

## Chapter 4: Syllable structure

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Continuous human speech can be sliced into speech sounds, represented on paper by IPA symbols. Our question is whether these segments can be grouped into larger units that are not necessarily meaningful (ie the groupings are based purely on the sound shape of the elements), what these larger units are, how they are organized, and whether they are of real use in phonological theory.

### 4.1 Our topic

Although the term SYLLABLE sounds familiar, it will be useful to first identify what phonologists mean, and what they do not mean, by this term.

#### 4.1.1 Syllables vs. morphemes

The existence of groups larger than segments but smaller than words is obvious: in the string *catlike* the first three segments, **k**, **a**, and **t** form a unit larger than a single segment, and so do the last few segments **lajk**. That their structure is similar: both have a vowel at the middle, surrounded by consonants at both edges. Units like **kat** and **lajk** are called SYLLABLES. Incidentally, these two units are meaningful, they are MORPHEMES. But syllables and morphemes are not necessarily the same: for example, *butter* consists of two syllables, *syllable* of three, and *category* of four, but all three are a single morpheme, while *cats* is one syllable, but two morphemes. The sound string **rokɪt** may be analysed as a single morpheme (*rocket*), or two morphemes (*rock it*), but since the phonological shape is identical, this string is two syllables in either case. SYLLABIFICATION (the segmentation of sound strings into syllables) is related to the phonological shape of the word, while analysing into morphemes is dependent on meaning.

#### 4.1.2 Syllabification vs. hyphenation

At a first glance, the terms syllabification and HYPHENATION may be synonymous. We must draw a clear distinction between the two, however.

Hyphenation is an orthographical device. The point of separation within a written word is a printer's convention. For example, the word *English* is usually hyphenated as *Eng-lish* by British, but as *En-lish* by American printers, similarly to the different spelling conventions in the case of *colour* and *color*. Such conventions are to a large extent arbitrary.

Syllabification, on the other hand, is a theoretical issue: in normal speech syllable boundaries are not expressed by a pause (nor are morpheme boundaries, for that matter).

Accordingly, there is room for debate on where syllable boundaries fall: some analyst would argue that *letter* should be syllabified as in (1a) because this is what explains certain facts, while another comes to the conclusion that it should be as in (1b), since this is what fits her principles.

(1) *Possible syllabifications of letter*

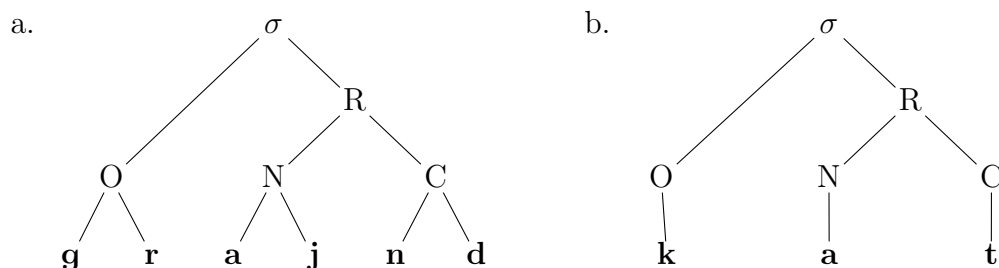
- a. lett.er            b. le.tter

(Note that the word is hyphenated as *let-ter*, which suggests that the consonant belongs to both syllables, it is AMBISYLLABIC.) This shows that hyphenation and syllabification are different businesses. Note also that hyphenation is indicated by hyphens, while syllable boundaries are represented by dots, as in (1).

## 4.2 The structure of the syllable

Accepting that the notion of the syllable is a useful one, let us see its structure.<sup>1</sup> (The lowercase Greek sigma,  $\sigma$ , represents the syllable by convention.) We may encode the fact that the consonants at the beginning of a syllable, as well as the vowels after them, are more closely related to each other than the consonant(s) to the vowel(s), by packing them into syllabic constituents. The syllabic constituent typically holding the vowel of a syllable is called the NUCLEUS (or the PEAK). In some languages the nucleus may be occupied by certain consonants. The consonants preceding the nucleus occupy the ONSET, those that follow it are in the CODA. For reasons to be explained in §4.4.1 and §4.5.1, the nucleus and the coda together form a fourth syllabic constituent, called the RHYME. Lines of a poem rhyme when they contain the same sounds from the last (stressed) vowel to the end. It is not an accident that this is also called rhyme: it is the identity of the rhyme of the last syllables that make them rhyme: e.g., *cat* and *bat* rhyme, but *cat* and *cap*, or *cat* and *cut* do not.

(2a) shows the tree diagram of the complex syllable **grajnd** (*grind*) and (2b) that of **kat** (*cat*).

(2) *Syllable trees for grind and cat*

The syllable **grajnd** in (2a) is special in that all of its constituents contain two segments, they are branching. It is more usual for syllabic constituents not to branch, but to contain only a single sound, as in *cat* in (2b).

<sup>1</sup> Note that with this we already take it for granted that syllables do have an internal structure, although there is an alternative option, namely, that they do not.

### 4.3 Finding syllable boundaries

To syllabify sound strings, we need guidelines that decide in an unambiguous manner where syllable boundaries fall. We will first look at two universal principles organizing syllable structure, the SONORITY SEQUENCING PRINCIPLE and the ONSET MAXIMIZATION PRINCIPLE. Then some considerations against the latter principle are discussed.

#### 4.3.1 Sonority Sequencing

SONORITY is a scalar property of speech sounds, that is, some sounds are less sonorous, others more sonorous, and yet others even more so. Sonority is related to the loudness or vocalicness of sounds: vowels are very sonorous, sonorant consonants are less so, obstruents are the least sonorous sounds.

Speech sounds can be organized into a SONORITY HIERARCHY. One—rather elaborate—hierarchy is given in (3).

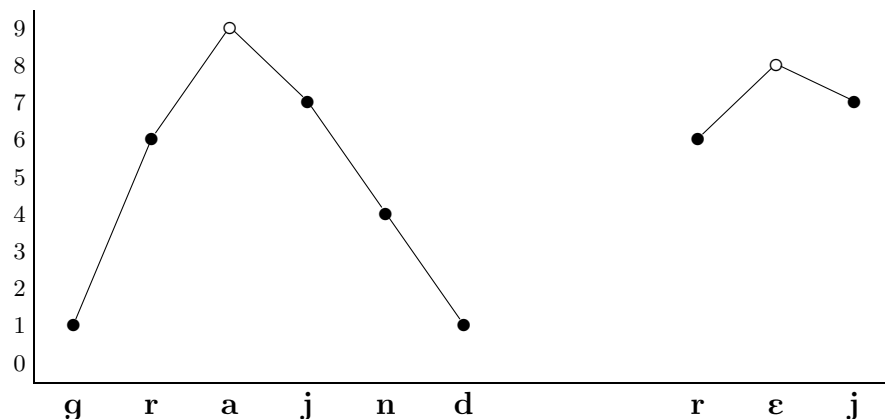
(3) *A standard sonority hierarchy*

sonority index		sounds
more	9	low vowels (e.g., <b>a</b> <b>ɑ</b> )
sonorous	8	mid vowels (e.g., <b>e</b> <b>ɛ</b> <b>ə</b> <b>ɔ</b> <b>o</b> )
↑	7	high vowels/glides (e.g., <b>i</b> <b>j</b> <b>ɪ</b> <b>u</b> <b>w</b> )
	6	rhotics (e.g., <b>r</b> <b>ɹ</b> )
	5	laterals (e.g., <b>l</b> )
	4	nasals (e.g., <b>m</b> <b>n</b> <b>ŋ</b> )
	3	voiced fricatives (e.g., <b>v</b> <b>ð</b> <b>z</b> <b>ʒ</b> )
↓	2	voiceless fricatives (e.g., <b>f</b> <b>θ</b> <b>s</b> <b>ʃ</b> <b>x</b> )
less	1	voiced plosives (e.g., <b>b</b> <b>d</b> <b>g</b> )
sonorous	0	voiceless plosives (e.g., <b>p</b> <b>t</b> <b>k</b> )

The sonority sequencing principle states that in any syllable the segment in the nucleus has the highest sonority, and the sonority of any other segment is lower than that of its neighbour in the direction of the nucleus and higher than that of its neighbour in the direction of the edge of the syllable. In the sonority profile of a syllable the nucleus constitutes the peak,<sup>2</sup> and sonority is falling in both directions away from the nucleus; there may be no sonority fall before the nucleus and no sonority rise after the nucleus within the syllable. (4) illustrates this in the case of *grind* and of *ray*.

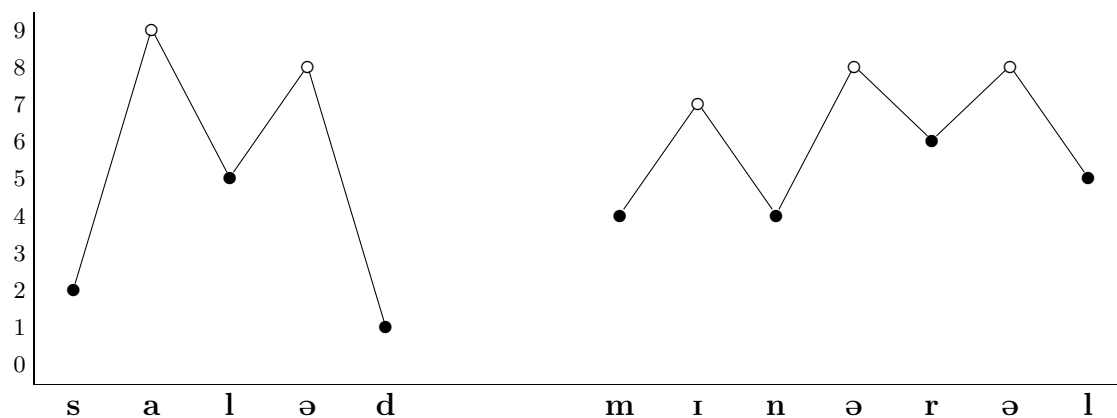
<sup>2</sup> Recall, peak is an alternative name for the nucleus.

(4) *The sonority profiles of grind and ray*

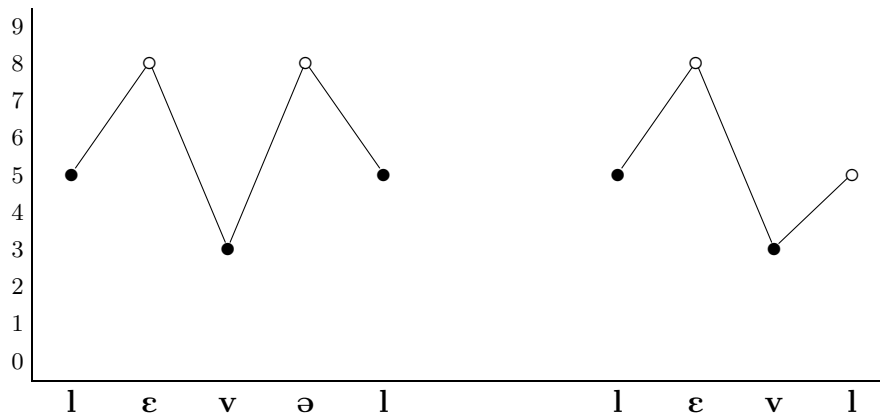


Being MONOSYLLABIC (having one syllable), both of these words exhibit one peak in their sonority profile, here shown in white. BISYLLABIC (two-syllable long) words will obviously have two sonority peaks, as *salad*, and TRISYLLABIC (three-syllable long) words three, as *mineral*, both shown in (5).

(5) *The sonority profiles of salad and mineral*



We have already mentioned that a nucleus may be occupied by a consonant. This is illustrated by the pronunciations of *level* (**levəl** and **levl**) in (6).

(6) *The sonority profiles of level with schwa and with syllabic l*

The sonority profiles of **level** and **levl** both have two peaks. While in the first case, these two peaks are occupied by two vowels, **ε** and **ə**, in the case of **levl**, the second syllable has no vowel. Nevertheless, since the word-final **l** of this word constitutes a sonority peak itself, **levl** is also bisyllabic. A consonant which is a sonority peak (which is in the nucleus) is called a syllabic consonant.

If we believe that a given segment has to unambiguously belong to one of the neighbouring syllables, we need a way of deciding whether this should be the first or the second. That is, in the cases of (6), whether the syllabification is **lε.vəl** or **lev.əl**. Neither of these options violates the sonority sequencing principle. To make a principled decision, we need further guidance.

### 4.3.2 Onset maximization

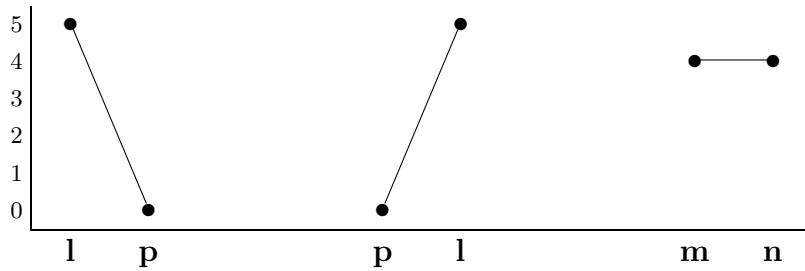
The ONSET MAXIMIZATION PRINCIPLE says: if a segment may belong to both the coda of the first and the onset of the second syllable, it belongs to the onset of the second syllable.

The principle gives preference to the syllabification **lε.vəl** over **lev.əl**. A single INTERVOCALIC consonant (i.e., a consonant between two vowels) is always the onset of the second syllable, rather than the coda of the first: VCV is syllabified V.CV and never VC.V.<sup>3</sup>

The situation with consonant clusters is more complex. The sonority profile of a consonant cluster may be falling, rising, or level, as (7) illustrates. (Examples: **lp** as in *alpine*, **pl** as in *apply*, **mn** as in *chimney*.)

<sup>3</sup> Note that by maximizing the onset we inevitably minimize the coda. Thus the principle could equally be called “coda minimalization principle”. As we are going to see at the end of this chapter, there is a universal preference in human languages for onsets over codas.

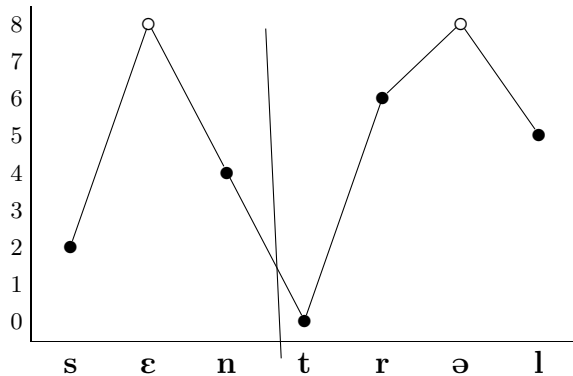
(7) *Falling-, rising-, and level-sonority clusters*



The sonority sequencing principle rules out the syllabifications *a.lpine* and *appl.y*, but does not select any of the other two possibilities: *al.pine* or *alp.ine* and *app.ly* or *a.pply*. But onset maximization rules out *alp.ine* and *app.ly*, leaving us with the intuitively correct syllabifications: *al.pine* and *a.pply*. Thus, we may conclude that the gross pattern is the following: in the case of a falling-sonority cluster the first consonant is a coda, the second an onset; in the case of a rising-sonority cluster, both consonants are in an onset.

(8) illustrates this with an **-ntr-** cluster as in *central*.

(8) *Syllabifying central*



The syllabification of *chimney* depends on whether our version of the sonority sequencing principle allows sonority plateaus within a syllable (that is, whether segments of equal sonority can occur next to each other in the same syllable), or not. In the latter case, that is, if consonants of equal sonority may not occur in the same syllable, the only possibility is *chim.ney*, since stuffing both nasals on either one side of the syllable boundary (*chi.mney* or *chimm.ey*) results in the unwanted sonority plateau.

The two principles, sonority sequencing and onset maximization, do not always produce the right syllabification. Consider, for example, a string like **atləs** (*atlas*). Of the two divisions allowed by sonority sequencing (*a.tlas* and *at.las*), onset maximization will dictate the first one. Yet there is reason to believe that this is not right (see §4.4.3), the correct syllabification ought to be *at.las*, despite onset maximization. Apparently, we need a further principle to determine the correct syllabification.

### 4.3.3 Word edges

Many phonologists say that the onset-hood of a consonant cluster can be tested at the beginning of words. That is, if a given cluster occurs word initially (which is an empirically easily decidable question), then it also occurs syllable initially (which, as we have seen, is a theoretical issue). To take the example at hand: the syllabification of *atlas* cannot be *a.tlas*, because words in English do not begin with the cluster **tl**.

If we extend the argument in the other direction, and claim that word-initial clusters are all potential syllable-initial clusters, we will end up claiming that a string like **distəns** (*distance*) is syllabified as **di.stəns**, since **st** is possible word initially, therefore syllable initially, so onset maximization lobbies for this division. Note, however, that sonority sequencing is violated by a syllable beginning with a fricative (whose sonority index is 2) followed by a less sonorous plosive (with a sonority index of 0). Further extending the word-edge test to the end of words, one is forced to discard onset maximization. It is a well-known fact of English that checked vowels (**ɪ** **ɛ** **ɑ** **ɒ** **ʊ** and stressed **ə**) do not occur at the end of words. Consequently, some analyst might be tempted to claim, they do not occur at the end of syllables either. Accordingly, a string like **lemən** (*lemon*) cannot be syllabified as **le.mən**, since this would create syllable-final **ɛ**, which should be impossible, *since* word-final **ɛ** is impossible, it must be syllabified as **lem.ən**. To achieve this syllabification overriding the output of onset maximization, a CODA CAPTURE rule is needed, which resyllabifies an onset consonant into coda position. Only stressed syllables are strong enough to capture the onset of the following syllable, and to force it into their own coda, so the noun *récord* **réko:d** is resyllabified to *rec.ord*, but the verb *recórd* **rikó:d** is not, it remains *re.cord*.

The same consideration underlies English hyphenation conventions, cf. *lem-on*, with short **ɛ** in the first syllable vs. *de-mon*, having a free vowel **di:mən**, or the noun *rec-ord*, again with short **ɛ** in the first syllable, as opposed to the verb *re-cord*, with reduced **ə** in the first syllable.

Although it offers a trivial explanation of the syllabification of *atlas*, the idea that word boundaries and syllable boundaries should coincide is far from obvious. On the practical side, it leads us into several difficult situations, two of which are presented below.

If it is impossible for a syllable to end in a sound that words cannot end in, then we cannot syllabify words like **pá:riʃ** (*parish*), **féri:j** (*ferry*), **mí:rə** (*mirror*), **hóri:j** (*hurry*), or **só:rəw** (*sorrow*), since the syllable boundary before the **r** in these words is inhibited by the fact that words cannot end in a checked vowel, while **r** is also impossible word finally, so the boundary cannot be after it either. Another difficulty with the variable syllabification of intervocalic consonants is with l-darkening and r-dropping. Both of these phenomena are formulable by syllabic constituency: both processes occur in the syllable coda, but not in the onset (see §4.4.1 and §4.4.2 below). Yet neither process is sensitive to the “length” of the preceding vowel—whether it’s free or checked—, which is unexpected if the syllabic affiliation of a consonant depends on the status of this vowel: VCV is VC.V if the first vowel is checked.

In addition to these empirical counterarguments, it is not even a theoretical necessity that syllables begin and end exactly where words do. Another suprasegmental unit, the

rhythmic foot ignores word boundaries, and easily incorporates segmental material from two neighbouring morphemes, or words. Consider, for example, the sentence *Amanda should ignore the children*, its morphological and metrical structure shown in (9).

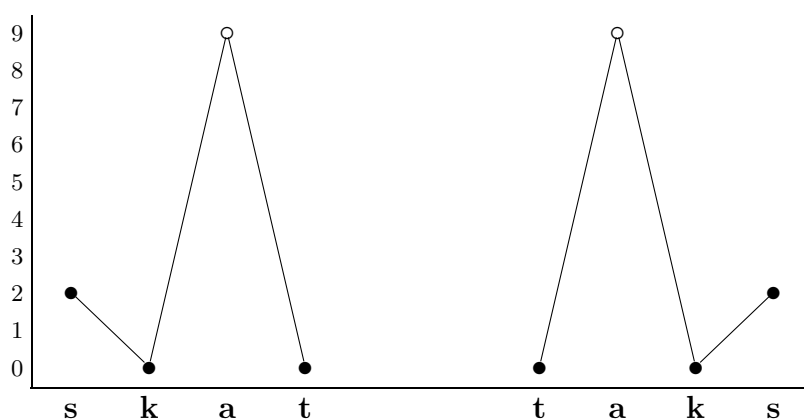
(9) A|mánda # should # ig|nóre # the |# children

A foot contains a stressed syllable and the following unstressed syllables. If there are two stressed syllables next to each other, the first foot will only contain a single syllable. If two stressed syllables are separated by many unstressed syllables, the first foot will be very long.

In this sentence, foot boundaries (|) and word boundaries (#) do not coincide, except for the last foot/word. This is because when determining the foot boundaries word boundaries are not taken into consideration. Therefore the two coincide only when two consecutive words or the last word of a sentence (*children*) begin with a stressed syllable. We also see that the sentence begins with a degenerate foot, one which does not begin with a stressed syllable (*A-*), thus is an incomplete foot, consisting only of an unstressed syllable, which is otherwise the ending of a foot. In fact, there is no reason to assume that foot and word boundaries should coincide: feet are defined on purely phonological (rhythmic) grounds, while words are units of meaning or syntax.

Given that the syllable is also a purely phonological category, one may easily hypothesize an analogous situation where it is not an absolute necessity that syllable boundaries coincide with word boundaries. In this case, word-initial (and -final) consonant clusters which seem to violate sonority sequencing are analysable as the end or the beginning of a “degenerate” syllable. (10) shows two such “offending” words, **skat** (*scat*) and **taks** (*tax*).

(10) *Syllables violating sonority sequencing*



Although these words behave as monosyllabic, they both contain two sonority peaks. This contradiction is solved by supposing that the **s** in **skat** is the end (the coda), and in **taks** it is the beginning (the onset) of a “degenerate” syllable (see §4.5.1.3 for more details).<sup>4</sup>

<sup>4</sup> There still remain a number of unsolved issues in this analysis. For example, we have no explanation for why only **s** occurs in such “degenerate” syllables in English.



## 4.4 Some phonological phenomena

So far we have seen one reason for assuming syllables: some pairs of neighbouring sounds are more closely related than other pairs. This relationship can be well expressed by assigning interdependent sounds to the same syllabic constituent, while sounds which are not related to each other will not be part of the same constituent. We now look at some well-known phonological phenomena of English to see if they can be expressed in terms of syllabic constituents, and whether this formulation is simpler than one in terms of neighbouring segments. If so, we gain further arguments for the notion of the syllable.

### 4.4.1 L-darkening within the word

At first glance, the syllable-less formulation of the l-darkening rule looks very simple: **l** is clear before vowels, and dark (i.e., velarized) elsewhere, that is, before consonants and word finally. The relevant rules are given in (11). These are linear rules, that is, they refer to the surrounding segments, the alternation is conditioned by what precedes or follows the segment.

(11) *L-darkening: the linear formulation*

- a.  $\mathbf{l} \rightarrow \mathbf{l} / \_ \mathbf{V}$
- b.  $\mathbf{l} \rightarrow \mathbf{l} / \_ \left\{ \begin{array}{c} \mathbf{C} \\ \# \end{array} \right\}$

Thus the **l** in *look, play, pillow, calling* is clear, while that in *kill, belt, silky* is dark.<sup>5</sup>

A more thorough examination of the l-darkening rule, however, reveals that (11) is oversimplified. On the one hand, we do find clear **l** before a consonant (notably **j**): e.g., in **valjʊw** (*value*); on the other, dark **l** may precede a vowel: e.g., in **travɫɪŋ** (*travelling*). In the latter case, the **l** is dark because it is syllabic. The word is syllabified as **tra.vl.ɪŋ**, the middle syllable has no vowel, its nucleus is occupied by a consonant, the **l**. It is called syllabic **l**. Syllabic **l** is dark, irrespective of what follows it, consonant or vowel.

This small detail of the l-darkening rule hints at an interesting way of expressing the regularity: perhaps it is not the following segment that counts, but the syllabic affiliation of the **l**. Since in the case of syllabic **l** reference must be made to the syllabic constituent holding the segment (the nucleus), it may be more economical to formulate the whole rule in this way. Incidentally, the status of the **l** before **j** also becomes clear in the syllabic approach. (12) gives the details.

(12) *L-darkening: the syllabic formulation*

- a. **l** is clear in the onset
- b. **l** is dark in the rhyme

<sup>5</sup> We deliberately ignore here the alternation of clear and dark **l** found in word final position. To deal with this case we need a theory of syllabification across words. We leave this issue open for now.

An onset **l** is followed by a vowel in all cases except one, when it is followed by **j**. In a branching onset, **l** usually occupies the second position (**pl**, **bl**, **fl**, **kl**, **gl**), but there is one cluster in which it is the first: **lj** (e.g., **ljʌwd** *lewd* or **valjʌw** (*value*)). Thus, an **l** that precedes a **j** is the only preconsonantal **l** that is in an onset. Syllabic **l** occupies the nucleus, which is in the rhyme. Coda **l**, which is also in the rhyme, is either followed by a consonant (the onset of the next syllable), or is word final.

The fact that **l** behaves similarly in both the nucleus and the coda is one reason to claim that these two syllabic constituents form a group, called the rhyme.

#### 4.4.2 The distribution of [r]

In rhotic accents of English (like General American), **r** is found both before vowels and before consonants, while in nonrhotic accents (like Standard Southern British English) **r** occurs only before vowels. The distribution reminds us of that of clear and dark **l**, therefore the syllabic formulation may also be the same, given in (13).

##### (13) *Distribution of r (attempt 1)*

In nonrhotic accents, **r** occurs only in the onset.

The statement in (13) suggests that there is no syllabic **r**, that is, no **r** in the nucleus, in nonrhotic accents. This is not the case, however, we do find syllabic **r** in SSBE, too, as the words in (14a) show.

##### (14) *Syllabic r in SSBE*

- a. **kámɹ̩** (*camera*), **sígr̩ét** (*cigarette*)
- b. \***dézɹ̩t** (**dézət** *desert*) or \***ófɹ̩** (**ófə** *offer*)
- c. **bárn̩** (*barren, baron*), **vétr̩n̩** (*veteran*)

Crucially, in SSBE syllabic **r** does not occur before a consonant or word finally, forms like those in (14b) are impossible. In fact, not just syllabic but any **r** occurs not only before vowels, but before any syllabic segment, as (14c) shows. (This also likens the distribution of clear **l** and **r**, since **l** is clear before syllabic **r** too: e.g., **sélɹ̩j** (*celery*).<sup>6</sup>) Thus it is not (only) the syllabic affiliation of the **r** that decides whether it is pronounced or not, but the syllabic affiliation of the *following* segment. An **r**, whether in the onset or in the nucleus, is pronounced if immediately followed by a segment that is in a nucleus. This distribution is different from that of clear and dark **l** (recall, syllabic **l** is dark, irrespective of what follows), and hints at a mixed type of conditioning: it is not the host of the **r** that matters, but the host of the following segment. We will not speculate any further here on possible solutions of this anomaly. The distribution of **r** can thus be given as (15).

<sup>6</sup> Notice the paradox that both **l** (and **m** and **n**) may be followed by syllabic **r** and **r** may be followed by syllabic **l** (and **m** and **n**). This is appear to go against sonority sequencing. However, we cannot deal with this problem here.

(15) *Distribution of r (attempt 2)*

In nonrhotic accents, **r** occurs only before a segment in a nucleus.

## 4.4.3 Aspiration

(16a) contains the environments where voiceless plosives (here exemplified by **p**) are aspirated, (16b) contains cases where aspiration is missing. (For uniformity's sake, aspiration is marked by the superscript **h** even when a sonorant follows, where the transcription **p̥** is also used in other publications.)

(16) *Aspirated and unaspirated p*

a. pain	<b>p<sup>h</sup>éjɪn</b>	b. Spain	<b>spɛjɪn</b>
plain	<b>p<sup>h</sup>léjɪn</b>	splay	<b>spleɪj</b>
apace	<b>əp<sup>h</sup>éjs</b>	leper	<b>lépə</b>
complain	<b>k<sup>h</sup>əmp<sup>h</sup>léjɪn</b>	explain	<b>ɪkspléjɪn</b>
pagoda	<b>p<sup>h</sup>əgəwðə</b>	specific	<b>spəsífɪk</b>
placenta	<b>p<sup>h</sup>læséntə</b>	lap	<b>láp</b>

We see that voiceless plosives are pronounced as **p<sup>h</sup>**, **t<sup>h</sup>**, **k<sup>h</sup>** when followed by an optional approximant (**l**, **r**, **j**, or **w**) and a stressed vowel, unless preceded by **s**. If the plosive is word initial, the following vowel may be unstressed. This rather complicated description seems to call for a reformulation along syllabic lines. Phonologists do not hesitate to provide the alternative shape of the rule, running as in (17).

(17) *The aspiration rule: syllabic formulation*

Voiceless plosives are aspirated at the beginning of a word or a stressed syllable.

This formulation of the rule explains the optional approximant on the one hand, and the aspiration-inhibiting effect of **s** on the other. A syllable-initial voiceless stop is followed either by a vowel, or by an approximant which in turn is followed by a vowel. Furthermore, if **sC** clusters are thought to be tautosyllabic, then a voiceless plosive preceded by **s** is not at the beginning of a syllable. Note that in the Jones/Gimson transcribing tradition this is the reason why the stress mark is placed before the **s** in *explain* **ɪk'spleɪn**.

But in §4.3.3, we argued that **sC** clusters were in fact not tautosyllabic, that is, the **s** of a word-initial **sC** cluster is a “degenerate” syllable. The elegance of the syllabic formulation of the aspiration rule (in (17)) appears to undermine this view. However, explaining the absence of aspiration by the tautosyllabicity of the pre-plosive **s** is flawed. It is not only **s** that inhibits the aspiration of the following voiceless plosive, but any other fricative. The appearances mislead us only because fricative+voiceless plosive clusters within a morpheme are overwhelmingly **sC** clusters. The only other instance of this cluster is **ft**, but then **ft** does not occur word initially and is very rarely followed by a stressed vowel. But when it is, the plosive may be unaspirated: e.g., in **kaftán** *kaftan*.

It is unlikely that any analyst would be ready to syllabify this word as **ka.ftán**, except to explain the possible absence of aspiration.

Recall our discussion of the syllabification of the **-tl-** cluster in §4.3.3. Although onset maximization would prefer this cluster to be tautosyllabic (*a.tlas*), the fact that it does not occur word initially casts doubt on this. Aspiration in fact also supports the HETEROSYLLABIC analysis (namely, that the two segments are in separate syllables, *at.las*): in the rare cases of **-tIV-** strings (that is, **-tl-** followed by a stressed vowel, e.g., *Atlántic*), when the plosive is expected to be aspirated if tautosyllabic with the vowel, we do not find aspiration. The conclusion is that here the syllable boundary falls between the plosive and the liquid: *At.lán.tic*.

Accordingly, we may establish that for a voiceless plosive to be aspirated being at the beginning of a stressed or word-initial syllable is a necessary, but not sufficient condition. In addition, it must not be preceded by a fricative, even though such a fricative is necessarily heterosyllabic, even in *Spáin*, *specífic*.

There is a rather obvious alternative analysis for the absence of aspiration after voiceless fricatives. We may simply posit a phonotactic constraint: fortis plosives are illicit after voiceless fricatives. So plosives are not aspirated after voiceless fricatives, because they do not occur there. That is, **sp** is impossible within a morpheme, so *Spain* ought to be transcribed **sbéjn**, because the labial consonant in it is not fortis, but lenis. Recall, lenis plosives are voiceless in English unless they occur between sonorants, which is not the case if a plosive occurs after **s**: so here we expect to find a voiceless unaspirated consonant, which is indeed the case. Experiments have shown that if we clip the **s** from the beginning of *Spain*, native speakers hear *bane*. The reason why we always thought the word *Spain* contained **p** is the spelling, which contains the letter *p* following the practice of many, but not all languages that use Roman letters. For example, the Welsh spelling of the name of the country is *Sbaen*.

The sequence **sp** is thus only possible in English across a word boundary, as in *icepack ájspak*, and indeed, the **p** is aspirated here. Within a morpheme we only find **sb** (e.g., *Spain*, *explain*), rarely **zp** (e.g., *benzpyrene*, *gazpacho*) or **zb** (e.g., *husband*, *lesbian*). Plosives at other places of articulation are similarly distributed: **sd**, **sg** are common (e.g., *stop*, *still*, *school*, *ski*), **st**, **sk** only occur across a word boundary (e.g., *mistrust*, *oxtail*, *crosscut*, *disconnect*), **zt**, **zk**, **zd**, and **zg** are rare (e.g., *Aztec*, *Azkaban*, *Mazda*, *Glasgow*).

In currently wide-spread practice the homophonous words *disgust* **dis'gʌst** and *discussed* **di'skʌst** are transcribed differently. This is clearly untenable in a serious transcription system: it projects a spelling difference into the transcription. If we admit that a plosive after a voiceless fricatives can only be lenis, both words will be transcribed as **disgósds**.

This analysis of voiceless fricative+plosive clusters is rather plausible and if we accept it, we will not be forced to violate the sonority sequencing principle in order to explain why we find no aspirated plosives after voiceless fricatives.

#### 4.4.4 Yod-dropping

The distribution of yod (**j**) is not only more easily formulated by making reference to syllabic constituents, but also provides arguments about syllabic constituency. For our current purposes an examination of stressed syllables with yod is sufficient, therefore we will not be concerned with the somewhat different distribution of yod in unstressed syllables.

After consonants morpheme internally, the distribution of yod is rather constrained in English: it can only occur if followed by **ʌ** (or its pre-R version, **o**). Accordingly, sequences like **Cjɛ**, or **Cja** only occur in loanwords (e.g., *piéd-à-terre*, *piano*). This suggests that the yod and the following vowel share a syllabic constituent (most probably the nucleus), since, recall, phonotactic constraints hold within syllabic constituents (see §4.2). Surprisingly, a postconsonantal yod is also in a phonotactic relationship with the preceding consonant. English accents vary to some extent with respect to the distribution of postconsonantal **j**, we examine a conservative version of Standard Southern British English (also known as Received Pronunciation). (18) collects some of the relevant data.

(18) *The distribution of postconsonantal yod in RP*

a. compute	<b>kəmpjút</b>	b. enthuse	<b>ɪnθjúwz</b>
rebuke	<b>rɪbjúk</b>	consume	<b>kənsjúwm</b>
confuse	<b>kənfjúwz</b>	exude	<b>ɪgzjúwd</b>
revue	<b>rɪvjúw</b>	minute	<b>majnjúwt</b>
amuse	<b>əmjúwz</b>	volute	<b>vəljúwt</b>
		obtuse	<b>əbtjúws</b>
c. agglutinate	<b>əglúwtɪnejt</b>	deduce	<b>dɪdjúws</b>
peruse	<b>pəruwz</b>		
assure	<b>əʃó:</b>	d. acute	<b>əkjúwt</b>
eschew	<b>ɪstʃúw</b>	ambiguity	<b>ámbigjúwtɪj</b>
adjudicate	<b>ədʒɹúwdɪkejt</b>	exhume	<b>ekshjúwm</b>

The words in (18a) contain a labial consonant before the yod, those in (18b) a dental or alveolar consonant, and those in (18d) a velar or glottal one. In all these classes, the yod remains intact. It is only in the type in (18c) that the yod is lost (or, put alternatively, cannot occur).

Apart from *agglutinate*, all the words in the yodless group contain a postalveolar consonant before the **ʌ** (or **o**). The accepted syllabic explanation for the absence of the yod in this position is that postalveolar consonants cannot form a branching onset with yod in second position. This hypothesis is supported by at least two pieces of evidence: on the one hand, postalveolar consonants *can* precede yod, provided the two are not in the same onset. Unfortunately, this only occurs if the two are in separate morphemes, e.g., in *fresh urine* (**-fj-**), *church use* (**-tʃj-**). It is a stronger argument that branching onsets *generally* inhibit HOMORGANIC clusters: after labials the labial glide does not occur (**\*pw**, **\*bw**, **\*fw**, **\*mw**), after dentals and alveolars there is no **l** (**\*tl**, **\*dl**, **\*θl**),

**r** is impossible after postalveolars (\***tʃr**, \***ʒr**).<sup>7</sup> If so, we expect the glide yod not to be possible exactly after postalveolars.

The case of yod following **l** is more complicated. Yod may follow **l** only if the **l** is “lone”, that is, it is not preceded by a consonant. This is a strange rule: apparently the yod can “see through” the preceding **l** to check the properties of the sound before it. If, however, we suppose that the onset of the syllable can host a maximum of two consonants, the phenomenon falls into place: a consonant together with the following **l** occupy both available slots, not leaving any place for the yod, as is shown in (19b). On the other hand, a single **l** occupies only the first slot, the second being vacant for receiving the yod, as is shown in (19a).

(19) *The impossibility of yod after consonant+l*



Intriguingly, a yod appears after an **sl** cluster in the accent under examination: *sleuth* is **sljɥwθ**. That is, the **sl** cluster behaves like a single **l**. If we are to maintain the explanation of the presence and absence of yod in the **l**\_\_ and #**l**\_\_ environments, as opposed to the **Cl** environment, then we must conclude that the **sl** cluster’s syllabic affiliation is similar to that of single onset **l**’s and not to that of branching onset **Cl**’s. This is a strong piece of evidence for the claim made in §4.3.3, namely, that syllable and word boundaries do not necessarily coincide. In a word like *sleuth* the **l** belongs to an onset, but the **s** before it does not, at least not to the same onset as the **l**.

The same situation prevails with any consonant cluster of the shape **sC**. Thus if yod may appear after a given consonant **C<sub>x</sub>** and **sC<sub>x</sub>** is also a possible cluster, then yod may appear also after the **sC<sub>x</sub>** cluster. (20) gives an example for each cluster in question. (The **C<sub>x</sub>j** clusters not appearing here do not have an **sC<sub>x</sub>** counterpart, hence obviously also lack their **sC<sub>x</sub>j** pair. We take the nonexistence of **snj-** to be an accidental gap.)

(20) *C<sub>x</sub>j and sC<sub>x</sub>j clusters in English*

C <sub>x</sub> j	sC <sub>x</sub> j
beauty <b>bj-</b>	sputum <b>bj-</b>
mew <b>mj-</b>	smew <b>smj-</b>
duty <b>dj-</b>	student <b>sdj-</b>
new <b>nj-</b>	—
lewd <b>lj-</b>	slew <b>slj-</b>
argue <b>gj-</b>	rescue <b>sgj-</b>

<sup>7</sup> Note that the fact that there are English words beginning with **ʃr** does not warrant that the cluster in them is a branching onset.

As we have seen, the distribution of postconsonantal yod provides a significant argument for claiming that word-initial clusters do not automatically qualify as syllable-initial clusters, that is, as branching onsets. Furthermore, we see that *s* is singled out as the only consonant that may occur in the “degenerate” word-initial syllable.

It is hardly accidental that *sC* clusters are not treated as branching onsets in other languages either. Latin, Rumanian, and many Italian dialects allow words to begin with an *sC* cluster (e.g., Latin *via strata* ‘paved road’, Rumanian *stradă*, Italian *strada* — actually English *street* goes back to the same word.) Other Romance languages, however, did not allow for such a cluster to occur at the beginning of a word, these therefore inserted a vowel at the beginning (e.g., Spanish *estrada*, Old French *estrée*). It is only word-initial *sC* clusters that were thus “amended”, other clusters are acceptable in Spanish and French (e.g., Latin *clavis* ‘key’, Spanish *clave*, French *clé*; Latin *tres* ‘three’, Spanish *tres*, French *trois* **trwɑ**, etc.). Hungarian, which for a long period did not have any word-initial consonant cluster, also treated the two types differently. The usual branching onsets were nativized by inserting a vowel between the two consonants (e.g., Slavic *brat*, Hungarian *barát* ‘friend’; Latin *claustrum*, Hungarian *kolostor* ‘cloister’). The fate of *sC* clusters was different: Latin *schola*, Hungarian *oskola* or *iskola* ‘school’; Latin *Stephanus*, Hungarian *István*, etc. Farsi (Persian) follows the same strategy synchronically: **pelastik** ‘plastic’, **felæf** ‘flash’, but **ʔeski** ‘ski’, **ʔesnæk** ‘snack’.

## 4.5 Types of syllable

Any given language has a set of segments, an inventory, selected from the larger pool of human speech sounds. Some languages have voiced obstruents, others do not. Some have front rounded vowels, others have affricates, yet others have both. We can also detect certain patterns in this selection. For example, a language has voiced obstruents only if it also has voiceless ones. Or a language has front rounded vowels only if it also has front unrounded vowels. Such observations enable us to establish IMPLICATIONAL HIERARCHIES: the presence of voiced obstruents implies the presence of voiceless obstruents in a given language, and the presence of front rounded vowels imply the presence of front unrounded vowels, but not vice versa.

Similarly, the syllable inventories of languages vary: English and Hungarian have long vowels, French and Spanish do not. (Note that this is a syllabic difference if long vowels are represented as a single segment belonging to both slots of a branching nucleus.) All these four languages have codas, Hawaiian does not. Syllable types can also be arranged into implicational hierarchies. If a language has long vowels, it also has short vowels, that is, long vowels imply short vowels. The reverse is not true: a language with short vowels may or may not have long vowels, there is no implication here. We can use the following notation to communicate this fact.

(21) *Implications of short and long vowels*

a.  $VV \supset V$

b.  $V \not\supset VV$

It must be admitted that vowel length is a relative property, what languages may lack is not long vowels, but the contrast between short and long vowels. The length

of the vowels in a no-contrast system is immaterial: the vowels of such a language are systematically analysed as short. Thus the implication becomes trivial.

In §4.5.3, we are going to see further implicational relationships of syllable types. But before that we have to get acquainted with traditional names for some syllable types: OPEN, CLOSED, LIGHT, and HEAVY syllables.

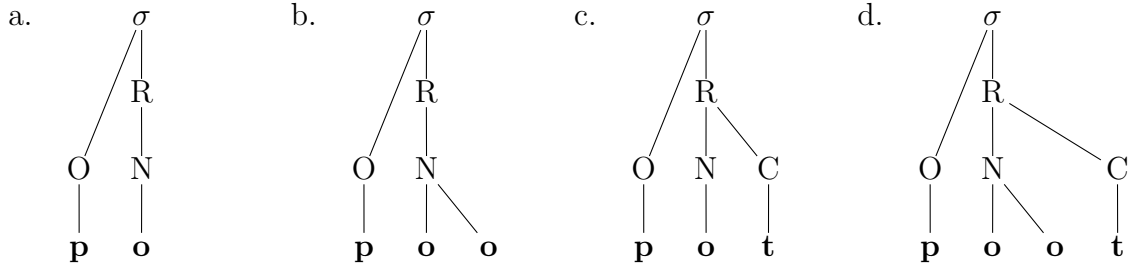
### 4.5.1 Syllable weight

Syllables may end in a consonant, or in a vowel. A syllable that ends in a consonant is a CLOSED syllable (viz., closed by that consonant, e.g., the first syllable of *panda* **paɪndə** is closed by the coda **n**); one which does not is OPEN (e.g., the second syllable of *panda*, or the first syllable of *paddock* **paɪdək** is open).

One may be tempted to identify syllable weight with graphic positions. There is indeed some similarity between the notions of FREE graphic position and open syllables on the one hand, and COVERED graphic position and closed syllables on the other. For example, the word *cinema* contains three open syllables, and its three vowels are each in free graphic position, while *map* is a closed syllable, and its vowel is in covered graphic position. But equating the two pairs is unwarranted, as the above example clearly shows: the first syllable of **paɪdək** is open, but the first vowel of *paddock* is in covered position. And vice versa: the vowel of *make* is in free position, but **mɛjk** is a closed syllable—see §4.5.1.2 though. It is also difficult not to notice that stop+liquid clusters, which do not “cover” the vowel letter preceding them (e.g., *maple*), are reminiscent of branching onsets, the type of consonant cluster which does not “close” the preceding syllable. The parallel, however, is again incomplete: *tl* and *dl* are stop+liquid clusters, but not branching onsets.

In many respects, however, it is not open and closed syllables that pattern together, rather, open syllables with a short vowel are opposed to open syllables with a long vowel *and* to closed syllables. An open syllable with a short vowel is called a LIGHT syllable, a syllable which is either closed or has a long vowel (diphthongs in English all count as long) is called a HEAVY syllable. Thus, the above *cinema* **sɪ.nə.mə** is three light syllables, *tambour* **tam.bo:** is two heavy syllables. Sometimes a third category is also identified: a syllable that contains both a long vowel and a coda consonant closing it, as the first syllable of *thirsty* **θɜːs.dɪj**, or a short vowel but two coda consonants, as in *lamp*, is called SUPERHEAVY. In most cases, a heavy and a superheavy syllable are equivalent. In English, as in many other languages, stress assignment is sensitive to the heavy–light distinction (cf. chapter 6). The relevant kinds of syllable are illustrated in (22). The syllables in (22a–b) are open, those in (22c–d) are closed. The syllable in (22a) is light, those in (22b–d) are heavy, that in (22d) is also called superheavy. The sequence **oo** in (22b) and (22d) is a way of representing a long vowel, i.e., it is equivalent to **o:**.



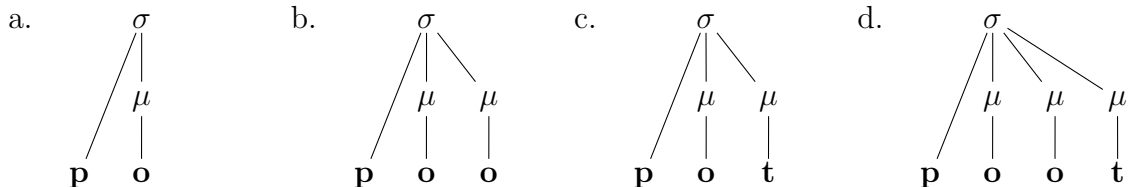
(22) *Branching in light, heavy, and superheavy syllables*

We can see that the relevant notion for syllable heaviness is *branching* in or below the rhyme. While in a light syllable neither the nucleus nor the rhyme branches, (22a), in a heavy syllable either the nucleus, (22b), or the rhyme branches, (22c). If both branch, as in (22d), we have a superheavy syllable.

Interestingly, the onset has no bearing on the weight of the syllable. Only the rhyme counts: an onsetless closed syllable (like **eg** *egg*) is heavy, just like one with a single onset consonant (like **peg** *peg*), or a cluster, that is, a branching onset (like **greg** *Greg*).

## 4.5.1.1 Moras

Syllable weight is measured in MORAS. Each segment in a nucleus is worth one mora, and in some languages (English among them) coda consonants are also moraic. Some phonologists would therefore represent the syllable types in (22) without syllabic constituents, with only moras (usually symbolized by the lowercase Greek mu,  $\mu$ ).

(23) *Moras in light, heavy, and superheavy syllables*

The weight of a light syllable is one mora, (23a), that of a heavy is two, (23b–c). Superheavy syllables contain three moras, (23d). Note that this definition of syllable heaviness avoids the awkward formulation of the previous approach: “branching somewhere in the rhyme.”

A way of justifying the phonological existence of moras is the phenomenon of COMPENSATORY LENGTHENING. In this change, which is frequently found in the history of various languages, the loss of a segment is made up for by the lengthening of another, neighbouring segment. A case in point is the lengthening of the broad vowels in nonrhotic accents of English. Before coda **r**'s were lost, the first syllable of *party* was closed, hence heavy (**par.ti**). The weight of this syllable was retained even after the **r** was lost and it became open. The change is illustrated in (24).

(24) *Compensatory lengthening in party*

The only difference between the two representations is the relinking of the second mora of the first syllable: in (24a) it is linked to the coda **r**; in (24b), the nonrhotic form, it is linked to the vowel, just like the first mora. The **r** is now not linked to any suprasegmental node ( $\sigma$  and  $\mu$  in this theory), and as a result it remains unpronounced. This simple change encodes a complex phenomenon: the loss of the **r** and the subsequent lengthening of the preceding vowel. Languages provide many examples of compensatory lengthening: Old English **nixt** turns into Middle English **ni:t** (Modern English **najt** *night*), Hungarian **nyolts** (*nyolc* ‘eight’) turns into **nyo:ts**, etc. In all these changes, we can see that syllable structure, the number of moras or, alternatively, the branching structure in the rhyme is stable, it is only the segmental material linked to them that changes. This justifies the hypothesis that the two exist independently of each other.

Quantitative poetry also supports the claim made by moraic theory, namely, that two light syllables are equivalent to a heavy one. For example, in a hexameter, a line made up of six dactylic feet (heavy–light–light), any foot, except for the second from the end, may be realized by a spondee (heavy–heavy). Since the weight of both a dactyl and a spondee is four moras, their interchangeability is all but surprising. Note, however, that the first heavy of the dactyl cannot be replaced by two light syllables: light–light–heavy or light–light–light–light will not do for a foot in a hexameter.

Stressability of a syllable is often bound to syllable weight, as the English stress rule mentioned in §4.5.1.2 shows. The same idea underlies the notion of coda capture, mentioned in §4.3.3: by capturing the onset of the following syllable, a light stressed syllable becomes heavy, which then gives justification for the fact that it is stressed.

Other languages also subscribe to the if-stressed-then-heavy inference. In Italian, for example, if an open syllable receives stress, its vowel will lengthen: the stressed vowel of *fátto* **fat:o** ‘fact’ remains short, but that of *fáto* **fat:o** ‘fate’ becomes long. Since vowels may not lengthen word finally in Italian, stressed syllables here will get closed by the initial consonant of the following word: *città nera* **tʃit'tan'ne:ra** ‘black city’. There is no **n** at the end of *città*, and the **n** is not geminate in **ne:ra** in isolation: it is because of the word-final stress that the last syllable must become bimoraic.

A similar tendency is observable in Hungarian too: word-final high vowels are long when stressed (e.g., *sí* ‘ski’, *bú* ‘sorrow’, *tű* ‘needle’), but short when unstressed (e.g., *nasi* ‘candy’, *bábu* ‘puppet’, *tet[y]* ‘louse’). It must be admitted that Hungarian also has a minimal word constraint to the effect that a single light syllable cannot constitute a content word. This constraint in itself is enough to force the lengthening of the final vowel in monosyllabic content words, stress does not have to be invoked.

### 4.5.1.2 Extrametrical consonants

Examining the place of stress in English verbs (also see chapter 6), we find a curious pattern. (25) contains the relevant data. In these words diphthongs are treated as long vowels, according to the traditional analysis.

(25) *Verbal stress patterns*

<u>penultimate stress</u>	<u>final stress</u>
a. <i>consíder</i> <b>kənsídə</b>	b. <i>lamént</i> <b>ləmént</b>
<i>bother</i> <b>bóðə</b>	<i>salúte</i> <b>səlúwt</b>
c. <i>cáncel</i> <b>kánsəl</b>	d. <i>agrée</i> <b>əgríj</b>
<i>devélop</i> <b>dívéləp</b>	<i>defý</i> <b>dífáj</b>

The data in (25a) show that verbs with a light ult are stressed on their penult. Verbs that end in a closed syllable, that is, contain a heavy ult, also have penultimate stress, as in (25c). So far it is only verbs with a superheavy ult, those in (25b), that are stressed on their ult, thus the division seems to be between light and heavy syllables on one side and superheavy syllables on the other side. The data in (25d), however, upset this generalization, since here plain heavy (i.e., not superheavy) syllables are stressed. Although there is a difference between the heavy syllables of (25c) and of (25d), the former are heavy by virtue of a closed syllable, the latter of a long vowel, it is not particularly neat to include such a distinction in a stress rule. In fact, this cannot even be done in a moraic theory, where both *-cel*, *-lop* and *-gree*, *-fy* are equally bimoraic.

By applying a little trick, the whole picture becomes much simpler. If we disregard the final consonant in each of these words, the choice boils down to the difference between heavy and light syllables. (Note that for this to work we must not take diphthongal offglides to be consonants.) The analysis of the types of verb in (25a) and (25d) remains, because these verbs are vowel final. The verbs in (25b) and, especially, in (25c) change their category. Without the final consonant, the ult of *cancel* is light (**-sə-**), so the verb will follow the pattern of *bother*. The verbs that end in a superheavy syllable (*lament* **-ment**, *salute* **-lwt**) will still contain a heavy syllable without the last consonant (**-men-**, **-lwt-**), accordingly they will have stress on their ult. In fact, by ignoring the last consonant, we get rid of most superheavy syllables of English altogether, since these mostly occur word finally. A word-final consonant which does not count in stress calculation is said to be EXTRAMETRICAL.

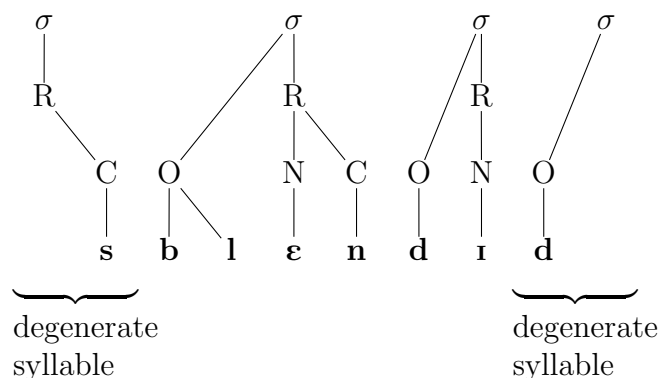
The notion of extrametricality is, nevertheless, a problematic one. We have seen above (in §4.3.3) that short lax vowels cannot occur word finally. Now if word-final consonants are extrametrical, lax vowels are expected not to occur in the  $\_C\#$  context. Yet they do (e.g., *cat*, *dog*, *nut*, *regret*), so one has to make arbitrary claims about why at the point of stress assignment the consonant is invisible, while at the point when phonotactic constraints are obeyed the consonant becomes visible.

### 4.5.1.3 Degenerate syllables

An alternative is to assume that a word-final consonant is part of a “degenerate” syllable, similarly to a word-initial *s*. In this way, the consonant is visible throughout the

calculations, but does not contribute to the weight of the last syllable. (26) shows the representation of the word *splendid* along these lines.

(26) *The syllables of splendid*



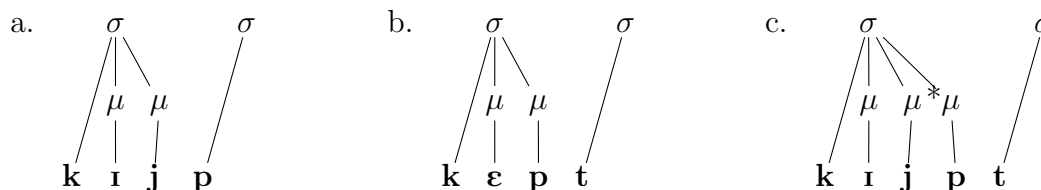
In (26) the degenerate syllables occur at the edges of the word. This is a general, perhaps exclusive pattern. If so, then it is a totally misguided idea to base syllabification (notably the decision of what is a possible onset) on what occurs at the beginning of the word and what does not, as suggested in §4.3.3.

#### 4.5.2 Closed syllable shortening

The phenomenon of CLOSED SYLLABLE SHORTENING may also be explained by mora counting. English exhibits some traces of this phenomenon (which indicates that it must have been active at some stage of the history of the language), but there are large portions of the vocabulary that do not show it.

A verb like *keep* **kɪjp** is represented as in (27a). Its past form *kept* **kept** is shown in (27b), while a hypothetical past form—occurring in child language—\***kijpt** is in (27c).

(27) *Moras in keep and its past forms*



The word-final consonant is extrametrical, hence the rhyme of *keep* weighs two moras. With the addition of the past tense suffix the word has two consonants at the end, only the second of which can be extrametrical. If the stem-final **p** were simply pushed into the rhyme without any further changes, the rhyme would end up with three moras, (27c), a SUPERHEAVY rhyme, which is (or rather was, at least when this form developed) impossible. As a result, the nucleus has to shorten, hand over one of its two moras to the now coda **p**. This is closed syllable shortening. The change of the quality of the vowel (**ij** to **ε**) is clear evidence that this change is a historical relic in the phonology of English.

If this were a phonological process happening now, the resulting short vowel would have to have the same quality as the long one, that is, **ɪ**.

### 4.5.3 Typology

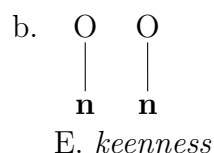
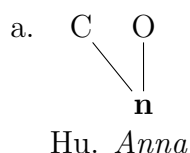
Languages differ with respect to the possible maximum size of their syllables, as well as the types of segment that may occur in different syllabic constituents. In this section, we are going to see some of this variability.

Languages like English and Hungarian have very complex syllable templates. Both languages have short and long vowels, that is, nuclei can branch in them. They also have coda consonants, so rhymes can also branch. Onsets can branch in English, but it is debatable whether the same is true of Hungarian onsets, too. It is certainly the case that words in this language may begin with more than one consonant (e.g., *próba* ‘trial’, *tréfa* ‘joke’), nevertheless that, as we have seen, is no reason to conclude that these clusters are branching onsets. The fact that syllables whose vowel is followed by what looks like a branching onset (a stop+liquid cluster) count as heavy, e.g., *paprika*, is a dactyl (heavy–light–light, so *pap.ri.ka*) support the view that these clusters are heterosyllabic in Hungarian, just like any other consonant cluster.

Languages usually allow any member of their whole inventory of consonants to occur in the syllable onset.<sup>8</sup> On the contrary, the set of potential coda consonants is often severely limited. English and Hungarian are quite liberal also in this respect, but constraints do exist, a coda nasal followed by a plosive, for example, cannot have its own independent place of articulation, it must assume that of the plosive. This is referred to as nasal place of articulation assimilation.<sup>9</sup>

Returning to CODA CONSTRAINTS, many accents of English do not allow the feature rhotic (or whatever is responsible for distinguishing **r** from other segments) in the coda. English also does not allow a coda position to copy all the features of the following onset, that is, this language does not have GEMINATES (Hungarian does have geminates, e.g., *Anna* **an:ɑ**, English has **anə**). Whenever a consonant is long in English the two halves are separated by a word boundary, that is, we are dealing with a fake geminate (e.g., *keen#ness* **kɪjnnəs**). A true geminate **n** is shown in (28a), its fake counterpart in (28b).

(28) *A true and a fake geminate*



<sup>8</sup> Actually, this is another reason why the membership of **ŋ** in the English segment inventory is doubtful: it is the only segment with an alleged phonemic status which does not occur in the syllable onset.

<sup>9</sup> Actually, the fact that phonotactic constraints exist between a coda and the following onset seriously undermines the argument for a hierarchical syllable based on these constraints: the coda and the onset following it are very distantly related as far as the canonical syllabic — onset, nucleus, coda, and rhyme — constituents are concerned.

Recall that word-final consonants were here analysed as the onset of a degenerate syllable, thus even the syllabic affiliation of the segments in a true and a fake geminate are different.

The coda is much more radically constrained in Japanese. Here it can independently contain the feature nasality only, all other properties of a coda consonant must come from the following onset consonant. The effect of this CODA CONSTRAINT is that there are only two types of consonant cluster in Japanese: (true) geminates and HOMORGANIC (of the same place of articulation) nasal+plosive clusters (recall, nasals are stops, i.e., their stopness must also come from the following position, which is only possible if there is a plosive there). In geminates, all properties of the coda come from the following onset (cf. (28a)), in nasal+plosive clusters, nasality is the coda's own property, but others, like, for example, place of articulation, come from the following onset. So consonant clusters like in *Nippon* 'Japan' or *Honda* (a brand name) are the only possible types in Japanese, other clusters are broken up, like *arubaito* 'part-time work' (from German *Arbeit* 'work'), *Reonarudo Dikapurio* ('Leonardo DiCaprio'), or simplified, like *ōkesutora* 'orchestra' (from English *orchestra*).

The ultimate coda constraint is one that does not allow anything to occur in coda position, in fact, one that does not allow a coda position at all. Hua (a Khoisan language spoken in South Africa) and Cayuvava (an Amerindian language spoken in Bolivia) are examples of languages which do not have codas, i.e., the rhyme cannot branch in these languages, they have exclusively open syllables. It is interesting to note the asymmetry existing between onsets and codas: while codas do not even exist in some languages, they are not obligatory in any language (that is, all languages have open syllables); onsets on the other hand exist in all languages, in fact, they may be obligatory (for example, they are so in Hua: *all* syllables must begin with a consonant; the obligatoriness of the onset also hints at why hiatus tends to be filled in most languages: this is a way to avoid onsetless syllables). It is difficult not to see the onset maximization principle as an instantiation of this universal preference for onsets vis-à-vis codas.

The syllable nucleus is also subject to variation across languages. We have already seen that one choice a linguistic system has to make is whether it allows its nuclei to branch: English and Hungarian do, Spanish and French do not. Another parameter is what type of segments are allowed to occur in the nucleus. To capture this variable, we can again make use of the sonority hierarchy shown in (3). It is usually enough to specify the lowest sonority index of what may be a nuclear segment, as any other segment with a higher sonority index will also be found there. This means that the set of possibilities is limited: we do not find linguistic systems in which some segment with a given sonority index may be syllabic, whereas another with a higher sonority index may not. The chart in (29) illustrates some possibilities.

(29) *Possible nuclear segments in some languages*

	Hungarian	Serbo-Croat.	Czech	Eng. unstressed	Eng. stressed
9	hat 'six'	brat 'brother'	vlak 'train'	—	cap <b>a</b>
8	fej 'head'	nov 'new'	led 'ice'	alga - <b>ə</b>	peg <b>ɛ</b>
7	fül 'ear'	vuk 'wolf'	zub 'tooth'	panic - <b>r</b> -	bit <b>ɪ</b>
6	—	vrh 'peak'	vrch 'hill'	leper - <b>r</b>	—
5	—	—	vlk 'wolf'	label - <b>l</b>	—
4	—	—	—	reckon - <b>n</b>	—
3	—	—	—	—	—
2	—	—	—	—	—
1	—	—	—	—	—
0	—	—	—	—	—

In Hungarian the lowest sonority value for a syllabic segment is 7, that is, all vowels may be sonority peaks, but consonants may not. Serbian and Croatian (or Serbo-Croatian) allow **r** besides vowels to be the syllable peak, that is, any segment with a sonority index of 6 or higher. Czech (and Slovak) are even more liberal, they allow segments down to sonority index 5 to assume the function of the head of the syllable: beside the vowels, **r** and **l** may also be syllabic, but nasals and obstruents may not. English is both more and less strict in this respect: in stressed syllables, we find only vowels as syllable peaks (like in Hungarian), in unstressed syllables any sonorant may occur in the nucleus, so the lowest sonority index here is 4. Interestingly, low vowels do not occur in unstressed syllables in English.<sup>10</sup>

There are reports of languages (Imdlawn Tashlhiyt Berber, spoken in North-West Africa, and Nuxálk (earlier known as Bella Coola), spoken in British Columbia, are the celebrated examples) where even voiceless stops can be syllabic, that is, there are no constraints whatsoever on the type of segment that is allowed in the nucleus. Whether these are genuine cases of syllabic obstruents is debatable and debated by phonologists.

The variability of syllable types in languages is quite large, we have only scratched the surface here. The parameters discussed in this section also go under the heading of phonotactic constraints, but most of those mentioned are independent of the neighbouring segments, it is only the syllabic constituent holding the segment that imposes restrictions on it.

## 4.6 Conclusion

We have seen that there is a phonologically defined level between segments and morphemes/words: that of syllables, which often enable an economical formulation of phonological phenomena. Syllables have an internal, hierarchical structure. The calculation of syllable boundaries is guided by universal principles. Languages show well-definable variability with respect to the complexity of their syllable types.

<sup>10</sup> The unstressed vowels of English show large variation, so although transcribed with the symbol **ə**, word-final schwa is a rather low vowel.

Despite all the positive evidence for syllables, we have also encountered cases that argue against syllable structure by making this level of abstraction unnecessary. Alternatives for explaining syllable-related phenomena without syllable structure do exist, but are beyond the scope of this book.