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ON THE RELATION BETWEEN LEXICAL AND PROSODIC PHONOLOGY*

1. Introduction. In recent years, the theory of generative phonology has undergone two important innovations which can be labeled as Lexical Phonology and Non-linear Phonology respectively.

The theory of Lexical Phonology is a theory about the organization of phonology. Its basic claims are that we must distinguish between lexical rules - which apply in the lexicon, and may interact with morphology - and postlexical rules which apply in the postsyntactic phonological component. I will assume here the particular model of Lexical Phonology defended in Booij & Rubach (1987). In this model, lexical rules are divided into two classes: cyclic rules, which interact with morphology and are subject to Strict Cyclicity (i.e. they only apply in derived environments), and postcyclic rules which apply after morphology and across-the-board (so-called 'word level rules').

'Non-linear phonology' is a convenient label for all those theories which claim that phonological representations are richer than just a linear concatenation of segments and boundary symbols. In this sense, the theory of Prosodic Phonology is, like e.g. Autosegmental Phonology, part of Non-linear Phonology, because it claims that segments are organized hierarchically in terms of prosodic categories like the syllable, the foot etc.

In sum, Lexical Phonology concerns the derivational aspect of phonological theory, and Prosodic Phonology concerns the representational aspect of phonology.

The most recent and elaborate version of Prosodic Phonology can be found in Nespor & Vogel (1986) [henceforth NV] who assume the following hierarchy of prosodic categories:

(1) syllable (σ)
foot (Σ)
phonological word (ω)
clitic group (cl)
phonological phrase (ϕ)
intonational phrase (I)
phonological utterance (U)

These prosodic categories have three potential roles: domains of rules, domains of phonotactic constraints, and bearers of prominence relations (strong/weak relations). NV argue that morpho-syntactic structure is mapped onto prosodic structure by means of a set of mapping conventions. They also show that prosodic structure is not isomorphic to morpho-syntactic structure. Phonological rules whose domains of application can be formulated in terms of prosodic phonological constituents are called 'prosodic rules'.

What is in need of clarification then is the nature of the relation between lexical rules and prosodic rules. NV consider them as two separate types of phonological rule, located in two different components of the grammar: lexical rules are located in the lexicon, and prosodic (= 'phonological') rules apply post-syntactically, as the following diagram taken from NV (p. 302) shows.

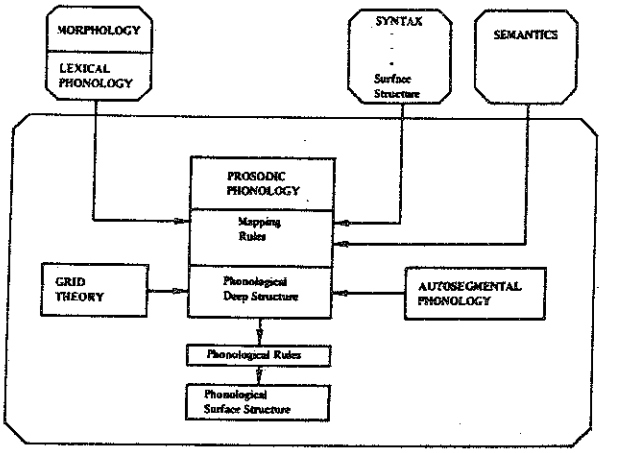


Fig. 1. Model of the interactions between prosodic phonology and the other subsystems of the grammar

NV argue that the attractiveness of this strict division between lexical and prosodic rules is that it embodies the restrictive hypo-

thesis that phonological rules cannot refer simultaneously to both morpho-syntactic and prosodic structure:

> "In other words, any phonological rule that applies in a domain created on the basis of morphological structure may refer only to the phonological domain, not to the morphological elements in the corresponding morpho-syntactic tree." (NV, p. 18)

A consequence of this hypothesis is that syllabification, or more generally prosodification, will not take place in the lexicon, but postlexically.

However, NV have already noted a problem for their model (p. 18-19): sometimes the internal morphological structure of words, which is completely erased at the end of the lexicon due to the Erasure Convention, must be available for the prosodic mapping conventions, because certain affixes appear to form phonological words of their own. The following passage is relevant here (NV p. 19):

> "As will be seen below, in order to create certain prosodic constituents, in particular the phonological word, the mapping rules must indeed have access to certain aspects of morphological structure (see Chapter 4). One possible solution would be to allow the mapping rules to apply before, or at least independently from, the rules of lexical phonology. In this way, the lexical phonology rules could apply before the prosodic rules, although their output would not be the only input to the subsystem of prosodic phonology. In any case, it seems that the accomodations necessary in order to obtain the correct type of interaction between the lexical and prosodic subsystems of the phonology will not require major modifications in either theory. We will leave working out the details of these modifications for future research."

In this paper I will argue, contra NV, that lexical rules and prosodic rules do not form distinct categories. Lexical rules, both cyclic and post-cyclic, can refer to prosodic domains, and the assignment of prosodic structure up to the word level forms part of the lexicon. In the following sections I will provide three types of evidence for this claim: prosodic structure is relevant for morphology (section 2), lexical rules may refer to prosodic structure (section 3), and the syllabification algorithm for words can only work properly if it applies in the lexicon (section 4). In section 5 it is argued that certain rules require prosodic and morphosyntactic information concerning a word to be present simultaneously, and hence the restrictive hypothesis proposed by NV is refuted.

2. The role of prosodic information in morphology. In this section I will give three examples of word formation processes which make use of prosodic information concerning their input words.

The first example is taken from Booij & Rubach (1987) and concerns Dutch. In this language, the choice between the two denominal adjectival suffixes -isch and -ief depends on the stress pattern of the basis word: -isch is attached if the final syllable is stressed, and -ief if the final syllable is unstressed:

(2)	a.	psychologíe	'psychology'	psychologisch	'psychological'
		hysteríe	'hysteria'	hysterisch	'hysterical'
		analogíe	'analogy'	analogisch	'analogical'
	b.	agrèssie	'aggression'	agressief	'aggressive'
		invèntie	'invention'	inventief	'inventive'
		àctie	'action'	actief	'active'

Consequently, the information concerning the stress patterns of the input nouns, and hence their prosodic structure (since prosodic constituents are the bearers of prominence relations) must be available for morphology. Since morphological rules apply in the lexicon, this kind of prosodic information must be derived there as well.[1]

A second example concerning the relevance of prosody for morphology is the well known observation that English comparative formation is restricted to mono- and disyllabic nouns. That is, in order to apply the comparative rule properly, the prosodic structure of the input adjectives must already be available: redder and happier are correct comparatives, but *excellenter is not.

Marantz (1982: 453) has pointed out that prosodic structure may also be relevant for reduplication processes. In Yidiny 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:

(3)	a.	ɖimurU	'house'	ɖimuɖimurU	'houses'
	b.	gindalba	'lizard'	gindalgindalba	'lizards'

In (3a), the reduplicated constituent has the form CVCV, because the /r/ of ɖimurU is the onset of the third syllable, whereas in (3b) a CVCVC-string is added because the /l/ belongs to the second syllable. This clearly illustrates the crucial role of prosodic structure in determining the actual shape of the reduplicated string.

To conclude this section, we have seen that information concerning the prosodic structure of words may be necessary for a proper application of morphological rules.

3. Prosodic information in lexical rules. It is not difficult to find examples in the relevant literature of lexical rules that refer to prosodic categories, in particular the syllable and the phonological word.

An example of a lexical rule that refers to the syllable is the French rule of Closed Syllable Adjustment which accounts for the alternation [e,ə]/[ɛ] as in premier 'first, masc.' [prəmje]/première 'first, fem.' [prəmjɛr]: the [e] and [ə] occur in open syllables, the [ɛ] in closed syllables. This rule must apply lexically, because postlexically French resyllabifies within phrases in such a way that a word-final consonant becomes the onset of the first syllable of the following vowel-initial word, the so-called 'enchaînement'. Hence, première amie 'first friend, fem.' will receive the following prosodic structure at the postlexical level: $(\text{prə})_\sigma(\text{mjɛ})_\sigma(\text{ra})_\sigma(\text{mi})_\sigma$ in which the [ɛ] occurs in an open syllable (cf. Booij 1984).

A first example of a lexical rule with as its domain is the rule of prevocalic schwa-deletion in Dutch:

(4) $\text{ə} \rightarrow \emptyset \; / \; \text{-- V} \ldots)_\omega$

This rule is cyclic since it must apply in between two morphological rules (Booij & Rubach 1987). For instance, the derivation of ambassadrice 'female ambassador', derived from ambassadeur 'ambassador' runs as follows:

Cycle 1	/ɑmbɑsadə/		
Cycle 2		+ ör	WFR: -eur Affixation
		∅	Prevocalic Schwa Deletion ($\text{ə} \rightarrow \emptyset / \_\_ \text{V})_\omega$)
Cycle 3		risə	WFR: -eur/-rice Substitution
	[ɑmbɑsadrisə]		

Applying all morphological rules before all phonological rules would produce the wrong phonetic form *[ɑmbɑsadərisə], because the conditioning vowel for Prevocalic Schwa Deletion would have been removed by -eur/-rice Substitution:[2]

/ɑmbɑsadə/		
	+ ör	WFR: -eur Affixation
	risə	WFR: -eur/-rice Substitution
		Prevocalic Schwa Deletion
*[ɑmbɑsadərisə]		

That this rule has the phonological word as its domain, and not the grammatical word, is shown by the fact that the rule does not apply across the internal boundary of compounds, nor across prefix boundaries, as is illustrated in (5):

(5) zijdə-aankoop 'silk buy' *[zɛidankop]
bə-adəm 'insufflate' *[badəm]

A second case of cyclic lexical rule with the phonological word as its domain is the rule of vowel deletion in Slavic languages like Polish (Rubach 1984: 97, 226):

(6) ˈ V → ∅ / ⎓ V]$_{verb}$

This rule only applies to verbs. However, it does not apply across prefix boundaries; that is, it does not apply to prefixed verbs like prze+oczyć 'to overlook' or po+otwierać 'to open up'. Hence its domain is the phonological word. It is a cyclic rule, since it is subject to the condition of Strict Cyclicity: it does not apply to VV-sequences in underived environments like the sequence /ea/ in the verb ideal-+izować 'to idealize'.

Lexical phonological rules may also have to refer to the notion 'extrasyllabic consonant', a notion that presupposes the availability of syllable structure. Consider, for instance, the following alternations in Dutch:

		I		II	
(7) filter	'filter'	filtreer	'to filter'	filteraar	'filterer'
		filtraat	'filtrate'		
regel	'rule'	reglement	'regulations'	regeling	'arrangement'
center	'centre'	centreer	'to centre'	centeren	'to center'
arbiter	'referee'	arbitrage	'refereeing'	arbiteren	'to referee'

To account for the allomorphy ər/r and əl/l, we should assume underlying forms like /filtr/, /regl/, /centr/ and /arbitr/, and a rule which inserts a schwa before an extrasyllabic consonant:

(8) ∅ → ə / --- C'

This rule must apply after affixation of the kind shown in (7I), but before affixation of the kind illustrated in (7II): the addition of vowel-initial affixes to roots as in (7I) causes the extrasyllabic /r/

to become onset of the following syllable. Hence schwa-insertion does not apply anymore. However, in underived words and in derived words of type II, schwa-insertion has to apply, even though these vowel-initial suffixes could have 'saved' the extrasyllabic consonant by making it the onset of the final syllable: *filtren, *reglen etc. are incorrect forms.[3] Clearly, then, rule (8) has to apply before certain morphological processes, and thus it is lexical. Yet it refers to the prosodic notion 'extrasyllabic consonant' (C').[4] A parallel situation obtains for English with respect to the alternation in related words like enter, entrance, entering: the level I suffix -ance makes insertion of a schwa before the /r/ in /entr/ superfluous, but the level II suffix -ing does not. Similarly, Wiese (1986) argues in favour of a phonological analysis of German in which rule (8) can apply at several levels of the lexical phonology of German.

Again, we conclude that prosodic structure must be created in the lexicon, because lexical phonological rules must be able to refer to it.

4. The prosodification algorithm. Now that we have seen that prosodification begins in the lexicon, the next question to be answered is how exactly this is to be performed. To begin with, I will make the fairly uncontroversial assumption[5] that syllabification is an anywhere rule that applies to underived forms and reapplies to (phonologically or morphologically) derived forms. I also provisionally accept NV's Strict Layer Hypothesis which reads as follows: "A given non-terminal unit of the prosodic hierarchy, X^p, is composed of one or more units of the immediately lower category, X^{p-1}." (p. 7). NV furthermore propose the following principle of Universal Grammar (p. 7):

(9) Prosodic Constituent Construction
Join into an N-ary branching X^p all X^{p-1} included in a string delimited by the definition of the domain of X^p.

This means that syllables are combined into feet, feet into phonological words, etc. However, as NV correctly claim, the domain of syllabification is the phonological word. This is crucial, for instance, for Dutch compounds, where each constituent forms an independent domain of syllabification, although morphosyntactically, compounds are one word (for instance, they have only one inflectional ending). Hence we find minimal pairs like the following in Dutch:

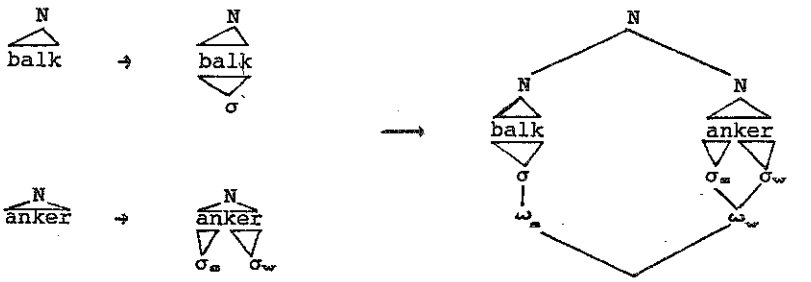
(10) [[bal][kanker] 'testicle cancer' $(bal)_\sigma(kaŋ)_\sigma(kər)_\sigma$
[[balk][anker] 'beam brace' $(balk)_\sigma(aŋ)_\sigma(kər)_\sigma$

In many languages compounds behave this way.

Note that we have to face a paradox now: on the one hand, the phonological word is constructed, directly or indirectly (via feet), out of syllables, but on the other hand the phonological word must already be present for the correct syllabification of the string of segments contained by a grammatical word.

This paradox disappears if we assume, as suggested above, that we prosodify from the beginning, i.e. in the lexicon. That is, when we combine two words into a compound, these words are combined with their prosodic structure, which has already been created for the two words independently. That is,the prosodification algorithm assigns each lexical morpheme (perhaps with the exception of clitics) a prosodic structure dominated by ω. The coining of a word like balkanker 'beam brace' has to be conceived now as follows:

(11)

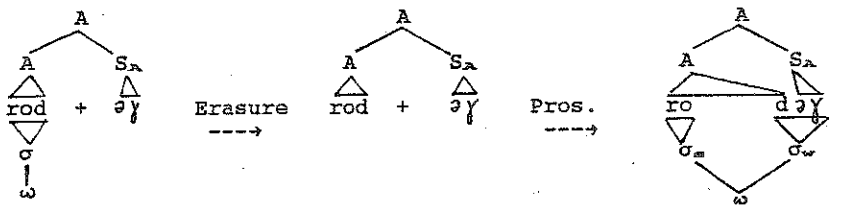


(for ease of exposition, the foot-labels have been omitted). The resulting compound has on the one hand a morphological structure in which the category of the top node is predicted by the principle that in Dutch compounds are right-hand headed. The prosodic structure is a combination of two phonological words, of which the first one is strong, as predicted by the stress rule for nominal compounds in Dutch.

With respect to complex words, things are slightly more complicated, as I will illustrate again with data from Dutch. Suffixes in Dutch divide into two classes, cohering and non-cohering suffixes (c.f. Booij 1983, 1985). Cohering suffixes have no independent prosodic structure, and therefore they integrate leftward into the prosodic structure of the base word. Consider, for instance, the derivation of

the prosodic structure of rodig 'reddish' derived from the adjective rood 'red':

(12)

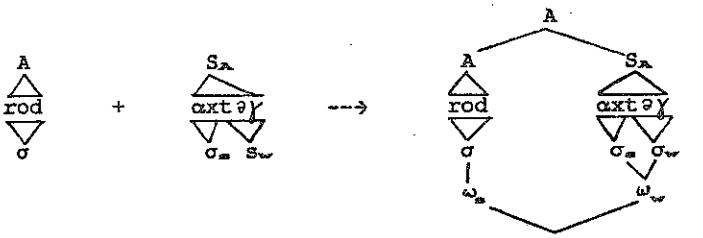


The suffix -ig is no lexical morpheme, and therefore it will not receive an independent prosodic structure. Consequently, the prosodification algorithm has to reapply to the string /rod+əɣ/ after the erasure of the prosodic structure of rood.

Non-cohering suffixes of Dutch like -achtig, -baar, and -zaam form phonological words of their own. Therefore, we will assign them a diacritic mark [+ W] for being subject to the rule which creates phonological words for morphemes. For most suffixes, this diacritical mark is predictable from its phonological structure: if a suffix is consonant-initial and contains at least one full vowel, it will be [+ W]. This means that in the case of Dutch it is only the suffix -achtig, for which this feature is unpredictable. Similar generalizations concerning the definition of the class of non-cohering affixes can be made for other languages (cf. NV p. 134 ff). As far as Dutch prefixes are concerned, they are all non-cohering.

Since non-cohering affixes are independently prosodified, they will not cause the erasure of prosodic structure of their base words. For instance, the word roodachtig will be derived as follows:

(13)



We summarize the prosodification algorithm as follows:

A. All lexical morphemes, and bound morphemes with the diacritic [+ W] receive phonological word structure.

B. When a prosodyless affix is added to an already prosodified word,

the last ω-node and the prosodic structure that it dominates are erased, and the prosodification algorithm reapplies.[6]

Note that we restrict the erasure of prosodic structure to the last phonological word. This restriction is crucial in case an affix is added to a word consisting of more than one phonological word. For instance, when we add the inflectional suffix -e [ə] to roodachtig, it is only the prosodic structure of the string achtige which must be redetermined. If we redetermined the prosodic structure of the whole string roodachtige, we would get the wrong syllabification pattern (ro)$_\sigma$(dɑx)$_\sigma$(tə)$_\sigma$(ɣə)$_\sigma$.

To conclude this section, we have shown that in order to avoid the paradox that syllabification both creates and presupposes phonological words, prosodification up to the word level must be seen as an algorithm that applies and reapplies throughout the lexicon. This conclusion corroborates the conclusion reached in the previous section that prosodic structure must be available in the lexicon.

5. Theoretical consequences. Above we saw that within the lexicon two types of structuring of phonological strings must be available, a morphosyntactic representation and a prosodic one. This entails that rules may refer to both types of information simultaneously. Note that NV explicitly claim that their organizational model is more restrictive because it excludes this possibility. As pointed out above, they themselves already mention the problem that the morphological structure of a word may be relevant for the creation of prosodic structure: compounds and derived words with non-cohering suffixes consist of more than one phonological word. In this section I will adduce some evidence that the possibility that rules refer to both types of structural information is indeed required.

A first type of rule which is relevant here, are rules of extrametricality as proposed by Hayes (1982). Such rules have the following form:

(14) "X → [+ extrametr.] / ----]$_D$, where X is a single phonological constituent such as rhyme, segment, consonant or suffix; and [...] D is the domain in which the stress rules of the language apply (usually the phonological word or phrase)." (Hayes 1982: 228)

For example, Hayes proposes a rule of Adjective Extrametricality for English which states that in adjectives the final syllable is extrametrical (hence we get correct stress assignments like magnánimous and

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For example, Hayes proposes a rule of Adjective Extrametricality for English which states that in adjectives the final syllable is extrametrical (hence we get correct stress assignments like magnánimous and

relúctant instead of the incorrect *magnanímous and *reluctánt). Clearly, this rule refers to both morphosyntactic information ('adjective') and to prosodic structure ('the final syllable').

A second class of such rules is formed by stress rules, which may be sensitive to the syntactic category of a word. For instance, in Dutch the stress rule for nominal compounds assigns the label 'strong' to the first constituent (e.g. húisdèur 'lit. house-door'), whereas adjectival compounds such as reuzesterk 'very strong' and hardgroen 'lit. hard green' have a stress pattern in which both constituents have equal stress.

This leads to the conclusion that NV's prohibition on the simultaneous use of morphosyntactic and prosodic information has to be given up for rules within the lexicon. It may still be valid, though, for sentence phonology: both Selkirk (1980) and NV (cf. figure 1) assume an organization of the grammar in which prosodic structure above the word level is derived from syntactic structure. At the level of application of prosodic rules, syntactic structure is no longer available.

In Booij (1985) I suggested that even the latter position may be too strong, since the prosodic rule of "coordination reduction", which deletes phonological words under identity to another phonological word, seems to make use of the syntactic notion 'conjunction', since the phonological word to be deleted, the gap, must occur adjacent to a conjunction. The following examples illustrate this phenomenon and the proposed syntactic condition:

(15) landbouw en tuinbouw
'agriculture and horticulture'
regelordening en regeltoepassing
'rule ordering and rule application'
het verschil tussen een derdeklasser en een zesdeklasser
'the difference between a third-former and a sixth-former'
*een derdeklasser uit Groningen en een zesdeklasser uit Amsterdam
'a third-former from Groningen and a sixth-former from Amsterdam'

However, it may be that this syntactic condition is too strong, since other kinds of constructions also appear to exhibit this reduction possibility, as was already mentioned in Booij (1985, fn. 11). For instance, deletions like the one in (16) also occur:

(16) Hij verwisselde de dagbladjournalistiek voor de weekbladjournalistiek
He exchanged the dailyjournalism for the weeklyjournalism'

The relevant restriction may be reformulated then as a prosodic restriction which states that reduction may take place at the end or

beginning of a phonological phrase, and that the two phonological phrases with the identical phonological words must be adjacent. Compare the prosodic structures (17a) and (17b): in (17a) deletion is possible, in (17b) it is not.

(17a) (een derdeklasser)$_\varphi$ ({en/met} een zesdeklasser)$_\varphi$

(17b) *(een derdeklasser)$_\varphi$ (uit Groningen)$_\varphi$ ({en/met} een zesdeklasser)$_\varphi$ (uit Amsterdam)$_\varphi$

(the phonological phrases are constructed according to NV's algorithm).

6. Conclusions. Prosodic structure up to the word level must be derived in the lexicon, since both morphological and phonological rules in the lexicon may need access to prosodic information concerning words. Moreover, this position is also necessary for a proper application of the prosodification algorithm. The prohibition on the simultaneous use of morphosyntactic and prosodic structure must be given up for the lexicon, while it may be maintained for sentence phonology.

Notes

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1. A parallel case in which the attachment of a suffix is dependent on the stress pattern of the input words can be found in Strauss (1983) for English.

2. A similar case in which a prosodically conditioned phonological rule has to apply before an allomorphy rule is given in Rubach (1987).

3. Phonetic forms like [fIltrən] do occur due to a casual speech rule of schwa-reduction. However, the schwa-less variants always occur besides the schwa-containing variants.

4. Instead of ordering rule (8) in between morphological rules, it is also possible to account for the difference between (7I) and (7II) by distinguishing between roots and stems, as suggested by Selkirk (1982). For instance, -eer would be a root suffix, and -ing a stem suffix. Schwa-insertion would then apply to stems only. Again, we would have a lexical rule, referring to the morphological notion

'stem' that also refers to prosodic information (the notion 'extrasyllabic consonant').

5. Not everybody agrees on this. For instance, Steriade (1982) holds the opinion that certain syllabification rules may be ordered in between (other) phonological rules. However, this question is not crucial for the problems under discussion here.

6. In languages with cyclic word stress like English, it may be that the erasure of the prosodic information of the basis word should be restricted to the minimum required, in order to keep certain information about the stress pattern of the basis word intact.

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