A THEORY OF
SYLLABIFICATION AND
SEGMENTAL ALTERNATION

With studies on the phonology of French,
German, Tonkawa and Yawelmani

PROEFSCHRIFT

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ROLAND GABRIËL NOSKE
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voor Joris
Roland Noske, A Theory of Syllabification and Segmental Alteration (LA 296).

CORRIGENDA

- Introduction, page 1. First sentence should read:

The topic of this thesis is the syllable, considered from the point of view of syllable-changing processes.

- Chapter 5, page 155. Figure (29) should be:

\[
\sigma \\
\emptyset \rightarrow X / _{-} X'
\]

- Chapter 6, page 199. French Syllabification (43) should read:

(43) French Syllabification

a. syllable imposition triggered by as yet unsyllabified full vowels (including nonalternating schwas), followed by mapping;

b. *optional* syllable structure imposition, triggered by as yet unsyllabified empty V's (alternating schwas), followed by mapping;

c. dumping;

d. syllable imposition triggered by consonants.
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Introduction

This topic of this book the syllable, considered from the point of view of syllable changing processes.

The syllable is a concept much referred to in various phonological frameworks. In generative phonology, which more than other theories (including classical American structurist phonology) focussed its attention on processes, the syllable was at first not recognised as a phonological category. This is notably the case in Chomsky & Halle (1968). Rather soon in the further development of generative phonology, however, it was noted that many rules seemed to be related to syllable structure. In a discussion on “natural rules”, Schane (1972: 207) mentions a type of rule which he terms “the preferred syllable structure rule”. The well-known truncation (or, from a different point of view, liaison) phenomena in French involve for example a rule which deletes the t in petit in petit garçon [pət i ɡarson] ‘little boy’, but which does not affect it in petit ami, [pət i ami] ‘little friend’. According to Schane, the sort of rule which deletes a consonant before another consonant is a natural rule because it creates a CV syllable structure, which is claimed to be the preferred structure. The opposite type of rule – a rule deleting a consonant before a vowel – would be highly unnatural from the point of view of syllable structure. Schane then continues by saying that (1972: 208)

... in French the whole complex interplay of elision and liaison is intended to guarantee the CVCV pattern.

At the stage of development of the theory at which Schane wrote these words, no formal link could be established between syllable structure and syllable-changing processes.

Earlier, Kisseberth (1969a, 1970b) had noted that in Yawelmani, two rules “conspire” to avoid triliteral clusters. These rules are (Kisseberth 1969a: 136, 1970: 293):

(1) $\emptyset \rightarrow V / C \_ CC$  
(2) $C \rightarrow \emptyset / CC+$

Although Kisseberth did not mention syllable structure, it is obvious that syllable structure is the real conditioning factor here. Yawelmani does not have syllables more complex than CVC, hence it has no triliteral clusters. In the framework Kisseberth was working in, this conspiracy remained a complete accident – there was no formal reason why the rules in Yawelmani should be organised precisely in such a way as to avoid this type of cluster. Kisseberth himself was not satisfied with the fact that he was not able to express formally the principle he felt condition the “conspiring” rules he had designed. He writes about the state of phonology in 1970 (1970: 293):
... the theory of phonology has hitherto been blind to phenomena of this sort, (partially because formal, structural sameness has been emphasized at the expense of functional sameness.)

Kisseberth then asks linguists to look at the relationship he feels exists between the conspiring rules.

We have taken this exhortation as our point of departure. In the course of this work we will develop a theory in which the relationship between syllable structure and the processes alluded to by Schane and Kisseberth has been formalised. Therefore, it will no longer be an accident that rules like the ones discussed by Kisseberth conspire. It will be shown that the phenomena under discussion are in fact conditioned by the syllable structure of the language in question.

In order to be able to formalise this theory, we will take a close look at the representation of the syllable structure, as well as at the way in which syllable structure is created.

Other theories relating to syllable structure and syllabification have hitherto not been successful in providing a satisfactory and genuine explanation for the relationship between the segmental alternation processes and syllable structure.

Regarding the structure of the syllable, these theories include the metrical models proposed by Kiparsky (1979) and Giegerich (1985), the CV-model of the syllable proposed by Clements & Keyser (1983) (and adopted by Wiese (1988)), the autosegmental model without subsyllabic nodes used by Kahn (1976), the X-model proposed by Levin (1985), the government based phonology by Kaye, Lowenstamm & Vergnaud (1990) and the moraic approach offered by Hayes (1989) and Itô (1986, 1989). With respect to the moraic approach, which has become very popular of late, we demonstrate that this model runs into problems concerning the principles on which it is based. Instead, we adopt the true constituent model, in which subsyllabic nodes like onset and nucleus play a role similar to that of autosegments.

With respect to the assignment of syllable structure, basically two approaches have been taken in the literature: the rule approach, which represents a bottom-up creation of syllable structure, and the template matching approach, which, if anything, represents a top-down creation of syllable structure. To each theory objections can be raised because the data contain both bottom-up and top-down effects. We propose a theory which we have called the syllable assignment theory. Under this theory, syllable structure imposition is combined with the working of the general association conventions of autosegmental phonology. The conflict between a bottom-up and a top-down approach is thus avoided.

This study takes the principles and parameters approach, which has been dominant in generative grammar in the last ten years. Following this approach, there is a set of principles provided by Universal Grammar (UG) which explain the behaviour of language. Systematic differences in behaviour between languages are explained by the fact that certain 'switches' or parameters are set differently for different languages. In this thesis it will be shown that at least two such parameters play an important role in
the assignment of syllabic structure: the direction of syllable structure assignment, as well as the question of how many subsyllabic nodes are assigned by the process of basic syllable structure assignment.

We will make use here of the principles and parameters approach in a modified fashion. The modification is the following: Universal Grammar is supposed to consist of several simple modules whose interaction accounts for the complex behaviour of language. The extension we will propose pertains to the way in which the modules interact. Hence the organisation of the grammar, i.e. the way in which the modules are configured with respect to each other, and not only the parametrically determined form of the modules, is claimed to be different for different languages. This will be illustrated in our treatment of the syllabification in French. This version of the principles and parameters approach was suggested by Huang (1982), Muysken (1989: 134-135) and Lefebvre & Muysken (1988).

The thesis is organised in a deductive fashion: the general theory we have developed is presented first, in chapter 1. In that chapter, an extensive look will be taken at the internal structure of the syllable, the process of assignment of syllable structure, as well as the way this is triggered. In this way the link between the syllable changing processes and the syllable is established. In the same chapter, syllabically conditioned processes in German, French, Dutch, Navaho and Wiyot will be touched upon, for the purpose of outlining the theory.

In the next chapter, chapter 2, we will treat the moraic theory of syllable structure as devised by Hayes (1989). We will show that this theory is untenable.

The theory will receive its full motivation in the following chapters, where syllable-changing processes of Tonkawa (chapter 3), Yawelmani (with a short interlude on Tigrinya, chapter 4), German (including a comparison to Dutch, chapter 5) and French (chapter 6) will be treated. The analyses presented in this thesis constitute an integration of, and therefore supercede, the analyses of Tonkawa in Noske (1987), of Yawelmani in Noske (1985), of Tigrinya in Noske (1988b) and of German in Hamans & Noske (1988). The analysis of French given in this work significantly differs from the one presented in Noske (1981, 1982, 1988a), which it supplants.

A word must still be said about the transcription method used. Wherever possible, we have used the IPA standard (where \( y \) stand for a high rounded front vowel and \( j \) for an unrounded front glide). Only for the cases of Mokilese, Navaho, Tonkawa and Yawelmani have we opted to maintain the ‘American’ style of transcription (where \( y \) stands for an unrounded front glide and \( j \) for a voiced homorganic alveolar affricate (= \( dz \) in IPA)) originally used in the sources on these languages. As readers should be familiar with both systems, we expect that no misunderstandings will arise.
1 Syllable assignment and the true constituent model

1.1 Introduction: autosegmental theory and syllabification

In our undertaking to develop a theory of syllabically conditioned alternations, which adopts the principles and parameters approach, it is incumbent on us to exploit as many principles as possible which have already received their motivation. Following this approach, principles which govern the linking of tones to segments, as worked out in autosegmental theory starting with Goldsmith (1976) can be expected to be operative in other parts of phonology where there is also a process of linking between different layers. Devising completely different principles for linking phenomena between layers other than the tonal tier and those containing the tone bearing elements would result in severely curtailing the general validity of autosegmental principles.

Apart from these metatheoretical considerations, it should be realised that there is a very close parallel between the process of syllabification, i.e., the assignment of syllabic structure to a string of segments, and certain types of tone assignment. To see this, one has to realise what happens in those cases where a tonal melody is not part of the underlying form, but can be predicted. This is the case in languages where tone is non-distinctive at the word level, i.e. in intonational languages, like Dutch and English, where tone only has a role to play at the phrasal or sentential level, as well as in languages where tonal melodies are assigned to certain word categories. In these types of languages, tonal phenomena involve both the creation of an element or a sequence of elements (a tone melody), as well as the application of a linking process between the tier on which this element is located and the segments (or, skeletal elements). The creation of syllable structure takes place in a completely parallel way. Here too, an element is created (a syllable), which is then linked to a group of segments (or skeletal elements).

Therefore, we will make use of the basic principles of autosegmental phonology. These principles, which deal basically with the erection of links between elements on different layers, have had a long-standing usage in phonology, but have nevertheless hitherto not been applied in a systematic way in theories of syllable structure assignment. This is primarily due to the fact that at the start of the process of syllable structure assignment, syllable structure is presumably absent, and hence there are no elements to which the segments (or skeletal elements) can be linked. This is assumed to be so because syllable structure is generally predictable.\(^1\) Autosegmental theory, however, originates from the study of tone languages, i.e. languages in which the tones are generally not predictable, and hence should be assumed to be present in the un-

\(^1\) Barra Gaelic (see Borgström 1937, 1940, Clements 1986a) is quoted by some as an exception. In this language, a difference in syllabification is reported to be distinctive.
derlying representation. The application of autosegmental principles to tonal phenomena in languages where tone is not distinctive at the word level is a later development. It was later assumed that in non-tone languages a sentence melody is assigned, and that the principles of autosegmental theory are also operative in these languages.

We will thus advocate an approach in which syllable nodes and subsyllabic nodes — just like sentence melodies — are assigned, and in which the linking between the tiers on which these nodes are located and the segmental (or skeletal) tier takes place by way of application of general conventions, in the same way in which sentence melodies are linked to words and segments.

This approach contrasts with other theories, in that one has to assume that only the syllabic nodes and subnodes are assigned at the appropriate level. The establishment of the actual links between segments (or alternatively, skeletal elements) and the syllabic (sub)nodes is done by the same principles that link tones and skeletal elements. Assuming a more specific algorithm of syllabification in fact boils down to duplicating mechanisms of linking elements on different tiers. These mechanisms are universal, so they need not and should not be stated as part of separate rules or processes.

In a common sense view, it may seem strange that relationships between tones and tone bearing units are of the same nature as those between syllables and segments. This may be so because syllables are thought of as containing the segments, whereas tones do not contain tone bearing units (if anything, tone bearing units contain tones). This objection, however, stems from a pretheoretical point of view. The type of relationship expressed by loose expressions like “contain” here simply points to a mapping relationship between elements of two different types of set. In mapping, there is no intrinsic relationship as to which tier “contains” another. This is fundamentally different when an instantiation of one category (for example the metrical category phonological word) is projected from a group of elements belonging to another category. In that case, there is clearly a bottom-up process in constructing the “containing” category. This contrasts with the assignment of syllable structure, which as we will see, is not merely a bottom-up process. But even in the case of a full bottom-up projection of a higher category, the term “contain” can only be defined in terms of the process of hierarchical structure creation (or, bluntly, extrinsic (and therefore in this connection: circular) statements of which category is higher in the hierarchy), not merely in terms of a mathematical relationship between elements on different tiers. Note that also that the idea of ambisyllabicity (where one segment belongs to two syllables) is incompatible with the pretheoretical notion “contain” (whatever its exact meaning). Therefore, the type of objection outlined here is based on a misunderstanding of the theoretical status of association lines in the framework of hierarchical phonology.

After having developed our theory of syllabification, which we have called Syllable Assignment Theory, we will compare it with other theories of syllabification.
1.2 Some basic concepts of autosegmental phonology

As mentioned, our concept of syllabification exploits all the basic principles of autosegmental phonology, as developed by Williams (1976 (1971)) and Goldsmith (1976). Therefore it is useful to give a short outline of these principles. (For a more extensive overview than the one presented below we refer the reader to Van der Hulst & Smith (1982, 1985) and Goldsmith (1990)).

Crucial to autosegmental phonology (and to nonlinear phonology in general) is the idea of a multilayered representation. In their general overview, Van der Hulst & Smith (1985: 14) mention three arguments for separating a tonal and a segmental tier. The first is that it is observed that if an element bearing a tone (a so-called tone bearing unit (TBU)) is deleted, the tone may remain and be connected to another TBU. Consider the schematic example in (1) (taken from Van der Hulst & Smith (1985: 14)).

(1) H L H L tonal tier
    | + | + |
    omo omo segmental tier
    $\downarrow$
    $\emptyset$

Initially, the hypothetical form *omo omo* contains an alternating high-low tone pattern, starting with a high tone. However, as shown in (1), the second vowel is deleted, but not the low tone which is linked to it. As a result, this tone is now "floating". In this type of situation it is frequently noted that the floating tone is then linked to another tone bearing unit, even if this unit already bears another tone. In this case the result would be:

(2) H L H L
    | | + |
    omo omo

Here a low tone followed by a high tone is linked to what is now the second syllable of the form. The resulting sequence of a low tone followed by a high tone linked to the same TBU is realised as a *rising* tone. The process of linking unlinked tones to tone bearing units that are already linked to other tones is called *dumping* (cf. below for a summary enumeration of the basic principles of autosegmental phonology).

The second argument involves the fact that in many tone languages there are certain morphemes that consist exclusively of a tone or of morphemes that, although they have a tone bearing unit, do not have a tone themselves.

The third argument concerns the fact that words consisting of different numbers of syllables may display behaviour that strongly suggests that they have the same tonal melody. Cf. the following data of Etung taken from Edmundson & Samuel (1966). They give the following melodies on mono-, bi- and trisyllabic words (taken from Van der Hulst & Smith (1985: 14)):
The notations LH and HL indicate a rising and falling tone respectively. We see here that we have the same tone patterns in forms of one, two and three syllables. If there are not enough syllables to allow for a one-to-one relationship between syllables and tones, the tones are realised as rising or falling tones (so-called contour tones).

This has led to the development of the following Association Conventions:

<table>
<thead>
<tr>
<th>(4) Association Conventions</th>
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<tbody>
<tr>
<td>a. Mapping</td>
</tr>
<tr>
<td>Insert association lines between one tone and one TBU — going from left-to-right/right-to-left — starting with the leftmost/rightmost tone and TBU.</td>
</tr>
<tr>
<td>b. Dumping</td>
</tr>
<tr>
<td>Leftover tones are associated to the nearest TBU to their right/left.</td>
</tr>
<tr>
<td>c. Spreading</td>
</tr>
<tr>
<td>Leftover TBU’s are associated to the nearest tone to their left/right.</td>
</tr>
</tbody>
</table>

Let us now see step by step how these principles apply in the Etung case. In Etung, mapping takes place from left to right. (3a) and (3b) are forms that have only one tone. The low tone in (3a) and the high tone in (3b) are linked to the leftmost syllable by the principle of mapping, after which spreading to the following syllable in the bisyllabic forms and to the following two syllables in the trisyllabic forms has to take place.

In (3c) and (3d) there are two tones. In the case of the monosyllabic forms the first tone is linked to the syllable by mapping. The second tone is then dumped on this same syllable. In the case of the bisyllabic forms, mapping takes place from right to left, and after this process neither unlinked tones nor unlinked tone bearing units are left. Hence no spreading or dumping needs to take place.

In (3e–h), there are three tones. In the case of the bisyllabic forms the first two tones are linked by left-to-right mapping. The third, leftover, tone is then linked to the rightmost syllable by dumping. In the case of the trisyllabic forms, left-to-right association (mapping) between tones and syllables takes place, and all the nodes are satisfied; there are no empty nodes left over, neither syllable nor tonal nodes.

After Goldsmith had formulated these principles, Halle and Vergnaud (1982) rejected the idea of universal spreading, by showing that prelinked tones (i.e., tones

<table>
<thead>
<tr>
<th>(3) 1 syllable</th>
<th>2 syllables</th>
<th>3 syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. L</td>
<td>L L L</td>
<td>L L L</td>
</tr>
<tr>
<td>b. H</td>
<td>H H H</td>
<td>H H H</td>
</tr>
<tr>
<td>c. LH</td>
<td>L H L H L H</td>
<td>L H L L</td>
</tr>
<tr>
<td>d. HL</td>
<td>H L H L L H</td>
<td>H L L H</td>
</tr>
<tr>
<td>e. -</td>
<td>L HL</td>
<td>L H L</td>
</tr>
<tr>
<td>f. -</td>
<td>H LH</td>
<td>H L H</td>
</tr>
<tr>
<td>g. -</td>
<td>L LH</td>
<td>L L H</td>
</tr>
<tr>
<td>h. -</td>
<td>H HL</td>
<td>H H H</td>
</tr>
</tbody>
</table>
which are linked to a TBU in the lexicon) do not spread. Subsequently it was shown by Pulleyblank (1983: 117ff) that at least for some languages spreading simply does not apply at all, or not in certain word classes.\(^2\) If it does not take place, a default value (usually a low or a mid tone) is assigned to the relevant empty tone-bearing unit. (Although Pulleyblank claims that spreading takes place by rule, it in fact remains a general principle. Whether it applies or not is a parametrised choice.) A comparison of the Yoruba forms in (5) and (6), taken from Pulleyblank (1983: 123-125), shows how default assignment works ("·", "́" and "⁻" stand for a high, a low and a mid tone respectively.)

\[\begin{align*}
(5) \text{së ḏrë} & \Rightarrow \text{sôrë} \quad \text{‘to be friends’} \\
(6) \text{ri åsō} & \Rightarrow \text{ráśō} \quad \text{‘see a cloth’}
\end{align*}\]

We see that a process of vowel deletion is operative here, deleting the leftmost vowel in a sequence of two vowels. In (5), the mid tone which belonged to the deleted vowel has disappeared as well, but in (6), the second vowel has become high, i.e. it has adopted the tone of the first vowel. This is explained as follows: some vowels in Yoruba bear a tone of their own, others are toneless, i.e. without tone of their own. If these vowels end up having no tone, eventually a default tone value, here a mid tone, is assigned to them. In (5), the deleted vowel is toneless (in cases where it is not deleted it eventually receives a (default) mid tone). In (6) however we are faced with the following situation:

\[\begin{align*}
(7) \text{r i åsō} & \Rightarrow \text{r aṣ́o} & \Rightarrow & \text{r aśo} \\
 & | & | & |
H & H & H & \quad \text{H}
\end{align*}\]

Here the first vowel is deleted, but not the tone which belonged to it. The now floating \(H\) (= high tone) is mapped to the next vowel, the \(a\), which was toneless (in other cases this vowel shows up with the default mid tone). Since spreading is not operative, the following \(o\) remains toneless and receives a mid tone by default tone assignment.

We thus have four major principles in autosegmental phonology which, as we will see below, all play a major role in syllabic phonology also: mapping, dumping, spreading, and default value assignment.

These four principles reflect the tendency of both tones and TBU’s to avoid remaining unlinked. Mapping is either driven by the tones or by the TBU’s or both; spreading and default value assignment are driven by unlinked TBU’s; dumping is driven by unlinked tones. We will see below that in similar cases where two kinds of superimposed elements are to be linked, it is not always the elements on both layers that trigger the linking processes; in the case of a morphologically induced syllable assignment pro-

\[^2\] Smith (1985) shows that for Sierra Miwok it has to be stated for each prosodic morphological process in the phonological grammar whether spreading is switched on or not. This shows that spreading can be fully morphologically conditioned.
cesses, like the reduplication cases to be treated in section 1.4, it is only the elements on the higher level, that need to be linked to the lower level, while elements on the lower level may remain unlinked.

1.3 Syllabic structure and empty nodes

Having outlined the principles of autosegmental phonology, we now come to the structure of the syllable. A classic way of looking at the syllable is in terms of a division between onset and rhyme, where the onset contains all the material before the syllabic sonority peak, and the rhyme the remainder of the syllable. The division is given in (8).

\[(8) \quad \sigma \quad (\sigma = \text{syllable}; \ O = \text{onset}; \ R = \text{rhyme})\]

Thus, a syllable \(ta\) has the structure given in (9).

\[(9) \quad \sigma \quad \begin{array}{c} O \\ R \end{array} \quad t \quad a\]

The bipartition between onset and rhyme has been advocated by, among others, Pike & Pike (1947) and Fudge (1969). One reason that is usually mentioned is that these constituents are relatively independent of each other with respect to syllable weight and phonotactic restrictions; while it is observed that relatively few restrictions hold between onset and rhyme, there are many restrictions applying within the domains of the onset and of the rhyme themselves.

Because syllable structure is normally predictable, syllable structure is usually taken to be assigned by rule or algorithm rather than to be underlingly present in the lexicon (but cf. note 1). The process of assignment of syllable structure, syllabification, can be thought of as assigning a specific structure like (8) to a string of segments. According to this conception, the basic subsyllabic nodes like onset and rhyme are always assigned if there is material present in the string that requires to be syllabified. For instance, if a syllable starts with a vowel, (which has to be linked to a rhyme), the onset will be present but empty.

The fact that the onset is present can be demonstrated by a very common type of process, the filling of empty onsets. As a first example, let us consider the optional pronunciation of the word \(piano\) in French: \[pijano\].\(^3\) We assume a possible initial syllabification as in (10).

\(^3\) Other possible pronunciations of \(piano\) in French are \([piano]\) and \([pjano]\). For an explanation of this variation, see chapter 6, section 6.6.
The process we are faced with here is one of spreading of the high unrounded front vowel to the empty onset of the second syllable. The behaviour of the \(i\) is parallel to that of tones and the role of the onset to that of a tone bearing unit, cf. (11).

Because of the fact that \(i\) spreads to the onset, which is not the peak of the syllable, it is realised as a homorganic glide, i.e. a non-syllabic high vowel. We thus see that the notion of spreading can be used to explain a phenomenon for which otherwise a rule would have to be formulated. In the SPE-framework, such a rule would be formulated as in (12).

(12) **Glide insertion**

\[
\emptyset \rightarrow \begin{array}{c}
\scriptstyle \text{syll} \\
\scriptstyle \text{cons} \\
\scriptstyle \text{high} \\
\alpha \text{round} \\
\beta \text{back}
\end{array} / \begin{array}{c}
\scriptstyle \text{syll} \\
\scriptstyle \text{high} \\
\alpha \text{round} \\
\beta \text{back}
\end{array} \rightarrow V
\]

This rule, of course, explains nothing. It explains neither why the glide inserted after the high vowel is homorganic to that vowel, nor why glide insertion takes place precisely before a vowel and not before a consonant. Other syllabification theories which do not employ the notion of empty nodes have the disadvantage of having to state specific linking rules. In such a framework (see, e.g., Hayes (1989)), a rule like the following one has to be formulated:  

(13)

\[
\sigma \quad \sigma \\
\scriptstyle R \quad R \\
\scriptstyle V \quad [+\text{high}]
\]

---

\(^4\) Hayes (1989) does not use the concept of rhyme, but uses morae instead. For reasons of exposition, we have maintained the rhyme node in (13). We will come back to mora theory in the next chapter. There it will be shown (section 2.3.1.1) that the linking of the V directly to the syllable node (i.e. without an intervening onset-node as in (13)), presents additional problems in that in doing so the principles of autosegmental phonology are violated in a fundamental way.
Although here we are faced with a far more general and elegant rule than the SPE type rule in (12), it still does not explain why the process of linking the high vowel to the second syllable takes place precisely if and only if this syllable starts with a vowel.

Another example of an autosegmental process can be seen if we consider a process of onset filling in German. In German and indeed many other languages, foot-initial vowel which is underlyingly in word-initial position or which is word-internally preceded by a nonhigh vowel, automatically gets a glottal stop in front of it. Hence a word like *Theater* is pronounced as [tʰeʔatɐ]. We can thus say that the syllable structure assigned by syllabification is as in (14).

\[
\begin{array}{c}
\sigma & \sigma & \sigma \\
O & R & O \\
| & | & | \\
³ & e & a & t & R
\end{array}
\]

(14) says that an empty onset is filled with a glottal stop. It should be noted that (15) is not really a rule that needs to be stated. One only needs to state in the grammar that a foot-initial onset cannot be empty in German, and that the glottal stop is the neutral (or: default) consonant; language independent principles will take care of the rest. We are thus faced here with *default value assignment*, which, as we have seen in section 1.1., is an autosegmental principle, along with spreading.

If this process were accounted for in a linear framework, then we would have to write the following rule:

\[
\sigma \rightarrow \sum \{V\} \rightarrow V
\]

5 In the case of a high vowel as first part of a heterosyllabic vowel sequence, instead of default ʔ-insertion, spreading takes places as in the French case. Hence *Hiat*, 'hiatus' is pronounced as [hiaː t]. In Dutch (and also in certain varieties of German) also mid vowels spread and hence *theater* in Dutch is pronounced with a glide: [tʰeː jə:tʰə]. We will come back to this in chapter 2, note 7.

6 In a large number of varieties of German, a postvocalic or syllabic r is fully vocalised and is transcribed as [ə], [ɐ] or [ɒ]. In this book we have opted not to show this full vocalisation (which must be a late process) and to use [R], for greater transparuity. See also on this chapter 5, section 5.2.
Again we see that a consonant is inserted before a vowel and not before another consonant, something a linear framework cannot explain. If we try to formulate a rule in a hierarchical syllabic framework, but without empty subsyllabic nodes, we get a rule like the following:

\[ (17) \]
\[ \sigma \]
\[ R \]
\[ \emptyset \rightarrow \? \]

Although, like rule (13), this rule is more elegant than its respective linear counterpart, it does not explain why a glottal stop is inserted before a rhyme and not before a consonant.

The type of phenomena discussed here suggests that syllabification can generate empty syllabic nodes. It is these empty nodes that then trigger syllabic adjustment processes. The nature of the processes that occur is completely governed by the principles of autosegmental phonology. Here we have seen two cases of onset filling. Onset filling takes place either, as in the French case, by spreading of the high vowel to the empty onset position, or, as in the German case, by insertion of the neutral (or default) consonant glottal stop. It indeed seems that if there is a segment that needs to be syllabified, a complete syllabic structure consisting of onset and rhyme is superimposed onto the string of segments, and processes to fill the empty nodes can take place (although this will not necessarily happen in all languages).

1.4 Reduplication phenomena

Up to now, syllabic structure has been represented with only two basic nodes, onset and rhyme. We will claim that this syllable structure is not universal. Below, we will see that syllabic structure contains empty nodes in certain cases. Assuming that empty nodes trigger readjustment processes like those exemplified in the preceding section, we shall shortly focus our attention on reduplication phenomena.

But first we have to settle a terminological question. In the discussion above we referred to a syllable consisting of two nodes by using the traditional terms onset and rhyme. In the following discussion we will make a distinction between this kind of syllable, which is binodal, and a syllable type consisting of three nodes. These nodes are termed onset, nucleus, coda. In order to avoid terminological confusion we will refer to the nodes of a binodal syllable as onset and nucleus. Nucleus will thus indicate the second node of a syllable regardless of whether this syllable is binodal or trinodal in nature.

We now come to the reduplication phenomena. Recently, these phenomena have attracted the attention of a number of linguists. McCarthy & Prince (1986) convincingly
show that in many languages, reduplication can be seen as the assignment of an extra syllable of a specific shape to a copy of the string of the root. Consider the following data from Mokilese taken from Harrison (1976: 60-61) by McCarthy & Prince (1986: 21).

(18) **Mokilese Reduplication**

<table>
<thead>
<tr>
<th>Verb stem</th>
<th>progressive</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. podok</td>
<td>pod-podok</td>
<td>'plant'</td>
</tr>
<tr>
<td>b. wadek</td>
<td>wad-wadek</td>
<td>'pick'</td>
</tr>
<tr>
<td>c. kooko</td>
<td>koo-kooko</td>
<td>'grind coconut'</td>
</tr>
<tr>
<td>d. caak</td>
<td>caa-caak</td>
<td>'bend'</td>
</tr>
<tr>
<td>e. pa</td>
<td>paa-pa</td>
<td>'weave'</td>
</tr>
<tr>
<td>f. wi,a</td>
<td>wii-wi,a</td>
<td>'do'</td>
</tr>
</tbody>
</table>

In (18f) "." indicates a syllable boundary. We see here that the reduplicative prefix has the form of a long syllable, which either has the form CVC (in the cases of (18a,b)) or CVV in the cases of (18c-f). In the cases of (18a-d) the reduplicative prefix is simply a copy of the first three elements of the stem. This is not the case in (18e,f). Here, the reduplicative prefix cannot simply be a copy of the first three segments of the stem, since the stem itself consists of just two segments. In these latter forms, the vowel of the stem has apparently been copied into the reduplicative prefix and subsequently lengthened. As mentioned by McCarthy and Prince, this can adequately be accounted for by assuming that the reduplicative prefix is a heavy syllable.

They state that the reduplicative prefix simply has the form given in (19) ($\mu$ stands for mora).

(19) **Reduplicative prefix:** $\sigma_{\mu\mu}$

By this they mean a heavy syllable, which contains two morae. As is well known, the mora is the weight unit used by the Prague school and literature on poetic metre. McCarthy and Prince do not assume that a syllable consists of nodes like "nucleus" (or "rhyme"), but contains one or two (in exceptional cases three) morae. For present purposes, we translate their assumption into our framework and shall assume that such a bimoraic syllable has the following form:

(20) $\sigma$

<table>
<thead>
<tr>
<th>O</th>
<th>N</th>
<th>Cd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = nucleus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cd = coda</td>
<td></td>
</tr>
</tbody>
</table>

The process of reduplication in Mokilese can then be assumed to take place as follows: on the melodic (or segmental) tier, a copy of the stem is prefixed place to the stem itself. The reduplicative syllable is then superimposed onto this form and one-to-one association (mapping) takes place from left to right. Examples of this process are
given in (21) and (22), which correspond to (18a) and (18d) respectively:

\[(21)\]
\[
\begin{align*}
\text{a. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{b. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{O N O N Cd} & \Rightarrow
\end{align*}
\]
\[
\begin{align*}
p & \text{d o k} + p & \text{d o k}
\end{align*}
\]
\[
\begin{align*}
\text{c. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{O N Cd} & \Rightarrow
\end{align*}
\]
\[
\begin{align*}
p & \text{d o k} + p & \text{d o k}
\end{align*}
\]

\[(22)\]
\[
\begin{align*}
\text{a. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{b. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{O N Cd} & \Rightarrow
\end{align*}
\]
\[
\begin{align*}
p & \text{d o k} + p & \text{d o k}
\end{align*}
\]
\[
\begin{align*}
\text{c. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{O N Cd} & \Rightarrow
\end{align*}
\]
\[
\begin{align*}
p & \text{d o k} + p & \text{d o k}
\end{align*}
\]

The reader may wonder why in the reduplicated form in (22) the final \(k\) of the copy of the stem is not linked to the coda of the reduplicate syllable, or to the onset of the second syllable. Below, at the end of the next section (1.5), we will show that this is because reduplication, unlike regular syllabification, is a morphological operation. We will demonstrate that this type of morphological operation does not involve linking of as yet unlinked segments to a subsyllabic node which itself is already linked to another node. (Even if dumping applied here, \(k\) could not be not linked to the onset of the second syllable for the additional reason that \(kc\) is not a possible onset in Mokilese).

Now consider what is going on in (18e). Here mapping of elements on the melodic tier to subsyllabic nodes will fail to fill the third subsyllabic node, cf. (23):

\[(23)\]
\[
\begin{align*}
\text{a. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{b. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{c. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{O N} & \Rightarrow
\end{align*}
\]
\[
\begin{align*}
p & \text{a} + p & \text{a} + p & \text{a}
\end{align*}
\]

Then, as in the tonal literature, spreading will take place, producing the outcome \(paa\):

\[(23)\]
\[
\begin{align*}
\text{d. } & \sigma
\end{align*}
\]
\[
\begin{align*}
\text{O N Cd} & \Rightarrow
\end{align*}
\]
\[
\begin{align*}
p & \text{a} + p & \text{a}
\end{align*}
\]

That reduplication in Mokilese really involves assignment of a heavy syllable and not copying of the first three segments of the stem is confirmed by the data in (18f). If only copying were involved the outcome would be \(wia-wia\), instead of the observed \(wii-wia\). Assignment of a heavy syllable explains why we do not find \(wia-wia\). A reduplicate of
the form *wia-* would not consist of one (heavy) syllable, but of two syllables. Instead
the first two segments of the melodic tier are incorporated into the reduplicative affix
and subsequently spreading takes place:?

\[
\begin{array}{ccc}
(24) & a. & \sigma \sigma \\
& O N N \Rightarrow & \sigma \sigma \sigma \\
& w i a & w i a + w i a \\
\end{array}
\]

Apart from examples involving filling of the third position of the syllable in redupli-
cation, we also find examples of onset filling in reduplication phenomena. Compare the
following examples from Oykangand, again quoted from McCarthy & Prince (1986: 15),
whose source is Sommer (1981: 237):

(25) **Oykangand Reduplication**

a. /e^e^er/ 'rain' \(\epsilon\epsilon^e^er\) 'heavy rain'
b. /algal/ 'straight' algalgal 'straight as a ram rod'
c. /igu-/ 'go, walk' igigun 'keeps going'

Unlike (24), the coda node in (22) does link to an \(a\). This vowel, however, is preceded by
another \(a\). The two subsequent \(a\)’s in (22) must in fact be seen as a simplified representa-
tion for two adjacent slots on the CV- or X-tier linked to the same segment: \(i\)

\[
\begin{array}{ccc}
& X & a \\
(22) & X X & a \\
\end{array}
\]

The configuration in (i) represents an underlyingly long vowel. In a language where long
vowels are permitted, but diphthongs like \(ia\) are disallowed, only slots on the CV or X-tier
that are the second member of an underlying long vowel can be incorporated into the right
margin node.

We thus see that there are two possible representations for vowels that are long on the
surface, those given in (ii) and those given in (iii): \(i\)

\[
\begin{array}{ccc}
(25) & (ii) & N Cd \\
& X X & a \\
\end{array}
\]

The structure in (ii) represents an underlyingly long vowel which is syllabified into two
subsyllabic nodes, and hence is also long on the surface. The structure in (iii) represents a
vowel that is not long underlyingly but which has acquired surface length by the process of
spreading: the single X-slot has been linked to two subsyllabic nodes. This lengthening
process takes place only in a language where the process of spreading such as in (24c) is
operative.

A vowel can also be underlyingly long but short on the surface. This type of case can be
found when the syllable structure does not permit the second X slot of the long vowel in (i)
to be connected to the coda. This may happen if the coda is already filled with a segment.
Such a case is displayed in (iv), where the syllable is closed by a \(t\).

\[
\begin{array}{ccc}
(26) & (iv) & N Cd \\
& X X & t \\
\end{array}
\]

An example of such a shortening process can be found in Yawelmani (see chapter 4, section
4.4.1).
We see here that the reduplicate sometimes consists of two, sometimes of three segments. This can be explained in the following way: the reduplicative syllable is a heavy one. The initial syllable of the stem contains an empty onset. Cf. (26), which refers to (25b).

\[(26)\]

\[\sigma\]
\[\begin{array}{c}
\text{O N Cd O N Cd} \\
\text{a l g a l}
\end{array}\] 
\[\Rightarrow\]
\[\begin{array}{c}
\text{a l g a l + a l g a l}
\end{array}\]

Apparently, the mapping of the elements of the reduplicative copy on the segmental tier onto the tier containing the subsyllabic nodes (also called segment bearing units, cf. section 1.5) does not stop at the end of the syllable inserted by the process of reduplication. There is another empty node, the onset of the stem syllable, that is open for linking. Because of the process of reduplication, which involves the insertion of a copy of the melodic elements of the stem, the onset can now be filled.\(^8\)

---

\(^8\) In Oykanand, words may not begin with a consonant. Sommer (1981) has analysed this restriction as a restriction on the syllable. In his view, the 'g's in algalalgal belong to the first and second syllable respectively, because a syllable also cannot start with a consonant. This position has been criticised by McCarthy & Prince (1986: 15–16), who point out that the reduplication does not support this unusual claim. We have here adopted McCarthy & Prince's view, and rephrased their analysis in terms of our framework.

The reason why we do not get spreading in the reduplicated forms in (25a,c) (e.g. *edfèdèf and *iggigun) is not known, but there are two possible explanations. The first possibility is that spreading does not take place in this language, but only association. The second is that although spreading is available in the language, there is a general constraint against geminates. In both cases, the intervocalic consonant will be transferred from the right margin position of the first syllable to the onset position of the second syllable due to a general constraint on a third position filled with a consonant followed by a syllable with an empty onset.

One can also raise the question why the reduplicated form in (25a) is not *edfèdèf, which would be derived in the following way:

\[\begin{array}{c}
\text{O N Cd O N Cd} \\
\text{e d f e f + e d f e f}
\end{array}\] 
\[\Rightarrow\]
\[\begin{array}{c}
\text{O N Cd O N Cd} \\
\text{e d f e f + e d f e f}
\end{array}\] 

The reason why the 'f of the reduplicate does not map to the onset of the second syllable is possibly that the mapping should be contiguous, i.e., the mapping process stops whenever a segment is encountered (here 'e) which cannot map to a subsyllabic node.
After having seen the application of the autosegmental principle of spreading to a basically syllabic process (in the French case in (8)), as well as the application of the process of default value assignment, also an autosegmental principle (in the German case in (11)), we are here faced with the application of a third autosegmental process, the most fundamental of all, i.e. that of one-to-one association (mapping). Below, in section 1.5, where we define more precisely our concept of syllabification, we will see that the fourth fundamental principle of autosegmental phonology, viz. dumping, also has a role to play in syllabic phonology.

1.5 Syllabification and the true constituent model

Here we will treat in more detail our theory of syllabification. Generally, up till now, two types of theory of syllabification have been proposed. The first one is the rule approach, advocated in different versions by, among others, Kahn (1976), Steriade (1982), Levin (1985). In essence, it says the following:

(27) Rule approach to syllabification

(i) one syllable is associated with each [+voc] segment of the string;

(ii) a maximum number of consonants is associated with the syllable containing the [+voc] segment following them. The consonants must form a permissible syllable-initial cluster;

(iii) the remaining consonants are associated with the syllable containing the [+voc] segment preceding them. These consonants must form a permissible syllable-final cluster.

An example is given in (28).

(28) (string to be syllabified: CVC)

\[
\begin{array}{ccc}
C & V & C \\
\Rightarrow (27i) & C & V & C \\
\Rightarrow (27ii) & C & V & C \\
\Rightarrow (27iii) & C & V & C \\
\end{array}
\]

As Itô (1986: 4–7) points out, this approach has to stipulate syllabification rules, while other models of syllabification can derive the desired result by invoking independently needed principles. The rules in the rule approach duplicate part of the well-formed-
ness conditions on syllable structure (in Itô's terms: prosodic licensing) which are needed independently.

The second type of syllabification is known as the *template matching approach*. General mapping procedures map the string of segments to a syllable template, which functions as a set of well-formedness conditions. Such an approach is adopted by among others, Halle & Vergnaud (1978), Selkirk (1982), Noske (1982, 1988a), Itô (1986, 1989). The form of a template varies according to the authors, but often has a structure as in (29):  

\[
\begin{align*}
(29) & \quad \sigma \\
& \quad /R (N = \text{nucleus}, \ C_d = \text{Coda}) \\
& \quad O \ N \ C_d
\end{align*}
\]

Additional conditions can be applicable to the template. For an example, see the template and conditions proposed for French in Noske (1982: 259-261, 1988a: 46-48). These conditions have to state, e.g., which constituents are obligatory and which are optional. For example, it can be assumed that the nucleus (or peak) of the syllable must always be present. In some languages also the onset is obligatorily present. In addition, it must be stipulated how many segments may be linked to a specific node, and what their cooccurrence restrictions are.

It must be realised, however, that if the template were only a set of well-formedness conditions, the template would not itself trigger phonological processes. It would only block derivations in two types of cases: (i) in the case in which a node must be present and phonetically realised and there is no segment which can be linked to this node, and (ii) in the case where one finds segments in the string that cannot be parsed into subsyllabic nodes, because it contains segments that cannot cooccur. This latter situation would arise e.g. if the string contained a sequence of three intervocalic consonants or a sequence of two consonants and the syllable template allowed only for a single consonant in both the onset and the coda.

In contrast to the concept of the template as a set of pure well-formedness condi-

---

9 The structure is (29) is a hierarchical one, in the sense that there is branching at a level below the syllable node. Davis (1982, 1985) has argued that the arguments for a such a hierarchical structure are at least questionable by showing among other things that many distributional restrictions do not apply between constituents in the rhyme, but, e.g., between the coda and the onset. He instead assumes a flat structure:

\[
\begin{align*}
& \quad \sigma \\
& \quad /O \ N \ C_d
\end{align*}
\]

We have assumed here tacitly a non-hierarchical structure of this type. In addition, as we show in this chapter, syllable structure is sometimes bipositional and sometimes tripositional. As mentioned, we refer to the second node in a bipositional syllable structure (which is called "rhyme" by many authors) as well to the second node in a tripositional structure (which is called "nucleus" by many authors) as in a tripositional syllable as "nucleus". This is done to avoid the use of a confusing terminology.
tions, it has often been proposed that template mapping actually involves the creation of empty nodes which are present in the template but to which no segments correspond, as a result of the mapping process. Subsequently, either default segments are inserted into these empty nodes, or linking of the nodes to segments that are already linked to other nodes takes place, i.e., spreading. Above we have seen that this takes place in German and French respectively for empty onsets. Insertion of a default vowel can take place in empty nuclei (see ter Mors (1985) for Klamath, Noske (1985) for Yawelmani, Itô (1986, 1989) for Axininca Campa, Icelandic, Arabic, Temiar). Linking of empty nuclei to vowel segments already linked to other nuclei takes place in many Bantu languages when these languages adjust loan words of a more complex syllable structure to their own syllable structure requirements, because they allow in general only for open syllables.

We thus see that in the literature cited, the template is not exclusively used as a set of well-formedness conditions, but as the superimposition of a certain hierarchical structure. We think that there has been a general failure to realise that a theory in which the template approach triggers syllable repair mechanisms like onset and nucleus-filling crucially involves the imposition of a certain hierarchical structure. It thus seems that in such a theory, the template is of a complex and hybrid character: it is the expression of a set of well-formedness conditions as well as the assignment of a certain structure.\footnote{In Itô (1986, 1989) the word \textit{template} seems to have an unstable meaning. At the only place where she (vaguely) explains what a template is, it is a well-formedness condition: "A template is a kind of wellformedness condition defining the possible skeletal sequences of a language ..." (1986: 4). However, at other places she refers to it as a structure: "... the template is already filled ..." (1986: 70), "... epenthesis is formally association of a segment to a syllable template ..." (1986: 133), "associate r to the postnuclear position in the syllable template" (Icelandic Syllable-Mapping Epenthesis, 1986: 183), "... epenthetic segmental material is inserted to satisfy a syllable template already present" (1989: 239, italics ours).}

It is clear that this double role for the template shows that the theory is not well developed on this point. In the last decade, generative linguistics has in both syntax and phonology developed into a framework in which the interaction of very simple sub-modules accounts for the complex processes which are observed in language.

Therefore, it is better to separate the two roles of the template. As mentioned above, not all conditions are expressible within a template. In our view, then, syllabification is only the assignment of syllable structure, while conditions, which now can take a more simple form, are expressed separately. Most of these conditions will be applicable to one of the domains defined by the nodes onset, nucleus, coda.

In order to distinguish the type of syllable structure we propose from that of the template matching approach (where as we have seen its status is unclear), we will refer to our model of the syllable as the \textit{true constituent model}.

The syllabification theory we propose derives from the assumptions of autosegmental phonology. It makes use of the same association conventions. These conventions apply between the tier containing segments and the one containing subsyllabic
nodes, just like they apply between the tier containing tones and the one containing tone bearing units. Because of this parallelism, we will refer to the subsyllabic nodes as segment bearing units (SBU’s).

We assume, then, that syllabification takes place as follows:

(30) **Syllable Assignment Theory**

The string of segments is scanned for nonsyllabified segments in a directional way (RL or LR). If a nonsyllabified segment is encountered, a syllable of the canonical shape is superimposed onto the string of segments. Then, optimal linking between the segments and segment bearing units takes place, according to the general conventions of autosegmental phonology. Then the scanning process begins again, etc.

The directionality of syllabification has been proposed by many linguists, e.g. Steriade (1984), ter Mors (1985), Noske (1985, 1987, 1988b), Dell and Elmedlaoui (1985), Itô (1986, 1989). In chapter 4, sections 4.4.1 and 4.4.2, we will give evidence that the direction of syllabification is determined by a genuine parametrised choice in that several seemingly independent phenomena can be explained by the parameter setting.

The linking according to the general autosegmental phonology conventions simply involves association in a one-to-one fashion (mapping) of the segments to the subsyllabic nodes. This mapping is triggered by the subsyllabic nodes that were inserted when the first unsyllabified segment was encountered by the syllabification mechanism. Then, inasmuch as the well-formedness conditions permit, dumping takes place. It is in this way that an onset can be filled with more than one element. If an SBU has not been linked to any segment by one-to-one association or by dumping, then either the SBU will be filled with a default segment, or a segment already linked to another SBU will spread to it.

Here we see that all four major autosegmental principles concerning the linking of elements to their bearing units apply. The diagrams in (31) illustrates the workings of the four principles (v = vowel, c = consonant; we have abstracted away from intervening skeletal nodes or hierarchical branching of features within the segments; the default segment we have assumed for the nucleus in (31d) is ø (which is perhaps the default segment most frequently observed in languages, along with i)).

(31) a. **mapping** (direction in this example: left to right)
b. dumping

\[
\begin{array}{c}
\sigma \\
O N Cd \Rightarrow O N Cd \\
c v c c \\
\end{array}
\]

c. spreading

\[
\begin{array}{c}
\sigma \\
O N Cd \Rightarrow O N Cd \\
c v \\
\end{array}
\]

d. default value assignment (assumed default value here for nuclei: \( \sigma \))

\[
\begin{array}{c}
\sigma \\
O N Cd \Rightarrow O N Cd \\
c c \\
\end{array}
\]

By assuming the syllable assignment in (30), we have considerably narrowed the gap between normal syllabification and the processes of reduplication in e.g. Mokilese and Oykangand, as outlined in section 1.3. Recall that in these languages reduplication is the imposition of a specific syllabic structure on a copy of the verb root. Afterwards, association takes place. There remains only one major difference. The assignment of a syllabic structure to a verb root copy is a morphological operation, and is thus driven by the SBU's of the specified syllable, inserted by reduplication (this applies here especially to reduplication in Mokilese), while in regular syllabification it is the result of the phonological requirement that all normal elements (i.e. not forming part of a reduplicate copy) are required to be syllabified. Hence, with reduplication, there is only an obligation for the SBU's to be filled (i.e. linked to a segment) while the segments, on the other hand, do not need not to be linked to the SBU's. Therefore, one-to-one association (mapping) will take place, as well as spreading, but not dumping. It is for this reason that in Mokilese the reduplicated form in (18d) is caacaak and not *caakcaak (cf. (22), which is repeated here).

(22) a. 

\[
\begin{array}{c}
\sigma \\
O N Cd \Rightarrow O N Cd \\
c a a k \\
\end{array}
\]

This also explains why in general in reduplication, if the root contains a complex onset, the onset of the reDuplicate usually contains only the first element of that of the original.

In the formulation of the Syllable Assignment Theory (30), it was mentioned that the string of segments is scanned for nonsyllabified segments. This statement should be amended on one point: for the case of Tonkawa, to be treated in chapter 3, we will see that segments of a particular category (in this case vowels) do not by themselves induce the superposition of a syllable. Therefore, it may be a parametrised choice as to
which segments induce the superposition of a syllable. Usually all segments do, so the choice for a particular group of segments (as in the case of Tonkawa, where only consonants trigger the superposition of syllables), is the marked one. We should briefly mention here shortly a situation that can logically arise after the syllabification algorithm (30) has applied. A conflict can arise between the syllable assigned by the algorithm in (30) and the (separate) conditions on wellformedness of the syllable. Let us take a case in Afrikaans. Cf. the forms in (32) (Norval Smith, personal communication).

(32) a. kas /kast/ [kos] 'cupboard'
    b. kaste /kast+ə/ [kastə] (plural)

Because of the t in the plural of this form (which is not predictable), the underlying form of the singular must contain a t. However, the syllable structure conditions of the language do not allow a syllable to end in -st. Therefore, the syllable assignment algorithm and the association conventions will produce the following situation. (For the sake of the argument we assume that the algorithm applies from left-to-right (the choice is not critical here, right-to-left syllabification would lead to the same results, be it in a slightly more complicated way), and that the assigned syllable contains three nodes as we will shortly make plausible below for Dutch (in section 1.6.1)).

(33) \[ \sigma \]
    \[ O \quad N \quad Cd \quad O \quad N \quad Cd \]
    k a s t

The second syllable in (33) is ill-formed: the nucleus is not linked to any segment, a situation forbidden in any language. We are therefore faced with a conflict here between the fact that t needs to be dominated by a syllabic node and the fact that the second syllable is ruled out by the syllabic well-formedness conditions. This situation can be resolved in three ways.

The first one is that there is a spreading process filling the empty nucleus with another segment. However, no such segment is available. Only t could spread to the nucleus, because otherwise, association lines would be crossed (and as well known, this is generally forbidden by a most fundamental principle (perhaps the most fundamental) principle of autosegmental phonology). The segment t, however, cannot itself spread to the nucleus node, since Afrikaans, like nearly all other languages does not allow for syllabic t's. In addition, as will be argued for in chapter 5, there is a general prohibition against the spreading of a segment from the onset position to nucleus position.

The second possibility for resolving the conflict indicated above is that a default segment be assigned to the nucleus node in (33). The assignment of a default segment for a given node may not be operative in a given language (in this way, onsets can remain empty).
If it is now assumed that there is no default segment assignment for nuclei in Afrikaans, then only one way out (i.e., our third possibility) remains. Because the second syllable in (33) is illicit (since its nucleus is not linked to a segment), this syllable is ultimately deleted. As a result, t is also deleted because it is not linked to a syllable anymore. Hence t is phonetically not realised. This type of conflict resolution plays a major role in Unification Grammar (Carlson & Linden 1987, Shieber 1986, for an application to phonology see Wiese 1990). We will return to this in chapters 2 and 4.

1.6 The nature of the assigned syllable

The reader will have noticed that the reduplicated syllables in section 1.4 contain three basic nodes. This is in contradistinction with the usual onset-rhyme (in the terminology employed here: onset-nucleus) bipartition, which is usually adopted as universal. We have also seen some spreading effects to the third position (e.g. in (23d)).

We now come back to the theme this chapter started with. It seems that these same spreading effects take place during regular syllable assignment for certain languages. Let us consider a few cases.

1.6.1 Dutch

In Early Middle Dutch, there was a process of vowel lengthening in open stressed syllables (van Bree 1977: 281-282, van Loon 1986: 86-90, Schönfeld 1970: 30). Although the process is no longer productive, the functioning of the process can still be seen in present-day forms:

11 It is claimed by some that in Middle English essentially the same process has taken place. See, e.g., Strang (1970: 249), Steponavičius (1987: 167-168). In the opinion of others, however, (e.g. Dobson 1962) the process in Middle English was not that general and was subject to other factors.

12 The lengthening as displayed in (34) is sometimes reproduced in modern loan words. Hamans (1989: 140) reports that the plural of the name of the Kanak tribe in New Caledonia, which was quoted on the radio and in certain newspapers as [ka:nə:kən] (orthographically Kanaken), while another newspaper used the form [ka:nəkən] (orthographically Kanakken). The lengthening seems to be regular in the plural formation of certain learned word categories, mostly belonging to the areas of physics or chemistry. Examples are neutr[ɔ]n/neutr[ɔː]nen, alkan[ɑ]l/alkan[ɑː]len, g[ɛ]n/g[eː]nen.
The singular form in (34c) also shows the working of the well-known process of final devoicing. It can be assumed that the syllabification of the plural forms involved the superimposition of a syllable of the form:

(35) \( \sigma \)  
\[ O \quad N \quad Cd \]

After one-to-one association but before spreading we arrive at the following structure for (34b):

(36) a. \( \sigma \)  
\[ O \quad N \quad Cd \quad O \quad N \quad Cd \]
\[ d \quad a \quad k \quad e \quad n \]

We then get spreading:

(36) b. \( \sigma \)  
\[ O \quad N \quad Cd \quad O \quad N \quad Cd \]
\[ d \quad a \quad k \quad e \quad n \]

As mentioned above, this process is no longer productive. A plural of the form in (37b), is not pronounced with a long vowel.

(37) orthographic phonetic underlying  
form form form  
(37) orthographic phonetic underlying  
form form form  
| a. heg [he\( \chi \)] /he\( \chi \)/ 'hedge'  
| b. heggen [he\( \chi \)\( e_\)\( n \)] /he\( \chi \)+\( e_\)\( n \)/ (plur.)  

Cf. also the forms in (38) of which the singular forms in (38a,c) are homophones, but the plural forms in (38b,d) constitute a minimal pair:
(38) **orthographic** | **phonetic** | **underlying**
---|---|---
form | form | form
a. pad | [pat] | /pad/ | 'path'
b. paden | [paːdn] | /pad+ən/ | (plur.)
c. pad | [pat] | /pad/ | 'toad'
d. padden | [paːdn] | /pad+ən/ | (plur.)

According to Van der Hulst (1984: 103) forms like (37b) and (38d) contain an ambisyllabic consonant, which is short on the surface. In a recent article Smith et al. (1989) reminded phonologists that phonetic measurements have revealed that this shortening does not fully take place. Indeed Nooteboom (1972: 33, 39-40) has found that consonants following short vowels in Dutch are statistically significantly longer than those following long vowels. This can be explained elegantly by assuming that in the course of history of Dutch the direction of spreading has simply been reversed. Instead of spreading from the left, spreading from the right takes place, hence the following consonant is linked to the empty third syllable position:

(39) _Modern Dutch:_

```
\sigma \quad \sigma
O \quad N \quad Cd \quad O \quad N \quad Cd
\chi \quad \epsilon \quad \alpha \quad n
```

Hence the difference between Early Middle Dutch and Modern Dutch in this respect can be explained by the change in the setting of a single parameter. The fact that there are still plurals in Dutch behaving like the ones in (34) must be due to diacritical marking in the lexicon. The diacritic would indicate that the direction of spreading is reversed for these forms. Children learning Dutch frequently overregularise and pronounce the form in (34b) as [dakən]. In each case, it must be concluded that the syllable assigned during syllabification in Dutch contains three positions and not two, in Modern Dutch as well as in Early Middle Dutch.

1.6.2 German

The situation in German is not very different from the one in Dutch. Writing in a somewhat different framework from ours (i.e. that of CV Phonology, based on Clements & Keyser (1983)), Wiese (1988: 87) stresses that in his framework the minimal syllable nucleus in German must contain two elements:
Wiese (1988: 67) mentions that a long tense vowel can be realised as a short lax one in colloquial language [...]. In these cases however, the following consonant will become associated with the end of the first syllable, i.e. it becomes ambisyllabic in cases where there is only one consonant available. A syllable ending in a shortened vowel is impossible.

After having mentioned that this phenomenon of vowel shortening typically, but not exclusively, takes place in non-native words especially when the vowel does not carry the main stress, Wiese (1988: 68) gives the following examples of this type of alternation (a dash over the consonant means that it is ambisyllabic):

- Afrika [a:-fri:-ka:] vs. [af-rika:] ‘Africa’
- Metall [me:-tal] vs. [metal] ‘metal’
- zumal [tsu:-ma:l] vs. [tsüma:l] ‘even more so because’
- Philosophie [fi:-lo:-zo:-fi:] vs. [fiïo:-zofi:] ‘philosophy’
- zumal [tsu:-ma:l] vs. [tsüma:l] ‘calender’
- Kuli [ku:-li:] vs. [kuïi:] ‘coolie’

We can conclude that in German, when a vowel is shortened, the position it occupied in the third SBU of the syllable in question becomes empty and it then undergoes spreading from the following consonant. This, combined with the fact that a syllable

---

13 In chapter 5, we will see that the schwa/zero alternations in German can be explained as a direct consequence of syllabification. The analysis presented there crucially involves directional syllable assignment exactly as in the proposal in (30), with the direction set from right to left, and a tripositional syllable. That analysis will provide additional arguments for a tripositional syllable in German, independently of the phenomena mentioned by Wiese.

For reasons of exposition we have deliberately simplified matters somewhat. The usage of the term “canonical syllable” is slightly misleading in the case of German and Dutch. In these languages, syllables are always long, except in the case of schwa syllables (see Van der Hulst 1984, Lahiri & Koreman 1988). If during the right-to-left scanning process, a schwa which is as yet unlinked to syllable structure is encountered, then a binodal syllable is imposed. If during the same process, another unlinked segment is encountered, a trinodal syllable structure is imposed. In order not to confuse the reader at this early stage of the exposition of our theory, we have also rendered schwa syllables as trinodal.
ending in a short vowel is excluded in German, demonstrates that the syllable in German tripositional.14

1.6.3 Wiyot

Wiyot is an Algonquian language spoken in North Western California. The main source is Teeter (1964). In Wiyot, the syllable is nearly always heavy. Teeter writes (1964: 16-17):

Wiyot syllables always begin with a consonant or cluster followed by a vowel. Where the vowel is short they must also phonetically end in a consonant, the same as that of the beginning of the next syllable, except at the end of a word.

It is clear that the situation in Wiyot is quite similar to that in Modern Dutch. There are apparently three positions in the syllable, and spreading takes place from right to left. Thus the third position of the syllable is filled by the preceding consonant. At the end of a word, where there are no following segments from which spreading can take place, nothing happens, and this is thus the only position where we find light syllables. Apparently there is no filling of subsyllabic nodes by default segments in this language.

1.6.4 Navaho

In their monograph on the phonology and morphology of Navaho, Sapir and Hoijer (1967: 3-4) report that when “an initial or medial CV (sc. syllable, R.N.) precedes another syllable that begins with a consonant, the consonant of the second syllable is mechanically lengthened” (the process is reported as “consonant doubling” by Young and Morgan (1987: xv). Sapir and Hoijer give the following examples:15

\[(42)\]
\[a. \text{dišaah } \rightarrow \text{diš.šaah 'I start to go'}\]
\[b. \text{tažii } \rightarrow \text{tαž.žiih 'turkey'}\]
\[c. \text{niiol } \rightarrow \text{nii.yol 'wind'}\]

In (42b) and (43) (below) If we assume that a syllable contains three positions, it is quite clear that this “mechanical” lengthening can be understood as the result of a spreading process, just as is the case in Wiyot and the Germanic languages. There is more evidence for a canonical three-place syllable in Navaho, as Sapir and Hoijer continue:

\[\]

14 Open syllables with shortened tense vowels do occur in certain circumstances e.g. in Mutti [muti] 'mama'.
15 In (41b) the effects of a velar aspiration process (Sapir & Hoijer 1967: 6) can also be seen, changing t and k to \(t^x\) and \(k^x\) respectively.
CV syllables that occur independently in final position in the word are invariably closed with an h. Strictly speaking, then, CV does not occur independently or in final position: the h which closes a CV syllable is phonemically identical with the final h of a CVh syllable.

As examples Sapir and Hoijer give:

\[
\begin{align*}
(43) & \quad a. \text{to} \quad \Rightarrow \text{txwoh} & \quad \text{‘water’} \\
& \quad b. \text{to}\text{n}\text{i} \quad \Rightarrow \text{txwo}\text{n}\text{i} \text{h} & \quad \text{‘river’}
\end{align*}
\]

This can be explained by the assignment of a default consonant, h, to the final (third) SBU in the syllable. It may be no accident that h, like the glottal stop we encountered in the German case, is a glottal consonant. These segments are probably the most neutral consonants of all because they have no supraglottal articulation: they can be considered as minimal consonants.

Finally, Sapir and Hoijer note:

Followed by n, nC, or VV, (V and the other syllabic consonants do not follow CV), the boundary of the CV syllable is marked by a fall of sonority between its vowel and the n or V which follows.

This is the case in e.g. (43b) (in the first syllable), as well as in the following forms cited by Sapir and Hoijer. (The drop in sonority is not indicated):

\[
\begin{align*}
(44) & \quad a. \text{n}\text{i}\text{n}\text{i}\text{t}\text{i} & \quad \text{‘you have found him’} \\
& \quad b. \text{n}\text{i}\text{l}\text{o}\text{e} & \quad \text{‘Hail Chant’}
\end{align*}
\]

We think that this “drop in sonority” must be interpreted as the same kind of default assignment as the h-insertion at the end of a word. h in fact also constitutes a drop in sonority, more specifically a drop in voicing. If it is assumed that this is one and the same process, and that the introduction of the drop in sonority equals the insertion of a segment, the picture becomes quite clear. V’s and syllabic nasals cannot spread to preceding coda positions, because they are syllabic by nature: there is no evidence of gliding in Navaho, so it must be assumed that an element cannot spread from a nuclear position to a nonnuclear position, or that syllabic elements are subcategorised for exclusively nuclear positions). Hence, only the principle of default value assignment remains in order to fill the empty SBU.

It can be concluded, then, that Navaho also has basically a tripositional syllable.

\[16\text{ The aspiration referred to in note 14 is labiovelar before o, a, hence changing t, k to t and k }^{\text{xw}} (\text{Sapir & Hoijer 1967: 6}).\]
1.7 Summary of the Syllable Assignment theory

In this chapter, we have presented an outline of a theory of syllable structure and syllabification, which explains the nature of syllabically conditioned epenthesis and deletion processes. In saying *explained* we mean that these processes can be seen as the direct result of syllabification. We went through the following steps:

First, it was demonstrated that very general insertion processes like glide insertion (in hiatus position) or glottal stop insertion (in hiatus position as well as at the beginning of a word starting with a vowel) can best be seen as the filling of empty positions. By assuming this, these processes can be seen as the result of the general application of the principles of autosegmental phonology, in this case spreading and default value assignment. These principles have found their motivation elsewhere in phonology. Not assuming empty nodes means that one has to posit specific rules. This would of course result in a failure to capture generalisations.

Second, we showed that reduplication in certain languages involves the superimposition of a specific syllable type, involving three positions (or subsyllabic nodes), to a copy of the stem. In addition, we saw that in the case of Oykangand, spreading takes place from the copy of the stem to the empty onset position of the syllable to which the stem itself is linked.

Third, we posited a syllabification theory in which, as in reduplication, a specific syllable is superimposed on the segments. The only difference is that this superimposition is segment driven (or more precisely, skeleton driven if one adopts the presence of the skeleton as an intervening layer between the segmental melody and the subsyllabic nodes) and not triggered by the morphology, as in the case of reduplication. It is this type of syllabification, which, in conjunction with the independently motivated principles of autosegmental phonology, will be shown to account for syllabically conditioned alternation processes in a very natural way.

Fourth, we adduced evidence from the Germanic languages Dutch and German, as well as from the Amerindian languages Wiyot and Navaho that the syllable superimposed by syllabification contains three positions and not two, just as the syllable superimposed by Mokilese reduplication contains three positions. This was done by showing how spreading applies in all of these languages, as well as default assignment in the case of Navaho.

We can thus conclude that the observed difference between the West Germanic languages and languages like Wiyot and Navaho on the one hand and many other languages on the other is the result of a difference in the nature of the syllable assigned by syllabification.\footnote{In Noske (1985, 1987) and in chapters 3 and 4 below we show that for Tonkawa and Yawelmani respectively we need to posit a basic tripositional syllable as well. In these languages, syncope processes like “two sided open syllable deletion” (C → ∅ / VC __ CV) are clearly syllabically conditioned. Michaels (1989: 4–5) shows that the same is true for stressed syllables in English. This seems to disprove Vennemann’s claim (1988: 2) that no syllabically conditioned process can go in the direction of a more complex syllable than CV.}
This latter result is of great importance for the following chapters. We will see that the concept of a tripositional syllable is crucial to the understanding of the nature of the syllabically conditioned alternation processes in Tonkawa (chapter 3) and Yawelmani (chapter 4). The difference between a bi- and a tripositional syllable will also be shown to play a role in the explanation of the differences in schwa/zero alternation in German and French (chapters 5, 6). The choice between a bipositional syllable and a tripositional syllable is one of the parameters along which languages vary. The second parameter, concerning the directionality of syllabification, was mentioned in section 1.5, in our formulation of the syllable assignment theory (cf. (30)). A demonstration of the existence of this parameter will be given in chapter 4, regarding Yawelmani.

But before we go on exemplifying our own theory and the analysis of specific languages therein, we will first treat, in chapter 2, a competing type of theory for reasons of comparison and clarification.

We have already mentioned the rule and template matching approaches, and have mentioned that they are both unsatisfactory from the point of view of the analysis of alternation processes related to syllable structure. However, apart from labelling theories based on the way syllabic structure is built, theories can also be classified by the type of subsyllabic structure they use.

For this, we return to the issue of empty subsyllabic nodes, and the role the subsyllabic nodes are required to play during the erection of syllable structure. Most theories of syllabification do not provide for empty nodes. In the template matching approach (inasmuch the theory is not equivocal on this point and hence meaningless), this is so because templates are wellformedness conditions and not imposed structures.

In the rule approach, nodes are projected from segments or skeletal slots. Hence empty nodes like onset cannot come into existence if there is originally not a segment or skeletal slot to project it from.

In a theory as we propose it, the subsyllabic nodes have a dual role: they are there for skeletal slots to be mapped to, and they contain subcategorisation features. An onset node can only be mapped to a consonant (or glide), a nucleus node can only be mapped to a vowel (or, inasmuch the language permits, e.g., syllabic liquids and nasals, also to liquids and nasals).

Another type of theory of syllable structure does not recognise the existence of subsyllabic nodes at all. Instead, this type of theory uses the concept of *mora*, which stems from metrical theory and incorporates this into syllable structure. In the next chapter, we will treat this moraic theory in some detail.

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18 The government based phonology as proposed by Kaye, Lowenstamm and Vergnaud (1990) also allows for empty nodes.