants are universally extrametrical. According to her,

the extrametricality of final consonants seems intuitively to have something to do with the fact that the consonant is waiting around in abeyance to be attached as an onset to some syllable on the next cycle.

For instance, if a vowel-initial suffix were added to a stem, the stem-final consonant would lose its extrametricality due to the Peripherality Condition and be linked prosodically by the CV-rule. If the word with the extrametrical consonant is not subject to further operations, the extrametrical consonant will be prosodically linked at the end of the lexicon by some adjunction rule.

The advantage of this proposal is that we do not need a separate rule of Coda Erasure as part of the syllabification algorithm. However, it is conceptually inconsistent and makes wrong empirical predictions.

First, note that in this approach the notions 'extrametricality' and 'extraprosodicity' are identified. This is incorrect: 'extrametrical' means: not visible for the stress rules, whereas 'extraprosodic' means: not linked to prosodic structure. The fact that they are different notions can be illustrated by Polish: in certain Polish words, the last *syllable* is extrametrical, and hence these words have antepenultimate stress instead of the normal penultimate stress, e.g. *maternáyka* (cf. Franks 1985). Note that something can only be identified as a syllable if it is prosodified. Clearly, then, these notions should be distinguished.

A first empirical problem is that in Dutch, the visibility of the word-final consonant is crucially required for the assignment of stress: if the last syllable of a Dutch word ends in long vowel plus consonant, it gets final stress, whereas this is not the case for words with a final syllable ending in a long vowel (Van der Hulst 1984):

- (12)

tarief 'rate'	kanárie 'canary'
kanáal 'canal'	áda 'proper name, fem.'
kantóór 'office'	áuto 'car'

Note that this problem cannot be avoided by considering stress assignment as a postcyclic process that takes place after the adjunction of the extrametrical consonant. Stress assignment in Dutch has to apply as a cyclic rule, because morphological operations may need information about the stress patterns of input words, as shown above.

A second problem is that the consonant extrametricality approach predicts that only the last consonant of a stem can form the onset of the next syllable. However, it appears that in Dutch, consonant-clusters of the form /st/ can form complex onsets after a morphological operation, as illustrated in (13):

- (13)

liefst 'dearest'	lief-ste 'the dearest'
grootst 'biggest'	groot-ste 'the biggest'
leukst 'funniest'	leuk-ste 'the funniest'

The facts in (13) are accounted for by the assumption of a rule of Coda Erasure, after which the syllabification principles, including the Maximal Onset Principle, reapply. Since *-st* is a possible onset of Dutch, we will derive the syllabification as indicated in (13).

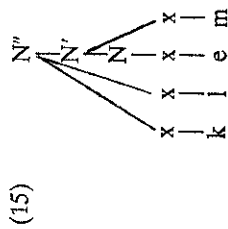
The applicability of the Maximal Onset Principle in resyllabification can also be seen in the following pairs of morphologically related words in Dutch:

- (14)

(a) filter /filtr/ 'filter'	(b) fil-treer 'to filter'
center /sentr/ 'centre'	cen-treer 'to centre'
regel /regl/ 'rule'	re-glement 'regulations'
integer /integr/ 'sound'	inte-greer 'to integrate'
oktober /oktoobr/ 'October'	okto-brist 'Octoberist'

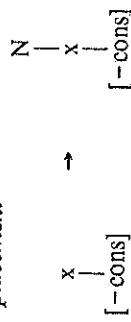
In the a-words, the final liquids will remain extrasyllabic on the first cycle. A schwa-insertion rule then applies to 'save' these extrasyllabic consonants. In the b-words, the whole cluster obstruent plus liquid becomes the onset of the next syllable, as indicated in (8b). If we did not assume Coda Erasure, but final consonant extrametricality instead, we would predict incorrect syllabification patterns like *fil-treer* or *reg-le-ment*.

Another proposal as to resyllabification was made by Levin (1985). Levin assumes that syllables are projections of nuclei. For instance, the word *claim* will be assigned the following syllable structure:

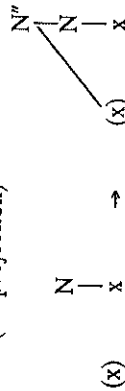


This structure is derived by the following set of rules:

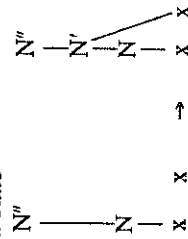
(16) (a) *N-placement*



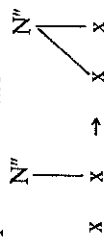
(b) *CV-rule (N''-projection)*



(c) *Coda Rule*



(d) *Complex Onset Rule*



Levin (1985:134ff) argues that it is not possible to avoid resyllabification by postponing coda formation until the end of the derivation. For instance, in Klamath there is a rule of vowel epenthesis that inserts the default vowel /a/ before an extrasyllabic consonant in the coda. Extrasyllabic consonants arise because a coda contains at most one consonant. For instance, in /gawm/ 'spring' the final /m/ cannot be syllabified, and hence it becomes extrasyllabic. After insertion of the epenthetic vowel /a/, the string is resyllabified, and the /m/ becomes the coda of the second syllable. The /w/, originally assigned to the coda of the first

syllable, has now to be resyllabified as onset of the second syllable. This is confirmed by the fact that rules that apply in closed syllables no longer apply to the first syllable of the derived string /gawam/. In sum, resyllabification cannot be avoided by postponing coda formation until the end of the derivation.

A similar situation obtains for Polish (Rubach & Booij 1990). The cyclic rule of Comparative Allomorphy inserts the sequence /ej/ after an extrasyllabic consonant. Hence, the coda rules must have applied on the first cycle in order to determine the prosodic status of consonants. Compare the forms in (17a), where there is no extrasyllabic consonant, with those in (17b), where the final consonant of the root is extrasyllabic:

- (17) (a) *positive degree:*
 prost+y 'simple'
 tęp+y [temp+i] 'blunt'
 podł+y 'mean'
 szodrz+y 'generous'
- comparative degree:*
 prost+sz+y
 tęp+sz+y [temp+š+i]
 podł+ejsz+y
 szodrz+ejsz+y
- (b)

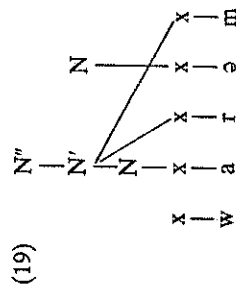
Levin then proposes that the CV-rule can also apply in a structure-changing fashion, i.e. it can delink a consonant from the N'-node, and assign it as an onset to the following syllable. Given the observation made above about the resyllabification of two consonants, this structure-changing power would have to be assigned to the Complex Onset Rule as well.

Given this modification, Levin's proposal is superior to Borowsky's suggestion. Moreover, Levin's theory can also handle cases of resyllabification in non-constituent-final position. For instance, the application of the Klamath rule of vowel epenthesis that inserts a vowel before an extrasyllabic consonant will also trigger structure-changing applications of the CV-rule to consonants before this inserted vowel. That is, Levin also accounts for certain resyllabification effects of phonological rules.

However, we still face problems if other types of phonological rules are taken into account. For instance, Dutch has a rule of schwa-insertion that optionally inserts this vowel (ə) between a liquid and a following non-coronal obstruent, as illustrated in (11):

- (18) warm 'warm' [wɑrəm]
 harp 'harp' [hɑrəp]
 melk 'milk' [mɛlək]

In this case we cannot simply reapply the syllabification algorithm to the output of schwa-insertion, because the first rule, N-placement, would create an ill-formed structure:



The syllabification algorithm can only apply properly, if first the coda linkings are removed. Therefore, I conclude that resyllabification effects cannot be accounted for by structure-changing applications of certain rules. Rather, they should be taken care of by a rule of Coda Erasure that applies by convention after each morphological or phonological operation, a position also taken by Clements and Keyser (1983: 54). The only difference is that they also allow for erasure of onsets. Note that they cannot differentiate between onsets and codas in structural terms, because they adhere to a 'flat' view of syllable structure. At present, I do not have positive evidence for the necessity of onset erasure, and therefore Coda Erasure seems to be the minimal form of resyllabification required.

5 Conclusions

In this paper I have argued that information about the prosodic structure of words is necessary for the proper application of both morphological and phonological rules. Consequently, morphology and phonology cannot be separated into two different, consecutive blocks within the lexicon, as suggested by Halle & Vergnaud (1987). Rather, phonology and morphology are interspersed, the classic view of Lexical Phonology.

A consequence of this organization of the lexicon is that syllabification rules must apply persistently. Hence, we also need some principle of resyllabification. It was argued that resyllabification should be accounted for by a convention of Coda Erasure rather than by consonant extra-metricity or structure-changing application of onset creating rules.

Notes

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- 1 Here I disagree with Nespor & Vogel (1986); cf. Booij (1988b).
- 2 There are also postcyclic lexical rules that refer to prosodic structure in structural description. An example is the Dutch rule of devoicing of obstruents in syllable-final position for which Booij & Rubach (1987) argue that it should be considered a lexical postcyclic rule. Another example is the rule of Closed Syllable Adjustment in French, a lexical postcyclic rule that refers to prosodic structure, as its name already indicates (cf. Booij 1984). However, these rules do not prove that prosodification is cyclic: for a proper application of these rules it is sufficient that prosodification applies postcyclically.

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