Part II

Syllable Structure

Chapter 2

The Representation of Syllable Structure

2.1. Introduction

In this chapter I will be concerned with the representation of syllable structure. Section 2.2.1. offers an introduction to the central issues that a theory of syllable structure has to address, indicating some of the current controversies, although no attempt has been made to give an historical account of all the syllable theories that have been offered in the past few years. In 2.2.2. and following sections I will then discuss three specific issues, viz. the role of the sonority hierarchy, syllable internal structure and finally the issue of syllabification. Throughout this chapter I am concerned with developing a model of syllable structure that will be applied to Dutch in chapter 3.

2.2. Theories of syllable structure

2.2.1. Introduction

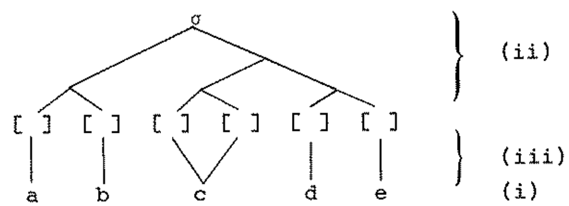
It is generally assumed that in developing a theory of syllable structure we face two tasks. Firstly, we must specify the notion "wellformed syllable (of language L)", and secondly, we must specify how an arbitrary string of language L is syllabified, i.e. parsed into wellformed syllables.

Two separate issues can be distinguished when addressing the first task. We have to characterize the sequences of segments that constitute a wellformed syllable (the **linear structure**) and we have to determine whether and, if so, how these segments are grouped into subsyllabic units (the **hierarchical structure**). Performing these tasks within an autosegmental framework implies that we must recognize a third issue, viz. the association between the autosegmental tiers and the central tier. In chapter 1 this central tier was identified as consisting of the terminal symbols of the syllable. I refer to the relation between the autosegmental tiers and the central tier as the **autosegmental structure**.

We can then distinguish the following common core in many proposals advanced in the recent past for the analysis of syllables (cf. Selkirk 1982b):

(1) i. the linear structure
ii. the hierarchical structure
iii. the autosegmental structure

(2)



With regard to all three aspects a characterization comprises two parts, a universal and a language-specific part. I will briefly indicate what is involved in these two parts, referring to some of the different points of view that exist in the literature in order to provide some general background for the subject matter of this and the following chapter.

2.2.1.1. Linear structure: universal

It has been widely observed that the shape of melodies (i.e. sequences of segments that must be associated to the central tier) that constitute a wellformed syllable is partly determined by the sonority of the segments: segments are more and more sonorous as we go from the edge of the syllable toward the center, 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. Following Selkirk (1982b), I will refer to this observation as the **Sonority Sequencing Generalization** (SSG).

Although the SSG occurs frequently in the literature on syllable structure, it is not always clear in what sense it plays a role in the theory. Some refrain from giving a theoretical status to a scale on which

segments are ranked because of certain ordering problems that seem to arise. Thus the SSG is said to be invalid because there are counter-examples such as syllable-initial clusters with s followed by a stop in the Germanic languages or 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. I will 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. Given a sonority scale (e.g. obstruent<sonorant consonant<vowel) and the SSG as parts of universal grammar the wellformedness of a syllable-initial sequence such as **kr**, 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 particular order these segments may occur. With Selkirk (1982b) I will furthermore adopt the position that the "sonority scale" is best interpreted as a multivalued **feature** [sonority], although I will continue to use both the terms 'scale' and 'feature'. I will discuss the consequences of these proposals in more detail in the chapter 3.

2.2.1.2. Linear structure: language specific

In most analyses of syllable structure two types of statements about segment sequences can be found, i.e. **colligational** and **collocational** restrictions, to use the terminology of Fudge (1969, 266). The former type of statement expresses the fact that certain segment types may occur in a particular position in the syllable, despite the fact that not all possible combinations actually occur. Statements of this type are usually given in the form of phrase-structure rules (generating syllables) or in the form of node admissability conditions, referred to as "templates" (accepting syllables). The second type of statement then excludes the combinations that are absent yet allowed by statements of the first type. They have been referred to by others as **filters** (Selkirk 1982a,b, Harris 1983) or **negative syllable structure conditions** (Clements and Keyser 1983).

In the model that I will adopt several filters will directly refer to the feature [sonority], ruling out sequences of segments that are adjacent or too close in terms of their sonority value. In this respect I follow Harris (1983), Selkirk (1982b) and Steriade (1982) who use the term **dissimilarity condition** to refer to filters of this type.

2.2.1.3. Hierarchical structure: universal

The issue of syllable internal structure has received a great deal of attention recently. In the early proposals it is argued that syllables have a constituent structure of the type that we find in the morpho-syntactic dimension (see Pike and Pike 1947, Saporta and Contreras 1962, Fudge 1969). Generally the argument in favor of (a particular) constituent structure boils down to the claim that it allows us to capture certain generalizations which will remain unexpressed otherwise (Harris 1983). More specific arguments will be discussed in section 2.2.3.

Some phonologists, however, have argued in favor of a "flat" syllable structure, e.g. Clements & Keyser (1983) following Kahn (1976), and Davis (1982), while others (e.g. Hyman 1983) have defended a syllable internal structure that is fundamentally different from the first approach mentioned here. Of course there are various intermediate positions as well.

Proponents of these different theories say, implicitly or explicitly, that they make claims about universal properties of syllable structure. For example, Clements & Keyser (1983) imply that syllables in **all** languages have a flat structure, not just the syllables that we find in English or some other language.

2.2.1.4 Hierarchical structure: language specific

Languages may differ with regard to the number of segments that are allowed to form one syllable or its constituents, and languages may differ as to the obligatoriness of parts of their syllables. So in a particular language syllables may consist of sequences of one consonant and a vowel, whereas in another language more complex sequences are allowed. Similarly, a prevocalic consonant is obligatorily present in one language and optional in another. The choices that a language makes from the set of universally defined possibilities, must be stated in the form of language-specific statements about the internal organization of syllables.

2.2.1.5. Autosegmental structure: universal

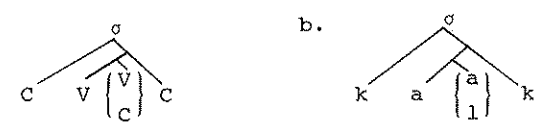
The separation of linear and hierarchical structure results in a model in which (auto)segments (units of the linear structure) are "inserted" into the (empty) terminals of a constituent structure. In recent literature the "insertion relation" is regarded as an instantiation of the autosegmental association relation. This means that universal aspects of the association between the terminals of the syllabic tree, in short (syllable) slots, and

segments involve first of all the **Wellformedness Condition** (WFC).

A second important point involves the principles that determine when a particular segment can be associated to a particular slot. In all versions of the autosegmental theory it is assumed that the syllabic tree somehow provides information that is crucial for a successful association of segments to the terminal elements of the syllabic tree. There are several views concerning this issue.

The first proposal, going back to McCarthy (1979), is that the terminal nodes of the syllabic tree are labelled 'C' or 'V', abbreviations for the feature bundles [+cons, -voc] and [-cons, +voc], or other conceivable bundles standing for the major categories 'consonant' and 'vowel'. Since the segments are specified for these features as well we can say that association is subject to a **non-distinctness condition**. A problem with respect to this 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. The structure of Dutch syllables and the assumptions that underlie the present example will be discussed in detail in section 3.3.3. In Dutch long vowels occupy two syllable positions, so adopting the C/V framework will lead to disjunctions in the syllable template such as in (3a):

(3) a. b.



In (3b) I have given 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.

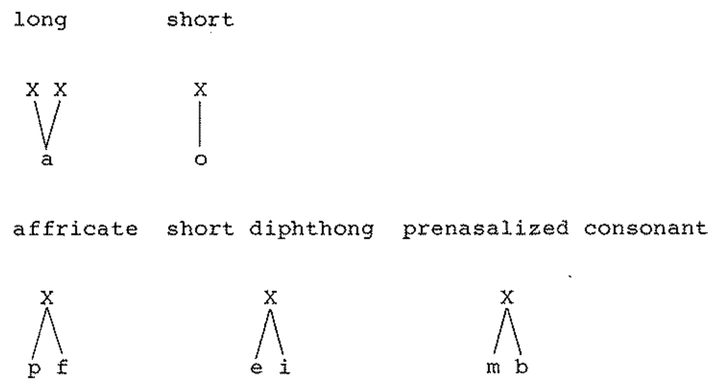
In a second approach it is assumed that all, or at least some, terminal nodes of the syllable tree are completely unspecified. Such terminals are usually represented by the symbol "X". For association to work properly it must now be said that certain segment types (for example vowels) can only be associated to a slot that is dominated by a node labelled "nucleus". Hence within this approach it is the specification of non-terminal, rather than terminal, nodes that gains a theoretical importance. This position is defended in Levin (1983), Kaye (1982) and Hyman (1983).

A third approach seeks to find other ways to secure proper association by providing terminals with a specification that generalizes over vowels and consonants, where necessary. In the analysis of the Dutch syllable I will adopt the third approach, although instead of the traditional binary major class features I will adopt a proposal advanced in Selkirk (1982b) and use the multivalued feature [sonority] to characterize the classes of segments that may be associated to the syllabic slots.

2.2.1.6. Autosegmental structure: language specific

A wellformed relation depends on factors other than the WFC and the non-distinctness condition alone. In many cases particular segments must be prevented from associating to two slots (i.e.such segments may not occur as long), while others must be associated to two slots (i.e. they must occur as long). Finally certain segment sequences may or must be associated to a single syllable terminal. This is one way in which complex segments are characterized. Thus we must allow segments to be augmented with association lines that indicate how they are to be associated:

(4)



I will make use of this possibility in my analysis of Dutch syllable structure.

After these general remarks about the theory of syllabic phonology I will now discuss in more detail a number of issues that were raised here.

2.2.2. A multivalued feature [sonority]

In the previous section I said that the wellknown sonority hierarchy can be

interpreted as a multivalued feature. In this section I will discuss several consequences of adopting this view. Firstly, I will show that there are independent reasons for having the multivalued feature [sonority] in the feature inventory: it is more adequate to characterize the major **natural classes** of segments than the familiar binary major class features, precisely because it is multivalued. Then I will turn to the apparent problem that not all languages make the same use of this feature. Finally I will discuss the position defended in Steriade (1982), who claims that the sonority scale is not a primitive of the theory and, hence, does not replace the major class binary features. Before turning to these issues, let me point out that the suggestion to use multivalued features, is neither a novel one, nor one that is restricted to the characterization of major classes. With respect to vowel height and place of articulation (to mention just two examples) proposals have been advanced to use multivalued features instead of binary features. The scope of this issue goes well beyond the subject matter of this book, but since I will rely rather heavily on the use of the feature sonority in my analysis of Dutch syllable structure it is appropriate to devote some attention to the reasons for regarding this feature as multivalued.

An appropriate starting point will be to consider briefly some wellknown deletion phenomena in French, exemplified informally under (5):

(5)

a. peti garçon	b. petit ami	c. petit oiseau
le garçon	l' ami	l' oiseau

A detailed discussion of French liaison can be found in various publications; see Lowenstamm (1979), Clements and Keyser (1983). Here I am only interested in the subissue of characterizing the natural classes that play a role in liaison. As we can see, obstruents are deleted before a consonant and a final schwa is deleted before a vowel or an approximant (or, to use another term: glide). Hence vowels and glides function here as a class and we wish our feature system to characterize them in terms of a common set of specified features. Using the following system the class of vowels and glides can be characterized as [-cons]:

(6)

	obstruent	nasal	liquid	glide	vowel
Cons	+	+	+	-	-
Voc	-	-	+	-	+
Son	-	+	+	+	+

In Chomsky and Halle (1968), where the system in (6) is adopted in chapter 7, it is argued in chapter 8 that another feature system is more appropriate. Their argument is attributed to J.C. Milner and C.J. Bailey (cf. SPE, p. 353-355). Milner and Bailey have noted that loanwords with an initial glide (superficially as in **oiseau**) trigger deletion of consonants, but fail to trigger deletion of final schwa(e.g. **peti whisky, le whisky**). Hence these glides behave as if they were true consonants, i.e. in foreign words a vowel is deleted before a vowel but not before a glide, and consonants are deleted either before a glide or before a consonant. In the native vocabulary, then, glides form a class with vowels, whereas in the non-native vocabulary they form a class with consonants. Given the feature system in (6), however, consonants and glides cannot be characterized as a **natural** class. A possible solution would be to give liquids a minus specification for the feature [vocalic]; consonants and glides can then be referred to as [-voc]. This would not prevent us from taking glides and vowels together as a natural class, i.e. as [-cons]. This is essentially the approach that Bailey and Milner suggest. However, they rename the feature [vocalic] as [syllabic]:

(7)

	obstruent	nasal	liquid	glide	vowel
Cons	+	+	+	-	-
Syll	-	-	-	-	+
Son	-	+	+	+	+
(Nas	-	+	-	-	-)

Having seen the basic argument for introducing the feature [syllabic] let us proceed to note that the analysis of liaison on which it is based is not completely accurate. Consider the following facts (also discussed in Clements & Keyser 1983, 99-100):

(8) b[õ] garçon bon ami bon oiseau b[õ] whisky

On the basis of these facts it is possible to argue that nasal deletion must be analyzed as an instance of consonant deletion. Note now that, given the feature system proposed by Bailey & Milner it is not possible to regard obstruents and nasals as a **natural** class. In the old feature system, however, these could be characterized as [+consonantal, -vocalic], liquids being [+vocalic]. So in the old feature system it was not possible to refer to consonants and glides as a natural class. In the new feature system this problem is eliminated: these segments do form a natural class. Now, however, it has become impossible to refer to obstruents and nasals as a natural class. An adequate analysis requires that both classes can be referred to. This implies that the feature [syllabic] should be **added** to the inventory of features and not be substituted for [vocalic].

This point is also discussed in Lowenstamm (1979), who makes reference to an epenthesis rule, formulated in Dresher (1978). This rule contains a disjunction, that could be avoided if the feature [vocalic] is retained.

The development of hierarchical models in phonology led to the suggestion that the feature [syllabic] should be "translated" into syllable structure. Although adding syllable structure to the phonological representation seems indeed to suggest that the feature [syllabic] is redundant this appears not to be true, as Selkirk (1982b) points out. The argument again involves the characterization of natural classes.

Suppose we eliminate the feature [syllabic] on the basis of its alleged redundancy in a theory that assigns a syllabic structure to strings of segments. Approximants such as **j** or **w** are analyzed, within the resulting system, as high vowels placed in a non-nucleus position. Though seemingly straightforward this system has an important drawback in that it complicates "simple" statements about the syllable structure of languages. To illustrate this point, Selkirk (1982b) discusses the following statement that is necessary in the description of many languages:

(9a) The onset of a syllable in L may be occupied by any consonant or glide of L

Within a feature system in which a feature [syllabic] is not utilized a disjunction in a formalized version of (9a) cannot be avoided:

(9b) The onset of a syllable in L may be occupied by any segment of L that is either [+cons] **or** [-cons, +high] (i.e. a true consonant or a glide)

The feature [syllabic] was introduced to generalize over consonants and glides. Hence elimination of this feature makes it impossible again to refer to all consonants together with the [+high] non-consonantals in terms of a single feature(column). This problem is not solved by having the feature [vocalic], which was precisely the point made by Bailey and Milner. It is therefore necessary to add still another feature to the inventory.

This feature should have the same coverage as the feature [syllabic], taking together consonants and [+high] non-consonantals. Of course various other ways are possible to change the system of features. Instead of finding a new feature system that is exclusively based on binary features, Selkirk (1982b) proposes to make a more radical move. She suggests that the characterization of major natural classes in terms of a set of binary features should be replaced by a system that is based (at least in part) on a multivalued feature, that I will refer to as '[sonority]'.

A common core of many proposed sonority scales is expressed in (10):

(10) obstruent nasal liquid high vowel mid vowel low vowel
-----------------increasing sonority-------------------->

I refer to Vogel (1977) for an extensive discussion of sonority scales that have been proposed in the literature. Her survey shows that the scale in (10) expresses a relative ordering of classes that can hardly be called controversial. In our discussion of liaison in French we saw that the following classes of segments must be referred to:

(11) a. obstruent + nasal
b. obstruent + nasal + liquid + glide

The following two classes, referring to all true consonants and all vowels respectively, are quite unquestionable candidates for the set of natural classes:

(12) a. obstruent + nasal + liquid
b. all vowels

There is one common element in all these classes: they consist of segments that form a **continuum** in terms of their sonority value. This fact suggests that the multivalued feature [sonority] makes it possible to give a new and adequate characterization of the major natural classes. Let us assume that each segment is specified for the feature [sonority] with an integer, indicating its value. We can now make the following generalization:

(13) **Definition of major natural class**
Any set of segments having the same sonority value or immediately consecutive values constitute a natural class.

This approach is not only adequate, it also explains, as Selkirk (1982b) observes, why consonants can be grouped together with high vowels and for instance not with mid vowels while excluding the high vowels. Such a class would not constitute a closed interval on the sonority scale. This is true, although certain problems remain to be solved. For example, a natural class consisting of liquids plus high and mid vowels seems very unlikely. Yet it is just as easy to characterize this class as it is to characterize the class of all vowels.

To support the previous arguments in favor of the multivalued feature [sonority], I will briefly refer to another argument, which was given by Hankamer & Aissen (1974). Hankamer & Aissen establish the need for a feature [sonority] by showing that it allows a generalizing treatment of assimilation phenomena in Pali, where less sonorous segments always assimilate to more sonorous segments. They then explicitly adopt the point of view that the feature sonority can replace the major class features (p. 136). They furthermore cite results obtained in Underhill (1973) (a paper which has not been published as far as I know) viz. that rules are found to refer to the following classes (p. 140):

> stops + fricatives; fricatives + nasals; nasals + liquids; liquids + glides. He [i.e. Underhill;HvdH] observes that it is an inherent property of a universal binary feature notation that it is in principle impossible for all of these classes to be natural; some of them will be difficult to specify no matter what system of features is chosen. According to his results, this necessary consequence of the binary feature representation is not in accord with the facts, and consequently the decision to represent major class distinctions in terms of binary features is wrong.

Having given some plausibility to the idea that we can make good use of a multivalued feature [sonority], let us discuss now the second issue that was mentioned at the beginning of this section, i.e. the fact that the grouping of segments in terms of their sonority seems to differ from language to language. Starting out with the assumption that there is a common core in all language-specific sonority scales that can be expressed in a universal scale, it seems necessary to allow one type of difference between a universal scale and language-specific scales, i.e. that distinctions made on the former are neglected on the latter. For example: universally fricatives count as more sonorous than stops but in a particular language it may be completely unnecessary to distinguish between the two for the purpose of syllable structure rules or phonological rules, suggesting that the universal difference in sonority is not used in the language. In such a case we might say that no use is made of the possibility, made available by universal grammar, to differentiate between these two classes of segments. There is nothing suspicious about this. It is precisely this type of freedom that allows languages to have different inventories of segments in the first place.

The issue discussed here is also raised in Steriade (1982, 91-101). She shows that the scale that Selkirk proposes for English does not allow the formulation of negative conditions for onset clusters in both Latin and Greek, and she proposes to allow language-specific sonority scales. It seems to me that this is hardly a controversial claim to make. Steriade's specific proposals bring us to the third issue that I want to raise in this section, viz. the question whether the sonority scale is indeed a primitive of the theory and as such replaces major class features or whether it can be derived in some way from a standard binary feature system. Steriade adopts the second position. In her theory the sonority scale does not replace binary features, but rather is derived from the feature system in the following way:

(14) **Latin Sonority scale**

```
[-son, -cont, -cor] : p,k,b,g
[    ,      , +cor] : t,d
[    , +cont, -cor] : f
[    ,      , +cor] : s
[+son, -cont, +nas, -cor] : m
[    ,      ,     , +cor] : n
[    , +cont, -nas, +lat] : l
[    ,      ,     , -lat] : r
```

This proposal is crucially based on the assumption that features are hierarchically ordered. To arrive at a language-specific scale Steriade specifies which features must be taken into account. In this sense the sonority scale is a parameter, the values of which are all phonological features. For a particular language L we have to specify which features are relevant with respect to the sonority scale.

The requirement that the hierarchy of features present on a scale is fixed universally prevents the possibility, as Steriade argues, of setting up a scale in which for example the nasals are placed in between the stops and the fricatives:

(15) **An illformed scale**

```
[-cont, -son, -cor] : p,k,b,g
[     ,     , +cor] : t,d
[     , +son, -cor] : m
[     ,     , +cor] : n
[+cont, -son, -cor] : f
[     ,     , +cor] : s
[     , +son, +nas, +lat] : l
[     ,     ,     , -lat] : r
```

It is stipulated that in the hierarchy of features [son] is higher than [cont]. The common core of all sonority scales is then derived from a universal hierarchy of features.

In itself this is not enough, however. Surely the following partial scale must also be ruled out:

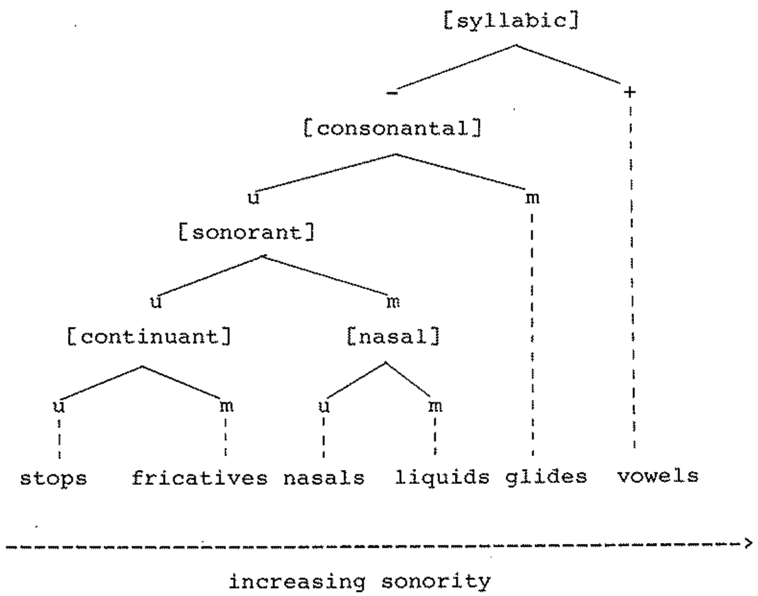
(16) **Another illformed scale**

```
[-son, +cont] : fricatives
[    , -cont] : stops
```

Assuming that a sonority scale is derived from the hierarchy of features, we must somehow indicate that, for segments specified as [-son], the [+cont] segments count as more sonorous than the subclass of [-cort] segments.

Interestingly, Farmer (1979) showed that a sonority scale can be derived from the binary feature system unambiguously by assuming that segments that have a **marked** value (in the sense of Kean 1975) for a particular feature are always more sonorous than the segments that have the unmarked value. This is shown in the following figure:

(17)



However, we should not at all be surprised by the existence of this relation given the fact that feature hierarchies and markedness specifications on one hand and the sonority scale on the other hand were developed, at least in part, to explain the same phenomena, i.e. to explain facts about language change, acquisition, etc.

The conclusion to be drawn from this is that we face here two rivalling proposals to classify segments in terms of their sonority. In one proposal we have a feature system in which there is at least one multivalued feature, i.e. the feature [sonority] and in the other proposal we have a binary feature system supplemented by a set of marking conventions plus a hierarchical ordering defined on the set of features. The crucial difference between these two proposals lies in the fact that in Steriade's view sonority functions as a cover feature, that has a secondary status in the system. In Selkirk's proposal, sonority is not a cover feature. It seems to me that the latter proposal is the more simple and homogeneous one and that the burden of proof lies, for this reason alone, with those who argue in favor of a more redundant theory that makes use of both the traditional major class features and a cover feature [sonority].

In chapter 3 I will offer another argument in favor of Selkirk's proposal. I will show that we want to be able to say that not all classes of segments that are differentiated in terms of their sonority are "equally spaced apart", i.e. I will make crucial use of the fact that the sonority

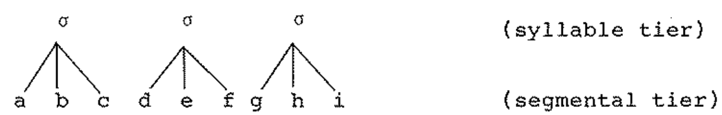
distance between obstruents and nasals is larger than the distance between nasals and liquids. It is not clear how such use can be made of the sonority scaling in Steriade's theory.

2.2.3. Constituent structure

In this section I will be concerned with the issue of syllable internal structure. In the literature we find various proposals, some of which I have alluded to in 2.2.1.3. I will here discuss the most important ones in more detail, focussing on the major differences.

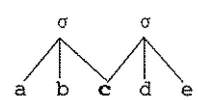
One of the first proposals in the field of generative phonology concerning a non-linear representation of syllable structure can be found in Kahn (1976). Kahn does not discuss the issue of syllable internal constituent structure explicitly. His main concern is to argue in favor of the syllable as an 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 to abandon syllable boundaries as a means of characterizing syllables in the formal representation. Instead he assumed that syllables must be represented by means 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:

(19)



It has been claimed that one advantage of adopting this formalism is that given the WFC one can allow a single segment to be associated to two syllables:

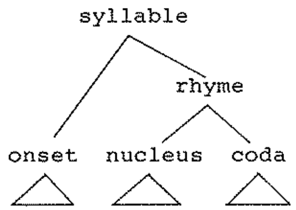
(2Ø)



Segment **c** is now characterized as "ambisyllabic" and Kahn showed that there is evidence that segments having this status are needed. Certain phonological rules crucially refer to ambisyllabic segments.

A second approach takes up a more traditional view on the syllable. The idea is that syllables have a more complex structure than was assumed by Kahn, roughly as in (21):

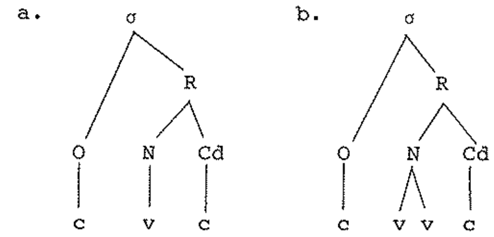
(21)



One of the main reasons for proposing this more complex structure comes from the often 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, is only 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 do 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 some marginal cases) irrelevant with respect to the "weight" of syllables. 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 attract stress, whereas syllables with short vowels do not. This can be explained if one assumes the presence of at least the following syllable internal constituents: a rhyme and a nucleus, and if one furthermore stipulates that the latter may contain vowels only. On the further assumption that long vowels are represented as a sequence of two short vowels, we can now say that syllables with a **branching nucleus** attract stress.

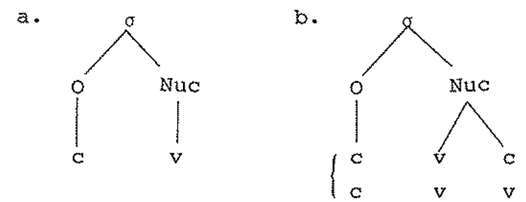
(21)



Small c's and v's stand for segments. I ignore here the autosegmental structure of syllables.

In other types of systems where syllable weight interacts with stress assignment it is the case that all closed syllables belong to the stress-attracting set. In this type of case we could say that syllables with either a branching nucleus or a branching rhyme attract stress. However, to avoid the disjunction, we might assume that such languages lack the distinction between a nucleus and a rhyme node, having only one node. (In this case I will assume that this node is in fact the nucleus). We can now make a more simple statement, viz. that syllables with a branching rhyme attract stress:

(22)

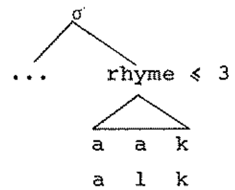


In chapter 5, section 5.2. I will return to the relation between stress and syllable structure in more detail.

Other phonologists have pointed out that the constraints on sequences of segments inside a syllable (expressed in **collocational restrictions** or **filters**) provide evidence for the proposed representation, the claim being that 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**. In a stronger form this argument involves the claim that the set of wellformed syllables in a language L is simply the cartesian product of the set of wellformed onsets and the set of wellformed rhymes. Thus, the claim is that there are no restrictions at all holding between the rightmost segment of the onset and the leftmost segment of the rhyme.

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 section 2.2.1.5. 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:

(23)



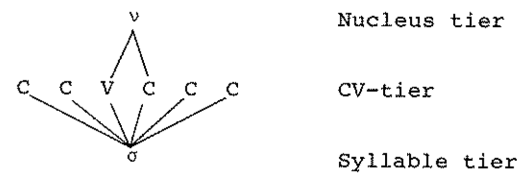
The type of syllable structure discussed so far has been incorporated in the theory of metrical phonology (see Kiparsky 1979, 1982b and Selkirk 1982a, b). As might be expected it is assumed by proponents of this framework that the syllabic tree is uniformly binary branching. However, adopting the structure in (21) does not necessarily imply that one thinks of intrasyllabic nodes as being binary branching only. Various specific other views are consistent with (21). I will use the term "metrical" here to designate the whole class of views on syllable structure that conform (roughly) to the structure in (21).

Recently Clements & Keyser (1983) have argued against theories of the syllable, that are based on (21). Their claim is that Kahn's "autosegmental" theory should be preferred. However, their theory departs from Kahn's in one important respect. Clements & Keyser (henceforth CK) admit that there is evidence which suggests that the category **nucleus** plays a role in phonological organization. The argument in favor of the nucleus is that we cannot define the distinction between heavy and light syllables without reference to this category. CK (p. 12) define the nucleus as consisting of a long vowel or diphthong or a short vowel plus the immediately following consonant.

CK then propose that phonological representations involve, in addition to the σ-tier, CV-tier and the segmental tier also a ν-tier. Tiers such as the σ-tier, CV-tier and the ν-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 (CK, p. 18). The segmental tier, itself a composite of several tiers, such as the nasal, the laryngeal tier and the tonal tier, are referred to as **phonetic tiers.** Notice that, although an intrasyllabic constituent is recognized, it is not so recognized that the syllable has an internal structure. The syllable and the nucleus are regarded as simultaneous representations:

(24)



The central tier in CK's theory consists not of completely unspecified slots (i.e. X's), but of C's and V's. The onset and coda always dominate C's but the nucleus has two varieties:

(25)

I refer to their work for arguments in favor of assuming two nucleus types. It is not clear to me whether CK want to use the difference illustrated in (25) to account for the fact that closed syllables count as heavy in one type of stress system and as light in another. They could use it by saying that only V's count for heaviness. In languages where closed syllables count as heavy, the closing consonant would be dominated by V. In the other type of case a closing consonant would be dominated by C. It seems to me that this is the move that CK must make, because they cannot account for the two types of systems otherwise.

With regard to the other intrasyllabic constituents, CK 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 (CK, p. 15-16). Furthermore, constraints on syllable initial and syllable final clusters might just as well refer to the syllable boundary.

The final constituent that has to be considered then is the **rhyme.** CK defend the view that this constituent is also unnecessary. They do not directly discuss the argument in favor of rhymes involving the two types of stress systems where syllable weight plays a role. However, I have suggested above that CK can probably deal with this distinction by adopting two types of nuclei. CK then discuss several other arguments in favor of the category rhyme, the most important of which we also mentioned above. First they argue against the argument based on the fact that collocational restrictions holding between onset and peak are much less common (or even absent) than restrictions between peak and coda. CK counter this argument by observing that "cooccurrence restrictions holding between the nucleus and preceding elements of the syllable appear to be just as common as cooccurrence restrictions holding between the nucleus and following elements" (p.20). For the examples they give from English I refer to their study. In Dutch similar examples can be found. According to the inventory made in Bakker (1971) the following sequences are missing, at least in Dutch monosyllabic morphemes and nearly all of them in polysyllables as well:

(26) a. * wȳ, wø̄
b. * sȳ, sø̄
c. * fø̄
d. * jē, jī, jȳ
e. * kw plus round vowel
f. * sn plus ī or ȳ

We should compare such restrictions to those holding between the nucleus and the following segments. I will discuss these restrictions in detail in chapter 3. It will become clear there that the restrictions that hold between the nucleus and preceding elements refer more to individual segments than to classes of segments, while, in the case of the nucleus and following segments, reference to classes constitutes the norm. Despite that difference, however, which may be gradual rather than absolute, it cannot be denied that collocational restrictions may hold between **any** pair of adjacent segments, since in chapter 3 we will see that restrictions may hold within the pre- and postnuclear parts of the syllable as well. Giving CK the benefit of the doubt, we might conclude that collocational restrictions cannot be used as convincing arguments for a particular syllable internal structure. The same point is also made in Davis (1982), who discusses examples in which we find cooccurrence restrictions holding between pre- and postvocalic consonants in English and Mazteco.

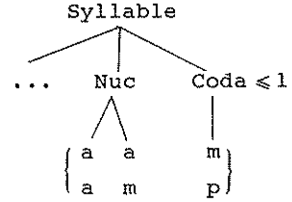
CK proceed with a discussion of the argument involving the upper limit of the sequence consisting of the nucleus and following segments. They discuss

an example from Turkish. In Turkish both the cluster **ks** and **ʃk** may follow a short vowel, yet the cluster **ʃks** may not. As CK say, this could be expressed by saying that Turkish does not permit four-membered rhymes. In the CK theory an account is also possible, however (p.22):

> We might assume that final consonant clusters ending in /s/ do not belong to the level of core-syllable representation in Turkish but are formed by a later rule of s-affiliation, which affiliates /s/ to an immediately preceding nucleus. This rule will permit the adjunction of /s/ to the sequence /ak/ to form /aks/, but will prohibit the adjunction of /s/ to a sequence like /aʃk/, where the final segment lies outside of the nucleus.

Although this explains the Turkish case, nothing like it can work in Dutch to account for the facts that we discussed above (cf. 23). It will be clear, however, that given CK's definition of the nucleus, the example from Dutch that we mentioned above could be handled by saying that in Dutch the coda may contain at most one consonant. Compare (23) with (27):

(27)



However, CK do not admit a category **coda** either. Of course we can formulate a constraint saying that Dutch does not allow a syllable final cluster of two consonants if this cluster is preceded by two vowels (i.e. a long vowel or diphthong), but it is clear that we are then putting the definition of a rhyme into our constraint. It seems to me that CK have not succeeded in countering the present argument in favor of a more detailed structure than they are assuming.

A third argument that has been advanced in favor of the rhyme, not mentioned so far, concerns speech errors, word games and experimental testing. As CK point out it appears to be the case that this type of evidence does not point in one direction. Speech errors have been reported such as **stress and pitch -> piss and stretch**, as well as those in which the "moved" part corresponds to the rhyme.

The fourth and final argument that CK discuss concerns rhyming traditions. It is often said that the rhyme is that part of the syllable that "rhymes". But in the strict sense this is only true of masculine rhyme, where we can indeed observe that precisely that part of the syllable that concerns us here must be identical for the rhyme to be successful. But, as CK observe, there are also other forms of rhyme involving two syllables ("feminine rhyme") or three syllables ("extended rhyme"):

(28)	**Masculine Rhyme**	**Feminine Rhyme**	**Extended Rhyme**
	hoog - droog	hoge - droge	hogere - drogere
	kaal - schraal	kale - schrale	handelen - wandelen

There is one common aspect to these three forms of rhyme. The rhyming unit is a **foot minus the onset of the head of the foot**. In rhyming then one cannot say that the onset in general is irrelevant. It is only the onset of the head of the foot that is irrelevant:

(29) **Illformed feminine & extended rhymes**
harten - parken
kinderen - tintelen

These rhyming pairs are illformed due to different 'non-head' onsets. Rhyme then is not a matter of "rhymes", but of feet minus the onset of the strongest syllable.

The latter argument is not entirely unproblematical. One might argue that whatever syllable happens to be the head of the rhyming foot must be parsed according to the onset/rhyme distinction and that therefore each syllable must in principle then be parsed according to the onset/rhyme division. For CK it would be "wiser" therefore to regard rhyming as one of the types of external evidence, which, as we saw above, do not point in one direction.

I conclude that, although CK are right on several points, there is some reason to be sceptical with respect to their claim that the nucleus gives us all the syllable internal structure that we want. It is important to realize that if CK were not convinced of the superfluousness of the categories rhyme, onset or coda (or any other category, except for the nucleus), they could easily have added another structural tier to their theory (CK, p.19). This brings me to a different, more principled objection to their approach.

Apart from supplying us with the arguments against the metrical theory of the syllable that I have just discussed CK also claim that the autosegmental theory of the syllable is more restrictive than the metrical theory which makes use of binary branching trees. They argue that for any sequence longer than two segments ambiguity exists with respect to the binary branching tree that goes with it. In the case of three segments we have two possibilities, in the case of four segments we have five possibilities, and so on. It will be obvious that whatever the number of segments there is always only one flat structure.

I claim that the autosegmental approach that CK advocate suffers from an equally damaging richness, however. Adding the possibility of simultaneous representations leads to a significant increase of the descriptive power of the theory: in essence it allows us to analyze the same string in almost as many ways as there are conceivable binary branching trees. To see this we only have to realize that CK allow the possibility to have structural tiers that are not piled on top of each other, but that are in a sense competing. Nothing precludes the possibility then to add a structural tier with a unit called **A** to which all segments up to and including the first segment of the nucleus are linked or any other conceivable substring of the syllable.

One might wonder why CK do not simply accept that the structure of syllables is not flat (whatever the details of the non-flat structure may be). The reason is, I think, that non-flat structure seems to clash with the autosegmental mode of representation. A flat structure allows us to employ the quite elegant autosegmental conventions in building up syllabic structure in the process of syllabifying a string of segments. This is true (if the segments are grouped in flat syllables), but apart from that point I see no evidence for saying that the structure of syllables is "autosegmental". The relation between nodes that represent prosodic categories (going from the category **segment** to the category **utterance**) is fundamentally different from the relation between, for instance, tones and tone bearing units and I see no advantage in claiming that we capture a significant generalization by expressing the relation that holds in the former and the latter case in terms of the same formalism. In the case of prosodic constituent structure the "association lines" express a **syntagmatic** relation holding between units of a certain prosodic level, and a part-of relation with respect to units of the next prosodic level, whereas in the case of tones the association lines express a **paradigmatic** relation of cooccurrence between phonological features. So, although the notation may be the same, the interpretation of it is drastically different. The formal properties of **autosegmental structure** (expressed in the Well-formedness Condition) have no bearing on the question what internal structure we must assume for syllables (or any other prosodic category), because autosegmental structure was assumed to characterize a quite different phenomenon. Without feeling an a priori commitment to binary branching trees, I claim then that there is no reason to allow a similar commitment with respect to flat structures.

I 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. I 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 theory that I will discuss here differs in some respects from the one Hyman proposes, but I do not think that these differences do damage to the central idea that Hyman wants 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**. I 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:

(30) **Heavy syllable** **Light syllable**

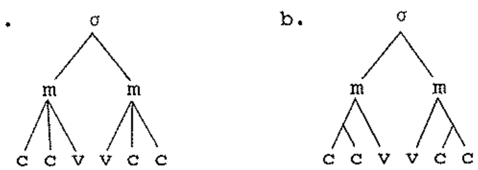
In the following section I will show how one could handle the two different kinds of systems in which syllable weight plays a role. Let me point out here what the mora theory has to offer, when we compare it to the other available theories.

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. All prosodic constituents seem to consist of one or more units that are lower on a prosodic hierarchy: 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*.

One might ask whether the mora theory is "autosegmental" or "metrical", referring to the question what the internal structure of morae looks like in cases where more than two segments form part of it:

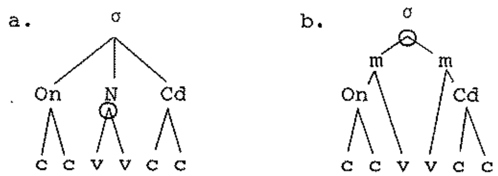
(31) a. b.



It seems to me that the mora theory is compatible with both views. If the structure in (31b) is adopted one might say that the mora-theory does not exclude the possibility of defining a category 'onset' or 'coda'.

At this point let me compare for the sake of clarity the mora theory and the metrical theory, assuming here a variant of the latter which allows us to focus on the essential difference. For the metrical theory, I assume a category **nucleus**, that can be used to define the difference between light and heavy syllables, and furthermore the categories onset and coda, but not the category rhyme. In the former theory I will adopt variant (31b) and also assume the categories onset and coda. Looking at the figures in (32), we can see that the essential difference between the two approaches lies in the fact that in the mora theory we have "lifted up" the distinction that is made at the nucleus level in the metrical theory:

(32) a. b.



A possible objection to the mora theory might come from the fact that it is not directly supported by collocational restrictions. The mora theory shares this property with the autosegmental theory that CK defend. Proponents of both theories must largely deny the relevance of what was called above "the immediate constituent structure principle of phonotactics" or claim, as CK do, that these restrictions do not support a particular structure. I will return to this issue in chapter 3, section 3.4., with reference to the situation in Dutch.

The present sketch of views concerning intrasyllabic structure has made clear that some amount of internal structure is absolutely necessary. The crucial and compelling evidence comes from the interaction between stress/tone and syllable weight, whereas the relevance of the evidence coming from phonotactic constraints may be subject to some debate. Since a certain amount of structure must be assumed, I reject CK's view on syllable structure as being flat. The solution they propose for representing syllable weight (simultaneous structure) follows from a desire to represent syllable structure in an autosegmental fashion. I have pointed out above that there is no reason to follow CK in this respect.

We have now discussed some of the prevalent views on the representation of syllable structure. In chapter 3 I will return to the issue of syllable internal structure, and the various alternatives we have seen in this section. I will confront the metrical representation and the mora representation with data from Dutch and show that both theories provide an adequate basis for structuring Dutch syllables.

2.2.4. Syllabification rules

The problem of syllabification can be stated as follows. Given a string of arbitrary length S consisting of segments of a language L, we have to be able to decide whether S is a possible sequence of syllables of L. As a first approximation to this issue, we will say that S is a possible sequence of syllables if and only if it can be exhaustively parsed into a sequence of

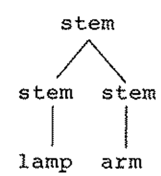
wellformed syllables, i.e. a string of syllables that conform to the syllabic template(s) of L. It turns out that this solution does not lead to a unique parsing in all cases. Suppose that L is Dutch. For the following string of segments two parsings are possible, such that the resulting syllables are wellformed:

(33)
lamparm → lamp.arm (a)
lamparm → lam.parm (b)

The problem is of course that **lamparm** 'part of a lamp, litt.: lamp arm' is a compound. In Dutch, as in many other languages, a syllable boundary coincides with the break between members of a compound. Hence, only solution (a) is correct in this case. On the other hand, if **lamparm** was not a compound, then most native speakers of Dutch would agree that (b) represents the correct syllabification. What this means then is that two types of cases must be distinguished. In one case, the syllable boundary is determined by morphological principles, whereas if no compound(like) structure is involved, other principles determine the syllable break. Let us refer to the 'other principles' as syllabification rules proper.

With respect to the characterization of the domain of syllabification rules proper we might argue that this domain is a particular morphological category such as the stem or the word, the interpretation of which depends on the morphological theory that we adopt. For Dutch I take the category **word** to apply to inflected lexical items, whereas the category **stem** is split into two categories, i.e. the **inflectional stem** (input for inflectional rules) and the **derivational stem** (input for word formation rules). One might argue that in Dutch each derivational stem is also an inflectional stem, but this depends on one's analysis of the non-native vocabulary. Since I will not go into this here, I will simply use the term **stem** and neglect the distinction made above. Uninflected compounds constitute a **stem** that itself consists of two stems:

(34)



Still pursuing the same line of reasoning we might say that the domain of syllabification is a stem that does not itself dominate another stem. The following examples show, however, that there is more to it:

(35) vijandachtig → vijand.achtig (a)
vijandachtig → vijan.dachtig (b)

In the case of **vijandachtig** 'enemylike' syllabification (a) is correct; yet **-achtig** is not a stem but a suffix. Now consider the following example:

(36) vijandig → vijand.ig (a)
vijandig → vijan.dig (b)

In the case of **vijandig** 'hostile' syllabification (b) is the correct one whereas again **-ig** is a suffix. What we have to say, apparently, is that not only stems, but also certain suffixes constitute a domain for syllabification rules.

There are other suffixes like **-achtig**. Booij (1977) points out that suffixes like **-ling** and **-loos** also constitute a domain for syllabification:

(37) half.ling **not** hal.fling
verf.loos **not** ver.floos

In various places such suffixes have been referred to as "compoundlike". It is only with respect to syllabification, however, that they behave like subparts of compounds.

It appears to be the case then that not only stems but also certain suffixes constitute the domain for syllabification rules. In addition all prefixes (e.g. **ont-**, **ver-**, **her-** etc.) constitute a barrier for syllabification rules proper:

(38) ont.erven **not** on.terven
ver.edelen **not** ve.redelen
her.eiken **not** he.reiken

The question which arises is how this property, shared by all stems, all prefixes and certain suffixes, should be expressed in the grammar.

It is quite generally accepted that utterances of a language are organized hierarchically in two dimensions; cf. Fudge (1969), Selkirk

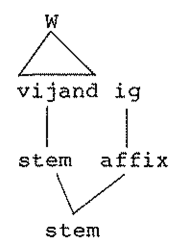
(1982c), Nespor and Vogel (1982). In one dimension, the morpho-syntactic dimension, an utterance is associated with a constituent structure tree that reveals how the utterance is built up out of the minimal grammatical units of the language, i.e. stems, affixes, words, etc. In the other dimension, the prosodic dimension, an utterance is associated with a constituent structure which indicates how it is built up in terms of **phonological** units, i.e. segments, morae, syllables, etc. In this view there is a unit that is built up out of syllables which is usually referred to as the phonological (or prosodic) word. One of the tasks we face in specifying the grammar of a language L is to describe the relation between the morpho-syntactic and the prosodic hierarchy.

Our examples above have revealed that the two hierarchical structures are not unrelated. In at least one respect the prosodic organization is determined by the morpho-syntactic organization, i.e. the partitioning of a string into syllables depends on the morphological structure. Assuming now that the syllables of a language are organized into a unit called the prosodic word, we might express the property of morphological units that appear to be the domain for syllabification in terms of the following rule:

(39) X ---> prosodic word
1. where X is of the category stem and X does not dominate another category labelled stem
2. where X is a prefix
3. where X is a suffix belonging to the set {-ling, ...} (i.e. specified as [+W])

The rule given under (39) gives us a partial specification of the function that relates the morpho-syntactic and the prosodic hierarchy. Much more must be said before we have specified how the complete utterance is organized prosodically. I will limit myself here to a single remark about the further organization up to the level of words.

Let us return to our example **vijandig**. **-ig** is not specified as [+W], hence the function in (39) will give us only a partial mapping:

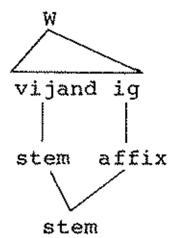
(4Ø)


We therefore have to adopt the following rule:

(41) [-W] suffixes are integrated into ("cliticized" to) the preceding phonological word

Applying (41) to (40) will give us (42)

(42)



At this point I have supplied enough information to return to the subject of this section, viz. the issue of the domain of the syllabification rules proper.

Above I said that syllabification rules proper specify how a string is parsed into a string of wellformed syllables. We can now say that the domain of these rules is the phonological word. Within this domain syllabification rules proper give us a parsing that is possible on purely phonological grounds, since it has been shown that the ambiguity that was found in examples like **lamparm** involves the delimitation in terms of morphological information of a higher prosodic constituent, called the phonological word.

Saying that the domain of syllabification is the phonological word entails that the notion wellformed syllable of Dutch must also be defined with respect to this domain. Apparently this approach is not indisputable, since Trommelen (1983) defines the notion wellformed syllable with respect to morphologically unstructured stems. There appear to be certain differences between syllable structure at the level of basic stems and the level of phonological words. I adopt the point of view, however, that these differences constitute a morphological and not a phonological fact. The set of syllables that occur in underived and uncompounded stems is a proper subset of the set of syllables that occur in (complex) words. By characterizing the larger set we characterize the smaller set as well. I see no reason to restrict the discussion of a **phonological** unit like the syllable to a subset occurring only in a particular **morphological** category.

Given that the domain of syllabification rules proper has been identified, I can proceed with formulating these rules. I said that a string of a language L constitutes a phonological word of L if and only if it can be exhaustively parsed into a sequence of wellformed syllables, i.e. no segments may be left unassociated to a syllable node. The following set of syllabification rules count as an algorithm to construct syllables out of an arbitrary string of segments. Although my purpose in this section is to explore the process of syllabification, I have to make a decision with respect to the particular syllable internal structure that I want to arrive at. I will formulate in detail here rules that create syllables consisting of morae and then indicate shortly how metrical syllables can be constructed. Furthermore I refer to Steriade (1982) where a theory of syllabification is developed that is compatible with the metrical theory of the syllable.

The first rule of the algorithm locates **sonority peaks** and assigns to them a node **m** (for mora). A sonority peak is defined as follows:

(43) **Sonority peak**
A segment **p** is a sonority peak if neither the preceding segment (if present) nor the following segment (if present) is higher in sonority.

To be able to express "peakhood" in formal terms, we could express the sonority of segments in terms of a grid structure in which the sonority values are translated into columns of X's. To give an example, let us assume the following sonority scale for a language L:

(44)

```
stops   fricatives   nasals   liquids   vowels
|----------|---------|---------|--------|--->
1          2         3         4        5
           ---increasing sonority--->
```

A grid alignment can be said to be wellformed if a segment that is more sonorous than its neighbour(s) also has a higher grid column than its neighbour(s) and if no segment that is equally sonorous as its neighbour(s) has a lower grid column than its neighbour(s). To make this concrete let us suppose that L is Spanish. The word **microbio** gets the following grid:

(45)

```
a b c d e f g h
        *
  *   * *   * *
* * * * * * * *
m i k r o b i o
```

The definition for sonority peak can now be stated as follows:

(46) **Sonority peak**
A segment constitutes a sonority peak if neither the preceding segment (if present) nor the following segment (if present) has a higher grid column

In the above example, b, e, g and h satisfy the definition for "peakhood". Hence, our first rule (47) assigns node **m**, as in (48):

(47)

```
          m
          |
X  --->   X   where X is a sonority peak.
```

(48)

```
  m     m   m m
  |     |   | |
m i k r o b i o
```

Harris (1983) shows that in Spanish closed syllables and syllables containing a vowel sequence (or a vowel-glide combination) count as heavy. Hence the first segment following a peak must be assigned a node **m** too:

(49)

```
          m     m
          |     |
X  --->   X  /  X ---
```

There is of course a rule that must apply before rule (49). In a word like **Panama** we do not want the penultimate syllable to be bimoric:

(50)

```
*  m    \ /
   m    m m m
   |    | | |
 p a n  a m a
```


It will be obvious that we must first create "maximal onsets". Here the familiar maximal onset principle comes in, formulated as follows:

(51) **Maximal onset principle**
Given two possible parsings, choose the one where onsets are maximalized, such that no illformed syllables arise.

Maximal onsets can be created by formulating a separate rule or by reformulating rule (47) that creates the first mora:

(52)

```
                              m
                            / | \
(X ....X ) X      --->  (X ...X )X
  1     n   n+1           1    n  n+1
```

where X_{n+1} is a sonority peak, and $X_1 \ldots X_n$ is a maximal sequence of segments such that **m** is a wellformed mora.

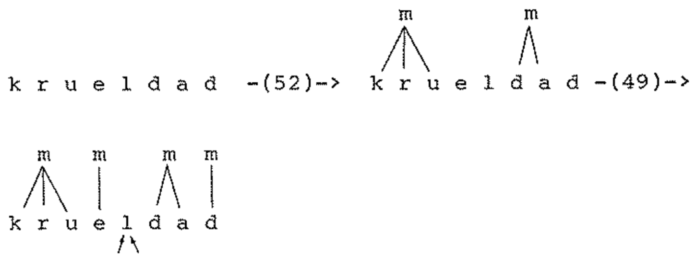
It would be just as easy to incorporate the introduction of an onset node in rule (52). In order not to complicate the issue, I have chosen here to ignore the category onset. In rule (52) reference is made to the notion 'wellformed mora'. It is of course assumed here that the grammar contains a specification of what counts as a wellformed syllable, which includes a specification of what counts as a wellformed mora.

Let us now turn back to the second mora rule. We saw that in Spanish any segment following the sonority peak qualifies as a second mora. This means that in Spanish light syllables are of the type CV and heavy syllables of the type CVC or CVV. In the previous section we have seen, however, that there are also languages where CVC syllables are classified as light. Hence in such languages only vowels qualify as a second mora. A consonant following the sonority peak is analyzed as part of the first and only mora. Intermediate cases arise too. In Lithuanian only sonorants (whether a vowel or a consonant) qualify as a second mora and there may be languages in which only voiced segments count as morae. An important observation is that, if a language tolerates a voiced consonant as a second mora than **all** segments that are more sonorous count as a mora too (in this case sonorant consonants and vowels). We could say then that rule (49) is parametrized in terms of a 'sonority threshold'. The post peak segment ('X') must pass a certain sonority threshold to count as a mora.

Rule (49) is further parametrized in the sense that it may be absent altogether. This is the case when the language in question does not make a weight difference among syllables in the sense just described.

So far we have discussed two rules. The next Spanish word shows us that we need a third rule. After application of (51) and (49) we will get (53):

(53)



The consonant /l/ must still be assigned to the second mora of the first syllable. The rule in question can be formalized as follows:

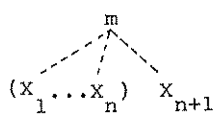
(54)

where m is a wellformed mora.

If we adopt the "autosegmental" view on syllabic organization we might say that this rule is essentially identical to a subpart of the WFC (i.e. the spreading clause). In other words, given the WFC, rightward association need never be formulated explicitly if we assume that it is a general requirement that the WFC may not introduce association lines that violate language-specific wellformedness conditions. In the previous section I have cast doubt on the significance of applying autosegmental principles to syllabic organization, so I will not press this point.

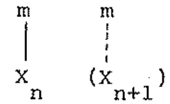
Let me summarize what has been said so far. I adopt below the dashed-line notation to indicate the structural change of the rules:

(55) I.



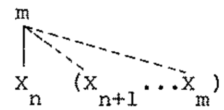
where X_{n+1} is a sonority peak and $X_1 \dots X_n$ constitutes a maximal sequence such that **m** is a wellformed mora

II.



where X_{n+1} has a minimal sonority value V

III.

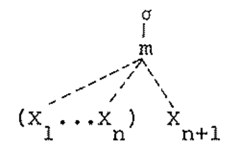


where **m** constitutes a wellformed mora

One may distinguish between languages in which syllables bear stress and languages in which morae bear stress and say that in a mora-counting language the syllable can be dispensed with as a prosodic category, at least for the purpose of stress assignment. I will not speculate here on the question whether there are indeed languages that do not have the syllable as a prosodic category. For a discussion of a possible case in point I refer to Hyman (1983).

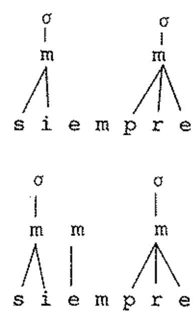
Restricting ourselves to the "normal case" where the category syllable is present we must extend rule (51) slightly in the following way:

(56)



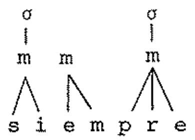
To summarize let us consider the following example:

(57) **siempre**



by (56)

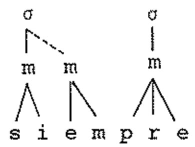
by (49)



by (54)

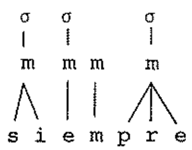
Assuming a general convention we can say that the second m is adjoined to the preceding σ-node:

(58)



One final problem deserves our attention. Consider again the previous example:

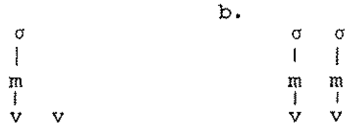
(59) *



I have assumed that glides in Spanish are represented as vowels underlyingly. Hence a sequence of two vowels is ambiguous. It may appear on the surface as a sequence of two vowels or as a single syllable containing a diphthong. In itself this would not be a real problem. We would simply have to allow that certain strings can be parsed in two ways. The question is how we will derive more than one parsing.

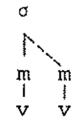
A possible solution is to say that the syllabification rules are **optional** and **persistent**. Recall our requirement that a string is only accepted as properly syllabified if the parsing is exhaustive. There may not be any remaining segments left unassociated. This means then that, although optional, the rules will continue to apply until there is no possibility left for them to apply successfully. Given a string VV, we derive either (60a) or (60b) after applying the rule that creates the first mora:

(60) a. b.



Applying the rule that creates the second mora, (60a) can be changed into (61):

(61)



This completes the discussion of syllabification, assuming the mora-theory. An algorithm to construct metrical syllable structure could employ the concept of a threshold too. A first rule locates sonority peaks and assigns to them a nucleus node. The post-peak segment can then become a sister of a sonority peak if its sonority value has the threshold value, thus creating a branching nucleus. Following the creation of the nucleus, maximal onsets are created and then the category coda is assigned to remaining consonants. Onsets, nuclei and codas are combined into syllables either directly or after combining nuclei and codas into rhymes.

2.3. Conclusion

In this chapter I have discussed various current theories dealing with syllable structure. I have argued in favor of a "three dimensional" approach in which we distinguish linear, hierarchical and autosegmental structure. To characterize the linear structure I have adopted the point of view that a multivalued feature [sonority] should be employed. With respect to the hierarchical structure I have discussed various alternative proposals and argued against the autosegmental theory of syllable structure. Finally I have discussed a procedure to assign syllable structure to a row of segments. Both proposals concerning syllable structure and syllabification will be discussed with reference to Dutch in the next chapter where I offer a detailed discussion of syllable structure and syllabification.