Archangeli and Pulleyblank (1994), Pulleyblank (1995). Itô *et al.* (1995) consider the role of underspecification in Optimality Theory. Keating (1988b) shows the relevance of underspecification in phonetic representation. See also Stevens *et al.* (1986), Stevens and Keyser (1989).

Much has been written on single-valued vowel features, and on the notion that the vowel space is triangular (§2.3). See for example Sanders (1972), Anderson and Jones (1974), Schane (1984), Goldsmith (1985), Rennison (1986, 1990), Anderson and Ewen (1987), Kaye *et al.* (1990), Harris (1994), Harris and Lindsey (1995), Lombardi (1996) and Cyran (1997).

For reading on umlaut and harmony processes (§§2.4, 2.4.1), see the papers in Vago (1980) and van der Hulst and Smith (1988a), as well as Aoki (1968), Anderson (1973), Ultan (1973), Vago (1973), Ringen (1975), Halle and Vergnaud (1981), Hume (1990), van der Hulst and van de Weijer (1995) and Polgárdi (1998).

For accounts of Yawelmani harmony (§2.4.2), see Kuroda (1967). Archangeli (1984), Pulleyblank (1988a) and Archangeli and Pulleyblank (1989, 1994) give accounts of harmony in Yoruba (§2.4.3). For a discussion of harmony in Nez Perce, in particular whether it involves spreading of ATR or of **a**, see Anderson and Durand (1988).

The notion of segment-internal headedness (§2.5) originates in the model of dependency phonology (Anderson and Jones 1974; Ewen 1980a; Anderson and Ewen 1987; van der Hulst 1989). See Lass (1984a: ch. 11) for an overview. Essentially the same concept is employed in government phonology (Kaye *et al.* 1985, 1990; Harris 1994). The term 'dependency' is used in different senses elsewhere, particularly in feature geometry; see e.g. McCarthy (1988), Mester (1988) and Piggott (1992). For an overview of dependency in phonology, see Ewen (1995).

For proposals on the representation of consonants in single-valued feature theory (§2.6), see, besides the dependency and government references given above, Smith (1988), Harris (1990, 1997) and Harris and Kaye (1990). Ladefoged (1975: ch. 12) offers an account in terms of a multivalued feature [place], whose values correspond to the traditional articulatory labels for place of articulation.

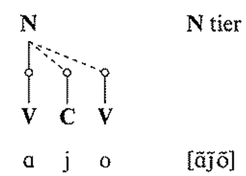
For binary treatments of the representation of laryngeal features (§2.7), see Halle and Stevens (1971), Ladefoged (1973), Iverson (1983), Lombardi (1991) and Steriade (1996). For analyses in terms of single-valued features, see Ewen (1980b), Davenport and Staun (1986) and Harris (1994).

3 Syllables

3.1 Introduction

In the first two chapters of this book we considered the internal structure of the segment in some detail. In the course of our discussion, we saw that certain features may be relevant to stretches of speech larger than just a single segment. This generally involved cases where two adjacent segments agreed in their specifications for place or voicing, for example. In other cases, such as vowel harmony, the two segments involved appeared not to be immediately adjacent, in that consonants could intervene which did not appear to be affected by the harmony process in question. However, we argued that the adjacency condition was in fact met, provided that we interpreted adjacency to refer to successive elements on some tier.

There are still other types of cases in which stretches of adjacent segments appear to agree with respect to a certain property. For example, in the South American Indian language Terena (or Tereno), spoken in Brazil (cf. Bendor-Samuel 1960), the 1st person singular morpheme is realised by spreading nasality from left to right throughout the word. Thus the form for 'his brother' is [ɑjo], while the form for 'my brother' differs only in the fact that all the segments are nasalised, giving [ɑ̃j̃õ]. In the kind of notation we have been developing (ignoring considerations of underspecification, etc.), we can show that sequences of segments can share a single nasal feature or autosegment as shown in (1) (we are assuming that nasality is expressed by a single-valued feature **N** (cf. §2.3); we also use the single-valued features **V** and **C**):

(1)


In cases like this, a single feature appears to be the property of a sequence of segments, rather than of an individual segment. This raises the question of whether there are particular strings of segments which are involved in processes like this more regularly than others, perhaps strings which form independently motivated constituents of some kind. In other words, do certain strings regularly form **domains** for the application of such processes, or is it the case that *any* string of segments is a candidate for feature sharing of the type illustrated in (1)?

It certainly seems to be the case that the 'word' is a constituent which acts as a domain of this sort. Word-bound nasal agreement processes like those in (1) are not uncommon, although they may be more complex than is the case in (1). In Terena, for example, the situation is not as straightforward as we have suggested. Rather, nasality spreads from the beginning of the noun only as far as the first obstruent (which is realised as a prenasalised stop or fricative), as shown in (2) (examples from Bendor-Samuel 1960: 350):

(2)	a.	owoku	'his house'	õw̃õŋgu	'my house'
	b.	piho	'he went'	mbiho	'I went'
	c.	emoʔu	'his word'	ẽmõʔũ	'my word'

In (2a), nasality spreads as far as the velar stop, where it is blocked from spreading any further, while in (b) it cannot spread beyond the first segment, a bilabial stop. In these cases the stop is realised as prenasalised, i.e. as a complex segment (cf. §3.6 below). Notice that the glottal stop in (c) does not block the spreading, even though it is not itself affected.[1] (3) gives the representation after spreading for the form 'my house':

(3) N   N tier

V C V C V

o w o k u   [õw̃õŋgu]

We ignore here the question of the details of how the **N** autosegment is associated with the voiceless stop to give a prenasalised stop. What appears to be involved here is similar to the effects discussed for Apinayé in §1.4; in Terena the stop 'accepts' the spreading feature, but blocks its further spreading, yielding a segment whose left edge is nasal, but whose right edge is oral. What (3) demonstrates is that the *domain* of nasal spreading is the whole word, even though there is an extra restriction – the presence of a stop – which can block the spreading from reaching to the end of the domain in question.

[1] The transparency of glottal stops to the spreading of nasality in Terena is perhaps due to the fact that such segments lack a place node in their feature representation (cf. the discussion of /h/ in §1.3.5).

We can find many other processes of feature agreement whose application is determined by whether or not the string of segments involved is within a particular domain. Thus, in English, obstruents in a cluster must agree in voicing, but only if they occur within a simple word (i.e. one containing only a single morpheme; (4a)) or in words containing a stem and certain types of affix (e.g. the plural suffix; (4b), where we represent the boundary in question by +). Agreement is not found in compound words, as is shown by the forms in (4c), where the boundary is represented by #:[2]

(4)	a.	Brigden		[brɪgdən]
		tactile		[tæktaɪl]
	b.	dogs	DOG+PL	[dɒgz]
		cats	CAT+PL	[kæts]
	c.	matchbox	MATCH#BOX	[mætʃbɒks]
		textbook	TEXT#BOOK	[tɛkstbʊk]
		pigsty	PIG#STY	[pɪgstaɪ]

In terms of the autosegmental representations developed in Chapter 1, then, (5a) and (b) are the only possibilities; (5c) and (d) do not occur within the simple English word; rather, they are only found when # intervenes:

(5) a.   b. L

C C   C C

c. * L   d. * L

C C   C C

(We use here the single-valued feature **L** to represent voicing (cf. §2.7); voicelessness is therefore unmarked, so that (5c) represents a sequence of a voiced and a voiceless obstruent.)

The phenomenon of nasal place assimilation in English discussed in §1.2 provides another example of the applicability of a process being dependent on a domain. The constraint that a nasal is obligatorily homorganic with a following stop at the end of a word holds only within the monomorphemic word, as in (6a): it does not hold if the final stop is a realisation of a past tense suffix, say, as in (6b), nor in compound words, as in (6c), and is thus, in the analysis of Borowsky (1993), a word-level rule:

[2] For discussion of the relationship between the morphology and phonology of suffixation and compounding, in particular within Lexical Phonology, see e.g. Kaisse and Shaw (1985). For a different kind of approach, see Harris (1994: ch. 1).

(6)	a.	kind		[kaɪnd]
		lamp		[læmp]
	b.	climbed	CLIMB+PAST	[klaɪmd]
		banged	BANG+PAST	[bæŋd]
	c.	gumdrop	GUM#DROP	[gʌmdrɒp]
		moonbeam	MOON#BEAM	[muːnbiːm]
		gangbang	GANG#BANG	[gæŋbæŋ]
		Sten gun[3]	STEN#GUN	[stɛngʌn]

We are, of course, not denying that optional assimilation may occur in forms like those in (6c), giving for example [muːmbiːm] for *moonbeam* and [stɛŋgʌn] for *Sten gun*; however, such assimilation is largely restricted to coronal nasals, with labials and velars being much less likely to undergo assimilation, so that *[gæmbæŋ] for *gangbang* and *[gʌndrɒp] for *gumdrop* are improbable realisations. Thus, these examples differ from those in (6a), where homorganicity is obligatory, and in (6b), where it is impossible.

Processes like these appear to show that morphological and syntactic structure may be relevant to phonological processes. In the examples which we have been considering, the domains within which feature agreement holds appear to be morpho-syntactic in nature. However, many phonologists would argue that the role of such morpho-syntactic units is indirect, and that the relevant domains are phonological units, usually referred to as **prosodic** or **phonological words** or **phrases**.

One well-known process of this kind is that of *Raddoppiamento Sintattico* (RS) in Italian (see Nespor and Vogel 1986). This is a process which lengthens a word-initial consonant when it follows a word-final stressed vowel.[4] Nespor and Vogel (1986: 38) give the following examples:

(7) a. La scimmia aveva appena mangiato metá [bː]anana.
'The monkey had just eaten half a banana.'
b. Il gorilla aveva appena mangiato quáttro [b]anane.
'The gorilla had just eaten four bananas.'

RS applies in (7a), as the final vowel of *meta* is stressed, but not in (7b), because *quattro* has penultimate stress. However, RS fails in many contexts in which the segmental conditions appear to be met:

(8) a. La volpe ne aveva mangiato metá [p]rima di addormentarsi.
'The fox had eaten half of it before falling asleep.'

[3] Note that although the spelling of *Sten gun* would suggest that it consists of two separate words, its stress pattern (/stɛ́ngʌ̀n/) shows that it behaves as a compound word in English.

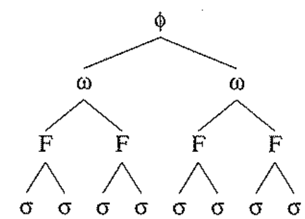
[4] Writers on RS observe that there is a great deal of regional variation in the way in which the process operates. We are not concerned here with these variations.

b. Ho visto tré [kː]olibrí [k]osí [bː]rutti.
'I saw three such ugly humming birds.'

As part of an argument for positing prosodic (phonological) constituents which are distinct from syntactic constituents, Nespor and Vogel argue that RS only takes place if the two words are part of the same **phonological phrase**, a unit which, as noted, does not necessarily correspond to any syntactic constituent. Thus RS again provides an illustration of a process whose application depends on whether or not the elements affected are within the same suprasegmental domain.

This is a very simplified statement of RS, but it serves as an illustration of the importance of non-syntactic suprasegmental domains to certain phonological processes. In the remainder of this chapter, we will discuss in some detail what is probably the most familiar of these phonological domains, or **phonological constituents**, the **syllable**. In Chapter 4, we consider a larger constituent, the **foot**, and its interaction with the placement of stress and accent in languages. In this book, we will not consider constituents such as the phonological phrase, but will limit our attention to the **phonological word**. Underlying our discussion is the assumption that suprasegmental constituent structure has the general form in (9), where ϕ is the phonological phrase, ω the phonological word, F the foot and σ the syllable:

(9)



The **prosodic hierarchy**[5] in (9) shows a consistent structure, in that, at any level, a constituent splits into two identical constituents at the immediately lower level. This is a reflection of the principle formulated by Nespor and Vogel (1986: 7) as follows: 'A given nonterminal unit of the prosodic hierarchy, X^p, is composed of one or more units of the immediately lower category, X^{p-1}.' Thus the phonological phrase consists of two phonological words, the phonological word consists of two feet, and the foot of two syllables.

The syllable, then, is the smallest element in this hierarchy. It is clear that speakers in some sense know about the syllabic structure of the words in their language, i.e. they can decide both how many syllables there are in a

[5] Hence also the terms **prosodic word**, **prosodic foot**, etc.

word and, very often, where one syllable ends and the next begins. Most speakers of English, for example, will syllabify the words in (10) as shown:

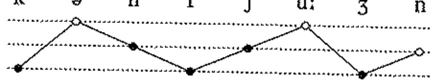
(10) albatross [æl]$_\sigma$[bə]$_\sigma$[trɒs]$_\sigma$
America [ə]$_\sigma$[mɛ]$_\sigma$[rɪ]$_\sigma$[kə]$_\sigma$
slender [slɛn]$_\sigma$[də]$_\sigma$

The existence of the syllable might seem a straightforward matter, given the discussion above. Nevertheless, things are not quite as simple as we have suggested. It is certainly not the case that native speakers agree on the exact location of syllable boundaries in all the words of a language, as is evidenced by the various syllabifications in (11):

(11) master [mɑː]$_\sigma$[stə]$_\sigma$ *or* [mɑːs]$_\sigma$[tə]$_\sigma$
revels [rɛ]$_\sigma$[vəlz]$_\sigma$ *or* [rɛv]$_\sigma$[əlz]$_\sigma$
pastry [peɪ]$_\sigma$[strɪ]$_\sigma$ *or* [peɪs]$_\sigma$[trɪ]$_\sigma$ *or* [peɪst]$_\sigma$[rɪ]$_\sigma$

Furthermore, it is not immediately apparent what it is that native speakers are counting when they say that, for example, *eccentricity* has five syllables and *remarkable* four – although there will seldom be disagreement between speakers on this point. From a phonetic point of view, it is often claimed that what is involved here is **relative sonority**, in particular the notion of **sonority peak**: each syllable has one sonority peak, i.e. a segment which is more sonorous than any of the others. Sonority is thus a relative, rather than an absolute, property. In auditory terms, the sonority peak is more prominent than the surrounding segments, and forms the **syllabic** element.[6] As we anticipated in §1.3.1, vowels are inherently more sonorous than consonants, and so the vowel, if there is one, in a syllable will be the **syllabic peak**. However, in syllables which do not contain a vowel the most sonorous consonant will be the syllabic peak. For example, in the pronunciation of English *bottles* as [bɔʔɫz], the [ɫ] will be syllabic in the second syllable, giving [bɔʔɫ̩z]. Notice that a sonorant consonant will only form the peak if there is no segment immediately preceding or following it with greater sonority. In the word *confusion*, pronounced [kənfjuːʒn̩], there are three sonorant consonants ([n], [j] and [n]). Only the final [n] is a syllabic peak, however, as shown in (12), in which we distinguish three degrees of sonority (vowels, sonorant consonants and obstruents); the peaks are indicated by an open circle, non-peaks by a closed circle:

(12) k ə n f j uː ʒ n



[6] As we have seen, the phonetic interpretation of sonority is not as uncontroversial as we are suggesting here. For discussions, see Malsch and Fulcher (1989), Nathan (1989).

The final [n] is the only sonorant consonant which is neither preceded nor followed by a more sonorous segment (the previous consonant is less sonorous, and there is no following segment), and so forms a syllabic peak, as do the vowels, which are more sonorous than their neighbours. In English, syllabic consonants are restricted to unstressed syllables, by virtue of the fact that stressed syllables tend to contain full vowels, while in unstressed syllables we typically find vowel reduction, with further optional deletion of the reduced vowel when it is followed by a sonorant consonant. Thus, as well as [kənfjuːʒn̩], we also find the pronunciation [kənfjuːʒən].

Even obstruents can be syllabic in English, but typically only in fast speech. Thus, pronunciations such as [s̩pɪʃs̩] for *suspicious* can be heard. In addition, English has items such as *psst!* [ps̩t] and *ssh!* [ʃ̩]. In other languages, though, syllabic obstruents (and indeed sonorants) are more widespread, in the sense that they may occur regularly in stressed as well as unstressed syllables (see e.g. Hoard 1978 on Northwest Indian languages, and Dell and Elmedlaoui 1985 on Berber).

On the one hand, the syllable divisions in (10) clearly demonstrate that syllabification is independent of the *number* of segments in a word: there are no languages, for example, which organise every sequence of, say, three segments into a syllable to give syllable divisions like *[ælb]$_\sigma$[ətr]$_\sigma$[ɒs]$_\sigma$. On the other hand, organisation into syllables equally clearly cannot be derived from any independently given morphemic structure, since the words in (10) are all simple, i.e. they contain only a single morpheme. Indeed, syllabic structure can even be in conflict with morphological structure:

(13) lending LEND+ING [lɛn]$_\sigma$[dɪŋ]$_\sigma$
writer WRITE+ER [raɪ]$_\sigma$[tə]$_\sigma$

The morpheme boundary falls after the stop in (13); the syllable boundary falls before it.

In some cases, morpho-syntactic boundaries may prevent the application of the 'normal' phonological syllabification rules of a language. In an intervocalic biconsonantal cluster in English, we expect the syllable boundary to fall before the first consonant (cf. *albatross* in (10)) or between the consonants (*slender*). We find exactly the same pattern in Dutch, as shown in (14):

(14) sterker STERK+ER 'stronger' [stɛr]$_\sigma$[kər]$_\sigma$
avontuur AVONTUUR 'adventure' [a]$_\sigma$[vɔn]$_\sigma$[tyːr]$_\sigma$

However, if the morphological boundary is strong enough, syllabification does not operate in the expected way, as shown in (15):

(15) avonduur AVOND#UUR 'evening (hour)' [a]$_\sigma$[vɔnt]$_\sigma$[yːr]$_\sigma$

Dutch *avonduur* is a compound word, in which the last consonant of the first element is underlyingly voiced, as is evidenced from the fact that the plural form of the first element is *avonden* [avɔndən] (cf. singular *avond* [avɔnt], with syllable-final devoicing; (12) in Chapter 1). The fact that the final stop of *avond* is also voiceless in *avonduur* shows that here too it is syllable-final. Both intervocalic consonants must then precede the syllable boundary. Thus the only segmental distinction between *avontuur* and *avonduur* is the placement of the syllable boundary; they are otherwise homophonous.[7] If syllable division is in itself bound to the prosodic word domain, then we must assume that each member of a compound word constitutes a phonological word.

We will now try to establish whether the native speaker's ability to parse a string into 'syllables' has any relevance to phonological theory. Can we, by invoking the notion of the syllable, explain phonological facts which we could not otherwise explain? In other words, are there properties of the phonological organisation of segments which lead us to formalise the syllable as a unit within our theory of phonology? If the answer to this question is negative, we do not require a unit of this kind in our theory of phonological representation, even though it seems to reflect a particular kind of organisation which speakers of a language attribute to strings of segments. In §3.2 we consider arguments which appear to support the need for the syllable as a unit in our *phonological* representations. We then discuss the question of how syllable structure is most adequately represented (§§3.3–3.7), and in so doing will address a variety of issues concerning the relation between syllable structure and segmental structure, and will provide further motivation for the syllable by showing that it may form the domain for the application of certain phonological rules. In §3.8, however, we consider one school of phonological thought which holds that some of the arguments in support of the syllable as a unit are spurious, while accepting that there is evidence for prosodic units smaller than the syllable.

3.2 Why syllables?

Although it is clear that there is a unit which native speakers recognise as a syllable, we still have to demonstrate that it is required in phonological analysis. One kind of evidence involves the native speaker's ability to judge whether or not an arbitrary string of segments is a possible word in the language. As we will show, this ability hinges crucially on the fact that the native speaker can only assign a well-formed syllabic organisation to a string of segments if the string in question is a possible word of the language.

[7] Suprasegmentally, however, there is a difference between the stress patterns of the words: *avon'tuur* vs *'avonduur*.

What would happen if our native speaker had no access to syllable structure, and could do no more than identify sequences of segments as being well formed or ill formed in his or her language? The native speaker of English, for example, would identify the string */lmɒk/ as ill formed because the consonant cluster /lm/ cannot occur at the beginning of any English word. In other words, the initial sequence */lm/ violates the **phonotactic constraints** of English. Similarly, */lɒpk/ is ill formed because the consonant cluster /pk/ cannot occur at the *end* of any English word, and */lɒpkmɜː/ is unacceptable because /pkm/ is not a well-formed English medial cluster, i.e. a sequence occurring between two sonority peaks. Thus it might appear that part of the phonological knowledge of a native speaker involves the specification of which consonant clusters are ill formed in the language, as in (16):

(16)	*initial*	*medial*	*final*
	*lm-	*-pkm-	*-pk
	*mr-	*-kmr-	*-km
	*nw-	*-tnw-	*-tn
	...	...	...

However, the list in (16), even if it were complete, displays a fairly obvious redundancy. The constraints on medial clusters in a language are not *independent* of those on initial and final clusters. Rather, if we split any of the medial clusters in (16) into two parts (wherever the split is made), the first part is an illicit final cluster and/or the second part is an illicit initial cluster:

(17)						
	*-pkm-	*pk+m	*or*	p+*km		
	*-rtdl-	*rtd+l	*or*	rt+*dl	*or*	r+*tdl

Medial clusters, then, are not independent units, but consist of two parts, a 'final cluster' followed by an 'initial cluster'. However, because these clusters are word-medial, 'initial' and 'final' here cannot refer to word-initial and word-final, or even morpheme-initial and morpheme-final. Rather, we must regard the ill-formed cluster as consisting of the initial and final parts of some unit distinct from the word or morpheme. This unit is the syllable, whose well-formedness depends purely on phonological factors.[8]

A second type of argument for the existence of the phonological syllable involves the fact that phonological processes can be shown to be conditioned by the syllabic organisation of the string of segments, and also the fact that

[8] We are ignoring here the fact that word-initial syllables can have initial clusters which can appear *only* at the beginning of words (e.g. /kn/ in Dutch *knuffel* 'cuddle'). Thus **alkne* would be ill formed in Dutch. Furthermore, certain word-final clusters cannot appear as the final cluster of a non-final syllable. For example, although an English word may end in the sequence /rst/ in a rhotic dialect (as in *burst*), there are no monomorphemic words in which a non-final syllable ends in this cluster.

there are many processes which affect segments at the 'edges' or 'margins' of syllables. A case in point would be final devoicing in Dutch, which we considered in §1.3.1. Given the organisation of segments into syllables, the generalisation is quite simply that a syllable-final obstruent (or obstruent cluster) is never voiced. If we do not have the syllable as a phonological unit, we are still able to describe the process, but we are forced to state a disjunction in the rule: devoicing takes place in *two* environments, as demonstrated in (18). On the one hand, obstruents are voiceless in word-final position (18a), and on the other, there are no voiced obstruents in the environment in (18b):

(18)	a.	/bɑd/	[bɑt]	'bath'
		/lœyd/	[lœyt]	'loud'
		/lœyt/	[lœyt]	'lute'
	b.	/ɑtlɑs/	[ɑtlɑs]	'atlas'
		/ɔrtnər/	[ɔrtnər]	'folder'
		/prɪsmaː/	[prɪsmaː]	'prism'

In an *SPE*-type formalism, in which the syllable was given no formal recognition, such apparent disjunctions were represented as in (19):

(19) $/\_\_\left\{\begin{array}{l}\#\\ \mathrm{C}\end{array}\right\}$

i.e. the environment of the process is defined as preceding *either* a word-boundary *or* a consonant. A formulation such as (19), however, like any other involving a disjunction in the environment, betrays the fact that we have failed to find what it is that is shared in that environment.

Notice that the question of the *underlying* value for voicing is not at issue: in (18a), as we have seen, the obstruent may be underlyingly voiced (e.g. /lœyd/) or voiceless (e.g. /lœyt/), depending on its behaviour in other contexts ([lœydə] *luide* 'loud (INFLECTED)' vs [lœytən] *luiten* 'lutes'), while in (18b) there is no evidence available to decide whether the obstruent is underlyingly voiced or voiceless, given the fact that there are no alternations to be found.

In a non-syllabic formulation, it is, in spite of (19), very difficult to identify the environment in (18b) in which 'final' obstruents must be voiceless. The environment is not in fact 'immediately preceding a consonant', as (19) suggests, because of the existence of the forms in (20a), which do not display devoicing of the medial obstruent. Indeed, a voiceless obstruent can also occur in what appears to be the same environment, i.e. preceding /l/ or /r/ (20b):[9]

[9] Here and elsewhere, we indicate stress by placing ˈ before the stressed syllable; see Chapter 4 for discussion of stress and accent.

(20)	a.	/ˈkoːbraː/	cobra	'cobra'
		/sjaːˈbloːn/	sjabloon	'template'
	b.	/ˈmeːtroː/	metro	'metro'
		/paːˈtroːn/	patroon	'pattern'

Rather, the generalisation is that an obstruent in a medial cluster does not undergo devoicing if the cluster is a well-formed syllable-initial. If this is not the case, as in *atlas* (there are no syllable-initial */tl-/ clusters in Dutch), the first syllable ends before the /l/, and so the obstruent is syllable-final. The difference in syllabification is shown in (21), in which the (a) forms show the obstruent in syllable-final position, where it must be voiceless, while the (b) forms show that the second syllable begins *before* the obstruent, so that the obstruent is syllable-initial, and hence does not devoice if it is underlyingly voiced:

(21)	a.	[ɑt]$_\sigma$[lɑs]$_\sigma$	b.	[koː]$_\sigma$[braː]$_\sigma$
		[ɔrt]$_\sigma$[nər]$_\sigma$		[paː]$_\sigma$[troːn]$_\sigma$

Thus devoicing in Dutch takes place in the single environment in (22), i.e. in syllable-final position, rather than in the two apparently unrelated environments in (19):

(22) $\_\_\,]_\sigma$

The aspiration of voiceless stops in English provides another example of a syllable-edge process.[10] Aspiration takes place when the stop is followed by a primary or secondary stressed vowel, but only if the stop is the first element in the syllable. Thus no aspiration takes place if the stop is preceded by /s/ (the only consonant which can precede the stop to yield a well-formed syllable-initial cluster), irrespective of whether the consonants involved are in word-initial position (23a) or word-medial position (23b). However, a word-medial stop preceding an unstressed syllable is unaspirated, whether or not it is preceded by /s/ (23c):

(23)	a.	tile	[t^{h}aɪl]$_\sigma$
		stile	[staɪl]$_\sigma$
	b.	retire	[rɪ]$_\sigma$[ˈt^{h}aɪə]$_\sigma$
		distend	[dɪ]$_\sigma$[ˈstɛnd]$_\sigma$
	c.	mutter	[ˈmʌ]$_\sigma$[tə]$_\sigma$
		muster	[ˈmʌ]$_\sigma$[stə]$_\sigma$

[10] For a fuller account of aspiration in English as a syllable-based process, see Spencer (1996: §6.2.1).

Thus the environment in which aspiration is found is $_\sigma[$ __, i.e. at the beginning of a stressed syllable.[11]

Another source of evidence for the status of the syllable as a phonological unit can be found in the behaviour of Dutch vowels which are often referred to as 'lax' or 'checked' (cf. the discussion of lax vowels in §1.3.3). This is the set of vowels which cannot occur in syllable-final position in Dutch, i.e. in **open** syllables. Thus (24) would be ill formed in Dutch, because the vowel in the final syllable is lax:

(24) *[maː]$_\sigma$[krɔ]$_\sigma$

Lax vowels are not found in word-final position, then. But they are also not found preceding a cluster which is a well-formed syllable-initial, as in (25a), although they *can* precede a cluster which is not a well-formed initial cluster, such as /rk/ in (25b):

(25) a. *[mɑ]$_\sigma$[kroː]$_\sigma$
b. [mɑr]$_\sigma$[koː]$_\sigma$ Marco (name)

Furthermore, if the following syllable starts with a vowel, the preceding vowel cannot be lax, as in (26a):

(26) a. *[hɪ]$_\sigma$[aːt]$_\sigma$
b. [maː]$_\sigma$[kroː]$_\sigma$ macro 'macro'
[hiː]$_\sigma$[aːt]$_\sigma$ hiaat 'hiatus'

Tense vowels are required in all these contexts, then, giving for example the forms in (26b).[12]

We should notice that the existence of constraints of this kind removes an ambiguity with respect to syllabification. The fact that *macro* cannot be realised with a lax vowel in the first syllable indicates that the syllabification which we have been assuming is indeed correct; i.e. both the /k/ and the /r/ are assigned to the second syllable, rather than the first, even though syllables ending with /k/ are well formed in Dutch, as are syllables beginning with /r/.

The fact that the /k/ in, for example, *macro* is assigned to the second syllable is due to a principle which appears to hold true of languages in general: given an intervocalic consonant or consonant cluster, assign it to the beginning of the second syllable, unless an ill-formed syllable-initial cluster is thereby formed.[13] Anything preceding a well-formed initial cluster is then assigned to the end of the previous syllable. This is usually referred to as the **maximal onset principle.**[14]

In English, the assignment of stress provides further evidence for the existence of the syllable. Syllables which are closed or contain a long vowel attract stress, whereas syllables ending in a short vowel do not. This restriction is illustrated by the examples in (27), taken from Chomsky and Halle (1968: 71):

(27) arena [ə]$_\sigma$['riː]$_\sigma$[nə]$_\sigma$
agenda [ə]$_\sigma$['ʤɛn]$_\sigma$[də]$_\sigma$
America [ə]$_\sigma$['mɛ]$_\sigma$[rɪ]$_\sigma$[kə]$_\sigma$

The rules of stress assignment in English are highly complex, and we will not go into details of their operation here (but see, e.g., §4.3). However, we can observe that different classes of words have different syllables as their 'targets' for stress. The target in the class of nouns illustrated in (27) is the penultimate syllable, as illustrated by *arena*, whose penultimate syllable contains a long vowel, and *agenda*, with a penultimate syllable closed by a consonant. However, the penultimate syllable of *America* contains a short vowel and is not closed by a consonant, and so it rejects stress, which is then shifted to the antepenultimate syllable. Notice that the distinction we have just drawn can be characterised in a unitary fashion if phonological sequences are indeed divided into syllables. In other words, the application of the stress rules of English depends on whether a consonant following a short vowel belongs to the same syllable as the vowel (as in *agenda*, for example) or to the following syllable (as in *America*). This is not just a matter of the *number* of consonants following a short vowel, as might at first be thought, but, just like the Dutch examples in (20), involves placement of the syllable boundary, as is shown in (28) for the English word *algebra*:

(28) algebra ['æl]$_\sigma$[ʤə]$_\sigma$[brə]$_\sigma$

[11] In a later section, we will show that the structure of syllables with an initial /s/ + obstruent cluster is more complex than that of 'normal' syllables. This in turn will lead us to adopt a slightly different view of the environment in which aspiration in English is found.

[12] In Dutch, /ə/ is anomalous with respect to the tense/lax distinction. Although it is phonetically short, like the lax vowels, it can occur in the same environments as the set of tense vowels, e.g. word-finally ([kaː]$_\sigma$[də]$_\sigma$ *kade* 'quay') and in hiatus, albeit only in morphologically complex environments ([bə]$_\sigma$[aː]$_\sigma$[mən]$_\sigma$ *be+amen* 'to confirm'). For discussions of the status of /ə/ in the phonology of Dutch, see e.g. Trommelen (1983), van der Hulst (1984) and van Oostendorp (1995).

[13] A language which does not allow consonant clusters at the beginning of a syllable will have to assign the first element of a consonant cluster to the previous syllable, however.

[14] Dutch does allow lax vowels immediately preceding a CV sequence. One common source of this is the inflection of nouns and verbs: compare /pɑd/ [pɑt] *pad* 'toad' with /pɑd+ən/ [pɑdə] 'toads' and /lɛk/ [lɛk] *(ik) lek* '(I) leak' with /lɛk+ən/ [lɛkən] *(wij) lekken* '(we) leak'. (This is a lexical matter: compare /pɑd/ [pɑt] *pad* 'path' with /paːd+ən/ [paːdə] 'paths'.) Standard analyses of Dutch assume either that the intervocalic consonant syllabifies to the left, i.e. it forms part of the first syllable, giving e.g. [pɑd]$_\sigma$[ən]$_\sigma$, or that it is ambisyllabic, e.g. [pɑ[d]$_\sigma$ən]$_\sigma$. The first consonant of a well-formed initial cluster cannot be considered ambisyllabic in such analyses, as this would yield *[kɔ[b]$_\sigma$raː]$_\sigma$, rather than the well-formed [koː]$_\sigma$[braː]$_\sigma$ *cobra* 'cobra'. The second consonant of a well-formed final cluster, however, is ambisyllabic, e.g. [mɑr[m]$_\sigma$ər]$_\sigma$ *marmer* 'marble'. By analogy with forms with final clusters, it is also possible to analyse *padden* and *lekken* as containing a double (i.e. geminate) consonant, giving [pɑd[d]$_\sigma$ən]$_\sigma$ and [lɛk[k]$_\sigma$ən]$_\sigma$. For discussion, see van der Hulst (1984, 1985).

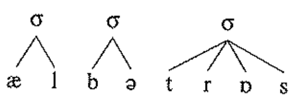
Here the vowel of the penultimate syllable occurs in an open syllable, even though it is followed by two consonants, and so the syllable rejects stress, which shifts to the antepenultimate.

The example of stress assignment in English has been extensively used to show the superiority of an approach to stress which incorporates the syllable over the treatment given by Chomsky and Halle (1968). In *SPE*, as noted above, there is no phonological unit corresponding to the notion of syllable, so that any cluster which is a well-formed syllable-initial, and therefore cannot be preceded by a stressed short vowel, must be specified individually in the stress rules. This is tantamount to incorporating the syllabification rules of a language in every rule which makes reference to syllable boundaries in one way or another, and clearly misses the generalisation illustrated by the forms in (27).

3.3 The representation of syllable structure

We have seen that the syllable is a unit which is required in phonological theory, and that segments can be seen as the constituents of which syllables are constructed. Using a common formalism, we can represent this in terms of the tree structures in (29a), a possible representation of the syllables making up English *albatross*:

(29) a.



b. $[\text{æl}]_\sigma[\text{bə}]_\sigma[\text{trɒs}]_\sigma$

Thus /æ/ and /l/ are constituents of a unit labelled **syllable** (σ), and similarly for the other segments. The tree structure in (a) and the labelled bracketing in (b) are equivalent. Notice, crucially, but perhaps confusingly, that the constituent trees in (a) have a quite different interpretation from representations such as (1), although they are apparently formally identical. Here the lines linking the levels denote **constituency**, whereas those in (1) and similar diagrams denote **association**. In other words, /æ/ and /l/ in (29a) are part of a larger unit σ, while no such claim is made in (1), which merely shows that the feature **N** is a property of each of the segments with which it is associated. This notational ambiguity, although unfortunate, is now so widespread that it seems pointless to try to avoid it here.[15]

We have already seen that there is evidence to suggest that syllables themselves may be grouped into constituents larger than the syllable, but smaller than the word. We consider this question in Chapter 4, where we discuss the

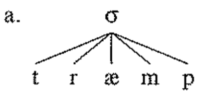
[15] We should notice, though, that Kahn (1976) considers the syllable node to be 'associated' to segments.

foot. Here, however, we consider first the nature of the *internal* structure of the syllable.

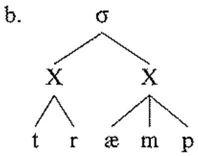
In the representations in (29) it is assumed that the syllable is a **flat** constituent, without any internal structure. This is evident from the structure given in (29a) for the syllable /trɒs/, in which each of the segments is an *immediate* constituent of the syllable node, with no intervening nodes. This is by no means uncontroversial, however, and various proposals regarding the internal structure of the syllable have been put forward.

We will distinguish three proposals in this area. The differences between the proposals is illustrated in (30), three representations of the internal structure of the English monosyllabic morpheme /træmp/ *tramp*. For the present, we use the symbol 'X' to label nodes which are intermediate between the syllable and the segment:

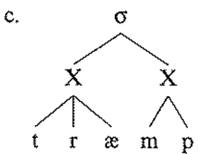
(30) a.



b.



c.

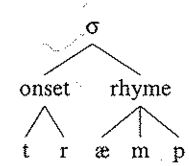


(30a) is a flat structure, like (29a), and as such is the minimal constituent structure which we might assign to the syllable. However, (30b) and (c) show two different ways of assigning further constituent structure within the syllable. (30b), in which we see a major split before the vowel of the syllable, illustrates the **onset–rhyme theory** of syllable structure, while (30c), where the split comes after the vowel, is one interpretation of an approach referred to as **mora theory**. We now consider these two approaches in some detail.

3.4 Onset–rhyme theory

As the name suggests, in onset–rhyme theory the syllable is analysed as consisting of two immediate constituents: the **onset**, containing any consonants preceding the vowel, and the **rhyme**, containing the vowel and whatever follows it:

(31)



Various arguments have been put forward for the division of the syllable into two constituents of this sort. Notice first, however, that although the name of the phonological constituent 'rhyme' is derived from the term traditionally used in verse, we cannot equate the two concepts: the elements which rhyme in the traditional sense are not necessarily just parts of the syllable, as might be suggested by a pair such as *bill–mill*, but may also involve something larger, as is evidenced by rhyming pairs such as *older–colder* and *higgledy-piggledy*. In the latter cases, the rhyming element is not just the rhyme of the syllable; apparently we are dealing with identity between the rhyme of the stressed syllable and any following unstressed syllables. (We will see in the following chapter that this state of affairs provides evidence for constituent structure *above* the syllable.) However, although the two notions of rhyme are different, the rhyming tradition does indicate the relevance of the onset–rhyme division as far as the *stressed* syllable is concerned.

Further evidence for the validity of the onset–rhyme division has been found in the apparent independence of the two constituents. That is, on the assumption that a syllable can be seen as a sequence of onset and rhyme, it has been claimed that the constraints on the co-occurrence of segments holding *between* onset and rhyme are much less severe than those holding *within* each of the two constituents. That is, given a list of well-formed onsets and well-formed rhymes, these can combine quite freely to form well-formed syllables.[16] Thus onsets and rhymes are seen as autonomous units, each with their own constraints on their internal structure.

The combination of onsets and rhymes is not in fact entirely free, as is evidenced by a number of restrictions on the well-formedness of English syllables, of the type given in (32), from Clements and Keyser (1983: 20–1):

(32) a. Stop + /w/ clusters are excluded before /uː ʊ ʌ aw/: */kwuːt/, etc.
b. English has virtually no words consisting of the form $sC_a\breve{V}C_a$, that is, *s*, a consonant, a short vowel, and the consonant again.

The second of these two constraints means that words such as **spop*, **skick* and **stit* are apparently ruled out, even though the same sequences without the initial *s* are well formed in English.

Nevertheless, although the existence of restrictions such as (32) leads Clements and Keyser to reject the onset–rhyme approach to syllable structure in favour of a flat syllable structure, it is clear that the relationship between the vowel and the following consonants, if any, in a syllable is closer than that between the vowel and the preceding consonants. Restrictions of the type in (32) are much more common *within* the onset or the rhyme than between the two constituents. English, for example, does not allow onsets consisting of a stop followed by a nasal (33a), rhymes consisting of a tense vowel followed

[16] In fact, we should restrict this to 'non-peripheral' syllables, because word-initial and word-final syllables typically display extra material before the onset and after the rhyme, respectively. We return to this in §3.4.4.

by /ŋ/ (33b) or, as we have seen, final consonant clusters in which a nasal is not homorganic with a following stop, at least within a single morpheme (33c):

(33) a. */kn-/, */pn-/, */gm-/
b. */-iːŋ/, */-ɑʊŋ/
c. */-mg/, */-ŋb/

Another argument in favour of identifying the rhyme as a constituent involves stress assignment. In English and Dutch, as in many other languages, the location of stress depends on the structure of the syllable; certain syllables may reject stress in contexts where we would otherwise expect it. In determining whether a syllable is stress-attracting or not, it appears that the number and type of consonants in the onset are entirely irrelevant, as is shown by an examination of the forms in (34), which belong to the same class as those in (27), i.e. the target syllable for stress is the penultimate:

(34) a. arena [ə]$_\sigma$['riː]$_\sigma$[nə]$_\sigma$
verbena [vər]$_\sigma$['biː]$_\sigma$[nə]$_\sigma$
angina [æn]$_\sigma$['ʤaɪ]$_\sigma$[nə]$_\sigma$
b. America [ə]$_\sigma$['mɛ]$_\sigma$[rɪ]$_\sigma$[kə]$_\sigma$
orchestra ['ɔː]$_\sigma$[kə]$_\sigma$[strə]$_\sigma$
cholesterol [kə]$_\sigma$['lɛ]$_\sigma$[stə]$_\sigma$[rɒl]$_\sigma$
c. agenda [ə]$_\sigma$['ʤɛn]$_\sigma$[də]$_\sigma$
appendix [ə]$_\sigma$['pɛn]$_\sigma$[dɪks]$_\sigma$
veranda [və]$_\sigma$['ræn]$_\sigma$[də]$_\sigma$

The distinction is a matter of rhyme structure alone, as is illustrated by the target syllables of all the forms in (34), where the identity and number of onset consonants play no role in whether the syllable attracts or rejects stress. This again implies that the rhyme must be a unit which can be addressed by phonological rules.

Similar evidence can be found in the behaviour of the diminutive suffix in Dutch, in particular when it follows a noun ending in a sonorant consonant. We saw in (14c) and (15) of Chapter 1 that the form of the suffix in these cases depends on the nature of both the final consonant and the vowel preceding it, as illustrated again in (35):

(35) a. duimpje DUIM+DIM 'thumb'
maantje MAAN+DIM 'moon'
bijltje BIJL+DIM 'axe'
boertje BOER+DIM 'farmer'
b. kammetje KAM+DIM 'comb'
mannetje MAN+DIM 'man'
belletje BEL+DIM 'bell'
barretje BAR+DIM 'bar'

The forms in (35a) contain a long vowel or diphthong followed by a sonorant consonant, and take a diminutive [tjə] (or [pjə] if the final consonant is labial), while those in (35b) contain a short vowel followed by a sonorant, and take a diminutive [ətjə]. Thus it is the shape of the rhyme as a whole which determines the choice of the appropriate form of the suffix. The onset, however, plays no role, as is shown by the forms in (36):

(36)	a.	aaltje	AAL+DIM	'eel'
		paaltje	PAAL+DIM	'pole'
		staaltje	STAAL+DIM	'specimen'
		maaltje	MAAL+DIM	'meal'
		baaltje	BAAL+DIM	'bale'
		kraaltje	KRAAL+DIM	'bead'
	b.	arretje	AR+DIM	'sleigh'[17]
		palletje	PAL+DIM	'catch'
		stalletje	STAL+DIM	'stable'
		malletje	MAL+DIM	'mould'
		balletje	BAL+DIM	'ball'
		knalletje	KNAL+DIM	'bang'

We now consider a further possible level of constituent structure within the onset–rhyme view of the syllable, the internal structure of the rhyme.

3.4.1 *Rhyme structure*

In (31) the rhyme was represented as a flat constituent. However, as in the case of the syllable, we can find arguments for considering the rhyme to consist of two constituents, the **nucleus** and the **coda**, as illustrated in (37):

(37) rhyme

nucleus coda

What evidence is there for claiming that the rhyme is not a flat structure, but has two immediate constituents as in (37)? We have already seen that certain syllables in languages may be stress-attracting, while others are not, and that this appears to be a function of the content of the rhyme – the onset is not relevant to such processes. In some languages, as in the English examples discussed in (27), this seems merely to be a question of the number of segments in the rhyme. The evidence of these forms suggests that the penultimate syllables of the forms *arena* and *agenda*, which are stressed, have something in common as opposed to the penultimate syllable of *America*, which rejects stress. From now on we will consider long vowels to be geminates, i.e. they

[17] Dutch has no noun *al*.

occupy two positions in the rhyme, and as such have exactly the same structure as diphthongs, which behave in the same way with respect to the stress rules of English (e.g. *angina* [æn]$_\sigma$[dʒaɪ]$_\sigma$[nə]$_\sigma$). Thus the distinction between **heavy** and **light** syllables in English (i.e. those which attract stress as opposed to those which do not) is simply a matter of the number of segments in the rhyme: heavy syllables contain two segments in the rhyme, as in (38a, b, c), while light syllables contain only one (38d):[18]

(38) a. *heavy*	b. *heavy*	c. *heavy*	d. *light*
rhyme	rhyme	rhyme	rhyme
a ɪ	i i	ɛ n	ɪ
angina	arena	ag**en**da	America

The target rhyme for stress in each word (the penultimate) is given in boldface.

The data from English does not offer any clues as to whether the rhyme should have the internal structure in (37), then; all that seems to be relevant is whether the rhyme node has more than one daughter. However, not all languages draw the distinction between heavy and light syllables in the same way. In some languages, it is not only the number of segments in the rhyme, but also the type of segment, which plays a role. In Selkup, a West Siberian language, for example, a two-segment rhyme consisting of a long vowel is heavy, while a two-segment rhyme consisting of a short vowel followed by a consonant is light, as shown in (39) (from Halle and Clements 1983: 129):

(39)	a.	kɨ'pɔɔ	'tiny'
		qu'mooqɪ	'two human beings'
	b.	'amɨrna	'eats'
		'uucɨkkak	'I am working'

Stress falls on the rightmost heavy syllable in Selkup, or on the initial syllable if there is no heavy syllable. Thus in (39a), the syllables [pɔɔ] and [moo], like the corresponding syllables in (34a), function as heavy and are stressed. However, the penultimate syllables in (39b), [mɨr] and [cɨk], respectively, function as light, even though their rhymes contain two segments. Thus in Selkup, like English, a rhyme containing VV is heavy, but, unlike English, one containing VC is light. Evidence like this can be interpreted as suggesting that in (39b) the penultimate syllable is light because the vowel and consonant belong to different constituents within the rhyme – the nucleus and the coda, respectively

[18] We represent the long vowel in (38b) as a geminate, i.e. as /ii/, rather than as /iː/. In the remainder of this book, we will only use the geminate representation when the geminate status of a long vowel is relevant to the point at hand.

– and what is relevant in establishing the distinction between heavy and light in this language is the number of segments in the *nucleus*, not in the rhyme as a whole.

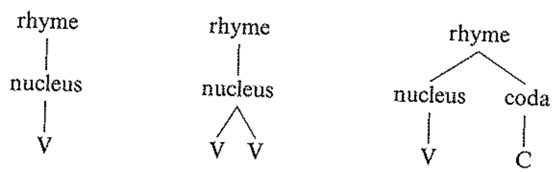
The distinction between the two types of languages with respect to what is referred to as **syllable weight** is summarised in (40), where we refer to the type of language instantiated by English as a **rhyme-weight language** and the Selkup type as a **nucleus-weight language** (cf. Hayes 1995):

(40) a. In rhyme-weight languages the nucleus plays no role in the distinction between heavy and light syllables: if the rhyme as a whole contains more than one element the syllable is heavy.
b. In nucleus-weight languages the structure of the nucleus node determines syllable weight: branching nuclei are heavy; non-branching nuclei are light.

In rhyme-weight languages we find the possibilities in (41):

(41) *Rhyme-weight languages*

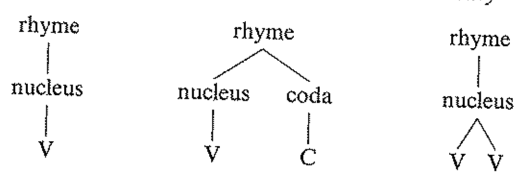
a. *light* b. *heavy* c. *heavy*



while nucleus-weight languages have those in (42):

(42) *Nucleus-weight languages*

a. *light* b. *light* c. *heavy*



Although these are the most common types, other possibilities are found. For example, a language like Dutch appears to represent a third type, in which weight depends solely on whether or not a syllable is closed, i.e. on the presence of a syllable-final consonant, irrespective of whether the vowel is long or short, as is shown by the data in (43):[19]

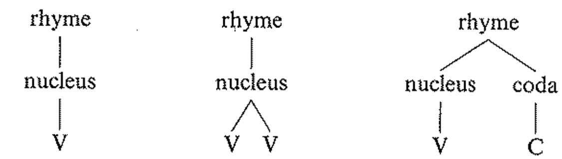
[19] This analysis depends on the assumption that the Dutch vowel system is appropriately analysed in terms of long vs short, i.e. as involving a *quantitative* distinction, rather than in terms of tense vs lax, with a *qualitative* distinction. In the latter case, the difference between heavy and light would depend on a feature on the vowel, rather than on the number of elements involved (see also §3.6 below).

(43) a.	kolibri	['koː]$_\sigma$[liː]$_\sigma$[briː]$_\sigma$	'humming bird'
	pagina	['paː]$_\sigma$[ɣiː]$_\sigma$[naː]$_\sigma$	'page'
b.	agenda	[aː]$_\sigma$['ɣɛn]$_\sigma$[daː]$_\sigma$	'diary'
	proportie	[proː]$_\sigma$['por]$_\sigma$[siː]$_\sigma$	'proportion'

In Dutch, like English, a VC rhyme is apparently treated as heavy, so that a form such as *'*agenda* is ill formed; however, unlike either English or Selkup, a VV rhyme can be skipped, as in (43a), giving for example '*kolibri*, rather than **ko'libri*. We might refer to this third type as **coda languages**, in which the branching of the nucleus is apparently irrelevant, so that the distinction between light and heavy syllables is as in (44):[20]

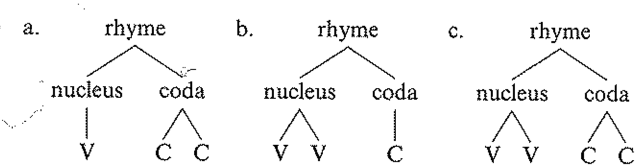
(44) *Coda languages*

a. *light* b. *light* c. *heavy*



In the discussion above, we have been considering rhymes with at most two segments. However, at first sight, it would appear that there are also rhymes with more than two segments, either because they have two consonants in the coda, such as Dutch *balk* /bɑlk/ 'beam', or because they have a complex nucleus and a consonant in the coda (English *pike* /paɪk/) or both (English *wild* /waɪld/). We might suppose, then, that the structures in (45) would be appropriate for such rhymes:

(45)



However, as we shall see, four-segmental rhymes, and even those containing three segments, are very restricted, and where they do occur, this tends to be in word-final, rather than in non-final, syllables. This in turn can be related

[20] It has also been claimed that there are languages in which the heavy–light distinction is sensitive to the nature of the consonant in the rhyme. For example, a rhyme containing a vowel followed by a sonorant consonant might be heavy, whereas one with a vowel followed by an obstruent would be light (see (65) below).

to the more general fact that the constraints on **peripheral** – i.e. word-initial and word-final – syllables seem to differ in various ways from those on medial syllables. We now consider one aspect of this phenomenon.

3.4.2 Syllabic prependices and appendices

With respect to the syllabic behaviour of peripheral consonants, we can identify two classes, both of which are illustrated by Dutch and English. We consider the first type in this section, and return to the second type, involving 'extrasyllabic' consonants, in §3.4.4.

It appears to be the major class and manner features which provide the information relevant to the status of a segment within the syllable. In particular, the well-formedness of particular sequences of segments within a syllable is determined by their relative sonority (cf. §1.3.1), in such a way that, within the onset, less sonorous consonants precede more sonorous consonants, while, within the coda, the reverse holds. The most sonorous segment in the syllable, normally the vowel, forms the nucleus. Thus the sonority 'slope' within a syllable typically rises as we go from the initial consonant to the nucleus, and then falls until we reach the end of the syllable. Syllables like English *tramp* /træmp/ and *quilt* /kwɪlt/ and Dutch *plank* /plɑŋk/ 'shelf' are therefore 'canonical' in the sense that the order of segments obeys the sonority hierarchy (the obstruent precedes the sonorant consonant in the onset, and vice versa in the coda). Thus, elements within the syllable are subject to what is often referred to as the **sonority sequencing generalisation**.

In the forms we have been considering so far, we have seen examples of what appear to be branching onsets (English *tray*), branching nuclei (Dutch *ui* /œy/ 'onion') and branching codas (English *help*). Co-occurrence of branching constituents appears also to be possible (e.g. English *cry, old, tramp, flounce*). However, it is not difficult to find words in English and Dutch which appear to allow more than just two consonants in the onset and coda, at least in peripheral positions. Interestingly, in many such words we find violations of the sonority sequencing generalisation, in that we find examples of more sonorous consonants preceding less sonorous consonants at the beginning of a word, and vice versa at the end.

We start by considering what appear to be codas containing up to four or even five consonants. There are restrictions here on the type of consonants that can follow the 'normal' coda: they are almost always coronal, and furthermore they are primarily found in morphologically complex forms. All of this is illustrated by the Dutch forms in (46a), and the English forms in (46b):

(46) a. /ɛrɣst/ ergst 'most serious'
/prɔmptst/ promptst 'most prompt'
/mɑfst/ mafst 'daftest'
b. /sɪksθs/ sixths
/θrʌsts/ thrusts

One common strategy is to consider these segments and sequences (underlined in (46)) not to be part of the syllable itself, i.e. the **core syllable**, but to form an **appendix**. Appendices, then, are considered to be outside the domain of normal syllabification processes.

In initial position we also find consonants which violate the sonority sequencing generalisation. As shown in (47a, b) for Dutch (and for the English translations), these occur in clusters consisting of /s/ followed by a voiceless obstruent (47a), with a further optional consonant (47b):

(47) a. /stɔk/ stok 'stick'
/spɪn/ spin 'spider'
b. /strɪp/ strip 'strip'
/spleːt/ spleet 'split'

However, such sequences cannot appear at the beginning of medial syllables in Dutch. Rather, they are split between two syllables, as shown in (48a, b), unless the sequence is preceded by another consonant (48c):

(48) a. [pɑs]$_\sigma$[taː]$_\sigma$ pasta 'pasta'
[hɑs]$_\sigma$[pəl]$_\sigma$ haspel 'reel'
b. [ɑs]$_\sigma$[traː]$_\sigma$ astra 'astra'
[ɛs]$_\sigma$[plaː]$_\sigma$[naː]$_\sigma$[də]$_\sigma$ esplanade 'esplanade'
c. [hɑm]$_\sigma$[stər]$_\sigma$ hamster 'hamster'

The fact that the vowel is short/lax in the first syllable of the forms in (48) shows that the following obstruent must be syllabified in the rhyme of the first syllable; as we saw in §3.2, if the syllable were open, the vowel would be long/tense in Dutch.

For the English equivalents, however, we do not find unambiguous evidence of this kind for suggesting that the /s/ must be syllabified in the coda. We have already seen (in (23)) that plosives following initial /s/ are unaspirated in RP ([stəʊn] *stone* vs [tʰəʊn] *tone*). This holds whether or not the relevant cluster occurs medially (unless a strong enough morphological boundary intervenes: [dɪskɑːd] *discard* vs [ðɪs kʰɑːd] *this card*) and irrespective of stress (['mɪstə] *mister* vs [mɪ'steɪk] *mistake*). Similarly, post-plosive medial /r l j w/ do not show the devoicing associated with word-initial position (e.g. [pl̥eɪ] *play* vs [spleɪ] *splay* vs [dɪspleɪ] *display*). This would appear to suggest that the

/s/ belongs in the onset in both *splay* and *display*. However, in §3.8 we consider an approach in which the /s/ in these words is assigned to the coda of a preceding syllable; anticipating this discussion, we will for the moment merely assume that /s/ in English, as in Dutch, is syllabified in the coda of the first syllable in words such as *discard*, *display* and *mister*, and therefore that onsets are maximally binary.

One language which is frequently cited as having word-initial clusters which spectacularly violate the sonority sequencing generalisation is Polish (Rubach and Booij 1990: 122–3; Rowicka 1999: ch. 5). Polish allows a wide variety of initial clusters, both two-consonant clusters which appear to allow almost any combination of two consonants (49a) and clusters with more than two consonants (49b):

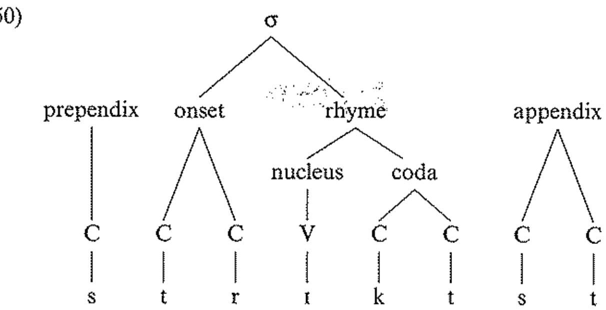
(49)	a.	ptak	'bird'	/pt-/
		scheda	'inheritance'	/sx-/
		skok	'jump'	/sk-/
		mnożyć	'multiply'	/mn-/
		lnu	'linen'	/ln-/
		rtęć	'mercury'	/rt-/
	b.	pszczoła	'bee'	/pʃʧ-/
		lśnić	'shine'	/lɕn-/
		bzdura	'nonsense'	/bzd-/

However, as in Dutch and English, the options for word-internal onsets in Polish are considerably restricted. Rubach and Booij assume that *any* peripheral consonant in Polish 'does not count from the point of view of the SSG [the sonority sequencing generalisation]'. Once this assumption is made, they claim, the number of exceptions to the SSG is dramatically reduced. Furthermore, assuming that initial peripheral consonants are not part of the onset means that there is no ambiguity in syllabifying a medial cluster like /rt/, which is found word-initially (*rtęć*). Because the initial /r/ is considered not to be part of the core syllable, a medial /rt/ cluster must be heterosyllabic: e.g. *karty* $[kar]_\sigma[ti]_\sigma$ 'cards'.

If, then, we assume that the consonants which violate the sonority sequencing generalisation in word-final position do not belong to the syllable, the same solution appears to be available for the initial consonants in (47). The consonant in question is not part of the onset of the syllable; rather, it forms a **prependix**.

On this view, the 'syllable' contains up to three parts, the obligatory core syllable and the optional prependix and appendix, as illustrated in (50), the representation of Dutch *striktst* 'strictest', where only the core syllable is dominated by the σ node:

(50)



The structure of the core syllable is determined by the type of constraints discussed in the previous section. At this point we do not consider the question of the relationship of prependix and appendix to the rest of the prosodic structure, except to notice that various proposals have been put forward. One suggestion is that these elements are attached at the level of the prosodic word, so that the consonant is a constituent of the word, but not of the syllable.

Languages vary as to whether they allow prependices and appendices. Dutch clearly allows both possibilities, resulting in the highly complex sequence in (50). In the same way, the possibilities *within* the core syllable also vary, e.g. whether the onset may be branching or not, whether codas are permitted (i.e. whether syllables may be closed) and what combinations of segments are permitted. In other words, these are **parameters** which vary from one language to another, and which must be formulated in such a way that we can account for facts about 'preferred' syllable structure, such as that all languages have CV syllables, i.e. open syllables with a single consonant in the onset. This appears to be the basic type of core syllable. Some languages allow only CV syllables, while others admit various types of more complex structures. In terms of the onset–rhyme analysis of the syllable, we require a parameter which allows a language to choose to make onsets optional. This parameter must be formulated in such a way that languages which allow onsetless syllables also allow syllables with onsets – languages which prohibit onsets are not found. We formulate it as (51):

(51) OBLIGATORY ONSET: **yes** *or* no

The fact that the setting 'yes' is in boldface in (51) indicates that this is the 'unmarked' (or default) setting. In studies on first language acquisition the unmarked setting is considered to be the one which the child assumes unless the data of the language being learned indicates that the marked setting is appropriate. We will not defend the various assumptions as to the relative markedness of the settings for the various parameters here, beyond saying that (51) reflects what appears to be the preferred minimal size for syllables. Notice that we might have formulated (51) as (52), which reflects this more directly:

(52) BRANCHING SYLLABLE: **yes** *or* no

A further parameter concerns the number of consonants permitted in the onset. We formulate this as (53):

(53) BRANCHING ONSET: yes *or* **no**

Languages which allow complex onsets seem to be more marked than those that do not; hence the unmarked setting as 'no'. Notice that there may be an interaction between the OBLIGATORY ONSET and BRANCHING ONSET parameters. If both are set to 'yes', we would have a language which would permit onsets with one or two consonants, but not empty onsets. If such languages are shown not to exist, then (53) is only required if (51) is set to 'no'.

Within the rhyme we will require similar parameters, formulated as in (54):

(54) a. BRANCHING RHYME: yes *or* **no**
b. BRANCHING NUCLEUS: yes *or* **no**

Notice that the markedness setting for the BRANCHING RHYME parameter implies that languages with codas are marked. This reflects a fundamental asymmetry between onsets and codas: the presence of the former is unmarked, the presence of the latter is marked. Stated differently, we expect syllables to be able to branch, but not the constituents within syllables. This in turn is reflected in the absence of a parameter regulating the branching of codas, which appears in (50) to be possible; we will see in §3.8 that there are powerful arguments to suggest that codas are never complex. If this is the case, then no BRANCHING CODA parameter is required.

Notice too that the unmarked value for the BRANCHING RHYME parameter may not be the same in all contexts, but may be dependent on the prosodic structure in question. Many languages require a stressed rhyme to be branching (English is typical in not allowing /'bɪ/, for example). A full account of parameter setting would have to take this into account.

We have already seen that there may be a dependency between the OBLIGATORY ONSET and BRANCHING ONSET parameters. A similar dependency holds between the complexity of the onset and the rhyme. It has been argued (e.g. Kaye and Lowenstamm 1984) that no language will allow complex onsets but not allow complex rhymes, i.e. will set the BRANCHING ONSET parameter to

'yes', but the BRANCHING RHYME parameter to 'no'.[21] On the assumption that the rhyme is the head of the syllable and the onset the dependent, a point of view which we will defend in §3.4.3, this can be accounted for by assuming that the dependent in any constituent cannot be more complex than its head. It has been suggested that this principle holds for a wide range of phonological constituents (see e.g. Dresher and van der Hulst 1998).

These parameters account for the core syllable. We will require further parameters to state whether prependices and/or appendices such as those in (50) are permitted in a language.

Finally, a set of parameters must be adopted which specify the permitted segmental content for each syllabic position. As we have already seen, the second position in the onset, for example, can generally only be filled by a sonorant consonant, which, as in English, may be restricted to a liquid or /j w/. Similarly, the second position in the nucleus can often only be filled by a limited set of vowels; in RP we find only high and central vowels, or the second half of a geminate. Codas generally only allow a subset of the consonants which can occur in onsets. Thus contrasts which are found in the onset are 'neutralised' in the coda, as we have seen with respect to final devoicing in Dutch – in onset position there is a contrast between voiced and voiceless obstruents which is not found in coda position. In terms of Harris's approach discussed in §2.6, the coda is a 'weak' position.

In §3.8 we discuss an approach to syllable structure in which parameters like these can be incorporated. In the meantime we turn our attention to the question of how syllabic structure is assigned.

3.4.3 Syllabification

It is generally assumed that lexical items, or underlying forms, need not be individually syllabified, i.e. syllabification is not distinctive. Rather, it is claimed to be by and large predictable on the basis of the feature content and linear order of segments, and, therefore, does not need to be specified underlyingly. Clearly, then, we need to have a set of principles which determine how strings of segments are assigned to the various syllabic constituents we have established above.

It might appear that we should simply start with the leftmost element in a string of segments. However, left-to-right assignment of segments to syllables would lead to problems with VCV sequences – the C would be assigned to the leftmost available constituent, the coda, whereas, by the maximal onset principle (§3.2), it should form the onset of the second syllable. We will

[21] This is not to say that a particular syllable may not have a CCV shape, of course; merely that if a language permits CCV, it also permits CCVV.

therefore assume that we first identify the syllabic elements; in other words, we start with the assignment of **syllabicity**, a procedure which we will refer to within onset–rhyme theory as **nucleus formation**. This involves assigning all sonority peaks (cf. the discussion in §3.1) to nuclei, as in (55) for English *albatross* /ælbətrɒs/ (we represent the nucleus by N):

```
(55) N         N        N
     |         |        |
     æ   l   b ə   t  r ɒ   s
```

We also require a process of **rhyme formation**. The rhyme is formed by creating a constituent of the nucleus and any following consonant which is not part of the onset of the next syllable (see below for onset formation). Within this constituent the nucleus is the head and the following segment is the dependent. As we saw in §2.5 with respect to the internal structure of the segment, head–dependent relations are invoked in linguistic structure when one of the elements of a constituent is in some sense more important than the other. In the case of the rhyme, the nucleus is clearly more important, in that it is the **obligatory** element of the rhyme: a rhyme must contain a nucleus, but need not contain any other segment. In the type of representation which we adopt here, the dependent is **adjoined** to the head, as in (56), the representation of the result of adjoining /t/ to /æ/ in the rhyme of the English monosyllabic word *at*:

```
(56)          N'
              |\
     N    →   N \
     |        |  \
     æ  t     æ   t
```

Thus /t/ is not the daughter of the node immediately dominating the nuclear vowel /æ/, but of a higher node, which bears the label N′ (= Rhyme). This convention is used to indicate that the nucleus is the head of the rhyme: the constituent as a whole bears the label of its head. The path leading from the head to the topmost label is referred to as a **projection** or **projection line** – in this case the structure in (57) is the **nucleus projection**:[22]

```
(57) N'
     |
     N
     |
     æ
```

[22] N′ is often pronounced as 'N-bar'.

Rhyme formation thus picks out the postvocalic segments in (55) (if a well-formed rhyme is thus formed) and adjoins them to the nodes created by nucleus formation, to give (58):

```
(58) N'          N'          N'
     |\          |\          |\
     N \         N \         N \
     |  \        |  \        |  \
     æ   l   b   ə   t   r   ɒ   s
```

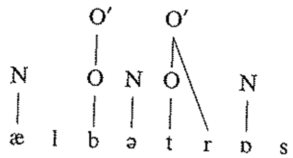
However, (58) is incorrect in one respect. Although adjoining /t/ to the nucleus of the second syllable yields a well-formed rhyme, it should be part of the onset of the third syllable. We must therefore order a process of **onset formation** before rhyme formation. This ordering is in any case what we would expect, given the existence of the Maximal Onset Principle introduced in §3.2. By this principle, non-nuclear material is assigned to the onset unless an ill-formed syllable-initial cluster would be created; only then does rhyme formation apply.[23] Thus, after nucleus formation (50), any (non-final) segment constituting a sonority 'valley' (the reverse of a sonority peak; cf. (12)) is assigned to an onset. The relevant sonority valleys here are constituted by /b/ and /t/ (but not /l/ and /r/, which are more sonorous than at least one of their neighbours). Onset formation gives (59):

```
(59) N       O  N  O      N
     |       |  |  |      |
     æ   l   b  ə  t   r  ɒ   s
```

Notice that although /t/ is syllabified in the onset and /ɒ/ in the nucleus, the intervening /r/ has not yet been syllabified. In English and other languages, as we have seen, onsets may be complex. The process of onset formation in such languages can be followed by adjunction of a second consonant to the head of the onset, giving (60):[24]

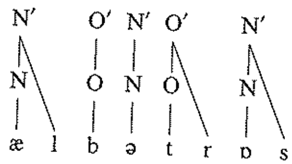
[23] In addition, there are phonetic indications that the /t/ here belongs to the onset of the second syllable rather than the coda of the first. This is clear from the fact that the /r/ undergoes the devoicing typical of syllable-initial position; this takes place only following an initial voiceless stop in English (cf. *tress* /tres/ [tr̥ɛs]). As pointed out to us by Neil Smith, *albatross* /ælbətrɒs/ [ælbətr̥ɒs] contrasts in this respect with *Albert Ross* /ælbət rɒs/ [ælbətrɒs], in which, on morphological grounds, the /t/ is syllabified in the coda of the preceding syllable, and, as a result, there is no devoicing of the /r/.

[24] We assume here that within the onset – a consonantal constituent – the 'most consonantal' (i.e. least sonorous) consonant is the head, so that in the onset of the final syllable of *albatross*, /t/ is the head and /r/ the dependent. This is probably the most widely held position; for the view that the more sonorous segment is the head within *any* construction, see e.g. Anderson and Ewen (1987).

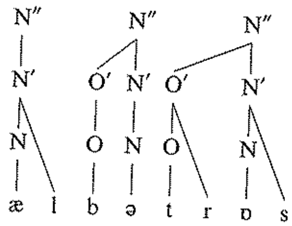
(60)


By convention, adjunction also assigns an extra level of structure even when there is no adjoined element, so that constituent structure is uniform. In other words, the head of the onset is identified by O′; the dependent in the onset is adjoined to the O′ node. Thus /b/ in (60) is also labelled O′, and, as head of the onset of the second syllable, has the same status with respect to its syllabic structure as /t/, the head of the onset of the final syllable.

Rhyme formation now follows onset formation, to give (61):

(61)


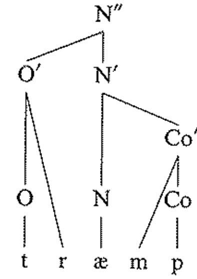
These processes are followed by **syllable formation**, which involves the grouping of a nucleus projection and a preceding onset projection, if there is one:

(62)


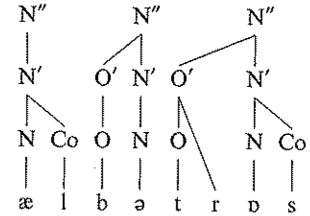
As in the case of rhyme formation, syllable formation involves the selection of the nucleus projection as the head of the syllable – the nucleus is the only obligatory element in the syllable. For the moment, we use the label N″ to characterise this, rather than the σ label which we have been using up to now. Notice that the status of the nucleus as head of the syllable is distinguished from its status as head of the rhyme by the extra prime: N″ vs N′.[25]

Although we have proposed rules of onset, nucleus, rhyme and syllable formation, we have as yet made no mention of a rule of coda formation. In view of the existence of syllables with apparently branching codas, such as English *tramp*, we might expect a rule which would select /p/ as the head of a coda constituent, to give the syllabic structure in (63):

[25] This notation is derived from that of X̄-syntax (Jackendoff 1977), applied to syllable structure by e.g. Kaye and Lowenstamm (1984) and Levin (1985). N″ is pronounced as 'N-double bar'.

(63)


Although this is consistent with what we have been arguing so far, we have also noted that there are arguments to suggest that complex codas are in fact not possible and that there is therefore no need for a process of coda formation as such (cf. also our discussion of parameters in §3.4.2). However, we do assume that there is a coda *constituent*, even though this may not be complex, and consequently that rhyme formation also involves assigning a coda node to the dependent. This gives the final structure in (64) for *albatross*:

(64)


The processes outlined above provide an adequate account of syllabification in languages in which there is no motivation for a branching nucleus. However, our account must be refined to deal with languages which have a vowel-length distinction (i.e. in which the nucleus node may dominate either one or two Vs). Furthermore, there is evidence that for some languages, a postvocalic sonorant consonant should be incorporated in the nucleus, rather than forming the coda. This is appropriate, for example, for languages in which rhymes consisting of a long vowel or of a short vowel followed by a sonorant consonant are heavy, but where those consisting of a short vowel followed by an obstruent are light, as shown in (65):

(65) a.	*heavy*	b.	*light*
	VV		V
	VR		VO

(where R = sonorant consonant and O = obstruent). A number of cases of this sort are considered by Zec (1995a: §2.3). One such is the nucleus-weight language Kwakwala, also known as Kwakiutl (Boas 1947), which displays a number of processes in which CVO syllables behave differently from CVR syllables. Stress, for example, falls on the leftmost heavy syllable, and on the final syllable if there is no heavy syllable in the word, to give the forms in (66):

(66) a. *heavy*
'qaːsa 'to walk'
'dəlxa 'damp'

b. *light*
bə'ha 'to cut'
gas'xa 'to carry on fingers'

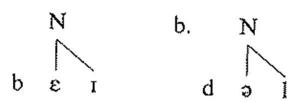
The forms in (66) follow the pattern in (65), such that /l/, a sonorant, makes the rhyme of the first syllable of ['dəlxa] heavy, while /s/, an obstruent, does not have the same effect in [gas'xa].

Rather than saying that syllable weight in these cases depends on whether the coda is filled by an obstruent or a sonorant, we might assume that the second element in the nucleus is subject to parametric variation: the degree of sonority which is required varies per language, such that certain languages demand that the second element of the nucleus be a full vowel, while others allow it to be a sonorant consonant. By assigning the sonorant consonant in such languages to the nucleus, rather than to the coda, we maintain the principle that syllable weight (or rather rhyme weight) is established on the basis of the number of segments within the various rhymal constituents, rather than allowing a situation in which the same rhymal configuration can be either heavy or light, with the distinction being made by whether a coda consonant is [+sonorant] or [−sonorant].[26]

Rhyme formation, then, involves the two processes in (67), which adjoin postvocalic material at different levels:

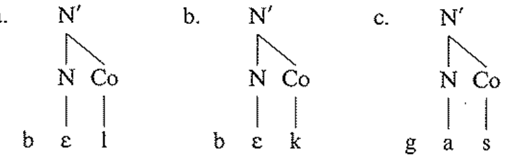
(67) a. Adjoin postvocalic segments of sufficient inherent sonority at N level.
b. Adjoin any other postvocalic segments at N′ level.

(67a) is illustrated by the Dutch word *bij* /bɛɪ/ 'bee' in (68a), where N now characterises a complex nucleus, and by the Kwakwala form in (68b), which contains a sonorant consonant in adjoined position:

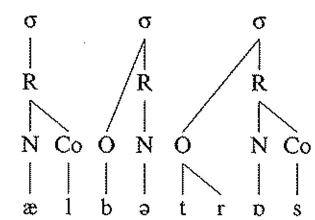
(68) a. b.


[26] As Harris (1994: 114) notes, 'to grant metrical processes access to melodic material . . . is to open the way for the generation of unattested systems in which stress assignment is sensitive to such dimensions as vowel height, backness or roundness'. However, it is not immediately clear whether there are *formal* grounds for allowing just those consonants which are [+sonorant] to occupy a nuclear position, even though it is clear that this is merely another aspect of the crucial role of sonority in syllabification.

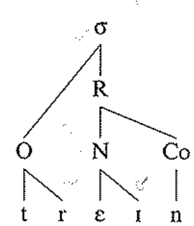
However, although (68b) is appropriate for Kwakwala rhymes containing a short vowel followed by a sonorant consonant, the corresponding Dutch sequence in *bel* /bɛl/ 'bubble' will have the structure in (69a), where the sonorant consonant is adjoined to N′ rather than to N. We find the same structure for a sequence of vowel and obstruent, in both Dutch, as for *bek* /bɛk/ 'mouth' in (69b), and Kwakwala (69c):

(69) a. b. c.


In what follows, we will employ a slightly simplified version of the representations that we have been using above. For clarity, we will return to the use of the labels σ and R, rather than N″ and N′. However, this is for convenience only; this relabelling does not affect the validity of the observations we have been making. In addition, our representations will not include the extra level of structure created by onset adjunction. Furthermore, we will not indicate the structure of complex onsets by the use of O′, but will simply use O alone. English *albatross* will therefore be represented as in (70):

(70)


and Dutch *trein* 'train' as in (71):

(71)


3.4.4 Extrasyllabicity and related matters

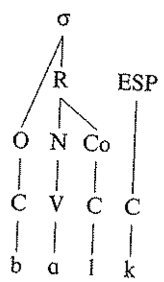
We have already seen that there are arguments for considering the prependix and appendix to be outside the syllable proper, so that we have now established a core syllable in which all constituents maximally display binary branching. However, as we anticipated earlier, there is a further set of arguments which suggest that even this simplified syllable structure can be further reduced.

These arguments concern consonants in the rhyme. We have already seen that peripheral final syllables allow appendices, which are primarily coronal, and whose presence typically violates the sonority sequencing generalisation. However, there is another set of 'extra' consonants in peripheral final syllables which we do not find in non-final syllables, as illustrated for Dutch in (72):

(72) a. *final syllables*
VCC balk /balk/ 'beam'
b. *non-final syllables*
VC balkon /balkɔn/ 'balcony'
VCC *balkpel

While the rhymes in final syllables of monomorphemic words can apparently contain VCC (72a), those in medial syllables cannot (with a few exceptions), as illustrated by (72b). In the acceptable form in (72b), *balkon*, the /k/ is syllabified in the onset of the second syllable, rather than in the rhyme of the first.[27] Notice that the final consonant in (72a) does not display the properties typical of appendices: it is not coronal, and the final cluster does not violate the sonority sequencing generalisation.

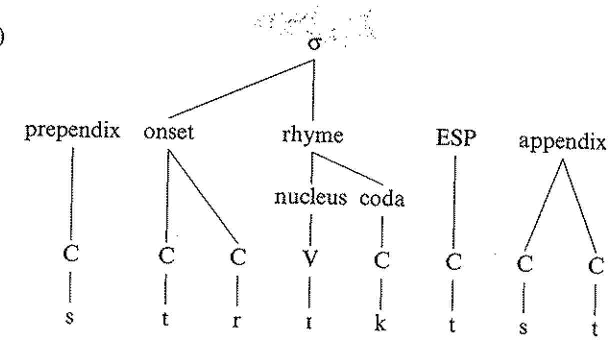
How can we give formal recognition to this observation? One common approach is to treat this extra consonant, like the appendix, as being outside the syllabic structure, i.e. as being **extrasyllabic**. Thus a word like Dutch *balk* might have the structure in (73), where the extrasyllabic consonant is indicated by ESP:

(73)


On this analysis, the core syllable is further reduced, to a structure with an optional onset, which may be branching, and a rhyme with an obligatory nucleus, which again may optionally branch, and may be followed by a single postnuclear consonant.

[27] Unsurprisingly, such sequences *are* permitted in compounds, such as *balkbrug* 'girder bridge'.

We have now arrived at the following structure for the core syllable and its various appendages:

(74)


As in the case of the appendix and the prependix, we have to consider where the extrasyllabic consonant belongs in the prosodic structure. We do not discuss this question at this point, but will return to it in §3.8, where we consider in detail an approach that regards what we have interpreted here as an extrasyllabic consonant as forming the onset of a further (incomplete) syllable.

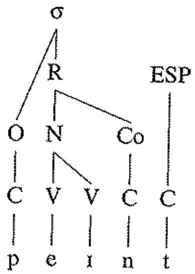
One category of rhyme which we have not yet considered is that involving a *branching* nucleus followed by two consonants (the second of which will be extrasyllabic, on the account just developed). Rhymes like these are found in English words such as *paint* /peɪnt/, *mild* /maɪld/ and *task* /tɑːsk/. Unsurprisingly, these rhymes are subject to severe restrictions – as well as occurring only peripherally in English, their composition is also restricted. Harris (1994: 77) notes, for example, that the coda consonant must be either a sonorant or a fricative, while what we have been calling the extrasyllabic consonant is nearly always coronal if the coda consonant is a sonorant. Furthermore, rhymes of this shape are very often lost in language change. For example, Lass (1984a: 257–8) notes that Old Icelandic, which had both long vowels and long consonants, permitted five rhyme structures in stressed syllables: VC, VVC, VCC, VV and what he calls 'overlong' or 'hypercharacterised' VVCC, as in (75) (the accent in the orthography denotes vowel length):

(75) a. fat /fat/ 'piece of clothing'
b. fát /faːt/ 'confusion'
c. fatt /fatː/ 'erect (NEUT)'
d. fá /faː/ 'to take'
e. fátt /faːtː/ 'few (NEUT)'

Later developments in most of the Scandinavian languages eliminated the overlong rhyme in (75e). Thus we find Swedish *fått* /fɔtː/, in which the vowel has shortened.

Syllables like these appear to have a structure containing three elements in the rhyme, as well as an extrasyllabic position, as shown in (76) for *paint*:

(76)



3.5 Mora theory

In our representation in (9) of the prosodic hierarchy, we observed that each constituent in the phonological phrase split into identical constituents at the immediately lower level, so that the phonological phrase consists of two phonological words, the phonological word consists of two feet, and the foot of two syllables. However, within the onset–rhyme theory of the syllable, the structure below the syllabic node no longer displays the property of splitting into identical daughter nodes – the syllable is made up of an onset and a rhyme, and the rhyme of a nucleus and a coda. This has been seen as a weakness in the onset–rhyme approach to syllable structure, especially in view of the fact that the distinction between heavy and light syllables has to be characterised as involving *either* branching of the nucleus *or* branching of the rhyme, rather than being given some uniform interpretation.

Alternative models have been proposed, in which attempts are made to provide a more direct characterisation of the notion of syllable weight. In one such approach, syllables are not divided into immediate constituents called onset and rhyme, but into 'weight units' or **moras**.[28] Light syllables contain only one mora (they are **monomoraic**); heavy syllables contain at least two (they are **bimoraic**). Thus in mora theory, unlike onset–rhyme theory, the immediate constituents of the syllable do belong to the same category: they are both moras.

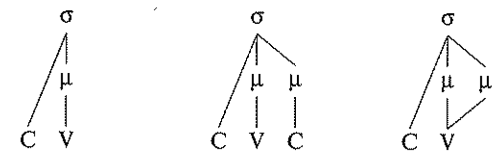
In this approach, each mora contains one segment which contributes to the weight of a syllable, possibly together with a number of segments which do not contribute to the weight. As noted above, heavy syllables have two moras, while light syllables have only one. Thus, in a rhyme-weight language, in which CVC syllables are heavy, the vowel and the final consonant will be assigned to distinct moras. As we have seen, however, initial consonants do

[28] See particularly Hyman (1985), Hock (1986), Hayes (1989a).

not contribute to the weight of a syllable, and so the first consonant in a CVC syllable will not belong to a separate mora. In some versions of mora theory, initial consonants are assigned to the first mora of a syllable, i.e. the mora dominating the vowel. More commonly, however, initial consonants, and in general any prevocalic material, are characterised as being associated directly to the syllable node, i.e. an initial consonant is 'extramoraic'. This characterises the fact that such material never contributes to syllable weight. The difference between light and heavy syllables in rhyme-weight languages in mora theory is shown in (77), where, following Hayes (1989a), we assume that initial consonants are extramoraic (cf. (41), where representations of rhyme-weight languages within onset–rhyme theory are given):

(77) *Rhyme-weight languages*

a. *light* b. *heavy* c. *heavy*

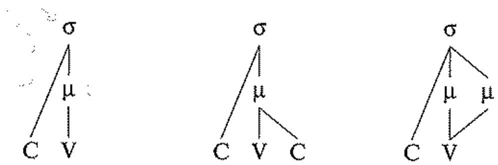


Here moras are represented as μ, and, as before, syllables as σ. In accordance with usual practice in mora theory, we assume that long vowels involve a single V specification, simultaneously associated with two moras, as in the case of the CVV syllable in (77c) (diphthongs would of course have two Vs, each associated with a mora).

In a nucleus-weight language, in which CVC syllables are light (cf. (42)), CVC syllables will be monomoraic, so that the final consonant does not associate with a separate mora, as in (78):

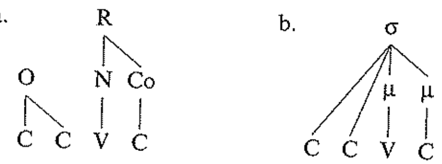
(78) *Nucleus-weight languages*

a. *light* b. *light* c. *heavy*



Although representations in mora theory look very different from those in onset–rhyme theory, there are perhaps more similarities than one might think at first sight. Both models are concerned with distinguishing 'weight-relevant' segments from those which do not affect syllable weight. In onset–rhyme theory, initial consonants form the onset, which is not relevant to weight, while in mora theory they can be seen as 'extramoraic'. The crucial difference is that this version of mora theory differs from onset–rhyme theory in not recognising an onset *constituent*:

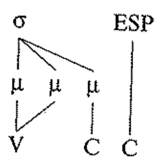
(79) a. b.



However, with respect to syllable-final consonants, as we have seen, the two models differ in a more obvious way. In mora theory, the number of moras determines whether a syllable is heavy or not, as can be seen in (77) and (78), where all heavy syllables have two moras and all light syllables one. In onset–rhyme theory, a heavy VC syllable in a rhyme-weight language (41) has exactly the same *structure* as a light VC syllable in a nucleus-weight language (42); the difference in weight does not follow from a difference in structure, but only by the setting of a parameter.

Overlong syllables, which, as we saw above, are typically peripheral, can be represented as trimoraic, as in (80):

(80)



where we assume that the second consonant is extrasyllabic.

A phenomenon which can be given a natural representation in mora theory is that referred to as **compensatory lengthening**. One such process involves the deletion of a consonant between a vowel and another consonant, with resulting compensatory lengthening of the vowel. An example is found in the early history of English and other Germanic dialects, where a postvocalic nasal was deleted before a fricative. This process is responsible for alternations within the paradigms of certain irregular verbs in English, e.g. *think* vs *thought*, as well as the differences between various Germanic languages shown in (81):

(81)

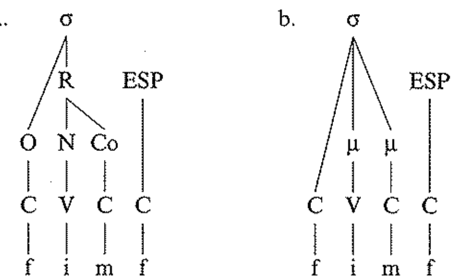
Modern German		*Modern Dutch*		*Modern English*	
fünf	/fynf/	vijf	/vɛif/	five	/faɪv/
Mund	/mund/	mond	/mɔnd/	mouth	/maʊθ/
Gans	/gans/	gans	/ɣans/	goose	/guːs/

Modern German, in which the vowel is short and the nasal has been retained, most closely represents the original situation, Modern English shows the

results of the loss of the nasal and the compensatory lengthening of the vowel, and Modern Dutch is hybrid with respect to this phenomenon.

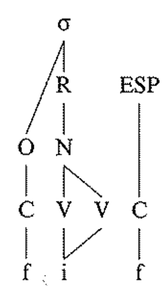
In onset–rhyme theory, compensatory lengthening is more difficult to express than in mora theory. In both theories, the nasal is deleted, but the number of segments in the rhyme remains unchanged. Consider (82)–(84), where we show what is involved in both theories in the change from Proto-Germanic **fimf* 'five' to **fīf*:

(82) a. b.



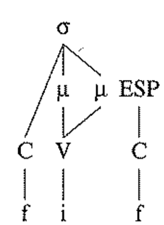
In onset–rhyme theory, as we have been presenting it up to now (but see §3.6 below), the nasal is delinked. Subsequently, the coda node is also delinked from the rhyme node, the C changes to a V, and becomes a daughter of the nucleus node, to give (83) (we ignore here the question of whether the extrasyllabic consonant can now be reassigned to the coda):

(83)



In mora theory, on the other hand, the process simply involves delinking of the nasal and the C node from the mora node, with reattachment of the mora node to the V node, as in (84):

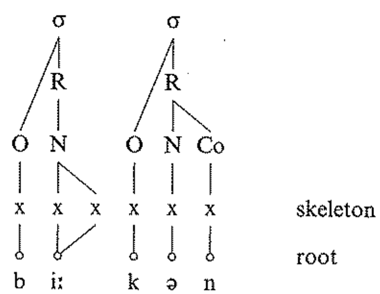
(84)



Certain of the advantages of the moraic account of this phenomenon can be countered in onset–rhyme theory by the introduction of a 'skeletal' tier, which we now consider in the context of the more general problem of the representation of segmental length, both consonantal and vocalic.

3.6 The representation of length

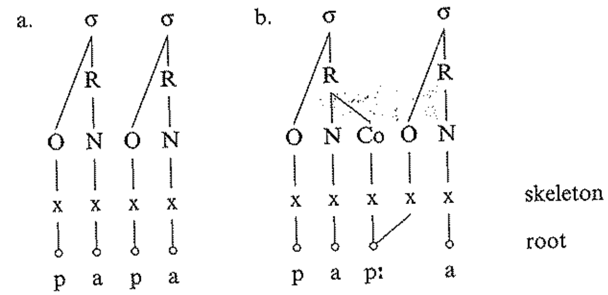
In our discussion of syllable structure we have been associating labels such as onset and rhyme or mora with C and V symbols functioning as abbreviations of segmental matrices (or, more correctly, feature trees such as (75) in Chapter 1). However, current approaches to phonological structure take a slightly different view of how this works. It is generally assumed that the **root** nodes of segments (see §1.4) associate to the 'terminal nodes' of the syllabic structure. In onset–rhyme theory these terminal elements are said to occupy a **skeleton** or **skeletal tier**. (85) gives a representation incorporating the skeleton for the English word *beacon* /biːkən/, where skeletal points are represented by 'x':

(85)


On this view, the representation of a long (or geminate) segment involves simply a single root node associated to two skeletal positions, whereas for short segments there is a one-to-one relationship between the skeleton and the root tier, as in (86):

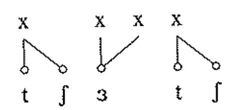
(86)


Such statements form part of a characterisation of the segment types allowed by an individual language. (86), then, characterises a language which makes a phonological distinction between long and short vowels. Exactly the same approach would characterise the phonemic contrast between long and short consonants in a language such as Italian, evidenced in minimal pairs such as *papa* /papa/ [papa] 'pope' and *pappa* /pappa/ [papːa] 'daddy':

(87)


Here the single root node is shared between two syllables; the geminate consonant /pː/ is simultaneously the coda of the first syllable and the onset of the second.

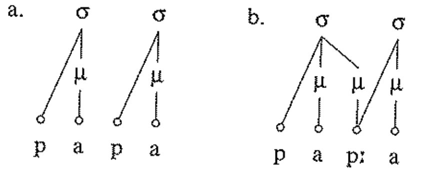
In addition to structures involving two skeletal positions associated to a single root node, the reverse is also found. Complex segments such as affricates (cf. §1.4) function as single segments with respect to the syllable, and therefore require only one skeletal position, but are segmentally complex. An affricate consists of a stop part and a fricative part, and therefore has two root nodes, so that *church* /ʧɜːʧ/ will have the representation in (88) (where we ignore the syllabic structure above the skeleton):

(88)


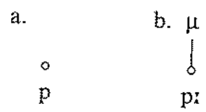
Underlying this account of skeletal positions, which originates with Clements and Keyser (1983), is the notion that skeletal positions are 'timing units' in the syllable. Because long monophthongs have the duration of two segments, they have two timing slots, but only one segmental tree – there is only a single articulation involved – while affricates show the reverse: they have the duration of a single segment, but involve two articulations.[29] For practical purposes, we can consider the notion of timing unit to be equivalent to that of 'segment'; the number of skeletal positions in a word is the same as the number of segments.

Do we also require a skeletal level of representation in moraic theory, or can moras be associated directly to the root node, as in (89), which would be the moraic equivalents of (87)?

[29] The analysis of complex segments is considerably more complicated than is here suggested. Although we have represented affricates as involving two distinct segmental trees, with two root nodes, van de Weijer argues that such two-rooted representations are more appropriate for consonants involving double articulations such as /p͡t/. Affricates, he suggests, involve complexity *within* the segmental tree, and contain both a [stop] and a [continuant] feature. For a discussion of these issues, see van de Weijer (1994).

(89)


Here the intervocalic geminate in (89b) is simultaneously associated to the second syllable node and to a mora dominated by the first syllable node. As such, it is formally distinct from a single intervocalic consonant, which is not immediately dominated by a mora. However, the lack of a skeletal tier in (89) raises the question of how geminate consonants might be distinguished lexically from single consonants in moraic theory. As we have seen, syllabic structure is not present lexically, but is assigned by rule on the basis of the factors discussed above, such as relative sonority. Thus, if geminate consonants have only a single root node in their representation, we must find some other means of distinguishing them underlyingly from single consonants. This might be achieved by assuming that a geminate consonant is always lexically associated with a mora; i.e. the difference between a geminate and a single consonant is the fact that the geminate always contributes to the weight of the syllable. The representation of the single consonant is shown in (90a) and that of the geminate in (b):

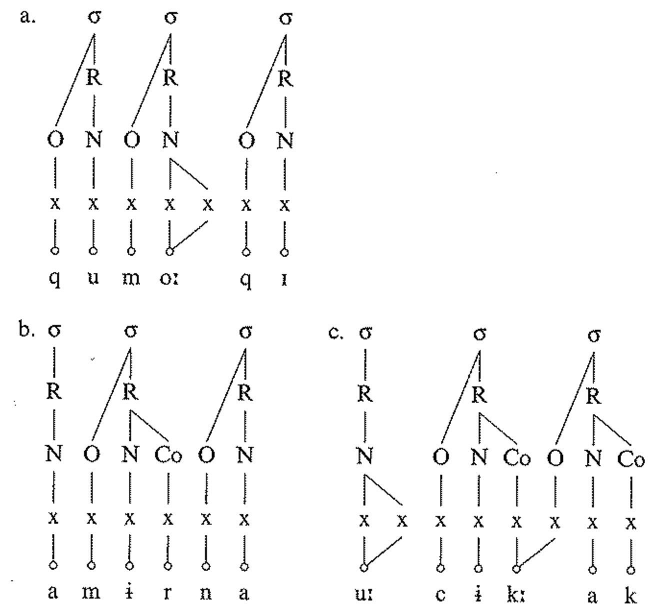
(90)


On this analysis, the presence of a geminate consonant means that the preceding syllable must be bimoraic. Therefore, as pointed out by Lahiri and Koreman (1988) and Tranel (1991), a syllable closed by a geminate should always be heavy. However, Tranel (1991) notes that in at least some cases, this prediction is not borne out. Consider again the nucleus-weight language Selkup (cf. (39)):

(91) a. quˈmoːqɪ 'two human beings'
b. ˈamɨrna 'eats'
c. ˈuːcɨkkak 'I am working'

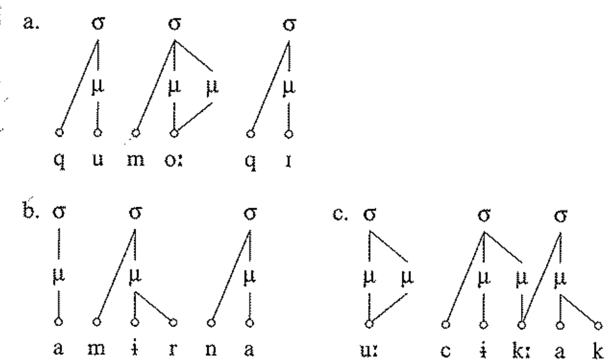
Stress in Selkup falls on the last heavy syllable, where VV but not VC counts as heavy, or on the first syllable of the word. Thus stress in (91a) falls on the penultimate, which is heavy, but in (b) on the antepenultimate, as the penultimate contains VC, and is therefore light. (91c), which contains a geminate consonant, behaves like (b) in having antepenultimate stress; the syllable

containing the geminate must therefore be light. This is not a problem for onset–rhyme theory, where, as shown in (92), (b) and (c) share the same structure:

(92)


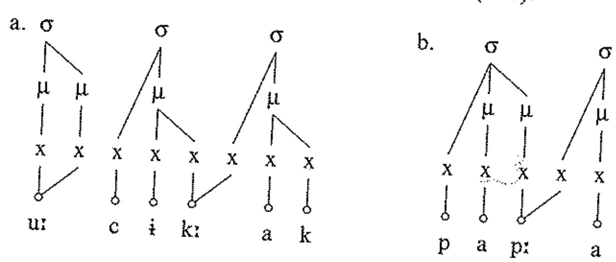
The /r/ in /amɨrna/ has the same status with respect to the skeleton (coda of the second syllable) as the first part of the geminate /k/ in /uːcɨkkak/, and so neither contributes to the weight of the syllable. In other words, as we might expect, both count as VC rhymes.

A representation in terms of mora theory which does not incorporate a skeletal tier appears to be unable to characterise /amɨrna/ as having the same structure as /uːcɨkkak/, as shown in (93):

(93)


In the absence of the skeleton, the penultimate syllable of (93c) is now wrongly characterised as having the same moraic structure as that of (a), and so is incorrectly predicted to take stress on the penultimate.

Thus, like onset–rhyme theory, mora theory apparently needs to incorporate skeletal positions in syllabic representations, so that geminates will have one of the representations in (94), rather than that in (89b):

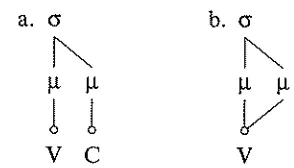
(94)


Whether or not the left half of the geminate contributes to weight is determined by whether the language in question treats VC as light or heavy. Selkup (94a) treats VC as light, so that although /kː/ occupies two skeletal positions, its first position does not project a mora, as opposed to Italian (94b), where the first position of /pː/ does. In general, whether or not a coda contributes to weight is determined by what is often referred to as the 'weight by position' rule, i.e. 'the rule or principle of syllabification that assigns a mora to a postvocalic consonant within the syllable' (Hayes 1995: 52). On this account, then, a rhyme closed by a geminate behaves in exactly the same way as one closed by a consonant cluster, and so geminates need bear no special marking in the lexicon.

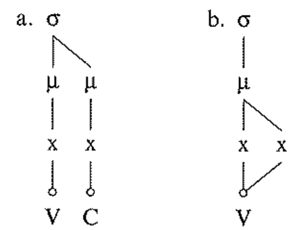
A similar problem for mora theory is identified by Lahiri and Koreman (1988), in their account of the stress system of Dutch. They consider Dutch to have a contrast between long and short vowels, i.e. to have a quantitative distinction in the vowel system, rather than between tense and lax vowels (a qualitative distinction; cf. the discussion in §1.3.3 above). Long vowels occur in open syllables only (except word-finally, where there may be a closing consonant), while short vowels can only occur in closed syllables. Thus, in onset–rhyme theory, we have two types of rhyme, VV and VC. As we saw in §3.4.1, stress in Dutch is weight-sensitive, but, contrary to the expected pattern, VC syllables are heavy and VV syllables are light, as illustrated by the forms in (95), where the target syllable for stress is the penultimate:

(95)	a.	[deːˈtɛktɔr]	detector	'detector'
		[wɪlˈhɛlmus]	Wilhelmus	(name)
	b.	[ˈmoːniːtɔr]	monitor	'monitor'
		[ˈfɛstiːvɑl]	festival	'festival'

The VV penultimate syllables in (95b) reject stress, which shifts to the antepenultimate. Lahiri and Koreman point out that this state of affairs is inexpressible if mora theory does no incorporate a skeleton, since long vowels are represented as bimoraic. The heaviness of closed syllables is in itself unproblematical (weight by position), but there is no way of characterising these as heavy while at the same time excluding VV:

(96)


Lahiri and Koreman propose that for Dutch, as in the case of Selkup above, we need to incorporate the skeleton in mora theory, such that Dutch long vowels are monomoraic, but are associated with two skeletal positions:

(97)


Selkirk would argue that x ≠ σ in Sugar fluency

It seems, then, that there is a body of evidence to suggest that syllable structure must incorporate a skeletal tier, both in onset–rhyme theory and in mora theory.

3.7 The independence of syllabic positions

We have been assuming that syllable structure is assigned to the strings of root nodes which are underlyingly present, although in specific cases, such as the representation of long vowels and complex segments, some syllabification information must be specified underlyingly, as we saw in §3.5. Lexically, then, we have strings of segmental trees without any syllabic organisation. The creation of syllabic structure presupposes the existence of segmental structure.

However, there are various phenomena in the languages of the world which suggest that syllabification and syllable structure are not as straightforward as this might suggest. Thus we find cases in which segmental material appears to be underlyingly present, but is only realised if it finds itself in an appropriate position in the syllabic structure. One frequently discussed case involves the realisation of /r/ in English.

3.7.1 /r/ in English

We can distinguish three different groups of 'dialects' of English as far as the behaviour of 'final' *r* is concerned. Let us refer to these as the 'fully rhotic' dialects, the 'fully non-rhotic' dialects and the 'intrusive [r]' dialects.[30] The fully rhotic dialects, such as Scots, realise postvocalic /r/ under all circumstances:

(98)	rotor	[rotər]
	queer	[kwiːr]
	queerer	[kwiːrər]
	hurry	[hʌrɪ][31]

Fully non-rhotic dialects, such as some varieties of RP, only realise /r/ if it can be syllabified into the onset of a following syllable, as in (99):[32]

(99)	rotor	[ɹəutə]
	queer	[kwɪə]
	queerer	[kwɪəɹə]
	hurry	[hʌɹɪ]

Thus the initial /r/ in *rotor* is realised, but the final one is not, while the intervocalic /r/ in *queerer* and *hurry* is syllabified into the onset of the second syllable, and so is realised (cf. *queer*, where the /r/ does not surface). Notice that the presence of a word boundary does not inhibit the realisation of the /r/, as shown by a phrase such as *queer and quaint* [kwɪəɹəŋkweɪnt]. /r/ realised in this context is said to be 'linking'.

The third group, the 'intrusive [r]' dialects, have the same realisations as in (99), but also realise [ɹ] in a further context. Thus 'fully non-rhotic' RP speakers have linking [ɹ] only in contexts in which there is an <r> in the orthography, while 'intrusive [r]' speakers insert the consonant between *any* vowel-final word[33] and a following vowel-initial word (i.e. when two vowels are in hiatus), irrespective of the orthography, giving pronunciations such as [kɒməɹəŋkəulən] for *comma and colon*, which for speakers of 'fully non-rhotic' dialects, would be [kɒməəŋkəulən], without the [ɹ].

In the 'intrusive' dialect, the insertion of the [ɹ] is totally predictable from the phonetic context, and so we do not have to specify it underlyingly. Rather, we simply require a rule which forbids empty onsets intervocalically in foot-

[30] This division is a simplification of the actual situation, but will serve to illustrate the point we wish to make here. Unsurprisingly, many speakers fall between the dialects identified above. For a discussion of the dialect situation in English, see Wells (1982).

[31] We are not concerned here with the phonetic details of the realisation in Scots English of /r/, which may vary from a trilled [r] through an alveolar tap [ɾ] to some kind of approximant [ɹ] or [ɻ], depending partly on its position in the word (see Wells 1982: 410–11). The only relevant factor here is whether or not the consonant is present phonetically.

[32] RP /r/ is realised as [ɹ] in all relevant contexts.

[33] The word-final vowel must not be high, however, and for some speakers can only be low.

internal position; if there is no segmental material available, then [ɹ] is inserted. In this case, then, syllabic structure is at least partly independent of segmental material, to the extent that each syllable *must* have an onset.

Fully non-rhotic speakers, on the other hand, must have different underlying representations for words which yield linking [ɹ] and those which do not. Thus, although *comma* [kɒmə] and *bomber* [bɒmə] have the same shape in isolation, the speaker must 'know' that *comma and colon* has no [ɹ], while *bomber and fighter* [bɒməɹənfaɪtə] does. Thus we must assume that *bomber* has an underlying /r/, to give /bɒmər/. 'Intrusive [r]' speakers, however, treat the two forms identically, and therefore can have identical underlying representations, i.e. /kɒmə/ and /bɒmə/.

How, then, does syllabification operate for speakers of the fully non-rhotic dialects, who apparently have underlying /r/ which is not realised in final position, as in [bɒmə] from underlying /bɒmər/? We return to this after our discussion of a related phenomenon, liaison in French.

3.7.2 Liaison

French displays two phenomena, liaison and *h-aspiré*, which have interesting repercussions for our analysis of syllable structure. We consider first liaison.[34]

In some respects, liaison is very similar to the linking-[ɹ] phenomenon of RP English. Both result from the loss of word-final consonants at an earlier stage of the language. We find Modern French forms such as those in (100), which, reflecting the earlier pronunciation, have a final consonant in the orthographic representations, which, however, is no longer realised phonetically:

(100)	petit	[pəti]	'small'
	gros	[gʀo]	'large'
	un	[ɛ̃]	'one, a'

In these words, the final consonant is not realised phonetically at the end of a phrase or if it is followed by a word beginning with a consonant, as in (101a). However, if the consonant is followed by a vowel-initial or glide-initial word, it *is* realised (101b):

(101)	a.	petit livre	[pəti livʀ]	'small book'
		gros camion	[gʀo kamjɔ̃]	'large truck'
		un pouce	[ɛ̃ pus]	'a thumb'
	b.	petit ami	[pətit ami]	'small friend'
		petit oiseau	[pətit wazo]	'small bird'
		gros arbre	[gʀoz aʀbʀ]	'large tree'
		un enfant	[ɛ̃n ɑ̃fɑ̃]	'a child'

[34] For a full discussion of liaison, see Tranel (1987: ch. 11). See also Selkirk (1972), Clements and Keyser (1983).

The realisation of the final consonant in some contexts (preceding vowels and glides) is the phenomenon referred to as liaison. Unlike linking [ɹ] in RP, a range of consonants is involved in liaison, as illustrated above for [t], [z] and [n]. Whether or not liaison actually occurs in the appropriate phonetic context is governed by a number of factors which need not concern us here, but which are morphological, syntactic and stylistic in nature (see Tranel 1987).

How can we account for liaison in a theory of syllable structure? Notice first of all that, whatever our treatment of [ɹ]-insertion in fully non-rhotic dialects of RP, our account for liaison must be different; there is no way of predicting – from the phonetic context alone – which consonant will be realised. For example, there is nothing in the phonetic context to lead us to expect [t] in [pətit wazo] 'small bird', but [z] in [groz wazo] 'big birds'. Rather, we must propose an account in which the final consonant is initially present, but is deleted in the appropriate context.

If the facts of liaison were as straightforward as we have just suggested, this would be as far as we would need to go. We would simply say that the phonological form of *petit* was /pətit/ and that of *gros* /groz/, and that French had a rule which deleted final consonants in the appropriate environments. However, the facts are considerably more complex.

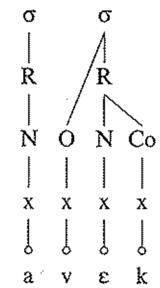
Notice first that not *all* consonants in French can serve as linking consonants in liaison. By far the most common are those in (101), i.e. the coronals [t n z], with [ʀ p g] also being found in a restricted number of cases (e.g. *au premier étage* [ɔpʀømjɛʀetaʒ] 'on the first floor', *beaucoup aimé* [bokupɛme] 'much loved', *un long été* [ɛ̃lɔ̃gete] 'a long summer'). Other consonants are not found in liaison processes. More importantly – indeed, crucially for rejecting the idea that French has a rule deleting 'final' consonants in general – there are many words in which final consonants *are* realised, as shown in (102):

(102)	a.	cher garçon	[ʃɛʀ gaʀsɔ̃]	'dear boy'
		cher livre	[ʃɛʀ livʀ]	'dear book'
		avec ça	[avɛk sa]	'with that'
	b.	cher ami	[ʃɛʀ ami]	'dear friend'
		cher oiseau	[ʃɛʀ wazo]	'dear bird'
		avec eux	[avɛk ø]	'with them'

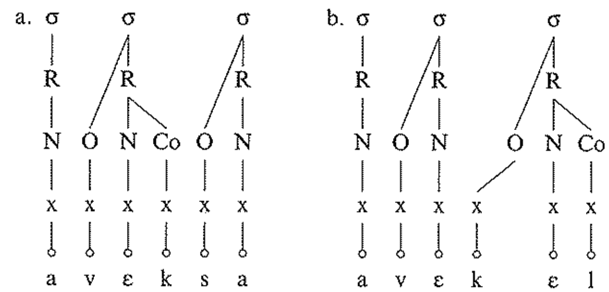
These consonants are not deleted under any circumstances; they behave like the liaison consonants in surfacing before vowels and glides (102b), but, unlike them, also before consonants (102a). Clements and Keyser note 'minimal' pairs such as *donc* 'therefore', which is always [dɔ̃k], and *dont* 'whose', which is [dɔ̃t] in liaison contexts, but [dɔ̃] elsewhere. We must therefore distinguish

between the two types of consonants in our phonological representation, to ensure that liaison only affects the relevant set of words in French.

Let us assume for the moment that the liaison facts force us to say that phonological sequences are underlyingly syllabified in French. On this assumption, the final consonant of non-alternating words such as *avec* and *donc* will, as in the regular case, be syllabified in the rhyme, as in (103):

(103)


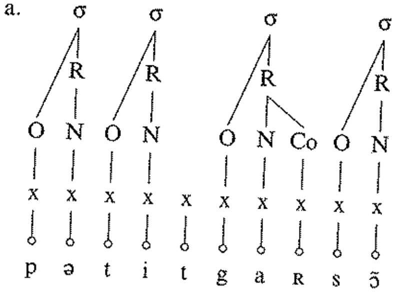
The final consonant will be phonetically realised even if the onset of the following syllable is not empty, as in (104a), *avec ça*:

(104)


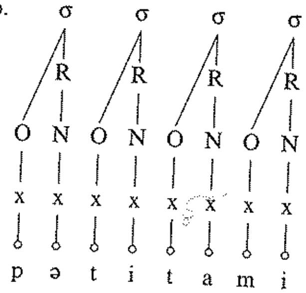
In (104b), *avec elle*, the final consonant 'resyllabifies' phonetically to allow the empty onset to be filled, giving [a.vɛ.kɛl], where we denote syllable boundaries with a dot. This again demonstrates the relevance of the Maximal Onset Principle (cf. §3.2); even though the final /k/ is first syllabified in the rhyme, on this analysis it shifts to the following onset when possible, even if that onset belongs to a different word. In general, French seems to avoids empty onsets within the phonological phrase – i.e. the domain of syllabification in French is the phonological phrase.

How do we prevent liaison consonants from being realised when they are followed by a consonant, while ensuring that they are realised when a vowel follows? We assume the following *surface* representations for *petit garçon* and *petit ami*:

(105) a.



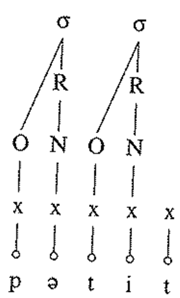
b.



In (105a) the final /t/ of *petit* is not associated to any syllabic constituent, while in (b) it forms the onset of the third syllable of the sequence. Thus, on the surface, the final consonant is only syllabified, and therefore realised, if the following onset is empty.

What, then, is the *underlying* representation of a word like *petit*? Recall that we must be able to identify the segmental content of the consonant, as we need to know how it surfaces in liaison contexts. One possible strategy would be to say that the underlying representations directly encode whether a final consonant is incorporated in the syllabic structure of a word, so that the final /t/ of *petit* is underlyingly not syllabified, as in (106):[35]

(106)

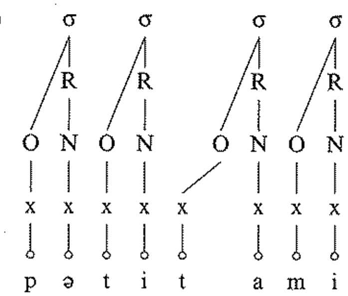


[35] We are assuming here that the linear order of segments is determined by the ordering of skeletal positions. This means that the root node of the final consonant is associated to a skeletal position – otherwise it would not be ordered with respect to the other elements in the string.

Contrast this with the representation for *avec* in (103), where the final consonant *is* underlyingly syllabified. Thus the skeletal position of the final consonant in *petit* is not dominated by any node. In the case of *petit garçon*, the /t/ remains unsyllabified, and is therefore not realised phonetically – it does not form part of the syllabic structure. In other words, the /t/ is not **licensed** in this word. The concept of licensing is used in determining whether or not a particular segment can be phonetically realised; in this case there is no node available in the syllabic structure to which the final underlying /t/ of *petit* can associate, and so it is phonetically not present.[36]

However, underlyingly unsyllabified consonants in French can be 'rescued' by the presence of a following onsetless syllable. Because a word like *ami* has no onset, and, as we have seen, French avoids empty onsets where possible within the phonological phrase, the lack of an onset licenses the final /t/ of *petit* in *petit ami*, giving the surface representation in (107):

(107)



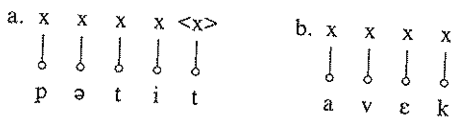
The final /t/ of *petit* is now associated to the empty onset of the first syllable of *ami*.

However, the account of liaison which we have just given, although adequate in the sense that the correct phonetic representations can be generated, is bedevilled by a problem. As we have already seen in this chapter (§3.4.3), syllabification is normally predictable from the linear order of segments. Our rules of onset, rhyme and nucleus formation were meant to reflect this. It seems undesirable to abandon this claim – which is seen as being generally true of languages – merely to account for one type of phenomenon in a particular language. Furthermore, the analysis we have given does not identify the appropriate category of segments as being 'abnormal'. In general in languages, as we have seen, segments are underlyingly not syllabified, and are, of course, phonetically realised. However, in the analysis we have given, the 'normal' category, i.e. the fixed final consonant in a word such as *avec*, is syllabified underlyingly, while the 'exceptional' category, a final consonant

[36] See for discussions of licensing Itô (1986), Goldsmith (1990).

undergoing liaison, for example the [t] in *petit*, is underlyingly not syllabified. Clearly, then, the account we have given is not optimal.

An alternative analysis is available, however, one which makes use of a concept similar to that of extrasyllabicity, which we introduced in §3.4.4. In this analysis, final liaison consonants are simply marked in the lexicon as being extrasyllabic, i.e. as being 'invisible' to the normal syllabification algorithm of French:

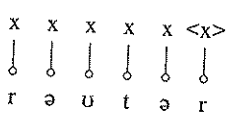
(108) 

where extrasyllabicity is denoted by < >.

Notice that the motivation for marking liaison consonants as extrasyllabic is different from the cases which we considered earlier in §3.4.4 with respect to extrasyllabicity. There we found that a consonant was extrasyllabic because its presence violated the constraints on syllable structure in the language in question. Here, however, there is no such violation involved: the pronunciation [pətit] would be well formed in French even if no empty onset followed (and, indeed, is a possible realisation of the feminine form *petite*, as in *la petite bonne* [lapətitbɔn]). Rather, it is an idiosyncratic fact about the set of words with liaison consonants that these consonants behave as if they were invisible for syllabification, and so it is appropriate to mark just these consonants as being exceptional. < > in (108) can therefore be viewed as a diacritic marker whose presence is not predictable from any phonological aspect of the segment involved.

We assume that the extrasyllabicity marking is not visible at the phonetic level when the final consonant is licensed by a following vowel-initial word, so that, as before, the final /t/ of *petit*, for example, can associate to the empty onset of *ami*.

The extrasyllabicity analysis also appears appropriate for 'fully non-rhotic' speakers of RP English, i.e. those who display linking [ɹ], but not intrusive [ɹ]. For these speakers, the final /r/ can be marked as extrasyllabic, being realised only when the following onset is empty, so that the underlying representation of *rotor* will be:

(109) 

3.7.3 *h-aspiré*

French displays another phenomenon relevant to the relationship between segments and syllabic structure, involving words beginning with what is normally referred to as an *h-aspiré*.

We have already seen that vowel-initial words in French trigger liaison; they are also involved in a number of other phenomena, such as the loss of the vowel in the definite article. Compare the consonant-initial words in (110a) with the vowel-initial and glide-initial words in (b):

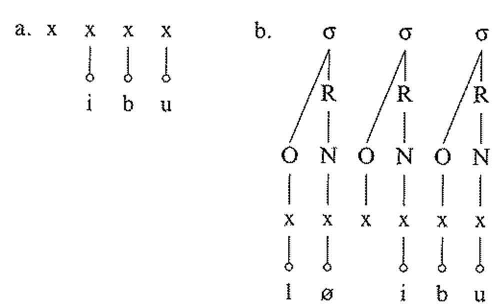
(110)	a.	le pouce	[lø pus]	'the thumb'
		la main	[la mɛ̃]	'the hand'
	b.	l'arbre	[laʀbʀ]	'the tree'
		l'étoile	[letwal]	'the star'
		l'oiseau	[lwazo]	'the bird'

It would appear that the vowel is elided in the same environment as that in which liaison is triggered. However, consider the forms in (111), all with an initial orthographic *h*:

(111)	a.	le hibou	[lø ibu]	'the owl'
		la hache	[la aʃ]	'the axe'
	b.	l'hirondelle	[liʀɔ̃dɛl]	'the swallow'
		l'humidité	[lymidite]	'the humidity'

The vowel-initial words in (111b) behave as we would expect from (110b); they trigger elision of the vowel in the definite article. However, those in (a), although also pronounced with an initial vowel (e.g. [ibu]), are resistant to the processes which normally affect vowel-initial words. The forms in (a) are the *h-aspiré* words.

In the case of *h-aspiré* words, we appear to have an initial consonant, which, although it is never realised phonetically, is nevertheless in some sense 'present' on the surface, in order to block elision from applying. Rather than having a consonant which is fully specified but unsyllabified, as in the case of liaison consonants, then, we have a skeletal position which is underlyingly present, but has no segmental content, as in (112a), and is therefore syllabified, as in (112b), the representation for *le hibou*:

(112) 

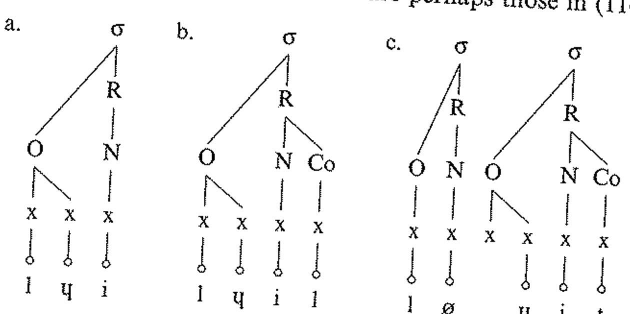
The onset of the first syllable of *hibou* is associated to a skeletal position, and so, for the purposes of elision, the word has an onset, thus preventing loss of the vowel. On the other hand, a word like *hirondelle* has no onset, like 'normal' vowel-initial words, and so elision is triggered.

Interestingly, there are a few vowel-initial words without orthographic *h* (113a) which also behave like *h-aspiré* words, as well as a number of glide-initial items ((113c); cf. the forms in (b), which permit elision):

(113)	a.	le onze août	[lø ɔ̃z u]	'August 11th'
	b.	l'oiseau	[lwazo]	'the bird'
		l'huile	[lɥil]	'the oil'
	c.	le yaourt	[lø jauʀt]	'the yoghurt'
		le huit avril	[lø ɥit avʀil]	'April 8th'
		le ouistiti	[lø wistiti]	'the marmoset'

The form in (113a), *onze*, must be treated like *hibou* in (111a), i.e. with a segmentally empty syllabic position. Those in (113c) apparently treat the initial glide as being a consonant, and so elision is blocked. However, in (113b), the surface glide does not block elision.[37] This means either that we must consider the glide to be syllabified not in the onset, but in the nucleus (this is the solution adopted by Tranel 1987: 174), or that we should allow complex onsets when the second element is a glide. French does in fact allow such onsets within morphemes (e.g. *lui* [lɥi] 'him', *loi* [lwɑ] 'law'), and so the best surface representations of the various forms are perhaps those in (114):

(114)



In (a) and (b) the semi-vowel [ɥ] is part of the complex onset whose head is [l], which is underlyingly present in (a) and becomes part of the onset in (b) as a result of elision. In (c), on the other hand, elision is blocked because the underlyingly complex onset has a head, which, however, has no segmental content (cf. *hibou* in (111a)).

By and large, liaison and *h-aspiré* interact in the expected way, such that words with *h-aspiré* block liaison, to give *petit hibou* [pəti ibu] 'small owl', for

[37] Notice that there do not appear to be examples of /j/-initial words which permit elision.

example.[38] Because the onset of the first syllable of *hibou* is associated to a skeletal position, the final unsyllabified /t/ of *petit* cannot be associated to it (liaison in French cannot form complex onsets, unless the second element is a glide, as discussed above – cf. *petit rêve* *[pətitʀɛv] 'small dream' – rather, its function is to prevent onsetless syllables). Because this onset is not associated to any segmental material, it too cannot be realised. On the other hand, *petit hymne* 'small hymn' will behave just like *petit ami* 'small friend' ([pətitimn] and [pətitami]); there is no skeletal position associated to the onset of *hymne*, which is underlyingly vowel-initial, like *ami*.

3.7.4 Compensatory lengthening and related processes

We turn now to a slightly different type of phenomenon, but again one in which we can make appeal to the concept of empty syllabic positions. A common type of argument for having a particular tier in phonological representation involves its independence from other aspects of the phonological structure. In particular, we can identify phenomena involving **stability effects**, in which some aspect of a segment is deleted, while some other aspect is apparently still present in the phonological representation. In such cases, the two aspects involved form independent parts of the structure. Thus, we saw in §1.4 with respect to tonal representations that there are cases where tone-bearing units are deleted, but the tones to which they were associated are 'left behind', and associate to a neighbouring tone-bearing unit. Tone is therefore appropriately represented on a separate tier.

Similar phenomena can be found to support the view that skeletal positions are elements on a distinct phonological tier. One such phenomenon involves compensatory lengthening, an example of which we introduced in §3.5. The term is used to describe the lengthening of a segment to preserve the number of elements on the skeletal tier, generally when some process has operated – or sometimes has failed to operate – in order to associate segmental material by other means to the skeletal node in question.

One such case, from Tiberian Hebrew, is cited by Lowenstamm and Kaye (1986: 104). Consider the nouns in (115):

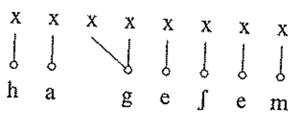
(115)	a.	seefer	'book'
		geʃem	'rain'
	b.	ʔiiʃ	'man'
		ʕaam	'people'
		haar	'mountain'

[38] Here, as elsewhere, we are ignoring various other optional phonetic processes, such as the one which typically deletes the schwa in *petit*, giving, for example, [pti ibu].

Tiberian Hebrew has a process in which the definite article /ha/ is attached to the beginning of the noun. When this happens, the initial consonant of the noun normally becomes a geminate, as in (116):

(116) hasseefer 'the book'
haggeʃem 'the rain'

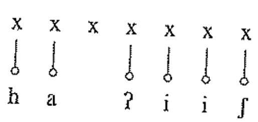
In (117) we provide a representation with both the skeletal and the root tier for [haggeʃem]:

(117)


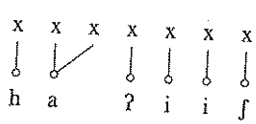
However, the forms in (115b) behave differently. The initial consonants in these words form part of a set, /ʔ ʕ h r ħ/, which never geminate in Hebrew. We might expect, then, that the article would simply be attached to the noun, with no further change, to give [haʔiiʃ] and [hahaar], for example. However, the actual forms are:

(118) haaʔiiʃ 'the man'
haaʕaam 'the people'
haahaar 'the mountain'

in which the vowel of the definite article is lengthened, rather than the initial consonant of the noun. We can attribute this to the fact that the process in question demands a 'template' in which there must be three skeletal slots preceding the noun. This demand is normally satisfied by the gemination of the initial consonant; however, if that consonant belongs to the set which cannot undergo gemination, one skeletal slot is left without segmental content, as in (119):

(119)


To satisfy the template, compensatory lengthening of the vowel takes place, by associating the vowel to the empty skeletal position:

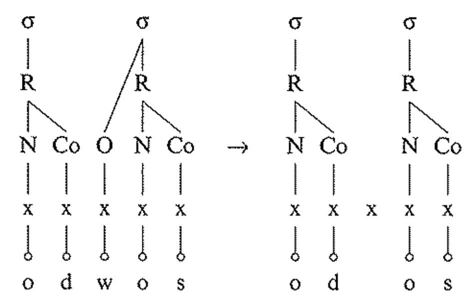
(120)


Phenomena like these suggest that syllabic positions can exist (albeit in this case temporarily) without segmental information, and provide strong evidence for assuming that syllabic positions form an independent part of phonological representation.

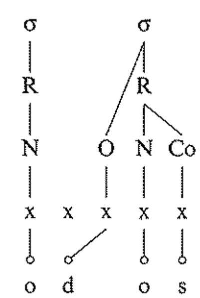
Other examples of compensatory lengthening display a more complex state of affairs. For example, Steriade (1982) and Wetzels (1986) discuss compensatory lengthening in the East Ionic dialect of Ancient Greek, in which a postconsonantal /w/ was lost, with concomitant lengthening of a vowel:

(121) odwos > oːdos 'threshold'
kalwos > kaːlos 'beautiful'
ksenwos > kseːnos 'stranger'

The deleted /w/ in (121) is not adjacent to the vowel which lengthens. Deletion of /w/ is shown in (122):

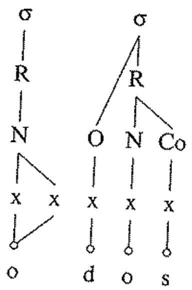
(122)


After the deletion of /w/ the second syllable becomes onsetless. To provide an onset for this syllable, the preceding consonant moves from final position of the first syllable into the onset position of the second syllable:

(123)


This in turn triggers compensatory lengthening of the vowel, as in (124):

(124)



The skeletal positions again behave independently from the content of the segment, thus justifying their presence in the syllabic structure.

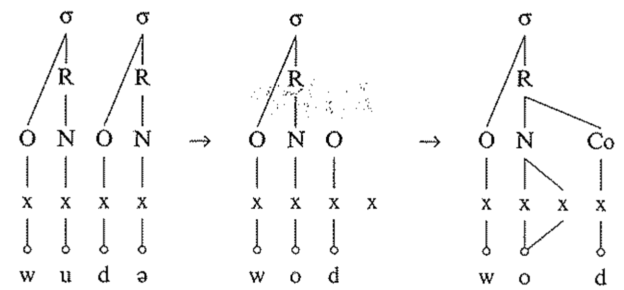
Such compensatory processes also appear to be relevant to sequences larger than the syllable. Although these are strictly speaking outwith the domain of this chapter, we devote some space to a consideration of some relevant examples here. One such involves a process in the history of English known as Middle English Open Syllable Lengthening (MEOSL). MEOSL, as the name suggests, is traditionally viewed as involving the lengthening of a vowel in an open syllable, i.e. in a stressed syllable followed by a single consonant followed by a vowel, i.e. schwa. Examples are given in (125) (from Lass 1992: 48):

(125)	/wikə/	> [weːkə]	'week'
	/wudə/	> [woːdə]	'wood'
	/berə/	> [bɛːrə]	'to bear'
	/nosə/	> [nɔːzə]	'nose'
	/samə/	> [saːmə]	'same'

The traditional interpretation appears to have nothing to do with the notion of compensation – nothing is lost as a result of the change in (125). However, one view of the change, first proposed by Minkova (1991), is that the lengthening is not triggered by the fact that the vowel is in an open syllable, but rather by the loss of the final schwa.[39] In other words, the equivalence is not between, for example, [wudə] and [woːdə], but between [wudə] and [woːd]. On this interpretation, the lengthening of the first vowel compensates for the loss of the second. This can again be argued to be the result of pressure to maintain the number of elements on the skeletal tier: a sequence of two syllables with short vowels is in some sense equivalent to a single syllable with a long vowel, or, alternatively, two light syllables are here treated as having the same weight as one heavy. The process can be characterised as in (126):

[39] But see for arguments against this reinterpretation, Lahiri and Dresher (ms).

(126)

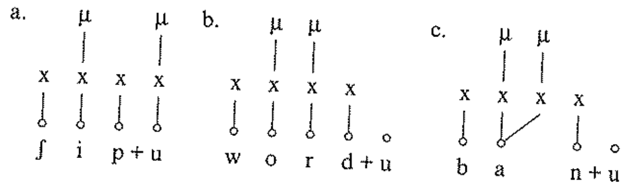


A similar account could be proposed to explain the different realisations of the diminutive morpheme in Dutch following a noun ending in a sonorant consonant. Recall from §1.3.1 that following a monosyllabic noun with a rhyme consisting of a long vowel followed by a sonorant consonant, such as *maan* /maːn/ 'moon', the form of the diminutive suffix is [tjə], but if the vowel is short, as in *man* /mɑn/ 'man', a vowel is inserted, to give [mɑnətjə]. As in the case of MEOSL, this can be viewed as compensatory, although in this case we are dealing with compensatory epenthesis rather than compensatory lengthening. In both cases, though, there appears to be a **template** defined in terms of elements on the skeletal tier which has to be satisfied by associating segmental material with all the skeletal elements.

Similar factors can be involved in the deletion of segmental material. For example, in the history of English, a process known as High Vowel Deletion deletes the vowels /i/ and /u/ when they follow a heavy syllable (VC, VV) but not a light syllable (V) (see Lass 1984a: §4.3.2). This leads to Old English forms like those in (127) (vowel length is indicated by a macron):

(127)		*singular*	*plural*	
	a.	scip	scipu	'ship'
		lim	limu	'limb'
	b.	word	word	'word'
		land	land	'land'
		bān	bān	'bone'
		sweord	sweord	'sword'

These nouns all belong to the same class, the *a*-stem neuter nouns, and would be expected to form their plural in the same way, i.e. by suffixation of /u/. However, /u/ can only be attached to a light syllable (a), while a heavy syllable (b) rejects the suffix. It appears then that, just as in the case of diminutive formation in Dutch, this morphological process places a constraint on the output. In terms of the skeletal tier, only three slots are permitted in the relevant part of the plural template. In moraic terms, these slots are dominated by two moras. If all the slots are already filled by the segmental material from the stem, the suffix cannot surface; otherwise, it does:

(128)


If the suffix cannot be attached to a skeletal position, it is simply not realised.

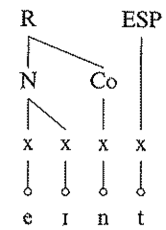
3.8 Licensing and government

In (74) we proposed a structure for the syllable which consisted of the 'core' syllable (made up of the onset, rhyme, nucleus and coda) and a number of optional constituents: a prependix, an extrasyllabic position and an appendix. We observed that although this appears to be a highly complex structure, this complexity was largely due to the fact that languages allow a far greater range of possibilities at word edges than they do word-internally. Thus extra consonants can occur at the left or right periphery of words, leading to initial and final clusters that we do not find word-internally as syllable-initial or syllable-final clusters, respectively. However, we have not yet discussed the exact status of the constituents which we have identified as falling outside the core syllable, 'what they are' and how they are integrated into the prosodic structure.

It is obviously desirable to have a theory of syllable structure in which the number of possibilities is restricted as far as possible, consistent with what we actually find. Our representation in (74) is an attempt to do this, in that what does not form part of the core syllable is viewed as having a peripheral status in the syllable. Let us continue this approach by considering what the maximal complexity of the constituents within the core syllable might be.

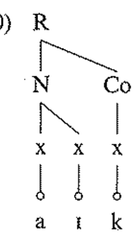
Recall that in the analysis discussed above the onset constituent within the core syllable is maximally binary – in an apparent three-consonant onset, the first consonant is assigned to a prependix outside the core syllable. However, the rhyme constituent does not appear at first sight to display this property; the existence of what are sometimes referred to as **superheavy** (VVC) rhymes, as in English *pike*, suggests that both the rhyme node and its daughter, the nucleus, can branch in the same syllable. This is confirmed by the fact that we also find VVCC sequences, as in English *paint*; we saw in (76) that the /t/

occupies an extrasyllabic position, but that it seemed appropriate to syllabify the /n/ within the rhyme, yielding (129):

(129)


Nevertheless, some phonologists have claimed that even this structure should not be permitted within the syllable. Rather, on this view *all* syllabic constituents are maximally binary, so that a branching nucleus cannot be followed by a coda consonant. This claim is particularly associated with an approach to syllable structure that we discuss in this section, an approach usually referred to as **government phonology** (e.g. Kaye *et al.* 1985, 1990; Charette 1991; Harris 1994; Brockhaus 1995; Ritter 1995).

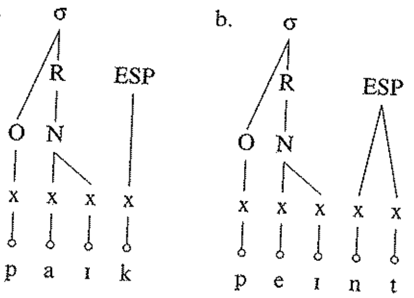
Notice that if we adopt the hypothesis that the rhyme is maximally binary, it is not just superheavy rhymes followed by an extrasyllabic constituent, such as that in *paint*, which must be accounted for in some other way. Word-final superheavies, such as the rhymes of English *rhyme* /raɪm/ and *pike* /paɪk/, are then also ill formed, as in (130), where both the Rhyme node and the Nucleus node branch:

(130)


If we accept the claim that the rhyme is maximally binary, so that structures such as (129) for *paint* and (130) for *pike* are ill formed, how can these forms be accounted for?

One possibility might be to extend the notion of extrasyllabicity further than we have been doing up to now, so that any consonant following a branching nucleus would be extrasyllabic. This would give a structure like (131a) for *pike*, while *paint* would presumably have two extrasyllabic consonants, as in (131b):

(131) a. b.



However, there do not at first sight appear to be independent reasons for treating these consonants as extrasyllabic, other than a desire to restrict all syllabic constituents to a maximum of two daughters. Why, then, should we want to claim that a structure with a branching nucleus within a branching rhyme is ill formed in any case?

As we have already noted, strings of the type under discussion, superheavies, are typically restricted to word-final position, as illustrated by the Dutch forms in (132). Those in (132a) are well formed, while the strings in (132b), with the same superheavy syllables in non-word-final position, are ill formed:

(132)	a.	kameel	/ka:me:l/	'camel'
		bordeel	/bɔrde:l/	'brothel'
	b.	*meelka	/me:lka:/	
		*deelbor	/de:lbɔr/[40]	

Given that these superheavy syllables are typically restricted to final position, an appeal to the notion of extrasyllabicity does not seem out of place. In other words, the final consonant of a superheavy syllable falls outside the core syllable proper.

However, at this point we should ask why constraints of this type exist. In other words, what is it about final position (indeed any 'edge' position) that allows so many of the 'normal' restrictions on syllable structure to be relaxed? We approach this question by considering some of the basic claims made within the model of government phonology.

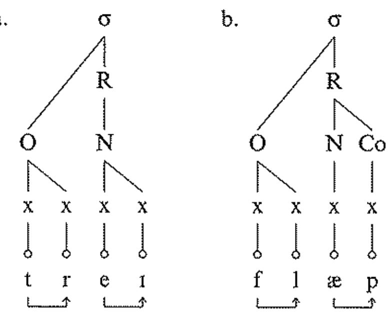
Government phonology provides a much more restrictive view of the syllable than other theories of syllable structure. As we have seen, central to the model is the claim that *all* syllabic constituents are maximally binary. This claim, then, holds not just of the onset, but also of the rhyme, as we have suggested above. However, up to this point we have been merely *stipulating* that all

[40] The forms in (132b) would be well formed if they were compounds, i.e. if a boundary intervened between the two syllables, e.g. *keelpijn* 'sore throat'. However, this does not affect the point being made.

branching is maximally binary. In government phonology, this principle is not a stipulation, but follows from the notion of **licensing**, which, as we shall see, gives us a formal means of excluding structures which apparently violate binary branching.

This concept of licensing is similar, but not identical to, that discussed in §3.7.2. In government phonology, the dependent within any domain must be **licensed** by the presence of the head. Within a syllabic constituent such as the onset or the nucleus, licensing relations are from left to right, i.e. constituents are **head-initial**, so that in (133a), /t/ licenses /r/ within the onset, and /e/ licenses /ɪ/ within the nucleus, while in (133b), /f/ licenses /l/ within the onset, and /æ/ licenses /p/ within the rhyme:

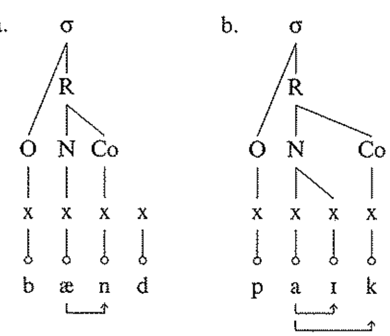
(133) a. b.



We indicate licensing as in (133).

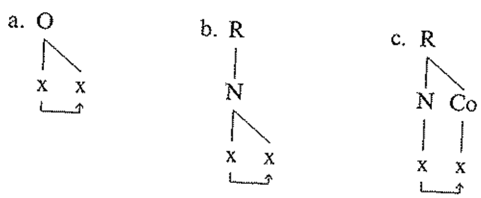
Crucially, one further restriction on licensing is proposed: it holds only between strictly adjacent skeletal positions (the **locality** condition; Harris 1994: 156). Thus in (133b) /f/ licenses the adjacent skeletal position /l/, and /æ/ licenses /p/, as we have seen. Consider now potential superheavy rhymes such as those of *band* and *pike*:

(134) a. b.



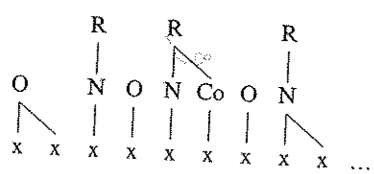
In (134a), the /d/ cannot be syllabified in the first syllable, as the /n/ occupies the coda position. In (134b), we have a head-initial branching nucleus node, so that the first vowel licenses the second. However, we also have a head-initial branching rhyme node. The head (the first vowel) should therefore license the other skeletal position in the rhyme, /k/. These two skeletal positions are not strictly adjacent (the second vowel intervenes), and so the structure is ill formed.

This version of government phonology, then, allows only the syllabic structures in (135):

(135)


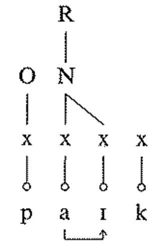
The three constituents, onset, rhyme and nucleus, are the only ones found in government phonology. Although we have included a coda node in (135c), this is not in accord with standard practice in government phonology. As we have seen, a coda can never be complex, and so it is argued that there is no need to have a constituent corresponding to it. The 'coda' position is generally referred to in government phonology as the **rhymal adjunct**; in what follows, however, we will continue to employ the term 'coda'.[41] Government phonology also claims that there is no constituent corresponding to the traditional notion of the syllable, in that phonological processes have no need to refer to this node. In addition, there are no constraints holding between onset and rhyme which would lead us to consider the syllable to be some kind of phonological domain (recall the discussion of the motivation for the onset–rhyme division in §3.4). Nevertheless, it is argued, onsets and rhymes always occur together; we do not find an onset without a following rhyme, and vice versa. Again, in the remainder of this chapter, we will continue to use the term 'syllable' informally.

All this means that phonological sequences in government phonology have the following general shape:

(136)


[41] In any case, it is not immediately clear that the fact that a particular category cannot branch, i.e. cannot be made up of two smaller units, necessarily means that it should not form a constituent, i.e. be part of a larger unit.

We have already seen that any dependent must be licensed by a head. If it is not so licensed, it cannot be realised. If we now return to the representation of a word like *pike*, the /k/ is apparently not licensed by any head:

(137)


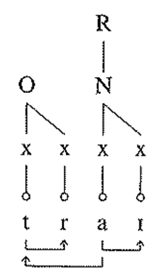
Recall that the vowel is not the licensor of a constituent containing /k/, as this would violate strict adjacency. How, then, can the /k/ be licensed?

Consider the following two principles, as formulated by Harris (1994: 160) (cf. also Kaye 1990: 311):[42]

(138) a. *Onset licensing*
An onset head position must be licensed by a nuclear position.
b. *Coda licensing*
A rhymal adjunct position must be licensed by an onset position.

This type of licensing differs from the examples of constituent licensing which we saw above. Here the licensing relationship is *between* two constituents, rather than within constituents, as in the case of the onset, rhyme and nucleus above. **Interconstituent licensing** differs in one very important respect from constituent licensing; it goes from right to left, rather than from left to right.

The principle of onset licensing (138a) is intuitively a straightforward one: an onset is only an onset by virtue of the fact that it is followed by a nucleus. (This is why theories which recognise a syllabic constituent typically characterise the nucleus as the head and the onset as the dependent; cf. (63) above.) Thus a word like English *try* will have the licensing relations shown in (139):

(139)


[42] Notice the term 'coda licensing' is used, in spite of the absence of a coda constituent in most versions of government phonology.

By left-to-right constituent licensing, /a/ licenses the non-head position in the nucleus, filled by /ɪ/; by right-to-left interconstituent licensing, it licenses the head position of the onset, filled by /t/, which, by left-to-right constituent licensing, itself licenses the non-head position in the onset, filled by /r/.

Although onset licensing appears to correspond to a traditionally accepted idea – that onsets are in some sense 'less important' than nuclei, coda licensing appears to embody a much more revolutionary concept. (138b) states that a coda consonant is licensed by the following onset, i.e. the head of the following constituent.

Government phonologists argue that this reflects the fact that there are very severe restrictions on the segmental material that can occupy the coda position. For example, Harris (1994: §2.4.4) shows that the sonority sequencing generalisation can be extended to give (140):

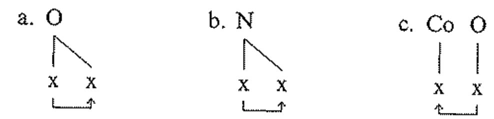
(140) In an optimal coda–onset cluster, the first consonant is no less sonorous than the second.

This, of course, is the mirror image of the sonority sequencing generalisation when applied to onsets, where the first consonant is generally less sonorous than the second. In other words, coda–onset sequences typically display rising sonority; the two elements of an onset constituent display falling sonority. Thus we find well-formed coda–onset sequences in monomorphemic items such as English *candy*, *custard*, *kilter*, *perfume*, etc., but not **cadny*, **cutsard*, **kitler*, **pefrume*. Furthermore, as Harris notes, languages may display restrictions on the well-formed clusters which can occur; frequently only the sequence sonorant–obstruent is permitted.

There are also other further respects in which the coda is influenced by the following onset. Thus we saw in Chapter 1 that in an English nasal coda + stop onset sequence, the nasal had to be homorganic with the stop, to give *camber*, *canter*, *canker* ([ŋk]), etc.

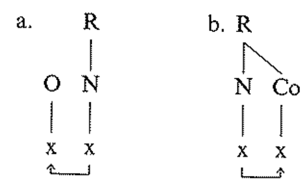
This behaviour leads Harris to subcategorise the various examples of licensing (both constituent and interconstituent) into two sub-types. In the case of onsets, nuclei and coda–onset sequences (often referred to as 'interludes'), he argues, we have to do with **governing domains**, in which there is a **government** relation between the two segments, i.e. between the head and the dependent. Government, then, is a sub-type of licensing. Within these governing domains, 'quite particular phonotactic restrictions are . . . in force'. In other words, the range of possibilities in the dependent position is at least partially determined by the head. We have already seen examples of this in the coda–onset domain. In the onset domain, as we have also seen, rising sonority must be respected, there is often a minimal 'sonority distance' required (i.e.

the dependent must not be too close in terms of sonority to the head) and there may be restrictions involving homorganicity (English does not allow */tl-/, for example). Within the nucleus, the second vowel is either identical to the first (long vowels) or, in the case of a diphthong, must often be one of a restricted set. RP English is typical in this respect in only allowing /ɪ ʊ ə/ as the second element of a diphthong. On the basis of these facts, Harris (1994: 168) characterises the structures in (141) as being governing domains:

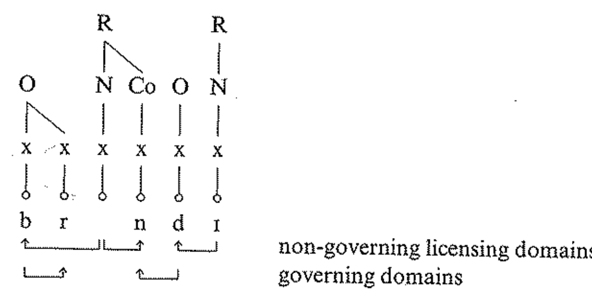
(141)


Thus the head of an onset can be simultaneously the governor in two domains, as shown in (141a) and (c).

Such phonotactic restrictions do not hold between the elements of the other licensing domains, however. As we showed above, there are typically no restrictions between the content of an onset and the following rhyme. Similarly, the *content* of the coda is independent of the nucleus, although there may, of course, be restrictions associated with syllable weight. Thus the two domains in (142) are licensing domains, but not governing domains:

(142)


In the light of these considerations, a word like *brandy* will have the structure in (143):

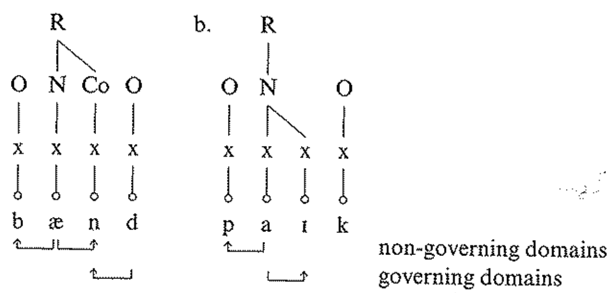
(143)


It will be noticed that the /n/ is licensed twice, once by the nucleus of the first syllable, and once by the onset of the second syllable, but is governed only by the onset of the second syllable, from which it gets its specification for place of articulation.

How can this theory account for syllables which apparently have more than two elements in the rhyme? We saw in (137) that *pike* has a branching nucleus, so that the final /k/ cannot be syllabified into the rhyme, because there is no following onset. However, government phonology argues that this consonant in fact displays none of the typical properties of a coda consonant. Normal coda consonants, as we have just seen, are highly restricted in their occurrence; peripheral final consonants, on the other hand, are free in their occurrence: there are few or no restrictions on which consonants can occur in this position. As Harris (1994: 72) observes: 'If the word-final consonant of a V(V)C or VCC cluster were syllabified in coda position, it would be reasonable to expect it to display the same kind of distributional characteristics as morpheme-internal coda consonants. In fact, it does not. If anything, it behaves just like a morpheme-internal onset.'

This point of view gains further support from a consideration of word-final superheavy VCC syllables, such as *band*. As we have seen in (134), the /d/ cannot be syllabified into the rhyme here. Up to now, we have been arguing that it must be extrasyllabic, but we are now in a position to make a much more specific claim. The relationship between the nasal and the final stop in *band*, *camp*, *rank*, etc., is exactly the same as that between the nasal and the stop in *brandy*, *camber*, *conker*, etc. Homorganicity is required in both cases. In words like *brandy* we associated this requirement with the fact that the nasal was the non-head in a governing domain of which the head was the onset of the following syllable, filled by the stop. Government phonology argues that exactly the same analysis is appropriate for *band*, i.e. the /d/ is considered not to be 'extrasyllabic', but to form the onset of a following syllable. Similarly, in *pike* the /k/, which shows all the distributional properties of an onset, is syllabified accordingly, to give (144):

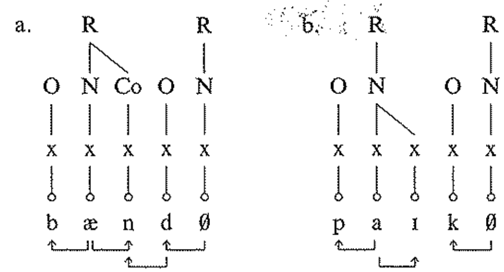
(144)



However, the representations in (144) are still ill formed, in that the onset consonant must be licensed by a following nucleus, as determined by

onset licensing. An *empty* nucleus must be assigned, to give the structures in (145):

(145)



Government phonology claims that this approach also allows an account of the fact that English *kept* /kɛpt/ has a short vowel, while *keep* /kiːp/ has a long vowel. Kaye (1990) attributes this difference to the effects of the coda licensing principle given as (138b). In *keep* the /p/ cannot be syllabified into the coda of the first syllable, because there is no following onset to license it. Therefore, it must itself form the onset. In *kept*, however, the onset /t/ licenses the coda consonant /p/, so that the /p/ can be syllabified into the rhyme of the first syllable. Because the /p/ is in the rhyme, the vowel must shorten, thus avoiding a rhymal structure VVC, which, as we have seen, is ill formed. *Kept*, then, has the same structure as *band* in (145a), and *keep* the same as *pike* in (145b).[43]

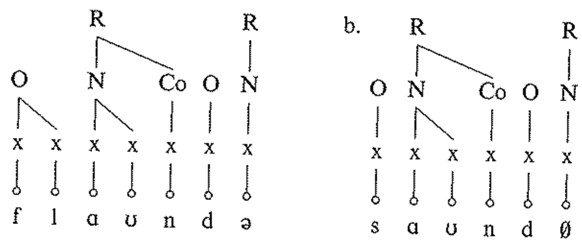
Further evidence for treating word-final postvocalic consonants as onsets can be found from various phonological regularities which treat word-internal rhymes and word-final rhymes alike, but only if the final consonant of the word-final rhyme is ignored. This again suggests that this final consonant is in fact the onset of a syllable with an empty nucleus. Thus, as we saw in §3.4.1, the English Main Stress Rule, as originally formulated by Chomsky and Halle (1968), places main stress on the penultimate syllable of a noun, unless that syllable is not heavy (VC or VV). Thus we find *agenda* with a heavy (VC) penult, but *America*, with a light penult (V), which therefore rejects stress. However, for verbs, the target syllable for stress is the final one, rather than the penultimate, so that *maintain* and *collapse* have final stress, whereas the final syllable of *astonish* rejects stress. Here, apparently, the distinction between heavy and light is VCC/VVC vs VC, rather than VC/VV vs V. If the

[43] This analysis holds for 'root-level' suffixation, in which the root + suffix are considered to be a single phonological domain, and therefore subject to the normal phonotactic restrictions on syllabic constituency. Suffixation may also occur at 'word level', in which case the sequence of root and suffix is considered to form two domains, so that otherwise ill-formed sequences are tolerated. The fact that the past tense of *seep* is [siːpt], not *[sɛpt], shows that here word-level suffixation is involved.

final consonant is ignored, of course, then our definition of light and heavy syllables in English is the same for both nouns and verbs, as we would expect. In the government approach, word-final consonants are onsets, and so the relevant syllables have the same shape as their non-word-final counterparts.

We have seen that government phonologists argue that branching within syllabic constituents is maximally binary. However, although the evidence for interpreting the final consonant in VVC and VCC rhymes as the onset of a following syllable is clear, it is difficult to see that *both* consonants in a VVCC rhyme such as that of *sound* or of *flounder* should be assigned to a following onset. The relationship between the /n/ and the /d/ here is the same as in words such as *band* and *brandy*, where we treated the nasal as a coda (more correctly, a rhymal adjunct). This leads Harris (1994: §2.4.4) to allow structures in which both the rhyme node and the nucleus node branch, but only for superheavy rhymes such as that in *flounder*. This is shown in (146):

(146) a. b.



Harris notes that codas in superheavy rhymes are subject to restrictions which are much more severe than in heavy syllables. He notes that the following holds for English superheavies:

(147) a. The coda position is restricted to a sonorant or a fricative (e.g. *colt, poultry, paste, pastry*).
b. A coda sonorant is unable to support a distinctive place contrast.
c. In the case of (b), the favoured place category determined by the following onset consonant is coronal.

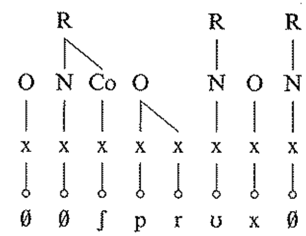
These restrictions, then, can be argued to stem from the complexity of the syllabic structure required to characterise superheavy rhymes.

3.8.1 Empty positions

It is evident from the above that the strategy adopted by government phonology means that 'syllables' containing rhymes with more segments than are permitted by the various principles discussed above are treated as sequences of at least two onsets and rhymes, with the resulting presence of empty positions. Much the same approach is utilised for the analysis of what we referred

to as prependices in §3.4.2. These are again interpreted as belonging to a different onset/rhyme sequence, as in (148), the representation for German *Spruch* /ʃprʊx/ 'motto' proposed by Brockhaus (1999) (see also Kaye 1996):

(148)



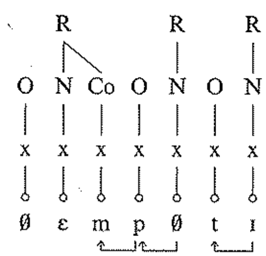
Here the initial /ʃ/ is assigned to the coda position of a syllable preceding the branching onset /pr/.

It is clear that the principles adopted by government phonology lead to a sharp reduction in the types of 'syllables' that are recognised in the model, and, as such, is to be preferred over less restrictive accounts. However, this comes at the cost of the introduction of what at first sight appears to be a very powerful, and apparently unrestricted, theoretical device, the empty position.

Is the motivation for the introduction of empty positions merely theory-internal, or are there indications to be found that they correspond to anything outside the model? An obvious sign of the latter state of affairs would be if we can find alternations between the empty position and some realisation.

One such example involves word-internal clusters, and therefore provides evidence for the recognition of empty positions in word-internal as well as word-peripheral contexts. The English word *empty* /ɛmptɪ/ will have the following representation in government phonology (we indicate only those licensing domains which are relevant):

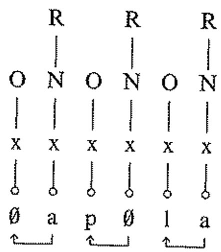
(149)



Here the /p/ cannot be assigned to the rhyme of the first syllable, which already contains a rhymal adjunct (/m/). Rather, the /p/ functions as the onset of the second syllable, which licenses the /m/ in the coda of the first syllable, by the coda licensing principle in (138b). Now the /t/ cannot be syllabified into the onset of the second syllable, as /pt/ is an ill-formed onset in English. As a result, we must propose an empty nucleus in the second syllable, which licenses the /p/ in the onset, by (138a). Finally, /t/ is syllabified into the onset of the third syllable, where it is licensed by the /ɪ/, rather than into the coda of the second syllable.

Interestingly, one possible realisation of *empty* is [ɛmpətɪ], where the normally empty position is filled by the default vowel, the schwa, thus providing some degree of independent evidence for the postulation of the empty nucleus.[44] There are other phenomena, too, in which similar realisations are found. We have already observed that intervocalic heterosyllabic clusters typically show falling sonority: e.g. *al.pa*, but not **ap.la*, whereas onset clusters typically consist of less sonorous followed by more sonorous consonants, so that English *play*, *brown* and *throat* are well formed, while **lpay*, **rbown* and **rthoat* are not. By constituent government, a coda is governed, and hence licensed, by the following onset; but if the second consonant is more sonorous than the first both consonants are syllabified into the onset.[45] However, this is not possible in a language which does not allow branching onsets, but does allow intervocalic sequences of two consonants displaying rising sonority. In such a case, the two consonants must be assigned to successive onsets, with an intervening empty rhyme:

(150)



where, by onset licensing (138a), the onset of each syllable is licensed by the following nucleus.

Support for structures like (150) can be found in the fact that vowel–zero alternations are much more common between the members of ill-formed medial clusters (i.e. those with rising sonority) than of well-formed clusters. Thus we do not find, for example, English [faɪndɪŋ] *finding* alternating with *[faɪnədɪŋ], but we do, as Harris (1994: 192) points out, find alternations such

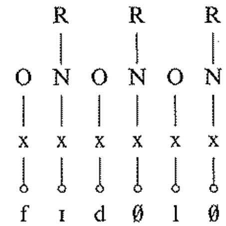
[44] The schwa here is normally interpreted as the realisation of the neutral feature @ (cf. §2.5).

[45] Recall from §2.6 that in the version of government phonology discussed by Harris (1994: ch. 4) the notion of sonority is replaced by one of segmental complexity. We do not consider this further here, except to remark that there is a fairly direct inverse relation between complexity and sonority: more sonorant consonants are less complex than less sonorant ones (see also Harris 1990). This in turn leads to a more general constraint on the government relation (Harris 1994: 170), such that the head in any construction is never more complex than the segment which it governs.

as [fɪdlɪŋ]/[fɪdəlɪŋ] *fiddling* corresponding to [fɪdəl] *fiddle* (cf. also words such as *athlete*, with the realisations [æθliːt] and [æθəliːt]).

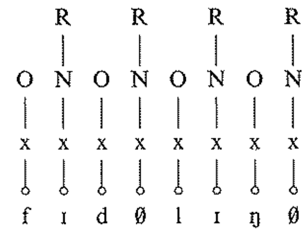
Harris analyses the *fiddle*/*fiddling* type of case by assuming that the representation of *fiddle* contains three syllables:

(151)



while *fiddling* will have the representation in (152):

(152)

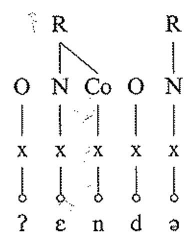


In (151), the empty nucleus of the second syllable *must* be filled by segmental material, i.e. schwa, while in (152) this is optional. We return presently to the question of why this should be.

Similar evidence can be cited to support the existence of **empty onset positions**. We find cases parallel to the alternation in *empty*, but this time involving the onset, typically in cases of hiatus. Compare the English and Dutch forms for *mayonnaise*, viz. /meɪəneɪz/ and /maːjoːnɛːzə/ (or its common abbreviation /maːjoː/). In the Dutch form the onset is filled by a glide, while English permits the onset to remain empty.

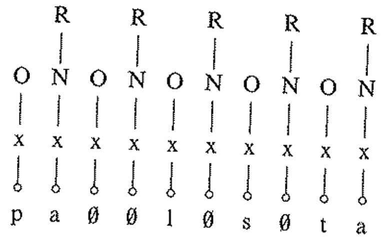
Some languages indeed reject empty onsets altogether at the phonetic level; German, for example, is generally claimed to insert a glottal stop wherever the onset is phonologically empty, so that a word like *Ende* /ɛndə/ 'end' is realised as [ʔɛndə]:

(153)



Analyses like these raise a general question which we have not yet addressed. How do we constrain the occurrence of empty positions in the syllable? In other words, why does the second syllable of (151) (/fɪdØlØ/) *require* that the underlyingly empty position be filled phonetically, while the empty position of the second syllable of (152) (/fɪdØlɪŋØ/) may remain empty? More generally, what is to stop us proposing surface representations like (154)?

(154)



The relevant constraint here is that an empty nucleus must be followed by a filled nucleus, or, more precisely, by a nucleus that is 'audible'; we will see below that 'being audible' does not necessarily mean that features are actually associated to the skeletal position. Whether or not a language permits a *final* empty nucleus is a matter of whether it allows what in other models are referred to as word-final coda consonants. Languages which do allow word-final consonants have final empty nuclei which license the consonant in the onset (cf. the representation of *pike* in (145b)), while those which allow only 'open syllables' do not allow final empty nuclei. This is a matter of parameter setting, and must be specified for each language.

In formal terms, a *non-final* empty nucleus must be licensed by a following nucleus, under what is referred to as **proper government**. The proper governor, i.e. the second of two nuclei, must not itself be empty. This principle, then, explains why the second syllable of *fiddle* in (151) must be realised with [ə]; the final nucleus is itself empty, and so cannot license a preceding empty nucleus. On the other hand, the nucleus of the third syllable in *fiddling* (/fɪdØlɪŋØ/) in (152) is filled, so that the empty nucleus in the second syllable is properly governed, and therefore need not be filled.

Notice that the principle is not that a rhyme with segmental content *must* be preceded by a rhyme that is empty. Rather, what the theory demands is that if an empty rhyme occurs it must be followed by a rhyme that is filled. Kaye *et al.* (1990: 219) formalise the principle governing the phonetic interpretation of empty positions as the **Empty Category Principle**, formulated as (155):[46]

[46] For a reinterpretation of the ECP, see Rowicka (1999).

(155) *Empty Category Principle* (ECP)
A position may be uninterpreted phonetically if it is properly governed.

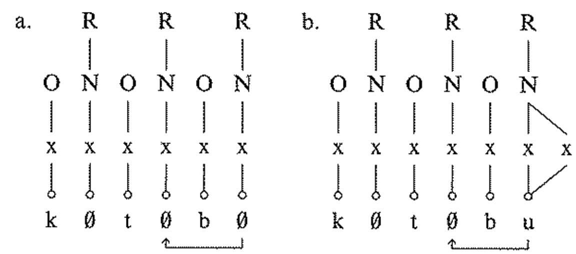
They discuss various examples of vowel–zero alternations in Moroccan Arabic which illustrate this principle:

(156) a. tan ktɨb 'I write'
b. tan kɨtbuː 'we write'

In (156), the vowel [ɨ], a high central vowel, is the phonetic realisation of an empty nucleus.

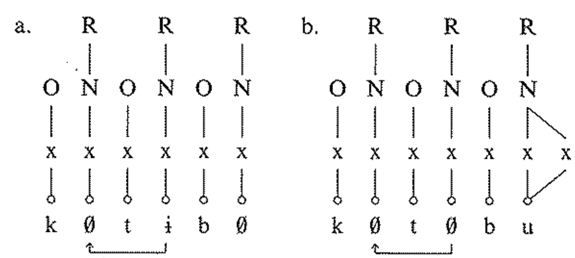
Compare now (157a) and (b), the initial structures for (156a) and (b):

(157)



The empty nucleus of the second syllable of (157a) must be given phonetic interpretation, as it precedes another empty nucleus, just as in the case of *fiddle*. However, the plural form involves suffixation of /uː/, so that the empty nucleus of the second syllable is properly governed by a filled nucleus, and therefore need not be realised. This yields the forms [kØtɨbØ] and [kØtØbuː], respectively. The singular form is now well formed, as the nucleus of the second syllable is filled, and can therefore properly govern the nucleus of the first syllable, as in (158a). However, the plural form is still ill formed, because the empty nucleus of the second syllable cannot properly govern the empty nucleus of the first, which must therefore receive phonetic content:

(158)



The first nucleus of (b) is now filled by [ɨ], to give the surface form [kɨtbu]. The constraint on empty positions plays a role in accounting for many paradigmatic alternations of this sort.

The ECP may be overridden by other factors. Charette (1990) discusses apparent schwa-deletion processes in French, such as that illustrated by the alternations in (159):

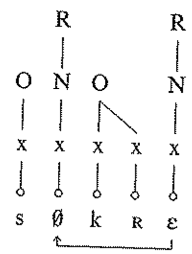
(159)	semaine	[səmɛn] ~ [sØmɛn]	'week'
	ennemi	[ɛnəmi] ~ [ɛnØmi]	'enemy'

The alternations here are in accord with the ECP, with all the empty positions being properly governed by a following filled nucleus. However, the form in (160) does not show the same alternation:

(160) secret [səkʀɛ] ~ *[sØkʀɛ] 'secret'

Here proper government appears to be obeyed, as indicated in (161):

(161)



Charette attributes the failure to allow the empty position in (161) to surface to the fact that a 'governing domain' intervenes, i.e. a domain containing a governing segment, in this case the head of the complex onset. Thus the presence of an onset cluster means that the ECP does not apply in *secret*, whereas it does apply in *semaine*, allowing the first nucleus not to be realised.

Let us consider finally a further case involving vowel–zero alternations, this time from the phonology of Dutch. Dutch has what is traditionally described as an optional process of schwa epenthesis between a liquid and a – in traditional terms tautosyllabic – consonant:

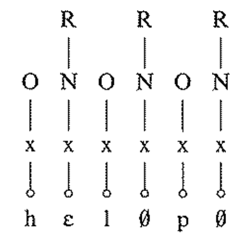
(162)	help	[hɛlp] ~ [hɛləp]	'help'
	worp	[wɔrp] ~ [wɔrəp]	'throw'
	balk	[bɑlk] ~ [bɑlək]	'beam'
	snurk	[snœrk] ~ [snœrək]	'snore'

However, if the final consonant is a coronal obstruent, the schwa is not found:

(163)	vilt	[vɪlt] ~ *[vɪlət]	'felt'
	hard	[hɑrt] ~ *[hɑrət]	'heart'
	hars	[hɑrs] ~ *[hɑrəs]	'resin'
	arts	[ɑrts] ~ *[ɑrəts]	'doctor'

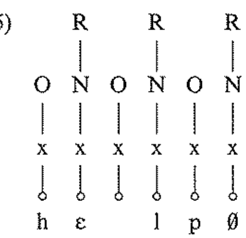
How can we account for this in government terms? The forms in (162), which permit the vowel–zero alternation, must have a structure in which both the final consonants are onsets:

(164)



This structure provides an empty position – the nucleus of the second syllable – which can be filled by segmental material under proper government. However, it is not clear how government phonology would account for the realisation without schwa, which would apparently involve a violation of the ECP, as two successive nuclei would then remain empty.[47] One possibility is that the /l/ in *help* is reinterpreted as the nucleus of the second syllable, as in (165):

(165)

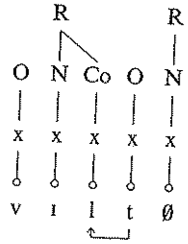


The phonetic plausibility of this is confirmed by the speech of one of the authors, for whom postvocalic /l/ is vocalised.

The forms involving final coronals appear to require a different representation. Observe that we are dealing here with homorganicity between the two consonants.[48] Recall that homorganicity between a sonorant and a following consonant is a classic situation in coda licensing; the place of articulation of, say, a nasal and a following stop is not independent. We suggest that *vilt* has the representation in (166):

[47] This difficulty does not arise when suffixation is involved: a form like *helpen* 'to help' has a filled final nucleus, which means that both the realisations [hɛlØpə] and [hɛləpə] are in accord with the ECP.
[48] We are assuming here that /r/ in Dutch is at least phonologically coronal.

(166)



i.e. the structure contains only two syllables, with no empty position between the /l/ and the /t/, and therefore no possibility of an alternation with a form with an epenthetic schwa. Thus /l/ is licensed by /t/, the onset of the second syllable.

Interestingly, if the liquid is followed by a sonorant consonant, the form with schwa always seems to be possible, irrespective of whether the sonorant is coronal, as shown in (167):

(167)	helm	[hɛlm] ~ [hɛləm]	'helmet'
	arm	[ɑrm] ~ [ɑrəm]	'arm'
	kern	[kɛrn] ~ [kɛrən]	'kernel'

This may reflect the presence of a 'minimal sonority distance' constraint in Dutch, as proposed by Harris as a language-particular restriction on the elements which are involved in some governing relationship. In turn, this can be associated with a more traditional notion, the **syllable contact law** (e.g. Vennemann 1988: 40), which, in government terms, states that not only do coda–onset domains involve falling sonority, but the sonority distance between them should be as great as possible. Thus the optimal coda–onset sequence is a highly sonorant consonant followed by a plosive. In the case of Dutch, an onset can license a homorganic sonorant coda only if there is sufficient sonority distance between them (however this is to be measured; in Harris's approach this is formulated in terms of relative complexity). Liquids and nasals are very close in terms of sonority, and so, even if the two consonants are homorganic, the second one cannot license the first, and so the syllabification must be as in (164), with an empty nucleus intervening between the two (onset) consonants, thereby allowing schwa 'insertion'.

This analysis is supported by the fact that, although Dutch allows the final sequence [rn] (*kern*), it does not permit either [rl] or [ln]. This suggests that the sonority distance between these consonants is too small to allow the second to license the first, and so they can only occur with an intervening vowel. This is illustrated by the forms in (168), where we contrast Dutch

forms with their cognates in English and German, which do not display this restriction:[49]

	Dutch		*German*		*English*	
(168)	Karel	[kaːrəl]	Karl	[karl]	Charles	[ʧɑrlz]
	kerel	[keːrəl]	Kerl	[kerl]	churl	[ʧɜrl]

Thus the different sonority distances between the members of the pairs [rl], [rn] and [rt] is reflected by their behaviour in Dutch: [rl] never forms a licensing domain, [rn] does so optionally and [rt] always involves coda licensing.

3.9 Summary

In this chapter we have considered phonological structure above the level of the segment. After briefly indicating in §3.1 that we can establish a prosodic hierarchical structure which corresponds to sentences, motivated among other things by phonological processes which have the various layers of this hierarchy as their domain of application, we focused in §3.2 on the first layer in this structure, the syllable. The need for a syllabic domain in phonological representations was motivated intuitively (by appealing to the awareness that native speakers have of syllabification) but also, and more firmly, in terms of restrictions on well-formedness (phonotactic constraints) and processes that refer to the syllabic domain or to its edges. In §§3.4–3.5 we reviewed a number of theories which differ in their view of the internal structure of the syllable. We concentrated particularly on two approaches, onset–rhyme theory and mora theory. The way in which strings of segments can be organised in syllables was examined in detail within the context of the former theory, and we also addressed the issue of how to represent cross-linguistic differences in syllabic organisation in terms of the setting of a number of parameters. Having established that syllable structure forms part of the phonological representation, we proceeded to investigate the relation between the terminal position of the syllable structure and the featural structures that represent the content of segments, and showed that this relation is autosegmental. This allowed us to show in §3.6 that a particular set of features can associate to more than one syllabic position, giving us a representation of phonological length. A further consequence of syllabic positions and segmental content being independent of each other is that one can exist without the other. In

[49] We are assuming here dialects of English which are rhotic, and dialects of German in which the /r/ is not vocalised. Notice that in Scots English, for example, [ə] is possible in these forms, as in the realisations [ʧɑrəlz] and [ʧʌrəl].

§3.7 we discussed various examples of this phenomenon. §3.8 was concerned with an interpretation of onset–rhyme theory within the theory of government phonology, in which the occurrence of syllabic positions is subject to their contracting appropriate licensing and government relations. Within this approach to phonological structure, we discussed further aspects of syllabic organisation and syllable-based processes such as vowel–zero alternations. In this model, syllabic positions crucially enter into a head–dependency relation, which plays an active role in characterising constraints and processes.

3.10 Further reading

Phenomena that involve the relevance of phonological properties to strings of segments (§3.1) are widely discussed in Firthian phonology (cf. §1.5) and in autosegmental phonology. The spreading of nasality and other features over larger domains is considered in van der Hulst and Smith (1982a). A variety of cases involving spreading of nasality are analysed in Piggott (1988) and Piggott and van der Hulst (1997). On *Raddoppiamento Sintattico*, see e.g. Napoli and Nespor (1979), Nespor and Vogel (1982), Kaisse (1985) and Loporcaro (1996). The prosodic hierarchy is discussed by Nespor and Vogel (1986) and Selkirk (1984a, 1995). On sonority, see Hankamer and Aissen (1974), Farmer (1979), Kiparsky (1981), Dogil (1988), Clements (1990), Ohala (1992), K. D. Rice (1992), Zec (1994, 1995a) and Basbøll (1999). Proposals for 'strength hierarchies', in which the notion of strength is related to sonority, are made by Lass (1971) and Foley (1977).

Anderson (1969), Vennemann (1972), Anderson and Jones (1974), Hooper (1976), Kahn (1976), Selkirk (1982) and Blevins (1995) provide arguments for the need to incorporate syllable structure in phonological representations (§3.2). See also the papers in Bell and Hooper (1978). Awedyk (1975) provides a history of the concept of the syllable. For views on syllable structure (§3.3), see Steriade (1982), Clements and Keyser (1983), Harris (1983), van der Hulst (1984), Levin (1985), van der Hulst and Ritter (1999).

Onset–rhyme theory (§3.4) and rhyme structure (§3.4.1) are discussed in Fudge (1969, 1987), Cairns and Feinstein (1982), Lapointe and Feinstein (1982), Selkirk (1982), Davis (1985, 1990), Kaye *et al.* (1985) and Dell (1995). For proposals involving syllable appendices (§3.4.2), see Fudge (1969). Blevins (1995) provides an overview of syllable typology parameters. On syllabification (§3.4.3), see Pulgram (1970), Kahn (1976), McCarthy (1979), Selkirk (1982, 1984b), Steriade (1982), Dell and Elmedlaoui (1985), Anderson (1987), Clements (1990), Archangeli (1991) and Noske (1992). On ambisyllabicity, see van der Hulst (1985), Borowsky (1986) and Rubach (1996). Jones (1976) analyses a number of processes of consonant deletion and epenthesis in the history of English as involving the creation of ambisyllabicity within the foot. See also Jones (1989).

Discussions of mora theory (§3.5) can be found in Hyman (1985, 1992), Hock (1986), Hayes (1989a), Kubozono (1989), Tranel (1991), Pulleyblank (1994) and Zec (1995b).

On the representation of length, syllable weight, syllable quantity and the need for a representation incorporating the skeletal tier (§3.6), see Newman (1972), McCarthy (1979), Árnason (1980), Steriade (1982), Anderson (1984), Hyman (1985), Schein and Steriade (1986), Hayward (1988), Lahiri and Koreman (1988), Tranel (1991), Davis (1994), Hayes (1994), Broselow (1995), Piggott (1995), Broselow *et al.* (1997) and Rosenthall and van der Hulst (1999).

The notion that syllabic positions can persist independently of segmental content (§3.7) is presented in Clements and Keyser (1983). English /r/ (§3.7.1) is discussed in Wells (1982), Harris (1994: ch. 5) and McMahon *et al.* (1994). For discussions of liaison in French (§3.7.2), see Klausenburger (1978), Piggott and Singh (1985), Durand (1986b), Tranel (1987: ch. 11) and Charette (1991). Klausenburger (1977), Clements and Keyser (1983) and Tranel (1995) give accounts of *h-aspiré* (§3.7.3). On compensatory lengthening (§3.7.4), see the papers in Wetzels and Sezer (1986), as well as the papers by De Chene and Anderson (1979), Hock (1986), Hayes (1989a), Schmidt (1992) and Bickmore (1995).

On licensing in phonology (§3.8), see Itô (1986), Goldsmith (1989, 1990), Steriade (1995, 1996), Piggott (1997). For a treatment within Optimality Theory, see Itô *et al.* (1995). Licensing within a government-based model is dealt with by Kaye (1990) and Harris (1994, 1997). Kaye *et al.* (1985, 1990), Charette (1991), Brockhaus (1995), van der Hulst and Ritter (1999) and Rowicka (1999) are other works dealing with government in phonology. On empty positions, see Anderson (1982) and Giegerich (1981, 1985), as well as many of the works in government phonology cited above.

The acquisition of syllable structure is dealt with in Ingram (1978), Fikkert (1994) and Macken (1995). For a historical perspective, see Árnason (1980), Murray and Vennemann (1983), Lass (1987: ch. 3), Vennemann (1988), Jacobs (1989), Ritt (1994) and Kiparsky (1995). On the application of the notion of the syllable to sign language phonology, see Wilbur (1990, 1993), Perlmutter (1992), Brentari (1995, 1999).

There is an extensive literature on the interface between syntax and phonology with respect to prosodic structure; see for example the papers in Inkelas and Zec (1990), as well as Inkelas and Zec (1995) and Selkirk (1995).