The Framework of Nonlinear Generative Phonology

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1. INTRODUCTION

In this article we will provide an introduction to current views on the structure of phonological representations within the theory of generative grammar, thus providing the context within which the articles in this collection should be placed. Following a brief sketch of these views in section 2, section 3 and 4 will provide a discussion of the two main theories in this area, i.e. the theory of *autosegmental phonology* and the theory of *metrical phonology*. Section 5 offers a short summary of the articles in this volume.*

2. A SKETCH OF GENERATIVE PHONOLOGY

Present-day generative phonology finds its starting point in the theory presented in Chomsky and Halle's *The Sound Pattern of English* (SPE; Chomsky and Halle 1968). Although there are many differences between the SPE approach and current approaches, a number of fundamental assumptions have been maintained without change, such as the distinction between underlying and surface representations, rule ordering and the desire that linguistic generalizations be reflected in the notational system: the more significant the generalization, the simpler the notation. The theory proposed in SPE has a *derivational* aspect and a *representational* aspect. The first aspect involves issues such as the formulation of phonological rules, rule application, rule ordering and interaction with morphological rules, whereas the second aspect involves the structure of phonological representations at each level of the derivation. The changes that we will discuss here mainly involve the representational aspect. This

*Parts of this introduction have been borrowed from Van der Hulst and Smith (1982a) and from introductory sections in Van der Hulst (1984). Some other collections of articles in the field of nonlinear generative phonology are: Aronoff and Oerhle (1984), Clements and Goldsmith (1984), Van der Hulst and Smith (1982), Safir (1979) and Sezer and Wetzels (1985).

implies that we will not be primarily concerned with the theory of *Lexical Phonology*, which embodies a view on the derivational aspect different from that found in SPE. However, before proceeding to a discussion of the representational aspect, we will briefly characterize the main features of the lexical model.

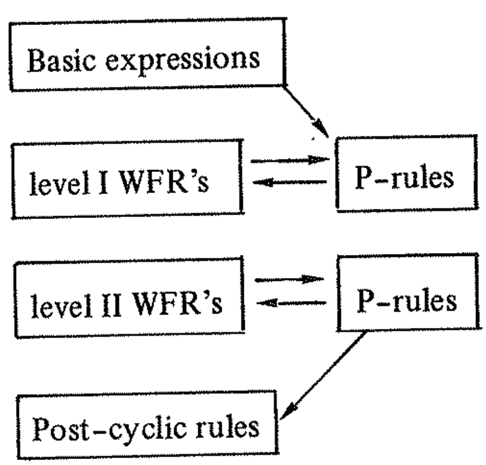
2.1. The derivational aspect: lexical phonology

The theory of lexical phonology is derived from a number of independent developments within the field of generative phonology and morphology.

The theory of lexical phonology as advocated in Mohanan (1982) and Kiparsky (1982, 1983) incorporates a proposal found in Pesetsky (1978). Pesetsky argued that rules which apply cyclically can be interpreted as rules applying in the lexical component after each application of a word formation rule. The advantage of this move is that cyclic application need not be stipulated, but follows from the organization of the grammar. In addition to this, the theory of lexical phonology revived a proposal advanced in Siegel (1974). Siegel proposed ordering word formation rules in blocks, and ordering certain phonological rules in between these blocks. This theory has become known as the ordered blocks (or levels) hypothesis. Combining these two proposals then gives rise to the following model:

> A stem enters the first level, and may be subject there to a number of morphological rules. After each application of a morphological rule the resulting complex structure passes through a list of lexical phonological rules relevant to that level. Every rule whose SD is met applies. The complex structure then enters a following level, where the same procedure is followed:

(1)



In this diagram one notices a class of *post-cyclic* rules. These are rules, that are more phonetically motivated then the *cyclic* rules, and that apply in more or less purely phonologically defined contexts. Post-cyclic rules may apply at the level of words (in which case we have post-cyclic lexical rules), and at the level of phrases and larger units (post-cyclic, post-lexical rules).

Cyclic lexical rules are subject to a condition, called the *Strict Cycle Condition*. In essence this condition forbids a rule to change phonological information within a particular cycle unless the substring which meets the rule's structural description came into being on that cycle. For technicalities we refer to Mascaró (1976) and Halle (1978).

In addition, all lexical rules (cyclic or post-cyclic) must apply in a "structure preserving" fashion. This does not mean that a lexical rule cannot change feature-values (it can, as long as it does not violate the Strict Cycle Condition), but it does mean that lexical rules do not create new segment types or new sequential or suprasegmental configurations, i.e. lexical rules do not violate constraints on lexical representations. If a language bars a segment type A from the inventory of underlying segments then a lexical rule is blocked in those cases where its application would create A. Similarly, if there is a sequential constraint barring the sequence AB then no lexical rule can apply to create AB.

An extensive application of this model can be found in Rubach (1984), and Mohanan (1982), each of whom considers a large body of data from a single language, and in Kiparsky (1982, 1983) who shows that many classical problems can be solved in terms of the lexical model. The model utilized in these studies displays certain variations but it is clear that a consensus of opinion on the essential nature of the interaction between phonological rules and morphological rules has been firmly established.

2.2. *The representational aspect: nonlinear phonology*

The changes that we have witnessed over the past few years with respect to the representational aspect have been caused primarily by a considerable extension of the empirical domain of the theory. The following quote from Chomsky (1955: 29) is still largely applicable to SPE:

> In this study, suprasegmental features (pitch, stress, juncture) have not been seriously considered. Ultimately of course, these phenomena must be incorporated into any full syntactic theory, and it may be that this extension still requires a more elaborate system of representation.

In SPE suprasegmental features are treated as if they were segmental features. The phonological representation is *unilinear,* i.e. it consists of a single sequence of segments and boundary symbols. Segments consist of an linearly unordered set of features, each of which has a binary value. The sequence of segments is associated with a hierarchical structure that is non-phonological, i.e. morphological and syntactic. Currently a phonological representation is considered to be a three-dimensional object, in which we find not just one sequence of segments, but several sequences. Hence the representation is termed *multilinear* or *nonlinear*. These sequences (called *tiers*) are linked to a central tier that consists of abstract units (called *slots*) to which the segments on the other tiers are associated. This pivotal tier (called the skeleton or *skeletal tier*) also constitutes the interface between the *(morpho) syntactic hierachical* structure and a *phonological hierarchical structure*. From today's point of view the quote given above sounds almost like an understatement.

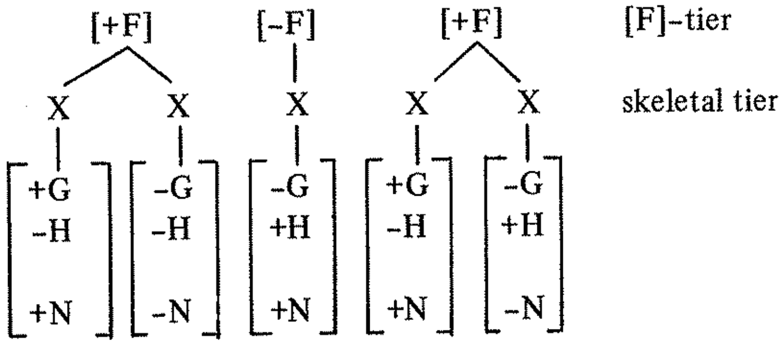
We will now sketch in abstract terms the two ways in which the SPE conception of phonological representations has been altered, before proceeding with a discussion of the type of data that have motivated these changes. Present-day nonlinear phonology incorporates the results of two independent theories which were proposed more or less at the same time by students at MIT. The first theory is called *autosegmental phonology* and proposes that representations are *multilinear*. The second is called *metrical phonology* and proposes that representations are *hierarchical*.

2.2.1. Autosegmental phonology

The central claim of autosegmental phonology is that we must abandon the view of segments as unordered sets of specified features. It has been shown that the scope of a specified feature need not be a single segment. The scope of a feature may both be smaller and bigger than a single segment. Before giving some examples let us emphasize that the term *segment* must be redefined if features are to be allowed to have different scopes. We must first determine what it is that features may have within their scope. The current view is that features have scope over abstract units, called *slots* (also sometimes referred to as *timing units*). One view of slots is that they are completely unspecified units, represented by the symbol "X", another is that we have two types of slots, normally represented by the symbols "C" and "V". These different views will be discussed in section 4.2. For the time being we will use the symbol "X".

The sequence of X-segments is referred to as the *skeletal tier*. There is of course no objection to calling the units that constitute this tier *segments*, as long as we realize that the interpretation of this term has been changed. The second point to be precise about is the status of features. The idea is that features are also segments; segments on their own, hence *autosegments*. If, in a particular language, there is good reason to represent the feature [F] as having scope over more than one slot then a sequence of such features is regarded as a sequence of [F]-*segments*. On the assumption that all other features are synchronized (i.e. have the same scope, in this example over one slots only), the following representation is the result:

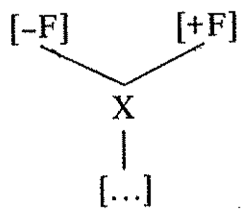
(2)



An understandable, but strictly speaking confusing, term to use for the third "cumulative" tier is *segmental tier*. It is possible to maintain that such a cumulative tier does not even exist and that it just happens to be the case here that the [G]-tier, the [H]-tier and all other tiers (except the [F]-tier) are subject to the same function that associates them to the skeletal tier. However, since *wide scope* is the special case rather than the norm it is defensible to assume that the third cumulative tier has a theoretical status, and that features are bundled in the traditional way, unless there is evidence to the contrary. On this one may consult Goldsmith (1979).

But autosegmentalists have not only argued in favor of wide scope. Features must also be permitted to have *narrow scope*:

(3)



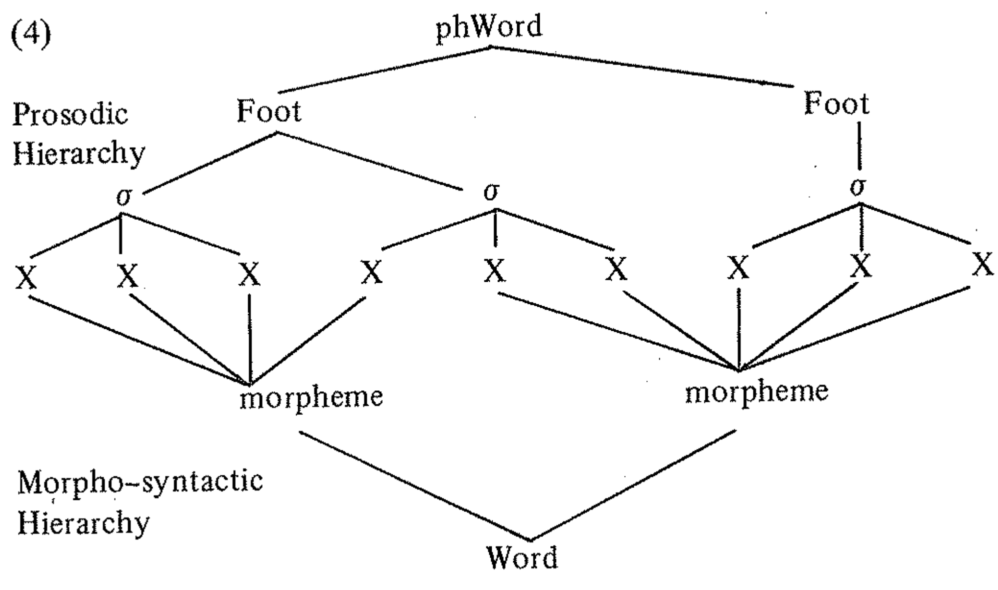
The need to give features both wide and narrow scope (the reasons for which we will discuss in the next section) has led to the development of the theory of *autosegmental phonology*.

2.2.2. Metrical phonology

The second change in our conception of phonological representations is logically independent of the first. As we said above, the only hierarchical structure that is imposed on the row of segments in SPE is of a *morpho-syntactic* nature. This hierarchical structure tells us that substrings of segments constitute morphemes, words and finally phrases and sentences. Even in SPE it is pointed out that syntactic bracketing is not appropriate in all cases to characterize the phonological word, or domain over which intonational contours extend. To remedy this defect certain rebracketing operations are suggested. In subsequent work it has been pointed out that the mismatch between morpho-syntactic structure and other necessary kinds of structure is even more serious. The clearest examples involve rules that specify what sequences of segments are wellformed in a particular language. In SPE it was assumed that the domain of these rules was the morpheme, but many phonologists have pointed out that another unit would be more appropriate. This unit is the *syllable.* The logical conclusion of the introduction of phonologically motivated units comprising substrings of segments was that a complete phonological (or *prosodic*) hierarchical structure was assumed, distinct from the morpho-syntactic structure, although not unrelated to it. This point of view did not develop as a result of the need for the units *intonational phrase, phonological word* or *syllable* in themselves. New research contributed to the establishment of additional units in the phonological hierarchy. Developments in the treatment of stress, for instance, led to the recognition of the *foot* as a constituent intermediate between the syllable and the word. The new theory of stress was termed *metrical phonology*, but this term soon came to be used to refer to a theory of phonological constituent structure in general.

The independence of morpho-syntactic and prosodic constituent structure is acknowledged by assuming two distinct tree structures imposed on the string of segments, which then forms the interface between these two structures.

(4)



"phWord" and "Word" stand for phonological and morpho-syntactic word, units which may but need not be isomorphic. A slightly more detailed discussion of the prosodic categories and their relation to morpho-syntactic categories is presented below in section 4.

2.2.3. *Autosegmental and metrical phonology combined*

First of all it turns out now that the slots constituting the skeletal tier can be interpreted as the smallest units, the terminal symbols, of the phonological constituent structure. Putting the two theories together in this way we can no longer look upon a phonological representation as a two-dimensional object. In fact this would have been impossible anyway for a case in which two features were "*autosegmentalized*". This explains why the theory that is discussed here is called *three-dimensional* (as well as *nonlinear*).

Since we now have an overall idea of the organization of a phonological representation, we may be more specific about the relation between the skeletal tier and the other *phonetic* tiers, using the latter term to refer to all other tiers.

An important insight captured in autosegmental phonology is that the relationship between autosegments and slots need not always be stipulated. In certain cases this relationship is predicted by rule. In the simplest case the relationship can be brought about by associating autosegments to slots in a one-to-one fashion, going from left to right; this is called *mapping*:

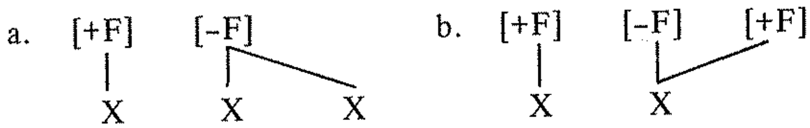
(5)	[+F]	[-F]	[+F] ...
	⋮	⋮	⋮
	X	X	X ...

The dotted lines indicate the structural change of the mapping rule that introduces the association lines. These are themselves represented by an unbroken line (cf. 7). If one-to-one association was the only possibility there would be little point in distinguishing between autosegments and slots in the first place. However, as we have already seen, autosegmental phonology was developed precisely because the association is not always one-to-one: autosegments may have wide or narrow scope, which implies that the relation may be many-to-many. The original claim of autosegmental phonology is that, where deviations from the one-to-one pattern arise, the number of autosegments is different from the number of slots. Two types of situation may arise. Either there are more slots than autosegments or there are more autosegments than slots:

(6)	a.	[+F]	[-F]		b.	[+F]	[-F]	[+F]
		X	X	X		X	X	

According to the theory of autosegmental phonology representations as in (6) may lead to cases in which features have either wide or narrow scope:

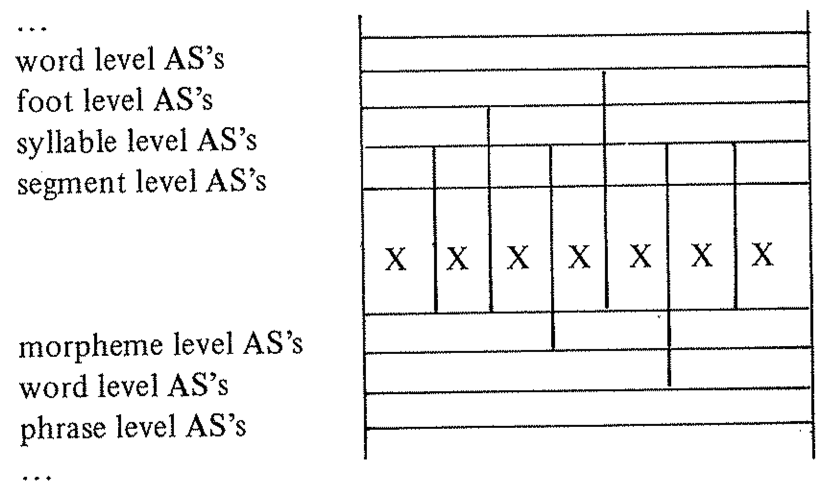
(7)



In (7a) we find *spreading* and in (7b) *dumping*; these are technical terms that we will continue to use here. Ignoring the issue of whether spreading and dumping are the norm or the exception, it will be clear that a mismatch between the number of slots and the number of segments always holds within a particular *domain*. The most general position is that autosegmental association can in principle be bound to any domain that the theory defines. This includes morpho-syntactic domains as well as phonological domains.

It turns out to be the case then that we must be able to express the fact that a particular domain comprises not only a sequence of slots, but also one or more autosegments. The following figure illustrates this conception of phonological representations ("AS" stands for autosegment):

(8)



To provide an example, in most vowel harmony systems we find morpheme level autosegments. The study of autosegmental features in domains other than the morpheme or the word (usually meant as a morpho-syntactic domain) has so far not supplied us with many well-documented examples. We refer to Van der Hulst and Smith (1982b) and Hart (1981), where a slightly different point of view is presented. In forthcoming work Vago also applies and elaborates a version of autosegmental phonology, where autosegments occur on different levels.

The above suffices to give the reader an idea of the theory of nonlinear phonology. In the following two sections we will discuss the various types of data that have played a crucial role in the emergence and further development of autosegmental and metrical phonology, which will also enable us to discuss the technicalities in greater detail. At the appropriate places we will show how the articles included in this volume fit in the framework at issue.

3. AUTOSEGMENTAL PHONOLOGY

3.1. The characterization of complex segments, tonal and non-tonal

The standard theory is characterized by what Goldsmith (1976) has called the "absolute slicing hypothesis". An abstract representation of speech sound is split up into slices, called segments. Each slice is specified with exactly one value for each feature of the total set of features that is required to represent speech sounds. Hence segments have no linearly ordered subparts. In the majority of cases segments can be interpreted as functions from points in time to a particular state of the articulatory organs. So if a segment is specified as [+nasal] this means that while this segment is being articulated the velum is in lowered position. In real life it may be the case that the velum is lowered slightly earlier causing a preceding segment to be nasalized during part of its production. The absolute slicing hypothesis embodies the claim that such a half-nasalized segment is not to be represented as [-nasal, +nasal]. The definition of segments on which this hypothesis is based only allows specifications such as [@F], where @ ranges over + or –. In the SPE theory it is also possible to have an integer as the feature value, indicating a certain degree of, for example, nasalization, but integers are used for phonetic representations only. Since in this example the nasalization is dependent on the presence of a neighbouring nasal, the integer would indeed only be required as part of the phonetic representation, and not as part of the underlying representation, where the segment in question would be specified as [-nasal], thus abstracting away from the nasalization (which does not in this case distinguish between phonemes, in the classical sense). In some cases, however, we cannot abstract away from the fact that an articulatory state changes during the production of one slice, because in such cases the change is an intrinsic property of the segment, i.e. it is not caused by some neighbouring sound. Examples are numerous: affricates, pre- and postnasalized consonants, pre- and post-aspirated consonants, (short) diphthongs (see Ewen 1982 for a discussion of many of these segment types, usually referred to as *complex segments*). During the production of an affricate we have a change from a stop to a fricative type of articulation. Strict obedience to the absolute slicing hypothesis would require that we characterize such segments with a feature underlyingly specified with an integer (which would not reflect what was going on) or a separate feature directly refering to the change (which would reflect what was going on). In SPE the first possibility is blocked because all features are binary at the phonological level. The feature characterizing affricates is termed [delayed release]. (One can see here an attempt in the *name* of the feature to capture what is going on.) Similarly, we would need features like [prenasal], [postnasal], [preaspirated], [postaspirated], [diphthong] etc. With respect to tones too, there would be need for what we might call here *contour features* (as opposed to *level features*), e.g. features like [rise] and [fall].

There is no objection as such to adding contour features to the inventory of features. Formally they are not different from level features; the difference is merely terminological. The reason for questioning this strategy comes from the fact that we miss certain generalizations by using the contour features. The crucial argument has been advanced by Anderson (1976) with special reference to the contour features [prenasal] and [postnasal] and by proponents of autosegmental phonology (Goldsmith 1976) with reference to tonal contour features.

This argument involves the presence of frequently recurring conjunctions in the formulations of phonological rules. Conjunctions of contour tone features and level tone features are a case in point. They show up again and again and may constitute the norm rather than the exception. When the context bar is on the right a low tone typically appears together with a falling tone, when it is on the left a low tone typically appears with a rising tone. Recurrent conjunctions require an explanation. There must be some factor that the conjoined environments have in common, and our formalism must be able to express this.

An explanation is available if we decide to abandon (i.e. [fall]) contour features and replace them with sequences of level features. So F is replaced by a sequence consisting of a high tone feature and a low tone feature (HL). It will be clear that given such a move we no longer face the problem of recurrent conjunctions, since a structural description "{F, L} —" (i.e. a conjunction of F and L) can be replaced by "L —".

The mere decision to abandon contour features does not necessarily entail that we must also abandon the absolute slicing hypothesis embodied in SPE. In fact the decision to eliminate tonal contour features had already been taken by Woo (1969). The conclusion she drew from this was that it is impossible for short vowels to have contour tones. Assuming that long vowels can underlyingly be represented as a sequence of two short vowels Woo predicted that only long vowels can bear contour tones.

There are indeed languages in which contour tones may not occur on short vowels. A case in point is Lithuanian where complex tones (i.e. rising or falling tones) can only occur on long vowels or sequences of short vowels and sonorant consonants. This in itself supports the position whereby these tones are represented with two level features. Languages of this type can be said to have a constraint prohibiting more than one tonal feature linked to a single segment. If contour features are used, such a constraint is hard to express, since, as pointed out, contour features and level features are not formally different.

Unfortunately the prediction as such is false. There are many languages in which short vowels bear a contour tone, either underlyingly or at a later stage in the derivation. It seems then that our conception of segments must be altered in order to allow single segments to have two different specifications for one feature. This is the crucial motivation for abandoning the absolute slicing hypothesis:

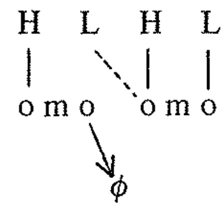
```
(9)   L     H
       \   /
         X
         |
       [...]
```

The same conclusion regarding "complex features" is found in Anderson (1976), who gives an argument that is completely parallel to the tonal example involving nasalization of vowels preceding either a nasal consonant or a prenasal consonant. In the cases he discusses there is no evidence for representing the complex consonants as two segments underlyingly (they are not contrastively "long"), hence the decision to represent a prenasal consonant as [+nasal] and [−nasal] directly implies that we must revise our conception of segments.

3.2. Supporting arguments for representing tonal features on an independent tier

The study of tone provided the main impetus for the development of autosegmental phonology, and its application in this area has convinced many more phonologists than its application in other areas such as vowel harmony. This volume does not contain a paper on tone, but to understand better where autosegmental phonology has its roots (and, according to some, its most convincing application) we will discuss the tonal motivation in some detail.

The first phenomenon that supports the autosegmentalization of certain features involves what has been called *stability*. In (10) a schematic example of a typical case of vowel deletion is given, leading to the emergence of a contour tone:

(10) 

Observe the fact that, while the vowel is deleted, the tone stays behind. Given the autosegmentalization of tonal features this phenomenon does not strike us as very unexpected. This is precisely the point. By representing features on different tiers we predict independent behaviour and this is what we find. Of course independent behaviour does not always involve deletion, but this is something that can be considered as the extreme case.

A second and even stronger argument in favour of separating a tonal and a segmental tier involves *defective morphemes*. In tonal analyses one will encounter morphemes that consist exclusively of tone and also morphemes that (although they contain a vowel or, better, a *tone-bearing unit; TBU*) have no tone. In a strictly segmental framework such entities are problematical, especially the "segmentless" tones. Within the autosegmental model defective morphemes are not in any sense anomalous. If morphemes consist of two independent tiers then there is no reason why one could not be lacking.

A third argument involves the phenomenon that words consisting of different numbers of syllables may display behaviour that strongly suggests that they have the same *tonal melody*. In Edmundson and Bendor-Samuel (1966) Etung is described as having the following melodies on mono-, bi- and trisyllabic words:

(11)

1 syllable	2 syllables	3 syllables
L	L L	L L L
H	H H	H H H
L͡H	L H	L H H
H͡L	H L	H L L
-	L H͡L	L H L
-	H L͡H	H L H
-	L L͡H	L L H
-	H H͡L	H H L

The notation H͡L indicates a contour tone. Goldsmith (1976: 132–134) discusses these facts:

> The conclusion is clear: we have in Etung a small class of tone formulas that may be spread over words of one, two or three syllables, proceed-

> ing from left to right. These melodies are L, LH, HL, H, LHL, LLH, HHL, and HLH. The occurrence of contour tones that motivate Leben's left-to-right mapping in Mende occur here, but the melodies HHL and LLH make it clear that the Obligatory Contour Principle is too strong in fact.

There are several issues that are relevant here, but let us first concentrate on the argumentation in favour of the autosegmental mode of representation. The facts from Etung provide us with three arguments.

Firstly, it is clear that in a strictly segmental framework it is not possible to express the generalization that there are eight melodies, simply because the notion melody has no status in such a framework. Secondly, the gaps in the monosyllabic case receive a straightforward explanation, which would not be available if we were working with contour features. We can account for the gaps in table (17) by saying that Etung has a constraint which prohibits more than two different tone features being associated to one tone-bearing unit (cf. Halle and Vergnaud 1982):

(12) $${*}\begin{array}{ccc} T_1 & T_2 & T_3 \\ \diagdown & | & \diagup \\ & V & \end{array}$$

where $1 \neq 2 \neq 3$

Thirdly, consider the distribution of contour tones: they only occur on the final vowel. As stated in the preceding section and also in the quotation from Goldsmith (1976), tones are associated to tone-bearing units (TBU's) in a one-to-one fashion, going from left-to-right. If the tones outnumber the tone-bearing units, left over tones are dumped on the last tone-bearing unit. This *explains* why contour tones in Etung are found on the final vowel only. If tones were characterized by segmental features it would remain a mystery why a bisyllabic word cannot have a contour tone on the first vowel.

At this point the most important arguments supporting the autosegmental model have been discussed. Proceeding on the assumption that the model has been sufficiently motivated we will discuss a number of essential conventions and principles in the next section.

3.3. Principles of autosegmental phonology

In the quotation from Goldsmith (1976) reference is made to two principles: the *Obligatory Contour Principle* (OCP) and left-to-right *mapping*.

According to the OCP, proposed by Leben (1971, 1973), we exclude the possibility that adjacent autosegments might have the same value.

Hence we exclude ...H H ... or ...L L ... in all cases. Goldsmith points out that the facts from Etung are problematical for this point of view since the total set of melodies comprises all eight possibilities that we get with three occurrences of two tones. If the OCP was a genuine universal principle there should be only six melodies:

(13)	*NO OCP*	*OCP*
	L L L	L
	L H H	L H
	L L H	L H
	H H H	H
	H L L	H L
	H H L	H L
	H L H	H L H
	L H L	L H L

It seems that Goldsmith is correct in saying that the OCP cannot be maintained as a universal principle (cf. Halle and Vergnaud 1982). Even Mende, the language that Leben used to argue in favor of the OCP, appears to have melodies of the forbidden type (cf. Dwyer 1978, and Conteh et al. 1983). This reduces the OCP to a principle that *allows* one to collapse identical autosegments if there is no reason to leave them separate. Intuitively, collapsing adjacent identical autosegments reduces the complexity of the representation. Thus some phonologists view the OCP as part of the evaluation metric (cf. Hayes 1984b).

The mapping rule too dates back to Leben (1971). In his original conception this rule merged the tonal tier and the segmental tier, so that the surface representation conformed to the SPE-theory. In this form the rule is also found in Williams (1971), with the difference that Williams' version of the mapping rule did not contain the *dumping* clause. It will be evident that the mapping-as-merger rule could not be maintained because the whole issue of short vowels with contour tones remains problematical in this case. Hence Goldsmith (1976) proposes to have the rule introduce *association lines*, leaving the tonal and segmental features on separate tiers.

Representing tones and segments on different tiers raises the question how they are related. This question is ambiguous. There are, to be precise, two questions to be answered:

(14) a. What constitutes a wellformed relation between the tonal tier and the segmental tier?
b. How does this relation come into being?

Goldsmith provides the answer to the first question by formulating a Wellformedness Condition (WFC):

(15) *Wellformedness Condition*
a. Association lines do not cross (no X-ing)
b. All TBU's are associated to at least one tone
c. All tones are associated to at least one TBU

The answer to the second question involves first of all three *Association Conventions* (AC's):

(16) *Associating conventions*
a. *Mapping*
Insert association lines between *one* tone and *one* TBU
-going from left-to-right/right-to-left
-starting with the left/rightmost tone and TBU
b. *Dumping*
Left over tones are associated to the nearest TBU
to their right/left
c. *Spreading*
Left over TBU's are associated to the nearest tone
to their left/right

The first option mentioned in each case is considered to be unmarked. This set of conventions may be too rich in various ways. In the study of tone, right-to-left mapping plays a marginal role, if it occurs at all. Also it may be unnecessary to allow cases in which we associate the first tone with the last TBU, and have left-to-right spreading. We refer to Haraguchi (1977) and Clements and Ford (1979) for further detailed discussion of the association conventions.

Subsequent developments have shown that the AC's are not only parametrized in the sense that the left/right options must be fixed, but also in the sense that it depends on the language in question whether they apply at all. In Clements and Ford (1979) it is argued that tones that are left over after one-to-one mapping or set afloat in the course of a derivation may either be left floating (in which case they are not phonetically interpreted) or be associated by a language-specific rule. This position, which was also embodied in William's Mapping Rule, is adopted in Halle and Vergnaud (1982) as well. A consequence of this is that the third clause of the WFC must be eliminated, and that *dumping* can no longer be regarded as a universal convention. It is even questionable whether any language has automatic dumping, in which case it isn't even appropriate to speak of a parameter.

Halle and Vergnaud (1982) go one step further and argue that automatic *spreading* too must be rejected. Whether or not spreading takes place is a language-particular matter, they argue. In languages that have no automatic spreading TBU's that remain unassociated will surface with the "unmarked tone value" that each TBU is supposed to have as a segmental specification. Hence clause b of the WFC can be eliminated too. The adoption of segmental tonal features seems somewhat awkward. Instead of assuming segmental values, others (e.g. Kiparsky 1983, Pulleyblank 1982) have proposed leaving all segments unspecified for tone. At the end of the derivation TBU's that are not associated with an autosegment are supplied with a *default value*.

The result of the developments just discussed is that both the WFC and the inventory of AC's are considerably reduced:

(17) *WFC*: no X-ing
AC: mapping

In Pulleyblank (1982) we find a defence of this type of impoverished autosegmental theory. As we will see later on, others have generalized the results reported here to other areas to which autosegmental phonology has been applied: cf. Smith's contribution to this volume.

Another parameter which is of relevance for the analysis of tone systems is that prior to mapping certain tones my be prelinked to TBU's or be associated by language-specific rules. The use of prelinked tones plays an important role in the analysis of so-called *pitch-accent* systems. For a discussion we refer to Hyman (1982) and Pulleyblank (1982). Odden (1984) discusses the interplay between language-specific association rules and the universal conventions.

3.4. Extensions of autosegmental phonology to non-tonal phenomena

The autosegmental model discussed in the preceding section has not only been applied to tone, but also to other phenomena which are traditionally grouped under heading of "suprasegmentals".

3.4.1. Intonation

Implicitly our discussion of tone above was largely limited to accounting for tone patterns of words in isolation. We have not given examples of the frequently attested cases of the ways in which these word melodies might influence each other in syntactic constructions. In both types of phenomena the focus is on *word melodies*. We use the term word melodies because they find their ultimate source as being part of morphemes constituting words or as being word level morphemes (suprafixes) themselves.

Intonation is of course a different matter. Intonational contours (or melodies) too can be viewed as melodies made up of sequences of level tones. The domain of these contours is not however, the word, but the utterance, or a part of an utterance. In the limiting case a single word may constitute the domain for an intonational melody (contour), since single words may constitute an utterance or a part of an utterance.

It would seem obvious that the autosegmental approach be extended to deal with intonation. Following proposals advanced in Liberman (1975), Pierrehumbert (1980) elaborates an autosegmental analysis of English intonation. We need a component generating contours from a limited inventory of tones, and a set of mapping rules linking tones to tone-bearing units within the appropriate domains. In this volume, the contribution of Gussenhoven offers a comprehensive approach toward English intonation from an autosegmental perspective.

3.4.2. Length

Length has traditionally also been considered as a suprasegmental property. How is length represented within an autosegmental model and what is there to say in favor of an autosegmental approach?

In our discussion of tone we have taken it for granted that any long segment is to be represented as two short segments. It is consistent with the autosegmental model to represent a long segment as either (18a) or (18b):

```
(18)  a.  V   V         b.  V   V
          |   |              \ /
          a   a               a
```

In any case there are no "long" segments as primitive entities. Recalling our discussion of the OCP (Obligatory Contour Principle), we say that (18b) is to be preferred to (18a), i.e. it represents the unmarked case.

In several studies (such as Leben 1980) is it pointed out that the autosegmental approach to length allows us to solve a number of problems surrounding long segments. In Hayes (1984b) one finds a clear exposition of these problems and the way in which they are resolved in the autosegmental model.

Hayes mentions the "exceptional properties" of long segments:

(19) a. *Ambiguity*
Long segments act in some contexts as if they were two segments, in others as if they were one.

b. *Integrity*
Insofar as they constitute two segments, long segments cannot be split by rules of epenthesis.

c. *Inalterability*
Long segments often resist the application of rules that a priori would be expected to apply to them.

We refer to Hayes's paper for great number of examples which illustrate quite convincingly these three properties.

The first property is simple to explain, because a long segment may be a single element on the phonetic tier and two elements on the skeletal tier. Different phonological rules may refer to either of the two tiers.

Integrity follows from the requirement that association lines may not cross. Consider the following hypothetical situation, in which there is a rule which inserts a vowel *i* in between two consonants:

```
(20)  Ø  →  i
            |
            V   / C - C
```

```
(21)  a.  C V C C V C        b.  C V C C V C
          | | | | | |            | | \ / | |
          p a m p a m            p a  m  a m
```

Clearly rule (20) can apply to (21a), but not to (21b):

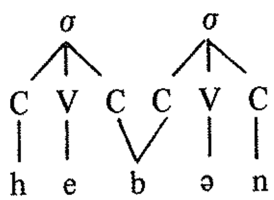
```
(22)  a. C V C V C V C       b. *C V C V C V C
         | | | | | | |           | | \ X   | |
         p a m i p a m           p a   m i a m
```

Observe that this mode of reasoning relies rather heavily on the assumption that all features are represented on a single tier, which is not, as we shall see, the case on all levels of representation. Here we will ignore this questions; cf. McCarthy (1984).

For the third property consider an example, discussed in Van der Hulst (1985). In Dutch, there is good reason for representing intervocalic consonants which follow a short vowel as long, although phonetically they appear as short. Medial consonants may be either voiced or voiceless. Dutch also has a rule of syllable-final deviocing of obstruents. A non-linear formulation of this rule is given in (23):

(23) $$[+\text{obs}] \rightarrow [-\text{voice}] \;/\; \underset{\mathrm{C}}{\underset{|}{\_}}\,)_\sigma$$

I.e. an obstruent linked to a syllable-final C position is devoiced. Now why doesn't this rule apply to medial voiced obstruents?

(24)  "to have"

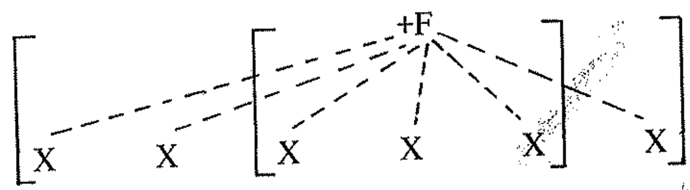
Hayes argues that inalterability shows up in those cases where a rule refers both to the skeletal tier and to the phonetic tier. In this respect Final Devoicing (23) is in line with his findings. In addition he proposes that as a matter of convention a rule referring to an association between A and B only operates if both A and B are not associated to another element. Hence Hayes' account of inalterability explains why Final Devoicing does not apply to the first half of intervocalic obstruents, even though this half is in syllable final position. A somewhat different convention governing inalterability is offered in Borowski et al. (1984).

3.4.3. *Vowel and consonant harmony*

Tonal features are clearly not the only ones which may have scope over several segments at the same time. One can even say that the phenomenon of harmony (as it is used in phonology) can be *defined* as a situation in which a particular feature necessarily extends over a number of segments within a particular domain. So, in Hungarian all vowels within a word are either [+back] or [–back] (we ignore a complication involving *neutral* and *opaque* vowels). Or in Arabic dialects all segments in a syllable are either "pharyngeal" or not. To handle phenomena of this type it seems obvious to extend the model developed for tone. We simply assume that tonal features are not the only features that may constitute a separate tier, but that this is possible for any feature at all. The most interesting hypothesis is that this is all we need to change in the model, assuming that all other things, such as possible domains, possible association rules etc. remain as we motivated them on the basis of the study of tone.

The proposal to extend the empirical domain of the autosegmental theory to vowel harmony is made in Clements (1976). Clements claims that it is possible to apply autosegmental phonology to vowel harmony, and that this model explains a number of essential properties of this phenomenon. The crucial point is this. If we say that a certain feature [F] is autosegmental in a language L this is essentially *all* we have to say to account for the fact that L has harmony involving the feature [F]. In particular we do not have to write a language-specific harmony rule. Assuming the WFC as a universal principle, the autosegment [@F] will be associated with all "[F]-bearing units" that are within its scope. Let us clarify this by means of a schematic example. In many cases of harmony affixes harmonize to the stem they are attached to:

(25)



Thus we explain why harmony is unbounded and bidirectional. As is pointed out in Clements & Sezer (1982) some additional parameters must be set, involving the domain of spreading, the segments which function as "F"BU's, etc. Van der Hulst's constribution offers a more detailed discussion.

It seems then that an autosegmental approach toward vowel harmony is well motivated and this would still be true even if the crucial principles were established to explain this phenomenon only. But tone-languages exist and this implies that the autosegmental approach toward vowel harmony merely makes use of principles that have been otherwise independently motivated. The question should therefore not be: why should we treat vowel harmony autosegmentally? (as Ringen 1984 puts it), but rather: why should we continue to treat it segmentally?

In sections 3.2 and 3.3 we discussed several diagnostic features for an autosegmental treatment. Although some of these features (melodies, multiple association) are absent in the case of vowel harmony, two other important diagnostic phenomena involving *defective morphemes* and *stability* do occur.

One type of defective morpheme has already been mentioned implicitly. Affixes that harmonize with roots can be represented as defective in the sense that they have no segment on the harmonic tier. Now do we also find affixes consisting solely of a segment on the harmonic tier?

An example of this has been discussed in Van der Hulst and Smith (1982a, 22-23). In Terena, as described by Bendor-Samuel (1960), the first person singular of the verbal forms and the possessive of nouns is expressed by *nasalizing* all vowels and sonorant consonants from left to right as far as the first obstruent, which appears in prenasalized form. We are dealing here with a prefix consisting solely of the feature [+nasal]:

(26) a. $\left[\begin{array}{cc} [+\text{nas}] & \\ & \left[\text{ayo}\right] \end{array}\right]$ b. $\left[\begin{array}{cc} [+\text{nas}] & [-\text{nas}] \\ & \left[\text{owuku}\right] \end{array}\right]$ c. $\left[\begin{array}{cc} [+\text{nas}] & [-\text{nas}] \\ & \left[\text{piho}\right] \end{array}\right]$

'my brother' 'my house' 'I went'

An example in which a root partly consists of a non-tonal floating element is given by Clements (1981) in his analysis of Akan vowel harmony. A set of roots starting with a sequence consisting of one out of a specific set of consonants and the opaque low [-ATR] vowel *a* selects prefixes that are [+ATR]. The analysis offered by Clements of such roots is as follows:

(27) $\left[\begin{array}{ccccc} +\text{A} & & -\text{A} & & \\ & & | & & \\ & \text{j}^{\text{w}} & \text{A} & \text{n} & \text{I} \end{array}\right]$

What we find here is that an autosegment introduced by one morpheme is realized on another. In the contribution by Van der Hulst one will find another example is which crucial use is made of a feature introduced by one morpheme but realized on another. We refer to this article for a detailed discussion of Hungarian vowel harmony within the context of both segmental and autosegmental models.

The conclusion that we may draw from the discussion so far is twofold. Firstly, the autosegmental model is perfectly capable of handling the phenomenon of vowel (and consonant) harmony in both an elegant and explanatory fashion, so that there is sufficient reason for adopting this theory, even ignoring the fact that it is independently motivated for the analysis of tone. Secondly, an autosegmental analysis entails certain predictions involving autosegmental melodies, multiple linking and floating features. Not all of these predictions are borne out, and this entails that at least some principles of autosegmental phonology are true for tone but not for harmony and vice versa.

3.4.4. Associative morphology

In our discussion so far we have seen that the independence of tiers may be exploited by the morphology. As sequences of segments may either belong to a single morpheme or be part of two morphemes, we may find two types of relations between units on different tiers as well:

(28)

	A single morpheme	Two morphemes
Concatenation	$[\,a\ b\ c\ d\ e\,]_{\mu}$	$[\,a\ b\,]_{\mu} + [\,c\ d\ e\,]_{\mu}$
Association	$\left[\begin{array}{ccc} a & b & \\ \mid & \mid\!\diagdown & \\ c & d & e \end{array}\right]_{\mu}$	$\begin{array}{l} [\,a\ \ b\ \ ]_{\mu} \\ \ \mid\ \ \mid\!\diagdown \\ [\,c\ d\ e\,]_{\mu} \end{array}$

In the case of tones the sequence $[ab]_{\mu}$ may indicate a certain inflectional category.

This raises the possibility then that a string of C's and V's with a string of features linked to it forms a single morpheme or that the string of C's and V's and the string of features each constitutes separate morphemes. This is exactly what we find. There are several types of morphological processes that have traditionally been recognized as deviating in some form from the simple concatenative model, and precisely these phenomena turn out to be susceptible to treatment in terms of CV string and feature string constituting independent morphemes, which are not therefore concatenated but associated. We might speak of *associative morphology* (rather than using the "negative" term *nonconcatenative morphology*). Examples of morphological processes that have been fruitfully approached in this way are various forms of ablaut, reduplication, many sorts of word game (cf. McCarthy, this volume), but their most impressive exemplification is found in the morphology of the Semitic languages, as analyzed in the work of McCarthy (e.g. 1979, 1981, 1982).

In Classical Arabic verbal morphology each verb may occur in a number of derivational classes (involving meanings such as habituality, iterativity etc.) and within each such class the verb has a number of inflected forms (indicating tense, voice, finiteness etc.). All the forms in the paradigm are characterized by a constant element, i.e. three or four "root" consonants that occur in each form. These consonants always occur in the same linear order, but forms of a verb may differ to the extent that different vowel patterns may be interspersed among the consonants which constitute the root. Also, one of the consonants may be doubled and occasionally an extra consonant is added:

(29)

	Perfective Active	*Perfective Passive*
I	katab	kutib
II	kattab	kuttib
III	kaatab	kuutib
IV	aktab	uktib

V	takattab	tikuttib
VI	takaatab	tukuutib
VII	nkatab	nkutib
VIII	ktatab	ktutib
IX	ktabab	ktubib

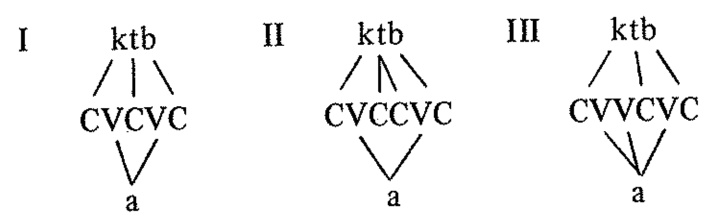
etc.

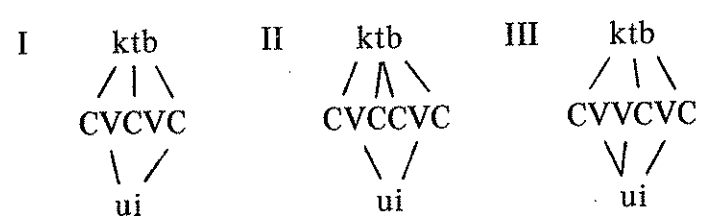
McCarthy has shown that the forms given here can be split up (along the horizontal axis so to speak) into three tiers, which we will assume to have morphemic status (McCarthy himself doesn't refer to the skeletons as morphemes):

(30) *katab*

ktb	→ consonantal tier carrying the lexical meaning "write"
CVCVC	→ skeletal tier carrying the meaning ... (derivational class)
a	→ vocalic tier carrying the meaning perfective active

In accordance with autosegmental principles McCarthy assumes that in those case where the number of C's or V's exceeds the number of consonants or vowels we find spreading:

(31)


(32)


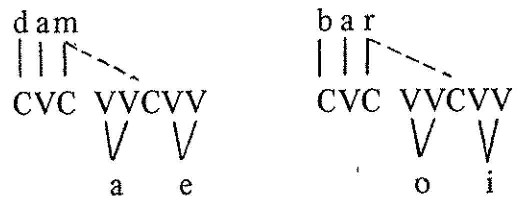
In cases V and VI it is necessary to associate an extra consonant *t* and in VII an *n*, which may be handled as prefixes.

Observe that spreading does not always behave as we might expect. In cases II, V and VIII the *t* spreads to two slots although it is not the rightmost consonant. Thus cases VIII and IX are distinguished only as to how spreading takes place. There are various ways in which such language particular deviations from the universal spreading conventions can be handled. One way would involve the use of prelinking.

Various other areas of morphology demonstrate the fruitfulness of the approach just sketched. We may find affixes which consist partly or entirely of a CV-skeleton.

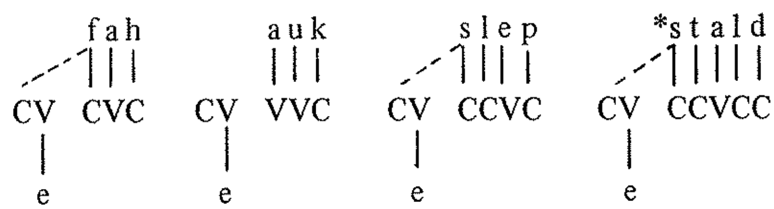
An example of a suffix which partly consists of empty C's is found in Hausa (discussed in Leben 1980, Halle and Vergnaud 1982), where the stem final consonant is "copied" in the plural suffix:

(33)	dámóo	dámàamée	"land monitor"
	báràa	bároòríi	"servant"



A similar case involving a prefix is found in Gothic, where the preterite is formed (in a certain class of verbs) by adding an extra syllable, consisting of the fixed vowel *e* ([ɛ]) preceded by a copy of the first consonant of the stem:

(34)	a. fahan	faifah	"to catch"
	b. slepan	saislep	"to sleep"
	c. aukan	aiauk	"to augment"
	d. staldan	staistald	"to stand"



As we can see the approach adopted here fails to account for the fact that verbal stems beginning with *st* or *sp* spread both consonants. A possible way to explain this is to assume that *st* and *sp* are in fact single consonants, complex segments. Suzuki (1982) argues at length that there is little independent evidence for the move, and he proposes a more elaborate model for handling the Gothic data.

The affixation process just described are usually referred to as "reduplication". Apart from such cases of "local" copying, we also find those where a prefix or suffix involves a complete copy of some part of the stem. It will be clear that when the affixed portion contains more than one C or more than one V, it becomes impossible to adopt the approach followed above.

Consider reduplication in Agta, where plurality may be marked by prefixing the first three skeletal positions:

(35) takki "leg" taktakki "legs"

As Marantz (1982) points out, this type of reduplication cannot be handled by simple spreading, because we then violate the "no X-ing" constraint (cf. 17):

```
(36)        *t a k k i
      CVC + CVCCV
```

To solve this problem Marantz (1982) proposes that reduplication arises by firstly adding something on the CV-tier and then copying the segmental material in toto, associating it from left to right to prefixed CV-material and from right to left to suffixed CV-material:

```
(37)  t a k k i     t a k k i
      ¦ ¦ ¦         | | | | |
      CVC      +    CVCCV
```

Left-over segments are ignored by convention.

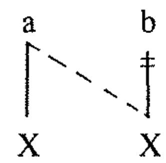
This approach will also work of course for the data from Hausa and Gothic discussed above. An interesting refinement of Marantz's approach is given in Ter Mors (1984).

A third type of situation in which CV-skeletal function in the morphology is found in Yawelmani (cf. Archangeli 1984, Noske, this volume) and Sierra Miwok (Smith, this volume). In these languages we find suffixes which select a particular CV-skeleton for their base.

Several of the articles in this collection deal with the morphological exploitation of the skeletal tier. McCarthy analyses speech games; Noske analyses the phenomena in Yawelmani, and Smith is concerned with data from Sierra Miwok, as we have mentioned above.

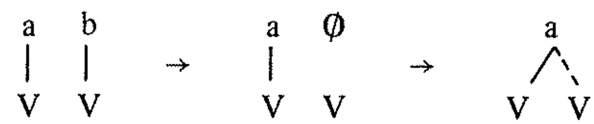
3.5. Rules

Autosegmental phonology is not purely a matter of representations of course. Given nonlinear organization we can develop new points of view with respect to various phonological processes. *Assimilation* can in general be viewed as spreading (plus dissociation):

(38) 

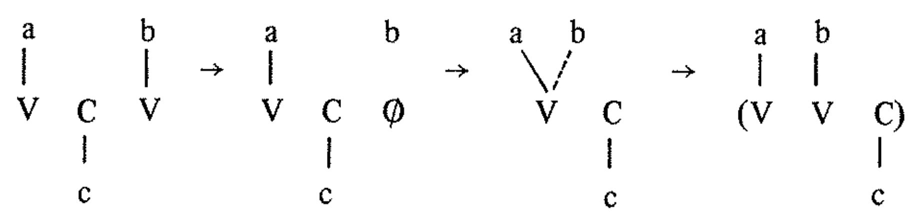
(38) illustrates a case of complete assimilation, if A and B represent complete sets of phonological features.

We have seen that the organization of phonological representations makes crucial use of the pivotal tier consisting of units which we identified as the terminal nodes of syllabic trees. Features are associated to these slots, and we have argued above, especially with respect to tones, that this explains the relative independence of tones. If we delete a V slot (and the non-tonal features associated with it) the tone may stay behind. But this line of reasoning can also be applied the other way round, i.e. we may delete all the features linked to a slot, and the slot may stay behind. Given such a state of affairs the most normal scenario is as shown below:

(39) 

I.e. rightward spreading. We may speak here of the "stability" of the slot-tier. Hence dissociation followed by spreading gives us a way of accounting for *compensatory lengthening*. We refer to Ingria (1981) and Clements (1984) for discussion of this type of process.

Another type of process that can be analysed differently, at least in a number of cases is *methathesis*. In Van der Hulst (1983), and Smith (1984) several cases of metathesis are handled by exploiting the possibility that vowels and consonants are represented on different tiers:

(40) 

As suggested in Anderson (1979), given the autosegmental organization of representations, it may be possible to reduce considerably the inventory of possible phonological operations. A comprehensive elaboration of this line of research has not been provided to date, but it will be quite clear that the approach described above allows us to express more precisely just what phonological processes involve.

Examples of how the CV-skeleton functions in the application of various other types of phonological rules (particularly *insertion processes*) can be found in the contributions by Hermans, Noske and Ter Mors.

3.6. Concluding remark

This concludes our discussion of the autosegmental approach to phonological representations. At the present moment there are numerous publications in which the applications of this model are investigated. It is becoming clearer and clearer that what started out as a new approach to tone, has led to a whole new conception of phonological structure, possessing fruitful problem solving capacity.

4. METRICAL PHONOLOGY

In the broad sense metrical phonology is concerned with *phonological constituent structure* and the *prominence relations* that hold between the categories of each hierarchical level. The theory of metrical phonology arose from Liberman's work on English word and phrasal stress (Liberman 1975). The treatment of English stress within this framework was elaborated in Liberman and Prince (1977), Selkirk (1980a) and Hayes (1981, 1982). A general typology of stress systems, based on the metrical theory, was proposed in Vergnaud and Halle (1978) and Hayes (1981).

Just as in the case of the autosegmental theory, metrical theory, developed to deal with stress, has been extended to other phenomena. In particular this has led to a revival of certain traditional ideas about syllable structure. It will be evident that the metrical notation is suitable for representing the well known fact that one element (usually a vowel) is more prominent than all the other elements within a syllable.

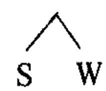
In this section we will first discuss the metrical theory of stress and then turn to syllable structure. We will not devote an extensive discussion to the various types of phonological constituents (some remarks are to be found in the next section), but refer instead to the relevant publications. In this volume Dogil, Neijt and Prieto discuss various issues in this area.

4.1. Stress

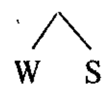
4.1.1. Phonological constituent structure: metrical trees

The basic idea behind metrical phonology is that the prominence relations involved in an utterance can be characterized in terms of a constituent structure that is augmented with an S/W labelling. The S/W labelling expresses the fundamental claim that, within a particular constituent, one daughter is relatively strong with respect to her sister. A second, independent idea is that nodes in the constituent structure are maximally binary branching. Hence the S/W labelling indicates, for each pair of sister nodes, which is the more prominent. The basic building blocks of the theory are then:

(41) a.



b.

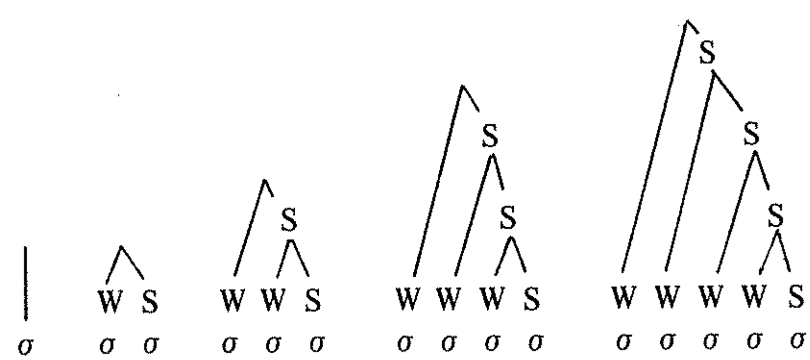


The labels S and W have no fixed phonetic interpretation. In this sense metrical trees are abstract and uninterpreted (cf. Prince 1983). It is a well known fact that prominence can be phonetically realized in a number of ways, or in particular cases, not at all. For a typological survey of the ways in which wörd level prominence can be realized in natural languages we refer to Greenberg and Kaschube (1978).

Binary branching trees, labelled in the above fashion, have one and only one terminal element that is exclusively domintated by nodes that are labelled with S (excluding the top node). This element is called the *designated terminal element* (DTE). This property makes them suitable for expressing properties of utterances that typically occur at one place in the utterance only. One such *culminative* property is word stresss (cf. Garde 1968, Hyman 1977, Greenberg and Kaschube 1978). Suppose we want to say that in a language L all words have main stress on the final syllable. The labelled trees in (42b), taking syllables as their terminal elements would express this fact adequately. The *stress rule* for L could be formulated as in (42a):

(42) a. Assign a uniformly right branching tree to each word
Label each right node with S and each left node with W

b.

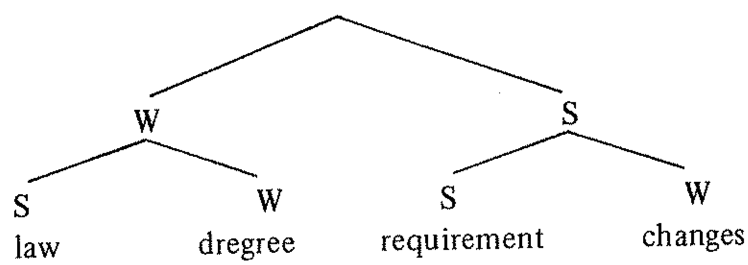


Monosyllabic words (i.e. the first case in 42b) receive a tree structure according to the rule in (42a), but cannot be assigned a label S, because this label indicates *relative* strength. Within a constituent that has one daughter only, it makes no sense to say that this daughter has such a relational property. Yet, taking stress to imply the potential of being associated with a intonational pitch movement, monosyllables can be stressed. If they cannot be associated with a pitch moment they are *clitics*. This implies that metrical trees are interpreted according to the following rule:

(43) Within a constituent C main stress falls on the only syllable or on the syllable that is exclusively dominated by nodes labelled S

The idea of labelling nodes of course presupposes the presence of these nodes. Liberman's point of departure is that the constituent structure required for the determination of relative prominence is given by the morpho-syntactic constituent structure. This can be illustrated clearly with reference to compounds. On the assumption that the relevant constituent structure is the one corresponding to the morphological structure the compound stress rule of English could consist of the following labelling rule:

(44) Label right node S iff it branches

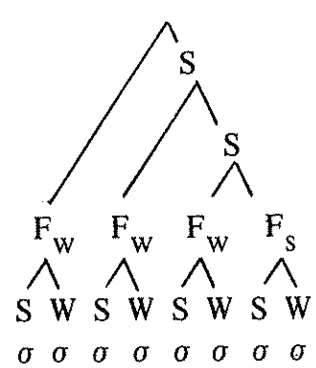


A very similar proposal was advanced in Rischel (1972), who uses the labels +/– instead of S/W. Rischel also points out that in certain cases the labelled tree must be restructured somewhat to arrive at a satisfying characterization of the stress pattern of compounds, a point that he discusses in more detail in Rischel (1983). This may be evidence for denying that the morphological structure of compounds is relevant, but we will not pursue this point here (cf. Van Zonneveld's contribution to this volume). Below the compound level matters are even more complicated. Either we are dealing with words that have no morphological structure at all, or else the morphological structure is simply not the one that is required. We trust that the reader is familiar with the fact that in many languages one may distinguish between affixes that behave prosodically as independent units, like stems, in which case the morphological structure can be utilized to assign the S/W lables, and affixes that are fully integrated into the prosodic structure of their base, in which case the morphological structure appears to be irrelevant. The labelled constituent structure that is required in complex words of the latter type must be built up as part of the stress assignment procedure, just the same as when we are dealing with words with no morphological structure. We follow in such cases a procedure such as that illustrated above in (42).

But also above the compound level the syntactic structure does not provide the appropriate structure. It has been pointed out in various places that higher level prosodic tree structure is not isomorphic to syntactic structure, although the former can be derived from the latter by means of an algorithm. Nespor and Vogel (1982), following Selkirk (1982b) discuss this mapping function, as does Neijt (in this volume). Nespor and Vogel (in their contributions to this volume) show that the constituent structure thus created not only provides a basis for assigning a relative prominence pattern to an utterance, but also functions as a theory of *phonological domains* to which phonological rules appear to be sensitive (cf. Selkirk 1980b). Rischel (1983) disagrees and claims that above the compound level, we do take the syntactic structure as a starting point. The resulting trees are labelled and then altered by transformational rules. A similar proposal is advanced in Giegerich (1983). It is clear that in both alternatives it is acknowledged that prosodic structure is not isomorphic to morphological or syntactic structure, but can be derived from it (directly or indirectly).

The Liberman and Prince theory embodies one other crucial innovation with regard to the treatment of stress. Prominence patterns typically involve more than just a single strong element surrounded by equally weak elements. If sufficient weak elements are present we will normally encounter a *rhythmic pattern*. Liberman and Prince propose two ways of dealing with rhythmic patterns. Within words such patterns arise by grouping syllables together into *feet*. A foot is defined as a relatively strong syllable follwed or preceded by a sequence of relatively weak syllables. To designate the strongest syllable of the word we must now assume that feet rather than syllables are gathered in a uniformly branching word tree:

(45)



To account for rhythmic patterns in phrases Liberman and Prince propose a different strategy, i.e. a procedure for creating such patterns that does not depend on the binary branching constituent structure, but crucially involves another hierarchical structure, distinct from the tree called the *grid*. We will discuss the grid in the next section.

4.1.2. Grids

In Liberman and Prince (1977) (henceforth LP) the string of segments (the "text") is associated with two hierarchical structures: a *metrical tree* and a *metrical grid*. Grids are secondary, i.e. derived from trees with the aid of a principle that LP term the *Relative Prominence Projection Rule* (RPPR) (p. 316):

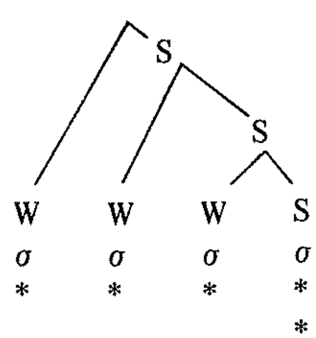
(46) *RPPR*

In any constituent on which the strong-weak relation is defined, the designated terminal element of its strong subconstituent is metrically stronger than the designated terminal element [DTE] of its weak subconstituent.

The role of grids is to interpret metrical trees. The grid makes explicit which prominence relations between the terminals are considered to be relevant for a characterization of the stress pattern of a string. In particular the grid makes it possible to characterize intuitive notions such as "rhythmic alternation", stress clash", etc. in explicit ways, as we will see below.

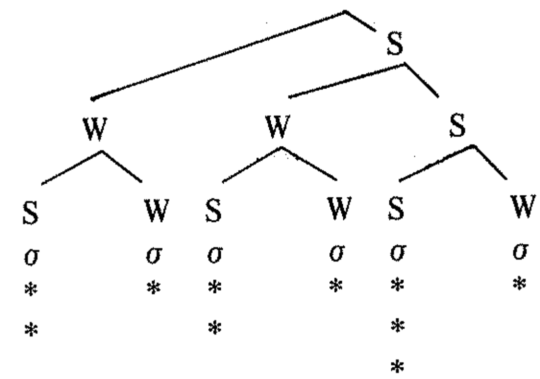
A grid that is in conformity with the RPPR is the one assigned to the tree in (47):

(47)



In a slightly more complex example the RPPR gives us the following tree-grid correspondence:

(48)



The relation between the string of syllables and the grid can be thought of in terms of autosegmental association. In fact LP's conception of grid-text alignment comes close to being a definition of the autosegmental wellformedness condition (p. 316):

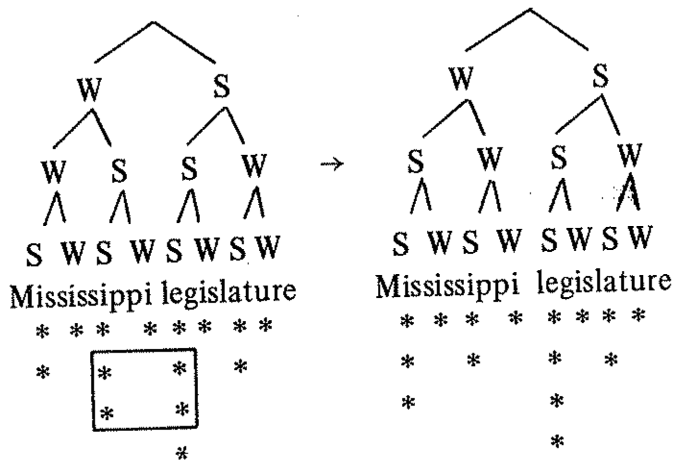
> A metrical grid is "aligned" with a linguistic phrase by the previously-mentioned function C, which maps the grid's terminal set one-to-one onto the syllables of the phrase, preserving order. The Relative Prominence Projection Rule (...) is to be interpreted as a wellformedness condition on such alignments.

Let us now look at one particular argument that LP give to substantiate their claim that grids are needed in addition to trees. We have seen that the grid is regarded as an interpretational device. In addition, LP argue that grids are necessary to define the notion of a *stress clash* or, to put it in more general terms, to capture the notion of linguistic rhythm. They observe that in certain configurations the relative prominence of words or phrases seems to be adjusted to avoid too close a distance between adjacent stresses. In order to make this precise LP define the following notions in terms of the grid (p. 314):

> Elements are metrically adjacent if they are on the same level and no other elements of that level intervene between them, adjacent elements are metrically alternating, if in the next lower level the elements corresponding to them (if any) are not adjacent; adjacent elements are metrically clashing, if their counterparts one level down are adjacent.

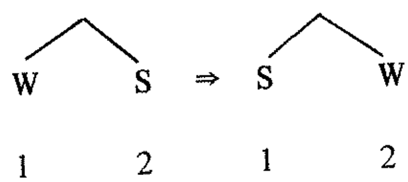
If a clash in the sense just defined arises, a metrical transformation (involving a relabelling operation), *Iambic Reversal* – also known as the *Rhythm Rule* – is performed on the tree. The grid that corresponds to the relabelled tree no longer contains a clash:

(49)



The relabelling rule is formulated as follows:

(50) *Iambic Reversal* (optional) (LP, 319)



Conditions:

1. Constituent 2 does not contain the DTE of an intonational phrase (i.e. the syllable which is exclusively dominated by nodes labelled S)
2. Constituent 2 is not an unstressed syllable (i.e. syllables which are exclusively dominated by nodes labelled W)

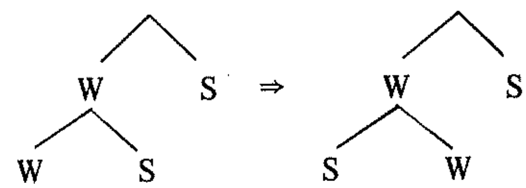
The crucial role attributed to the grid as part of the phonological representation is to locate environments, defined in terms of the grid, in which Iambic Reversal will apply.

The LP theory then uses both trees and grids. A proponent of this *grid-cum-tree* theory is Hayes (1984a), who offers a defence of the original LP conception, thus providing an argument against the two alternative theories we are about to discuss. The contribution by Hayes and Puppel in this volume also falls in this category.

4.1.3. Trees versus grids

Kiparsky (1979) points out that, strictly speaking, we do not need the grid to find the circumstances under which Iambic Reversal may apply. If we slightly complicate the rule it applies precisely where we want it to apply, without reference to the grid.

(51)



Kiparsky's proposal allows us to eliminate grids from the theory, or at least to reduce their function, leading to a *tree-only* theory. A recent defence of the tree-only approach can be found in Giegerich (1983). Giegerich argues in favor of a tree-only theory, i.e. we do not need the grid to account for rhythmic phenomena above the word level. Instead of producing rhythmic patterns by adding beats to the grid and leaving the constituent structure as it is, Giegerich proposes to modify the tree structure, by a series of metrical transformations.

A different route is also possible, however. Prince (1983) raises the question as to whether trees rather than grids should be abandoned. His position is supported in Selkirk (1984b). Offering the counterpart of Kiparsky's argument, both attempt to show that the Rhythm Rule can be formulated entirely in terms of the grid. The rule that Selkirk proposes roughly is as follows:

(52)

```
  * *      *   *
*  *  *  →  *  *  *
```

Prince chooses an even simpler formulation:

(53) Move *

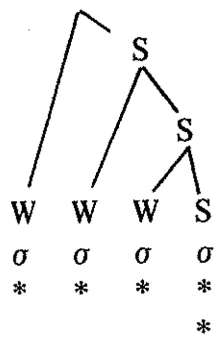
To produce the prominence pattern, including both main stress and rhythmic alternation Prince introduces rules that add beats to the grid directly without involving trees. To a certain extent this was also allowed in LP's standard theory. The major difference between the theory offered by Prince and the standard theory offered by LP is that the strongest stress, too, results from adding a beat to the grid, both at the level of words and at the level of phrasal stress.

Prince's point of departure is that the RPPR gives us a satisfactory interpretation of metrical trees (p. 24):

> Grid (9a) [our 47, repeated here as 54] is distinguished by being *minimal* in the obvious way: it has less structure than any other interpretation of the tree [w w w s]. The RPPR can be supplemented with a natural principle of minimality to pick out (9a) as fundamental. Divergences from the 'flattest' interpretation will arise from subtle variations of emphasis consistent with overall s/w–structure (...),

as well as from the pressures of eurhythmicity and phrasal demarcation. For example, in a [w w w s] tree like (9a) the first *w* is often felt to be more strongly stressed than the others. This fact might be recorded as a supplementary principle of prosodic realization, based on constituent structure and linear order, distinct from the primary interpretation of the stress pattern imposed by the metrical tree.

(54)



Prince then observes the following (p. 25):

> Because the grid carries over so little of the information in the tree, there is another, more direct route to the match-up. We can deal just with *terminals* according to a rule like this: "in any constituent C, the rightmost terminal is strongest".

To put it in more formal and general terms (p. 25):

> *End rule.* In a constituent C, the leftmost/rightmost terminal in C is associated to a stronger grid position than any other terminal in C.

It is undoubtedly true that the End Rule gives us the same information about relative prominence as the tree + RPPR. The question whether one of the hierarchical structures is superfluous is therefore a legitimate one.

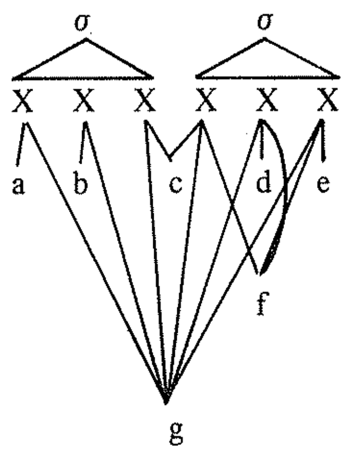
In this volume Hoeksema's and Van Zonneveld's contributions offer a discussion of the tree-grid controversy.

4.2. Syllable structure

A satisfactory theory of the syllable should consist of two parts. Firstly, it should define the notion of "wellformed syllable (of language L)", and secondly, it should specify how an arbitrary string of language L is syllabified, i.e. parsed into wellformed syllables. Here we will not deal with the issue of syllabification. On this the reader should consult the contributions by Noske and Ter Mors.

In our sketch of the metrical theory of stress we have assumed that the *stress-bearing units* are not vowels, but nodes labelled "σ", standing for syllable. On the other hand, our exposition of autosegmental theory showed that there is a central tier, called the skeletal tier, which serves as a reference point for all association. Finally the sketch of how metrical and autosegmental theory fit together showed that the slots which form the skeletal tier can be identified with the terminal nodes of the syllable:

(55)



(Small letters represent (bundles of) features.)

In this section we want to address two questions:

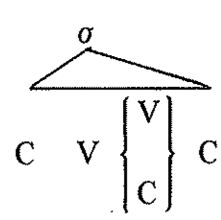
(56) a. How do we specify the terminal nodes of the syllabic tree?
b. What does the internal branching structure of the syllable look like?

4.2.1. Syllabic terminals

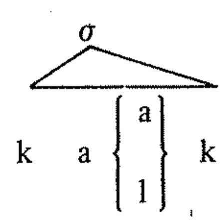
Let us first focus here on the precise nature of the labelling of the terminals. The original proposal, going back to McCarthy (1979), was that the terminal nodes of the syllabic tree are labelled 'C' or 'V', abbreviations for feature bundles [+cons, –voc] and [–cons, +voc], or other conceivable bundles standing for the major categories 'consonant' and 'vowel'.

An important problem with respect to this point of view is the following. It may be observed with regard to the syllables in various languages, including Dutch, that certain positions in the syllable may be occupied by either consonants or vowels. In Dutch long vowels occupy two syllabic positions, so adopting the C/V framework will lead to disjunctions in the rewrite rule introducing the relevant part of the syllable:

(57) a.



b.



In (57b) we have given as examples two Dutch monosyllabic words: *kaak* 'jaw', *kalk* 'chalk'. The fact that the third position can be filled by either the second part of a long vowel or a consonant, which follows a short vowel, becomes apparent when we see that a form like **kaalk* is illformed, i.e. the wellformed postvocalic cluster /lk/ cannot follow a long vowel. The fact that in the post-vocalic position we may find either vowels or consonants implies that we need a label which is more general than either C or V, say S (= sonorant).

The second problem is that it seems at first sight insufficient to label the terminals as either C or V. Why? Dutch allows syllables to begin with two consonants, and also to end with two consonants, but it is not the case that every combination of two consonants is wellformed. To make this more concrete let us give an example. The sequence in (58a) does not constitute a wellformed syllable in Dutch, while the one in (58b) does:

(58) a. *rkapm b. kramp

Does this mean that we also need labels which are more specific than C and V (apart from one that is more general)? We think not. It has been widely observed that the shape of syllabic melodies (i.e. sequences of segments that must be associated to a sequence of slots, constituting a syllable) is partly determined by the sonority of the segments: segments get more and more sonorous as we go from the edge of the syllable towards the centre or peak, which is by definition the most sonorous segment. On the basis of this particular sequencing of segments we can order segments on a scale, which, phonologists have claimed, can be independently motivated with evidence from language change, language acquisition etc. Selkirk (1982b) refers to this observation as the *Sonority Sequencing Generalization* (SSG).

In some cases the SSG can be violated. Syllable-initial clusters with *s* followed by a stop occur in the Germanic languages, and clusters like syllable-initial *mgl* or syllable-final *pl* in Russian. In the majority of cases, however, the linear structure of syllables is in conformity with the SSG. We can therefore adopt the point of view that the particular order in which segments occur in the syllable need only be specified where it deviates from the SSG. For this to work we must assign to each segment a sonority value. Given a sonority scale as in (59), and the SSG, as parts of universal grammar the illformedness of syllable-initial sequence such as *rk*, e.g. in Dutch, will follow if we say that Dutch allows initial clusters consisting of *k* and *r*, i.e. we do not have to say in what order these segments may occur:

(59) |——|——|——|——|

stop fric nas liq vow

But the SSG does not solve all our problems. There are consonant clusters, which conform to the SSG and are still not wellformed, e.g. initial *pf* or *mr*. All wellformed (non-exceptional) syllable-initial biconsonantal clusters in Dutch consist of an obstruent followed by a sonorant consonant. Hence it seems necessary after all to label the two C positions further:

(60) C C ....
[+obs] [-obs]

But (60) contains redundant information, since the SSG already tells us that the [+obs] must precede the [-obs]. Given the SGG then we might propose a different solution. In addition to a general (in fact: over general) template, we may assume a set of filters. For example to rule out *pf* and *mr* we may formulate the following filter (cf. Trommelen 1983):

(61) NOT: C C
[@obs] [@obs]

Given a filter such as (61) we may conclude that in the syllable rewrite rules it is sufficient to say that the first two positions are CC. Ignoring the internal structure we can say then that the syllabic terminals are labelled as in (62):

(62) C C V S C

In addition to (62) we need a set of filters (such as the one in (61)) to constrain "overgeneration". Harris (1983) suggests that many filters express *dissimilarities*, i.e. "unlikeness", and he also suggest that in a number of cases the unlikeness has to do with the inherent sonority of segments. This view is adopted in Selkirk (1984a) and Steriade (1982) who formulate filters in terms of the notion *sonority distance*. So instead of (61) one may formulate a *Minimal Sonority Distance* value *n*, where the precise value of *n* depends on the scale we use.

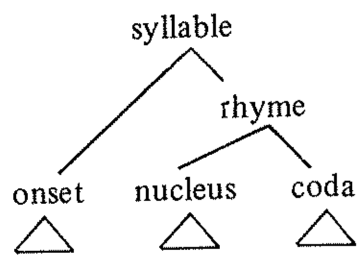
However, instead of using the sonority value for filters only, Selkirk argues that we might just as well provide the terminals of the syllabic tree with a specification in terms of a sonority value. We refer to Selkirk (1984a) and Van der Hulst (1984) for details concerning this proposal. It will be clear that the sonority approach not only captures a basic insight into the segmental structure of syllables, it also disposes of the "disjunction" problem in a manner that is less ad hoc. The symbols C, V and S are not primitives then, they are simple abbreviatory labels for slots with a sonority index.

4.2.2. Constituent structure

Having established how association takes place and what syllabic terminal nodes look like, let us turn to the second question. The issue of the internal structure of syllables has received a great deal of attention recently. In earlier proposals it was argued that syllables had a constituent structure of the same type as is to be found in the morpho-syntactic domain (see Pike and Pike 1947, Saporta and Contreras 1962, Fudge 1969). Generally the argument in favour of (a particular) constituent structure boils down to the claim that it allows us to capture certain generalizations which would otherwise remain unexpressed (Harris 1983).

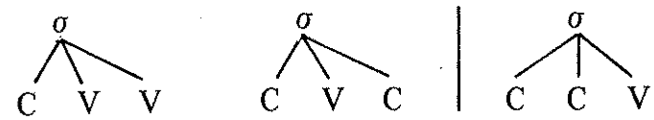
A commonly held point of view involves the following traditional view of the syllable:

(63)



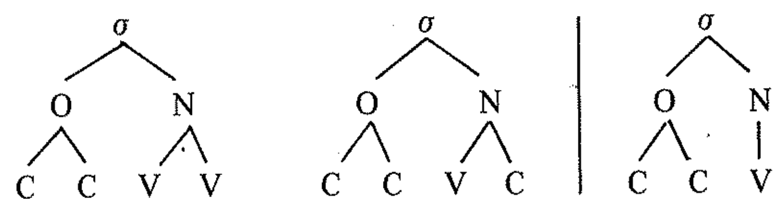
One of the main reasons for proposing a complex internal structure of this type comes from the frequently observed relationship between syllable structure and stress or tone assignment (cf. Newman 1972 and Hyman 1977). In many stress systems main stress, or a particular tone, may only be realized on syllables that contain a certain number of segments or segments of a certain type. These syllables are referred to as "heavy" as opposed to the "light" syllables that may not attract stress or a particular tone. It appears to be the case that prevocalic material and certain syllable-final segments are (with the exception of certain marginal cases; cf. Davis 1982) irrelevant as far as the "weight" of syllables is concerned. The claim is that the irrelevance of certain parts of the syllable should be expressed in terms of a specific syllable internal constituent structure.

Let us be more specific now about the relation between syllable structure and prosodic properties, limiting ourselves to examples involving stress. In many cases in which stress is sensitive to syllable structure, we find that syllables with long vowels (i.e. VV) or closed syllables (VC) attract stress, whereas open syllables with short vowels (V) do not. Now if we assume that syllables are completely flat there is no straightforward way of characterizing VV and VC syllables as a natural class:

(64) 

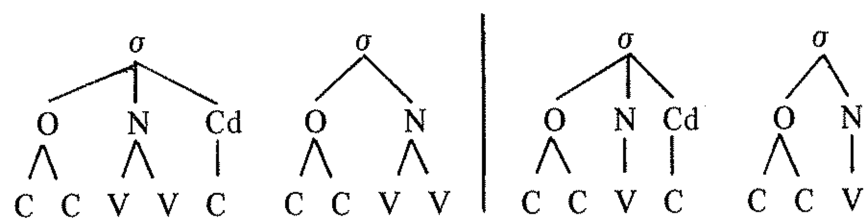
We cannot start counting the number of segments in a syllable, because, as stated above, prevocalic material is assumed to be irrelevant.

We can characterize VV and VC as a class, thus providing a formal basis for an explanation of their behaviour, if we assume the following degree of structure ('O' = onset, 'N' = nucleus):

(65) 

(Instead of N(ucleus), we could also use R(hyme); the name is immaterial.) We can now say that syllables with a *branching nucleus* attract stress.

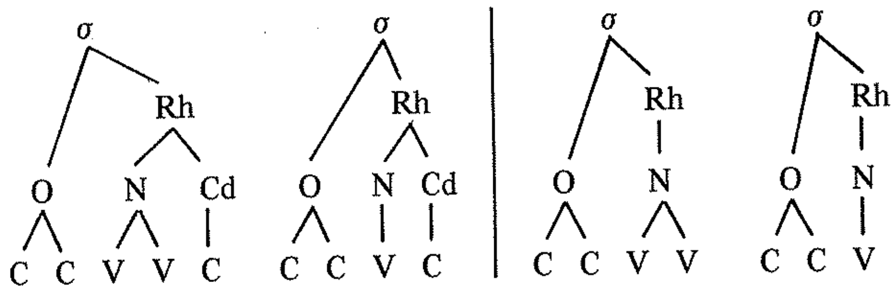
In other systems only syllables with a long vowel attract stress. Syllables with a short vowel, whether closed or not, are then treated as light. In this type of case we will say that the Nucleus is restricted to vowels. This can be handled in terms of a parameter: to be considered as part of the nucleus segments must possess a certain degree of sonority. This sonority threshold may differ from language to language ('Cd' = coda):

(66) 

The generalization with respect to stress placement is the same as in the previous system: a branching nucleus is stressed.

In still other types of system where syllable weight interacts with stress assignment it is claimed that only closed syllables belong to the stress-attracting set. To handle this type of case it becomes necessary to assume that the nucleus may only contain vowels, and in addition that the nucleus and the coda form a constituent:

(67)

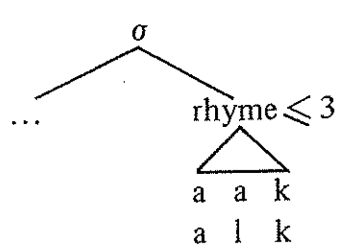


The generalization in respect of heavy syllables now becomes different: a syllable with a branching rhyme is stressed. It has been argued in various places, however, that the distinction between open and closed syllables plays a marginal role only in stress placement. This weakens the argument in favor of assuming a rhyme constituent.

Other phonologists have pointed out that the constraints on sequences of segments inside a syllable (expressed in terms of (sonority) *filters*) provide evidence for the proposed representation, the claim being these constraints are more likely to refer to segments that form a constituent than to segments that are separated by a constituent boundary. Selkirk (1982a) speaks here of the *Immediate constituent structure principle of phonotactics*.

Another widely used argument in favor of the type of intrasyllabic structure considered here, and in particular of the onset–rhyme division involves the common fact that syllables with long vowels (or diphthongs) may be followed by one consonant less than syllables with short vowels. The upper limit of segments that may follow the onset can be formulated in terms of the upper limit of the rhyme. To illustrate this point we may use a set of examples also discussed in the previous section. As was pointed out, in Dutch short vowels can be followed by two consonants (e.g. *kalk*), whereas long vowels can be followed by just one (e.g. *kaak*, but not **kaalk*). This might be expressed by saying that the rhyme may contain at most three segments:

(68)

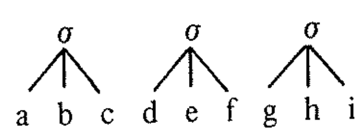


This is not a particularly forceful argument, since we can also express this by saying that in such cases the nucleus may contain maximally two segments, and the coda maximally one.

Summarizing we may conclude that whereas the nucleus is a firmly established internal constituent of the syllable, the constituents onset and coda may be defined negatively as what is left over after the nucleus has been established. The evidence for the adoption of a rhyme constituent is questionable.

Let us now look back into the past and discuss the first proposal in the field of generative phonology involving a non-linear representation of syllable structure, viz. that of Kahn (1976). Kahn does not discuss the issue of syllable internal constituent structure explicitly. His main concern is to argue for the syllable as an important unit to which phonological rules refer. In this respect Kahn's contribution follows the proposals by phonologists like McCawley (1968), Vennemann (1972) and Hooper (1976). Unlike his predecessors, however, Kahn proposed the abandonment of syllable boundaries as a means of characterizing syllables in the formal representation. Instead he assumed that syllables must be represented in terms of constituent structure. In search of a formalism Kahn turned to the theory of autosegmental phonology. Using the notions "tier" and "association line", the fact that a certain sequence of segments forms a syllable can be expressed by postulating an independent tier consisting solely of "syllable nodes". Segments that constitute one syllable are all "associated" to the same node on the syllable tier:

(69)

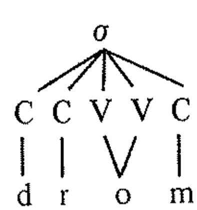


(syllable tier)

(segmental tier)

Kahn's theory does not fit into the 'traditional' conception of the syllable, but recently Clements & Keyser (1983) have argued in favor of a syllabic theory that is like Kahn's in that the relation between syllable nodes and (not segments but) syllabic slots is "flat":

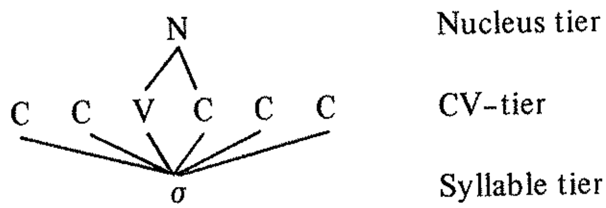
(70)



However, apart from the addition of a CV-level, which Kahn didn't have, their theory departs from Kahn's in one important respect. Clements & Keyser admit that there is evidence which suggests that the category *nucleus* plays a role in phonological organization. The argument in favor of the nucleus, which we have discussed above, is that we cannot define the distinction between heavy and light syllables without reference to this category. Clements and Keyser (p. 12) define the nucleus *universally* as consisting of a long vowel or diphthong or a short vowel plus the immediately following consonant, whereas we have suggested that there may be a threshold-parameter involving the sonority value of the second segment in the nucleus. We will not dwell on these differences here, however.

Clements and Keyser then propose that phonological representations involve, in addition to the σ-tier, CV-tier and the segmental tier also an N-tier. Tiers such as the σ-tier, CV-tier and the N-tier are referred to as *structural tiers*. They are not defined in terms of phonetic features but as structural units, representing the higher-level serial organization of speech units (p. 18). The segmental tier is itself a composite of several tiers, such as the nasal, the laryngeal tier and the tonal tier, which are referred to as *phonetic tiers*. Notice that, although an intrasyllabic constituent is recognized, it is not the case that the syllable is regarded as having a non-flat structure. The syllable and the nucleus are regarded as simultaneous (flat) representations on different tiers:

(71)

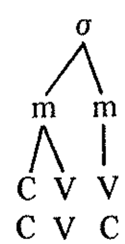


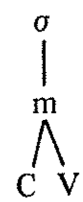
With regard to the other intrasyllabic constituents, Clements and Keyser argue that the categories *onset* and *coda* are unnecessary. They know of no phonological rule that refers to these constituents and argue that the presence of these categories would even complicate certain rules or necessitate special conventions (p. 15-16). Furthermore, constraints on syllable initial and syllable final clusters might just as well refer to the syllable boundary directly. A problem with this point of view might be that we can no longer straightforwardly express the fact that (as we saw in the case of Dutch) at most one additional consonant may follow the nucleus. Clements and Keyser furthermore defend the view that the rhyme is also unnecessary. For a more general discussion of their theory we refer to Van der Hulst (1984).

We would now like to discuss a third possible mode of representing syllable structure. The discussion so far has shown that despite the differences that exist between the metrical and the autosegmental theory they have in common that the irrelevance of onset material with respect to syllable weight is an unexplained fact. We will now turn to an approach to this problem that bears a strong resemblance to (and derives from) proposals that are advanced in Hyman (1983). The proposal that we will discuss here differs in some respects from the one Hyman proposes, but we do not think that these differences do damage to the central idea that Hyman wishes to express.

The essence of Hyman's idea is that syllables consist of constituents that he calls *weight units*. These weight units correspond to the traditional notion of a *mora*. We will therefore refer to this third theory as the *mora theory*. Within the mora theory, heavy syllables consist of two morae whereas light syllables consist of only one mora. In a language that makes the heavy–light distinction, a heavy syllable's first mora consists of the first vowel plus all *preceding* segments. The second mora consists of all remaining segments:

(72) a. *Heavy syllable* b. *Light syllable*





Let us point out here what the mora theory has to offer, when we compare it to the other available theories.

Firstly, the distinction between heavy and light syllables falls out as a distinction between branching and non-branching *syllables*. This implies that the relation between stress (i.e. foot structure) assignment and syllable weight can be formulated in strictly *local* terms. Foot assignment is sensitive to branching of syllables and not to properties of some node that is more deeply embedded.

Secondly, the "riddle" of the irrelevant onset (and post-nuclear material) is no longer there. There are no irrelevant constituents or parts of the syllable that must be ignored for the purpose of stress assignment. All segments of the syllable belong to some mora. A direct consequence of this is that syllables are no longer anomalous as part of the prosodic hierarchy. Virtually all prosodic constituents seem to consist of one or more lower level units of the same kind: an utterance consists of intonational phrases, intonational phrases consist of phonological phrases, phonological phrases consist of phonological words, phonological words consist of feet and feet consist of syllables. But then quite unexpectedly syllables (at least in the metrical theory) consist of onsets and rhymes and to make this more suspect onsets could just as well be absent. They do not participate in the hierarchy. In the mora theory syllables behave like other prosodic constituents. One might even say that morae too have the appropriate structure, since (at least in the view of some) we rewrite them as a sequence of X's. Hence the whole prosodic hierarchy can be characterized by rules of the type A → B*.

4.3. Concluding remarks

In the previous section we have discussed a theory of prosodic constituent structure and prominence. We have seen that with respect to the treatment of stress and syllable structure there are a number of lively controversies. It has not been our intention to make a choice from among the alternative proposals. The reader will find ample discussion of the alternative views on stress in the contributions to part I of this volume.

5. CONTENTS OF THE VOLUME

In this article we have provided a general overview of present-day generative phonology, focussing on autosegmental and metrical phonology. In doing so we have made reference to most of the articles contained in this volume. We will now present short summaries of all these articles.

PART II: STRESS AND ACCENT

Apart from Gussenhoven's contribution, all the articles in this section deal with stress (word and/or phrasal level) and thus bear on the issue of how stress is to be represented, in terms of trees, grid, both or neither. The reader must be prepared to discover that the various possibilities have their own protagonists, although not all the authors take a definitive stand on the issue.

Bruce Hayes/Stanisław Puppel: Rhythm Rule in Polish

Within the context of a tree-cum-grid theory, the authors offer an analysis of certain stress shifts, i.e. the shift of weaker stresses under the pressure of stronger ones so as to conform to a rhythmic pattern. They argue that although the rule which achieves this shift must itself be viewed as a language-particular rule, formulated as a relabelling rule on tree structure, it is the grid, built up in terms of universal principles, which offers an explanation for the initial motivation and propensity to apply the rule.

Jack Hoeksema: Formal Properties of Stress Representations

As the previous paper, this one deals with trees and grids. Hoeksema shows that one can conceive of a SPE-type of numerical stress representation (i.e. segments have a n-valued feature [Stress]), which is isomorphic with metrical grids and metrical trees. He offers a set of rigid definitions of different sorts of grid structures and shows that for each possible grid there is a corresponding numerical representation. Similarly he shows that a metrical tree can be represented uniquely in terms of a numerical representation. Trees, however, are more restricted (there are many more possible grids or numerical strings then trees), and they provide information about constituency. Hoeksema hypothesizes that the restrictions may turn out to be undesirable, while the evidence for constituency is often inconclusive.

Jan Kooij/Mies van der Niet: Stress Shift and Morphology

In this paper, the relation between morphological structure and phonological structure is discussed. The focus is on certain stress shifts occurring in morphologically complex Dutch words. The authors argue that the shift is a prosodic phenomenon, which can be tackled in terms of rules which apply to tree structure, although the relevant rules are restricted to certain morphologically defined environments. In this respect notions such as "root-formation" as distinct from "word-formation" appear not to play a role.

Carlos Gussenhoven: Intonation

Gussenhoven offers a comprehensive autosegmental analysis of English intonation.

Ron van Zonneveld: The Janus Syllable

Van Zonneveld shares with Hoeksema a certain scepticism as regards the need for nonlinear representations for stress. His subject is stress shifts in Dutch Complex Words. He combines a numerical notation with a linear S/W notation and argues that this is sufficient for dealing with shifts and reduction.

PART III: PROSODIC CATEGORIES

All the authors in this section assume that some kind of prosodic organization is necessary, and also that this organization takes the form of tree structure. They do not deal with stress as such, however, and therefore are not primarily concerned with the precise nature of the S/W labelling.

Geert Booij: Coordination Reduction in Complex Words

Booij shows that the phenomenon of morphological gapping (Dutch: *appel-* en *druivesap*; English: *apple* and *grape juice*) can only be handled properly if we allow rules that refer simultaneously to both the prosodic tree structure and the morpho-syntactic tree structure. In this particular case the rule must refer in any case to the category phonological word.

Grzegorz Dogil: Speech and Grammar Pathology

Dogil argues that abstract phonological representations, incorporating both autosegmental structure and prosodic organization, can be utilized fruitfully in the area of speech and grammar pathology. He first sketches a strongly phonetically oriented point of view on autosegmental structure, and then goes on to characterize the phonological hierarchy in terms of a categorial grammar, in which the specific categories are predicted on the basis of general markedness conventions. He demonstrates that the notion of complexity, defined in terms of the notion markedness, allows one to gain insight into speech and grammar disabilities.

Anneke Neijt: Clitics

Neijt argues that the particular shape ("monosyllabicity") and distribution of clitics can be derived from a single phonological property of clitics (i.e. their unstressability). She discusses how prosodic constituent structure can be derived from syntactic structure.

Marina Nespor: The Phonological Word

Like Booij, Nespor provides evidence for the category phonological word. She shows that the domain for application of an intervocalic voicing rule in Italian cannot be defined properly unless we assume a constituent of this sort.

Domingo Prieto: Prosody and Transformations

Prieto defends the view that certain cyclic syntactic transformations must apply after assignment of phrasal stress (=S/W labelling of the syntactic tree). Furthermore, both the syntactic and the prosodic tree structure function in the structural description and change of these syntactic transformations.

Irene Vogel: Constraining Prosodic Rules

Vogel's topic is the formulation of restrictions on rules in prosodic phonology. Firstly she offers proposals with respect to the formalization of prosodic rules, i.e. rules which make reference to prosodic bracketing, and secondly she offers specific proposals with respect to the interaction of these rules.

PART IV: CV-AUTOSEGMENTAL PHONOLOGY

All the papers in this section make use, in one way or the other, of the fact that we can distinguish between on the one hand several structural tiers (CV-tier, syllable tier) and several phonetic tiers.

Ben Hermans: Icelandic Aspiration and Preaspiration

Hermans offers a detailed discussion of a classic problem in Icelandic phonology, claiming that preaspirated consonants are to be represented as aspirated geminates.

Harry van der Hulst: Hungarian Vowel Harmony

Van der Hulst compares various approaches toward vowel harmony and concludes that an autosegmental approach is superior to a segmental approach. In addition he compares various possible treatments of neutral vowels, within the autosegmental model.

Christine ter Mors: Empty V-nodes in Klamath

Ter Mors analyzes vowel alternations in Klamath. To this end she discusses the process of syllabification. She shows that so-called empty V-nodes play a crucial role in the analysis.

John McCarthy: Speech Disguise

In this contribution, McCarthy provides evidence for the adoption of a CV-tier, by analyzing a speech game which can only be understood if we assume that it is possible to manipulate the phonetic tiers, leaving the structural CV-tier unchanged.

Roland Noske: Syllabification in Yawelmani

Noske addresses the old issue of conspiracies, i.e. situations in which apparently unrelated rules conspire to avoid certain illformed surface configurations, showing that such rules can be formally related by making use of the notions of syllabification and the CV-tier. He argues in favor of "local globality", i.e. a rule is blocked if its immediate output is ill-formed in terms of syllable structure.

Norval Smith: Nonconcatenative Morphology

Smith provides a reanalysis of Smith and Hermans (1982). He attempts to show that morphological templates in Sierra Miwok must be specified as to whether they require spreading or not. If this is not the case default rules operate to fill up the vacant slots in the template.

Camiel Hamans: Umlaut in Dutch

Hamans discusses umlaut phenomona showing that the domain can be expressed in terms of the prosodic hierarchy, in particular the (stress) foot.

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