# The syllable in phonological analysis

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This article gives an overview of the role that the syllable plays in phonological analysis. It explains how the syllable is used in the currently practised frameworks in phonology, contrasting Derivational Theory and Optimality Theory.

Section 1 asks the question of why syllables are necessary in phonological analysis and demonstrates that syllable-based generalizations offer insights unavailable in linear non-autosegmental frameworks. Section 2.1 explains how syllabification is carried out. Assumed here is the X-skeletal onset-rhyme constituency. Section 2.2 addresses the role of constraints in syllabification. Both the current practice and the origin of constraints are examined. Ambisyllabification, resyllabification and boundary blocking effects are the focus of section 2.3. Section 2.4 looks at the problem of extrasyllabic consonants and explains strategies that languages use to resolve this problem. The subject of section 3 is syllable constituency. The X-skeletal onset-rhyme theory is contrasted with the moraic onset-mora theory and new arguments are offered for the superiority of the former over the latter. Optimality Theory is discussed in section 4. It is shown how it has developed from Derivational Theory. A comparison of Optimality Theory and Derivational Theory is made and novel evidence is examined that speaks in favour of Optimality Theory. Section 5 is a summary of the conclusions. *

## *1. Why syllables?*

Neither Chomsky & Halle's (1968) *The Sound Pattern of English* (SPE, henceforth) nor the research that it provoked in the 1960's and the early 1970's recognized the syllable as a constituent in phonological analysis. The understanding was that all significant generalizations (rules) could be expressed with reference to a linear sequence of vowels and consonants. In this section we consider several examples showing that certain generalizations are better stated in syllabic terms.

(1) SLOVAK υ-GLIDING

Slovak [υ], a labio-dental approximant (a sonorant), alternates with [w], a velar semivowel (see Král' 1988, Isačenko 1968, Sabol 1984). In (1) morpheme boundaries are indicated and the alternating segments are italicized. [1]

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| | | | |
|---|---|---|---|
| (1) | labio-dental sonorant [υ] | | glide [w] |
| | a. zabaυ+i+t' 'to play' | - | zabaυ (imperative) |
| | b. hlaυ+a 'head' | - | hláυ (gen.pl.) |
| | c. zdraυ+ý 'healthy' | - | zdraυ+š+í 'more healthy' |
| | d. staυ+at' 'build' | - | staυ+b+a 'building' |

The generalization that the underlying //υ// (Rubach 1993) becomes [w] is expressed as rule (2) in the SPE framework. [2]

(2) SPE rule $\quad \upsilon \rightarrow w \,/\, \_\_ \begin{cases} \# \\ C \end{cases}$

A syllable-based analysis recasts (2) as (3).

(3) Syllable-based rule $\quad \upsilon \rightarrow w \,/\, \overset{\text{Coda}}{\overset{|}{\_\_\_}}$

The assignment of //υ// to the coda in *hláυ* 'head' (gen.pl.) and *zabaυ* 'play' (imper.) is straightforward: there is no other option as //υ// is in the final syllable of the word. In *zdravší* 'healthier' and *stavba* 'building' the reasons are equally compelling. First, the syllabification of CVCCV is CVC.CV in Slovak. Second //υ//, being a sonorant, could not syllabify into the onset because in that case a sonorant would be farther away from the nucleus than an obstruent, which is considered to be unacceptable from the point of view of the Sonority Sequencing Generalization (see section 2.2 below).

The difference between the SPE and the syllable-based rules comes to light when we look at the contrasts in (4).

| | | | |
|---|---|---|---|
| (4) | a. υ+bit' [v] 'hammer in' | vs. | staυ+b+a [w] 'building' |
| | b. υ+kopat' [f] 'dig in' | vs. | hláυ+k+a [w] 'head' (diminutive) |

The prefixes in (4) are labio-dental obstruents, voiced and voiceless, respectively. They derive from //υ//, since [υ] is found on the surface when the prefix appears in its vocalic form, for example, *υo+υiest'* [υoυiest'] 'bring to'. The SPE rule predicts, falsely, that the //υ// should appear as [w] in *υ+bit'* and *υ+kopat'*, a prediction that is not made by the syllable-based rule in (3). In order to generate the correct facts, the SPE analysis must write a vowel into rule (2).

(5) SPE rule (revised) $\quad \upsilon \rightarrow w \,/\, V \_\_ \begin{cases} \# \\ C \end{cases}$





However, (5) is unsatisfying for three reasons. First, the disjunction (word boundary or a consonant) is entirely arbitrary. Second, it is an accident that υ-Gliding coincides with the distributional limitation of [w] to syllable codas. Third, (5) loses sight of the rationale that is behind Obstruentization, /υ/ → /v/ (further to [f] if Voice Assimilation is applicable), in (4). This rationale is provided by the syllable-based analysis: changing the sonorant //υ// into the obstruent [v]/[f] is motivated by the need to syllabify //υ// and avoid Stray Erasure [3] (note: [vb-] and [fk-] are permissible onsets in Slovak). [4]

(II) LATERAL VELARIZATION

Spurious complexity of SPE analysis is illustrated by Lateral Velarization in British English (Received Pronunciation, see Gimson 1970, Jones 1972).

| | | |
|---|---|---|
| (6) | a. clear /l/: | Billy, colony, balloon, million [miljən] |
| | b. dark /l/: | Bill, battle, alter, belt, always |

The two variants of /l/ are in complementary distribution, with the dark /l/ appearing before a word boundary, a consonant or the glide *w*.

(7) Lateral Velarization $\quad l \rightarrow ɫ \,/\, \_\_ \begin{cases} \# \\ C \\ w \end{cases}$

This generalization is odd, because the disparate environments in (7) cannot be related in any way (they do not form a natural class.). A syllable-based analysis is simple: the /l/ is dark in rhymes or, alternatively, the /l/ is clear in onsets (Mohanan 1985). [5] The mysterious behaviour of /j/ versus /w/ is now related to the fact that [lj-] is a possible onset but *[lw-] is not: [lj-] is found in words such as *lubricate* and *allure* (Jones and Gimson 1977). [6]

(III) SONORANT SYLLABIFICATION

A different type of difficulty with the SPE format of stating generalizations becomes evident when we attempt to account for the occurrence of syllabic consonants in English.

(8) a. syllabic consonants: little [lɪtl], [7] simple [sɪmpl], button [bʌtn], simpleton [sɪmpltən]
b. nonsyllabic consonants: sell [sel], simply [sɪmplɪ], chutney [tʃʌtnɪ], kidney [kɪdnɪ]

The observation is that sonorants become syllabic in the environment after a consonant (*little* versus *sell*) and before a word boundary or a consonant (*simple*, *simpleton* versus *simply*). This generalization needs to be sharpened further in order to exclude the /*m*/ and the /*n*/ in *film* and *corn* (American English) from undergoing Sonorant Syllabification: the nasals are after a consonant and before a word boundary and yet they are not syllabic. The desired exclusion is achieved by restricting the left environment of the rule to the class of obstruents (see Rubach 1977). [8]

(9) Sonorant Syllabification $\underset{[+\text{sonor}]}{\text{C}} \rightarrow [+\text{syll}] \,/\, [+\text{obstr}] \;\text{——}\; \begin{cases} \# \\ \text{C} \end{cases}$

Evidently, (9) can be criticized along the lines discussed in connection with Lateral Velarization (excessive complexity, ununderstandable disjunctions). However, more interesting is the objection that (9) makes incorrect predictions and is thus descriptively inadequate. Suppose we create a new word which is exactly like *film* but the sequence of sonorants has been reversed: *fiml*. The prediction is that this word should be monosyllabic since /*l*/ is preceded by a sonorant rather than an obstruent and, consequently, the environment of (9) is not met. But this prediction is false. Native speakers agree that a potential word such as *fiml* must have a syllabic /*l*/.

A syllable-based statement of Sonorant Syllabification avoids the problems inherent in (9). The generalization here is that the sonorants that become syllabic are those that cannot be put into the coda by syllabification rules, because sonority violations would ensue (see section 2.2). This generalization covers both the words in (8a) and the hypothetical *fiml* (the liquid is further away from the vowel than the nasal). At the same time, it correctly excludes the words in (8b) and *film* (the liquid is closer to the vowel than the nasal, which constitutes the correct sonority curve).

(10) Sonorant Syllabification (syllable-based) $\underset{[+\text{sonor}]}{*\text{C}} \rightarrow \overset{\sigma}{\underset{[+\text{sonor}]}{\text{C}}}$

where * means 'unsyllabified', that is, 'extrasyllabic'.

Sonorant Syllabification finds its rationale in Stray Erasure and is seen as a strategy to avoid deletion (see footnote 3).





(IV) CiV LENGTHENING

Our final example is the celebrated rule of CiV Lengthening (Chomsky & Halle 1968).

(11) a. CiV Lengthening: Can*a*da - Can*a*dian, com*e*dy - com*e*dian, Newt*o*n - Newt*o*nian
b. No CiV Lengthening: K*a*ntian, Philad*e*lphian, Ch*o*mskyan
c. CiV Lengthening: opp*r*obrious, app*r*opriate, coll*o*quial

As shown by (11a), vowels are lengthened (and diphthongized) when followed by *i* and another vowel (Chomsky & Halle 1968). The words in (11b) indicate that the presence of more than one consonant blocks lengthening (Rubach 1984), but this is contradicted by (11c). This dilemma is difficult to solve in the SPE format but not in a syllable-based approach: lengthening takes place in open syllables. The relevant syllables are open in (11a) and (11c) but not in (11b) where the first consonant of the cluster is forced into the coda by the Sonority Sequencing Generalization (see section 2.2).

## 2. *Syllabification*

Given that the focus of this article is on how syllable structure is analysed, the central question is how syllabification is carried out. [9] In 2.1 we introduce a set of syllabification procedures (their nature will be further investigated in sections 3 and 4). Section 2.2 sharpens the understanding of these procedures by reviewing a number of constraints that restrict the application of syllabification rules.

### 2.1. *Syllable Structure Algorithm*

Assuming a derivational view, [10] syllables are built by applying a set of rules that we shall call the Syllable Structure Algorithm. In (12), we present a variant of this algorithm based on Levin (1985) and Steriade (1982). X's represent skeletal slots and are part of the underlying representation of morphemes. [11] In the typical situation, an X-slot is linked to one melodic segment (its root node), but, crucially, this is not always the case, and all logically possible discrepancies between X-slots and melodic segments are attested in underlying representations: [12]

– single melodic segment linked to two X-slots (long vowels, geminates)

– single X-slot linked to two melodic segments (for example, prenasalized stops, short diphthongs)

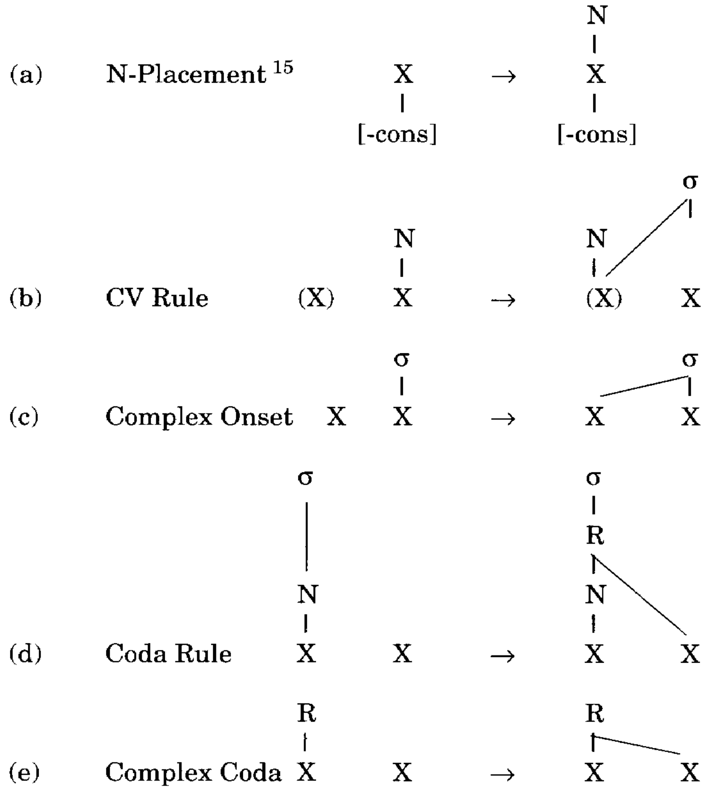
– X-slot with no melodic content, that is, a floating X-slot (for example, French h-aspiré, as in Goldsmith 1990)

– melodic segment with no X-slot, that is, a floating (or latent) segment (for example, Slavic yers, as in Rubach 1986).[13]

It is these disrepancies that motivate the distinction of the skeleton as a separate tier of representation.

Syllabification is a procedure of organizing X-slots into constituents, as shown in (12).[14]

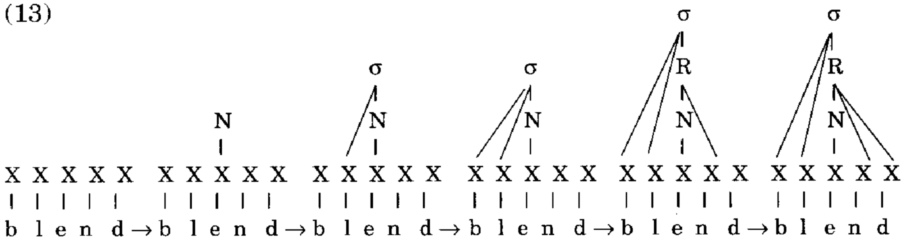
(12) Syllable Structure Algorithm (X-skeletal theory)



N-Placement assigns the nucleus node to segments with [-cons] melodies.[16] The CV Rule creates the basic syllable out of the prenuclear segment and the nucleus. The parentheses around the prenuclear X-slot mean that three options are available. First, the X-slot may be required by a given language. This means that such a language has CV syllables but not V (onsetless) syllables.[17] Second, the X-slot is optional: both CV and V syllables are attested (a typical situation). Third, the option of the prenuclear X-slot is not taken: all syllables in a given language are onsetless (see (50g) in section 4). Notice that the CV Rule applies always, even when there is no prenuclear X-slot (hence the parentheses), as in the English word *ash*. The reason is that the CV Rule provides the syllable node σ. N-Placement and the CV Rule are universal in the absolute sense: they are active in every language.[18]

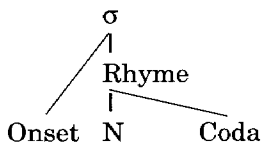
Given the formalism in (12), the CV Rule and Complex Onset as well as the Coda Rule and Complex Coda have independent functions. The CV Rule acts on a segment that directly precedes the nucleus, and thus is unable to affect the /b/ in *blend*. The /b/ is syllabified by Complex Onset. Similarly, the Coda Rule, which erects the rhyme node, looks at the segment immediately after the nucleus, and thus is unable to affect the /d/ in *blend*. The /d/ is syllabified by Complex Coda.

(13)



Syllables derived in this way resemble the structure advocated by Kuryłowicz (1947) and Pike & Pike (1947).

(14)



The difference between the representations in (13) and (14) is that onsets and codas are defined indirectly in (13): consonants in the onset are those that are linked to the syllable node σ while consonants in the coda are those that are linked to the rhyme node R.

Typological differentiation of languages is derived from the Syllable Structure Algorithm by three parametric distinctions (in addition to the options afforded by (X) in the CV Rule, see above).[19] With the exception of N-Placement and the CV Rule, a language may designate certain rules as inactive. Second, the ordering of Complex

Onset and the Coda Rule may be varied. Third, Complex Onset and Complex Coda may be iterative or not. These options are briefly exemplified below. [20]

Cayuvava has CV syllables but not CCV or CVC syllables (Blevins 1995, based on Key 1961). In terms of the Syllable Structure Algorithm, this means that Cayuvava uses only the absolute universal rules: N-Placement and the CV Rule. The remaining rules are inactive. Mazateco permits CV and CCV syllables but not CVC syllables (Blevins 1995, based on Pike & Pike 1947). Mazateco differs from Cayuvava in one respect only: it admits Complex Onset. Mokilese, on the other hand, has CV and CVC syllables (Blevins 1995, based on Harrison 1976). The active rules are N-Placement, the CV Rule and the Coda Rule. Finnish is like Mokilese but it admits CVCC in addition to CV and CVC (Blevins 1995, based on Keyser & Kiparsky 1984). It differs from Mokilese by designating Complex Coda as active. Italian is a mirror image of Finnish: CCV is permitted while CVCC is not (Blevins 1995, based on Basbøll 1974). Consequently, Complex Onset is active but Complex Coda is not. [21]

The second parametric distinction among languages – rule ordering – is illustrated by Polish and Slovak. Both languages admit the full range of the Syllable Structure Algorithm rules. However, Polish maximizes onsets while Slovak does not. That is, CVCCV is syllabified CV.CCV in Polish and CVC.CV in Slovak (see Rubach & Booij 1990a and Rubach 1993). These languages differ by the ordering of Complex Onset and the Coda Rule: Complex Onset precedes the Coda Rule in Polish but follows it in Slovak.

The iterative versus noniterative parameter is relevant for languages that have onsets/codas composed of more than two segments. [22] Klamath illustrates Complex Coda iteration, because it has CVCCC syllables (Blevins 1995, based on Barker 1963 and 1964). Polish exemplifies the iteration of Complex Onset. Thus, *bistro* 'fast food bar' is syllabified *bi.stro*. But this raises the question of how it is possible that the Coda Rule is active in Polish. If Complex Onset can iterate, then all intervocalic consonants will be drawn into the onset and the function of the Coda Rule will be limited to syllabifying word-final segments, because word-finally the Coda Rule does not compete with Complex Onset. This concern is unfounded. Words such as *monstrum* 'monster' are syllabified *mon.strum*. The iteration of Complex Onset is blocked by the Sonority Sequencing Generalization, a constraint on the well-formedness of onsets and codas. This shows that our presentation of syllabification procedures is thus far incomplete.





The way in which the Syllable Structure Algorithm applies is controlled by constraints.

### 2.2. Constraints

In this section a set of constraints is discussed, most of which are familiar from classic philological studies of the 19th century and the early 20th century.

(A) SONORITY SEQUENCING GENERALIZATION

19th century philologists debated the classification of sounds according to the degree of openness. Whitney (1865) proposes the following hierarchy:

(15) open vowels
mid vowels
glides and liquids
nasals
voiced fricatives
voiceless fricatives
voiced stops
voiceless stops

He notes that the lower we move down the scale the less vowel-like the sounds become. To put it in more familiar terms, the ability of a sound to form a syllabic peak decreases with the decrease in the degree of openness. Sounds produced with a wide opening between the articulators (for example, vowels) are more sonorous (they can be heard better) than those produced with a narrow stricture (for example, fricatives). That is, sonority correlates with the degree of openness. The number of syllables in a word is determined on the basis of "impulses of sounds", and those arise when the sonority curve varies producing sonority peaks. Thus, explains Whitney, one can produce [e] as long as one wishes and it will be perceived as one "impulse of sound" (one syllable). But if a less open sound interrupts the articulation of [e], then two syllables are perceived: *ene* (p. 293). By the same token, *alp* (decreasing sonority) and *pla* (increasing sonority) are monosyllabic while *apl* and *lpa* are disyllabic (p. 293).

As pointed out by Clements (1990), the first explicit use of the sonority hierarchy as a principle determining the well-formedness of syllables is found in Sievers (1881). [23] Thus, *mla*, *mra* as well as *alm*, *arm* are well-formed syllables while *lma*, *rma* as well as *aml*, *amr* are

not (p. 186). By the same token, strings such as *halme* and *achte* [axte] must be syllabified *hal.me* and *ach.te* (p. 192).

Sievers differs from Whitney in that he does not classify glides and liquids as forming one sonority class. [24] Another difference that Sievers shares with Jespersen (1904) is the classification of /r/ as more sonorous than /l/. A later suggestion, due to de Saussure (1916), groups /r/ and /l/ into one sonority class, that of liquids. This view is regarded as standard now.

To summarize, the order in which segments appear in onsets and codas is determined by the Sonority Sequencing Generalization, [25] that we shall abbreviate as SSG.

(16) Sonority Sequencing Generalization (SSG)
stop fricative nasal liquid VOWEL liquid nasal fricative stop

The importance of SSG is exemplified by syllable divisions in English and Polish. Both languages maximize onsets (Complex Onset applies before the Coda Rule), yet, precisely in the cases that would qualify as SSG violations, syllabification departs from the pattern of onset maximization.

(17) a. Onset maximization: suppress [sə.pres], supply [sə.plaɪ], approach [ə.prəʊtʃ]
b. SSG overriding onset maximization: comprise [kəm.praɪz], selfish [sel.fɪʃ],
salvation [sæl.veɪʃən], sensation [sen.seɪʃən], Afghan [æf.gæn]

Polish syllabification is more striking than English, since Polish permits all kinds of unusual clusters (see below) and yet SSG is borne out in all word-internal syllabifications (Rubach & Booij 1990a).

(18) a. Word-initial unusual clusters: *rtęć* 'mercury', *lśnić* 'shine', *mdły* 'nauseous'
b. Onset maximization: *do.bry* 'good', *ma.sło* 'butter', *gru.bszy* [gru.pšɨ] 'fatter'
c. SSG overriding onset maximization: *kon.to* 'account', *bur.ta* 'side', *wil.go.tny* 'moist'

An apparent difficulty with SSG is that it is not borne out in its entirety in all languages. For example, English, like many other Indo-European languages, syllabifies /s/ into the onset, even when /s/





precedes a stop. This syllabification is supported by both native speaker intuitions and phonological rules. Consider the facts in (19).

(19) a. Aspiration: *pie* [pʰaɪ], *til* [tʰɪl]
*vs.* no aspiration: *spite* and *despite*, *still* and *distil*
b. Complete devoicing of /r/: *cream, pray*
*vs.* no complete devoicing of /r/: *scream* and *discreet*, *spray* and *espresso*

As is well-known, the generalizations are that stops are not aspirated and /r/ is not completely devoiced when preceded by /s/ in the onset, as in *spite* and *scream*. The syllabification of /s/ in these examples in uncontroversial because /s/ is word-initial and it has no other option but to syllabify into the onest. The interesting observation is that stops are unaspirated and /r/ is not completely devoiced also word-internally after /s/: *despite, distil, discreet* and *espresso*. That is, the /s/ behaves here as in *spite* and *scream* and must therefore be in the onset rather than in the coda. The syllabifications are [dɪ.spaɪt], [dɪ.stɪl], [dɪ.skrijt], [ɪ.spre.səʊ]. [26] We note a violation of SSG, since /s/, a fricative, is further away from the nucleus than the stops [p t k]. [27]

Facts such as the syllabification of English /s/ led many researchers to postulate language-specific sonority sequencing principles (for example, Vennemann 1972 for Icelandic, Hankamer & Aissen 1974 for Pali, Hooper 1976 for Spanish, Vogel 1977 for Italian, and others). However, varying SSG for language-specific purposes does not seem to be an attractive idea. First, it remains true that most of the sequencing in syllable margins mandated by SSG is borne out, even though the details are not. If SSG is a language-specific matter, then the most robust patterns (for example, that nasal and liquids do not precede stops in onsets) become an accident. Second, it is not possible to assume that all language-specific restrictions on the constitution of syllable margins can follow from a language-specific SSG. For example, English has an onset restriction that prohibits */tj-/ and */dl-/. If this were to be included in the English SSG then /l/ would have to be regarded as less sonorous than /t/ and /d/. But then, /l/ would be less sonorous than the fricatives. We would falsely predict that *ulcer* and *selfish* could syllabify **u.lcer* and *se.lfish*, because English maximizes onsets (recall that *suppress* is [sə.pres]). The correct syllabifications are *ul.cer* and *sel.fish*, which follows from the universal SSG.

How can we therefore deal with language-specific violations of SSG? The answer lies in an interaction of constraints, a concept that

predates Optimality Theory (Vennemann 1998; see also section 4). Constraints can be general (or universal, as Optimality Theory has it) but various languages can designate them as active or inactive, a situation that we saw when discussing the rules.

Since constraints "legalizing" violations of SSG are always going to be more specific than SSG itself (they relate to "details" of syllable margins), they will override SSG. In other words, language-specific restrictions take precedence over SSG, a concept that has been explicit or implict in the work of all researchers in the 1980's and the early 1990's. An ability to override SSG can be rationalized under Kiparsky's (1973) Elsewhere Condition which dates back to Pāṇini: more specific generalizations (here: language-specific constraints) take precedence over more general generalization (here: SSG) and block the latter if there is conflict.

Below we review several well-documented traditional constraints which relate to SSG. They are of two kinds: some relax SSG in that they permit syllabifications that are prohibited by SSG; others "tighten up" SSG by prohibiting conigurations that would otherwise be permitted. We begin with the former: constraints that "legalize" SSG violations.

(B) S-ONSET

A trivial case of legal SSG violations is the one discussed for English in (19): /s/ plus stop is a well-formed onset. This generalization is often expressed as a syllabification rule (for example, Kenstowicz 1994). In terms of Optimality Theory (see section 4), it can be stated as a positive constraint: /s/ must be in the onset. [28] Let us add that the special status of /s/ is nothing surprising in Indo-European languages, because this was the only fricative in the phonological system of Proto-Indo-European. Its special behaviour is seen not only in the area of syllabification (as explained above) but also in the area of rule application. For example, the celebrated sound changes: Grimm's Law and the Second Consonantal Shift in German were sensitive to the presence of /s/ (for a summary, see, Hock 1991). Also, phonological rules of Slavic treat /s/ stop as a special case (for example, Spirantization and Iotation in Polish, see Rubach 1984).

(C) OBSTRUENT SEQUENCING SUSPENSION

SSG Predicts that stops should be further away from the nucleus than fricatives. But this is violated on a massive scale in Slavic languages. For examples, in Polish, the following onsets and codas are commonplace.





(20) a. szpieg [šp-] 'spy, wtorek [ft-] 'Tuesday', spory [sp-] 'big'
b. wieprz [-pš] 'pig', płetw [-tf] 'fin' (gen.pl.), klops [-ps] 'failure'

The well-formedness of the onsets and codas in (20) is cofirmed from two independent sources. First, native speaker intuitions agree with the structures in (20). Thus *nieszpory* 'vespers' is syllabified [ɲe.špo.rɨ]. Second, phonological rules operate in accordance with (20). For example, the imperative allomorph /-ij/ is added to stems that end in unsyllabifiable consonants.

(21) *nagl+ij* 'hurry', which is *nagl* with extrasyllabic */l/ [29]
vs. *kop* 'dig', which does not take /-ij/ because /p/ can be syllabified

The question is how structures such as those in (20) behave: do they take /-ij/, which would indicate that the final consonant is unsyllabifiable, or do they not? That is, are they like *nag*l* 'hurry' (hence *nagl+ij*) or like *kop* 'dig'? The latter is true: *ulepsz* [u.lepš] 'improve' (imper.), *nie martw się* [martf] 'don't worry' (imper.). We conclude that in Polish (as well as in other Slavic languages, but not, for example, in English) the Obstruent Sequencing Suspension is active.

(22) Obstruent Sequencing Suspension
Sonority sequencing is suspended for the class of obstruents

This means that stops and fricatives can appear in either order in onsets and codas.

(D) PLATEAU CONSTRAINT

Languages differ with respect to whether they do or do not permit margins made up of segments with the same sonority value (a sonority plateau), for example, two nasals or two stops. Polish exemplifies the former and English the latter type.

(23) Sonority plateau not tolerated:
a. rug.by, E.lec.tra, chim.ney
b. con.dem.na.tion *vs.* condem.(n)
hym.nal *vs.* hym.(n)

The /n/ in *condemn* and *hymn* cannot syllabify and, consequently, deletes (Stray Erasure, see footnote 3). In contrast, Polish tolerates plateaus: *hymn* 'anthem' (no deletion), *o.gro.mny* 'enormous',

*a.pte.ka* 'drugstore'. (Compare word-initial */pt-/*, */kt-/* and */tk-/* in *ptak* 'bird', *kto* 'who' and *tkanka* 'tissue'.)

(24) Plateau Constraint
Members of the same sonority class constitute well-formed syllable margins

The idea of sonority plateaus goes back to Jespersen (1904). Sievers (1881) did not recognize plateaus and treated them on a par with SSG violations. To be more precise, he described plateaus and fricative plus stop SSG offenders as secondary syllables ("Nebensilben", p. 187): *pta, kta, apt, akt* and *spa, sta, aps, ats*. He added, however, that these syllables were of little perceptual significance, because they were dominated by a high sonority syllable in their immediate environment (here by *a*).

(E) GEMINATE CONSTRAINT

A robust cross-linguistic generalization is that geminates ("true" and "false" alike) [30] are heterosyllabic. One might doubt whether a separate constraint is necessary here since geminate syllabification follows from SSG. However, this may but need not be the case. If the Plateau Constraint is active, as in Polish, then segments of the same class are permitted to syllabify together. We would thus predict that *motto* 'motto', *flotylla* 'fleet' and *wanna* 'bath-tub' should have geminates in the onset, because Polish maximizes onsets and permits plateaus. But the facts are different: geminates are always heterosyllabic. Therefore (25) must be a separate constraint.

(25) Geminate Constraint
Geminates are heterosyllabic [31]

This constraint, like those discussed earlier, has long been known in linguistics. There is a mention of it in Sievers (1881:194) and an explicit statement in Kuryłowicz (1947).

(F) JESPERSEN'S VOICE CONSTRAINT

In addition to their function of relaxing the sequencing imposed by SSG, constraints may introduce restrictions that do not follow from SSG. Such constraints typically refer to combinations of particular sounds rather than to classes of sounds (see collocational constraints in (G) below), but, in at least one case, the generalization is extremely robust, if not universal in the absolute sense (that is, entirely exceptionless). We state it in (26).





(26) Jespersen's Voice Constraint
Voiced segments cannot be further away from the nucleus than voiceless segments

Thus, for example, there are no onsets such as */bs-/* and codas such as */-sb/* because the voiced */b/* would be further away from the nucleus than the voiceless */s/*. This constraint, discovered by Jespersen (1904:186), has led to a new understanding of some aspects of Voice Assimilation. For example, Harms (1978) states that words such as *caps, books* and *roofs* must have the [s] rather than the [z] as the plural ending, because otherwise the Voice Constraint would be violated: *[kæpz]. This is insightful since now Progressive Voice Assimilation (*/z/ → /s/* after voiceless obstruents) can be eliminated and the phonetic effects are seen to follow from a universal generalization. It should be noted that Progressive Voice Assimilation has always been a sore point in the phonology of English, because it is not supported outside the */-s/* inflection and because Voice Assimilation is normally regressive in English: *describe - descriptive, script* (devoicing before a voiceless obstruent; here */b/ → /p/*).

(G) COLLOCATIONAL CONSTRAINTS

As mentioned earlier, Collocational Constraints refer to particular sounds rather than to classes of sounds, a point that is clearly illustrated in English. Familiar from both the traditional and the generative literature are restrictions on onsets such as */tl-/*, */dl-/*, [32] */θl-/* as well as *{stop nasal}. [33] Like the constraints discussed earlier, collocational restrictions are more specific than SSG and hence have a blocking effect. This is shown in (27). [34]

(27) a. at.las, med.lar, ath.le.tic
b. ag.no.stic, ack.now.ledge, ad.mo.nish

Restrictions on codas can be illustrated with the following celebrated example from Japanese (Itô 1986).

(28) Coda Condition *Coda
|
[-nas]

That is, all consonants except nasals are prohibited in the coda. This generalization is contradicted by obstruent geminates which, like other geminates, are heterosyllabic. Then, an obstruent does

appear in the coda. We conclude that Geminate Constraint (25) simply overrides Coda Condition (28).[35]

(H) SYLLABLE CONTACT CONSTRAINT

We begin with an example. The word *rapsodia* 'rhapsody' is treated differently in different dialects of Italian and Portuguese.[36]

(29) a. [rap.so]*dia*: prescriptive standard Italian and European Portuguese
b. [rap.pso]*dia*: Italian dialect of Rome
c. [ra.pi.so]*dia*: Brazilian Portuguese

These data raise three questions. First, why is /*ps*/ heterosyllabic in (29a), even though /*ps-*/ is a permissible onset from the point of view of SSG? Second, why does /*p*/ geminate in (29b)? And, third, why is *i* inserted in (29c)?

The answer to the first question cannot be that the Coda Rule precedes Complex Onset. In fact, the ordering is exactly the opposite in Italian, because onsets are maximized, as in *ca.pra* 'goat'. Heterosyllabic /*-p.s-*/ must be an effect of a collocational constraint that requires a certain sonority distance between members of onsets.[37] But, given this restriction, why would /*p*/ geminate in (29b), thereby creating the unwelcome /*ps-*/ onset? The answer to this question as well as to the question raised by (29c) comes from the Syllable Contact Constraint.

Developing the original idea of Hooper (1976), Murray and Vennemann (1983) propose a law that governs the interface between the final consonant of the coda of the first syllable and the initial consonant of the onset of the second syllable.[38] With a slight modification, this constraint can be stated as follows.

(30) Syllable Contact Constraint
In syllable contact, the sonority of the coda segment must be greater than or equal to the sonority of the onset segment

Notice that (30) is not a constraint that would expand or limit SSG and is thus different from the constraints discussed earlier in this section. Syllable Contact refers to the juncture between syllables while SSG governs the well-formedness of margins inside one syllable. The prediction of Syllable Contact coincides sometimes with the maximization of onsets. Thus, *suppress* is syllabified [sə.pres] rather than *[səp.res] because the latter violates Syllable Contact: /*p*/, the





coda consonant, has low sonority while /*r*/, the onset consonant, has high sonority, which is the reverse of what (30) mandates (in contrast, a hypothetical *Vr.pV* would be an excellent contact).

Returning to (29), notice that [rap.so] is a bad contact. The dialect of Rome improves this situation by gemination: [rap.pso], which obeys Syllable Contact because the coda and the onset have equal sonority. A more radical improvement is found in Brazilian Portuguese. The insertion of /*i*/ in (29c) creates a CV syllable and the contact problem does not arise, as there is no coda - onset interface: [ra.pi.so]. The bad contact [rap.so] remains untouched in prescriptive standard Italian and European Portuguese. This means that Syllable Contact is overridden by some more powerful constraints.[39]

To summarize the results of this section, syllabification is carried out by the Syllable Structure Algorithm (a derivational view) but its application is controlled by various constraints. Languages differ with regard to whether they designate a given syllabification rule or constraint as active or inactive. Rules may compete among themselves and constraints may compete among themselves over the same portion of the string. For example, Complex Onset and the Coda Rule compete over CVCCV. In Japanese, Coda Condition and Gemination compete over vowel-obstruent geminate-vowel strings. In such situations, rules need to be ordered and constraints must be prioritized.[40]

### 2.3. Ambisyllabicity

Speakers of Germanic languages differ from speakers of, for example, Slavic and Romance languages with regard to their intuitions about the syllabification of CVCV strings (unless the second vowel is stressed, see below). They hesitate and are unsure whether the intervocalic C belongs to the first or to the second syllable. In contrast, speakers of Slavic and Romance languages do not have any doubt whatsoever that the C belongs to the second syllable. This difference in judgement can be explained in a straightforward manner if we assume that consonants are ambisyllabic in Germanic but not in Slavic and Romance. To take a specific example, the /*n*/ in *tennis* belongs simultaneously to two syllables in English but is exclusively in the onset in Polish, which uses virtually the same word.

(31) English: σ σ
t e n ɪ s
Polish: σ σ
t e ɲ i s

The judgements about ambisyllabicity correlate with distributional generalizations about the occurrence of short vowels in stressed syllables (English, German, Icelandic and probably also other Germanic languages). Thus, as is well known, a short vowel may appear only in a closed syllable when this syllable is stressed. For example, *ten* [ten] exists as a word in English but [te] does not (see, for instance, Lass 1976). In order to avoid the *[te] syllable, the [n] in *tennis* must be in the coda, but it is also in the onset, as predicted by the CV Rule. This means that the [n] is ambisyllabic.

In addition to native speaker intuitions and distributional restrictions on short vowels, ambisyllabicity is supported in English by the operation of phonological rules and constraints. Instructive here is the inspection of /r/ in British English (Received Pronunciation).

Descriptive sources (Jones 1972, Jassem 1971, and others) report that /r/ is represented as a tap [ɾ] in intervocalic position if the following vowel is unstressed.

(32) a. [ɾ]: courage, carry, sorry
b. [r]: courageous, bring, rest

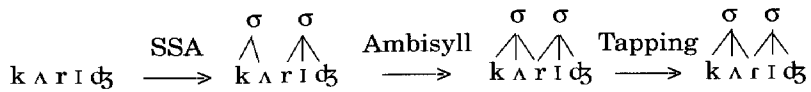
The occurrence of [ɾ] falls exactly in the context identified by Kahn (1976) as ambisyllabic: between vowels if the vowel after /r/ is unstressed, hence in *courage* but not in *courageous*. Thus, *courage* has the following representation.

(33) 


The distinctive property of the words in (32b) that have no tap is the fact that /r/ is solely in the onset, because either the vowel after *r* is stressed (*courageous*) or there is no vowel before /r/ (*bring*, *rest*), which makes ambisyllabification impossible. The conclusion is that Tapping occurs in codas (Rubach 1996). This generalization is implemented by Kahn's (1976) ambisyllabicity rule. Prior to the application of this rule, the /r/ is in the onset, an effect of the core syllabification by the Syllable Structure Algorithm (abbreviated as SSA).





(34) 


The fact that the /r/ is not only in the coda but also in the onset (ambisyllabicity) is irrelevant for Tapping, which is satisfied by the linking of the /r/ to the coda. But a different generalization *r*-deletion – looks at the linking of the *r* to the onset. As suggested by McCarthy (1993), /r/ – zero alternations in words such as *starry* versus *star* [sta:], *stars* [sta:z] and *starred* [sta:d] are best accounted for by assuming that /r/ is licensed in the onset (*starry*). Elsewhere, the /r/ deletes, because it fails to meet the requirement of prosodic licensing (this is the *r* in *star*, *stars* and *starred* which is exclusively in the coda).[41]

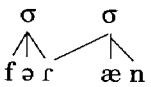
To summarize, from the point of view of Tapping, the /r/ in *courage* must be in the coda, but, from the point of view of *r*-Licensing, it must be in the onset, because it does not delete. It is precisely ambisyllabicity that captures this double-faced behaviour of /r/.

The claim that consonants are ambisyllabic in English has a long tradition. There is a mention of ambisyllabicity in Whitney (1865)[42] and an extensive discussion in, for example, Trager & Bloch (1941) and Smalley (1968). In the generative tradition, ambisyllabicity goes back to the work of, notably, Anderson & Jones (1974), Kahn (1976), Fallows (1981) and Clements & Keyser (1983). Since the middle 1980's, ambisyllabicity has been challenged by resyllabification (Selkirk 1984, Borowsky 1986, Myers 1987 and others). In this view, the C in VCV is first syllabified into the onset by the Syllable Structure Algorithm and subsequently put into the coda by Resyllabification. The rules that would, in the traditional view, require ambisyllabicity are reinterpreted as applying at different derivational stages: before Resyllabification (V.CV) or after Resyllabification (VC.V), depending on a given rule. The indecisiveness of native speakers as to the placement of the C of VCV either into the onset or into the coda is ascribed to the blurring of syllable boundaries in phonetic representation (Blevins 1995). But this view is not satisfying. It fails to explain why phonetic syllable boundaries are blurred for speakers of English but never for speakers of Polish or, more generally, for speakers of Slavic and Romance languages. Moreover, as noted by Rubach (1996), Resyllabification but not Ambisyllabification complicates the grammar because it requires extrinsic ordering and is based on the Duke of York[43] derivations (Pullum 1976).[44] With the advent of Optimality Theory, Resyllabification has gone into oblivion, because it is a derivational

concept and is thus at odds with the non-derivational, output-governed Optimality Theory. In sum, consonants are ambisyllabic in English. With this conclusion in mind, we now return to Tapping and *r*-Licensing in Received Pronunciation.

In addition to the context in (32a), the tap occurs as the so-called "linking *r*", that is, the /r/ which is pronounced at the end of the word when the next word begins with a vowel, as in *for Ann* and *for equality*. This is the context for which Kahn (1976) postulated an ambisyllabification rule. Notice that this rule, unlike the one discussed in connection with (32a), is not sensitive to stress. Its sole restriction is that the following word must begin with a vowel. [45]

(35) *for Ann*




The situation is parallel to that illustrated in (34). The /r/ is not deleted, because it is in the onset, and it is realized as a tap, because it is in the coda.

The ambisyllabicity in (35) draws attention to the role of word boundaries in syllabification. Languages fall into three classes from this point of view: ambisyllabification languages (Germanic), resyllabification languages [46] (Romance) and languages that permit neither of these options (Slavic). French liaison, as in *mo.n a.mi* 'my friend', is an instance of resyllabification. So is Italian *co.n a.mo.re* 'with love' (Pier Marco Bertinetto, p.c.). Resyllabification, like "linking *r*", is motivated by the pervasive tendency to avoid onsetless syllables. But resyllabification may also be driven by other considerations. In Italian, *s* resyllabifies into the coda of the preceding word in order to comply with the requirements of SSG: *la scala* 'scale' (Marotta 1996) and *paltò stretto* 'tight coat' are syllabified [las. ka.la] and [pal.tos.tret.to]. Polish shows no respect for CV syllabification and SSG at word boundaries, and consonants are neither ambisyllabified nor resyllabified. This generalization is absolute and it may not be circumvented even in instances in which the prohibition on resyllabification leads to the creation of unsyllabified consonants: *litr. o.le.ju* 'litre of oil', *wa.ga. rtę.ci* 'weight of the mercury'. The Polish choice is adjunction, as we explain in the following section.

### 2.4. Adjunction

Traditional studies of syllabification, such as that of Kuryłowicz (1947), were typically based on the following two concepts:





(i) the Law of Initials: onsets in word-internal syllables correspond to the permissible clusters at the beginning of the word;
(ii) the Law of Finals: codas in word-internal syllables correspond to the permissible clusters at the end of the word.

While in many instances the predictions made by these laws are in agreement with the current practice of syllabification, there is a significant residue of cases for which these predictions are incorrect. In (36) we look at word-initial clusters and word-internal syllabifications in Polish.

(36) a. rtęć 'mercury', łkać 'sob', msza [mša]
b. kar.ta 'card', pał.ka 'stick', zam.szo.wy [zam.šo.vɨ] 'suede' (Adj.)

The Law of Initials would mandate the following syllabifications for (36b): **ka.rta*, **pa.łka* and **za.mszo.wy*, but these are completely impossible. Similarly, in Italian, the existence of word-initial /*st-*/ in *stupido* 'stupid' does not warrant tautosyllabic /*st*/ in *veste* 'dress', which is syllabified *ves.te* in the dialect investigated by Loporcaro (1994). [47]

Word-internal syllabifications in Polish and Italian are exactly what the Syllable Structure Algorithm predicts. But how can we deal with the offending word-initial consonants? Clearly, we do not want to postulate a constraint that would circumvent SSG and permit the Syllable Structure Algorithm to syllabify the Polish /*rt-*/, /*łk-*/ and /*mš-*/ as onsets, since then we would lose control over word-internal syllabifications in (36b) and nothing would prohibit **ka.rta*. This means, however, that the initial *r*, *ł* and *m* in (36a) remain unsyllabified (extrasyllabic). Stray Erasure will take its toll and these consonants will delete, but this does not occur. We need to find a way of including extrasyllabic consonants into prosodic structure, but the relevant rule must not be part of the Syllable Structure Algorithm so as not to affect the words in (36b). A solution is to adopt rules of adjunction (Levin 1985).

A simple case of adjunction is found in English.

(37) ap*t*, ac*t*, cat*s*, walke*d*, dep*th*

The final consonants cannot be syllabified because a violation of SSG would ensue. However, ultimately they must be included in prosodic structure in order to escape Stray Erasure. The desired effect is

obtained by postulating Coronal Adjunction. [48] The limitation to coronals (in fact, to dental obstruents) predicts that *apt* and *act* are possible words in English while **atp* and **atc* are not. The *p* and the *c* in the latter pair cannot be adjoined and would therefore be stray-erased.

The English case is simple: word-final extrasyllabic consonants are adjoined to the coda at the end of the phonological derivation. The Italian case is parallel, but we have adjunction to the onset: *stupido* 'stupid'. The Polish case unveils further subtlety about the nature of adjunction. First, not only word-initial/final but also word-internal consonants are subject to adjunction. Second, there is adjunction not only to the syllable node but also to the phonological word node (PW). Third, adjunction interacts with phonological rules, in particular, with Voice Assimilation (obstruent-to-obstruent rule). As an example, let us look at the behaviour of /r/.

(38) a. brak zboża [g z] 'lack of corn' *vs.* brak rdzy [k r $d^z$] 'lack of rust' (Note: [$d^z$] is a voiced alveolar affricate.)
b. lot+y [t] 'flights' - lot zachodni [d z] 'western flight' *and* wiatry [t] 'winds' - wiatr zachodni [dr z] 'western wind'
c. kładek 'gangway' (gen.pl.) - kładk+a [tk] (nom.sg.) *and* Jędrek [d] 'Andy' - Jędrk+a [trk] (gen.sg.)

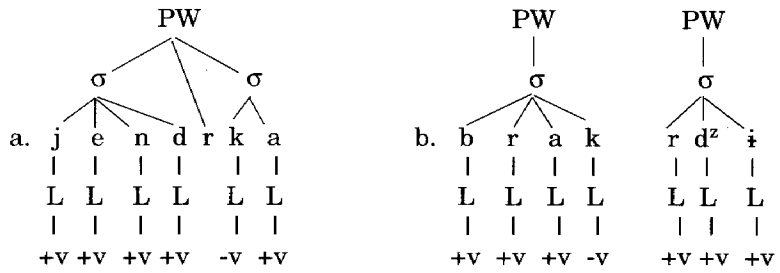
Word-initial extrasyllabic /r/ blocks Voice Assimilation, but word-final and word-medial /r/ does not. In its blocking effect, initial */r/ (where * means 'extrasyllabic') behaves like a syllabified sonorant; compare *trudy* [tr] 'efforts' (no $t \rightarrow d$ across *r* and *u*). This means that the /r/ in *rdzy* must be adjoined to the syllable node (Bethin 1992, Rubach 1997b). Word-medial/final */r/ behaves as if it were absent for the purposes of Voice Assimilation. Its prosodic affiliation must therefore be different from that of the initial */r/. Rubach & Booij (1990b) and Rubach (1997b) suggest that the word-medial/final **r* is linked directly to the phonological word node (Default Adjunction). One further assumption is necessary. [49] Sonorant Default, a universal rule that voices sonorants, [50] applies only to syllabified segments. Then, [+voice] is supplied to all vowels and syllabified sonorants, including the initial /r/ in (38a) that is now affiliated with the syllable (an effect of Initial Adjunction). The /r/ in (38b) does not belong to any syllable and therefore escapes Sonorant Default, remaining unspecified for [voice]. Now Voice Assimilation is free to apply across this /r/ because the obstruents are adjacent at the laryngeal tier (though not at the root tier, but





this is irrelevant). The representation of *Jędrka* 'Andy' (gen.sg.) and *brak rdzy* 'lack of rust' prior to Voice Assimilation are as follows (the letter <ę> stands for the sequence /en/ in Polish).

(39)




We conclude that adjunction rules may interact with phonological rules and that not only consonants at word edges but also word-medial consonants may be subject to adjunction. Furthermore, we may have adjunction either to the syllable node or to the phonological word node, but the former rather than the latter is the typical case.

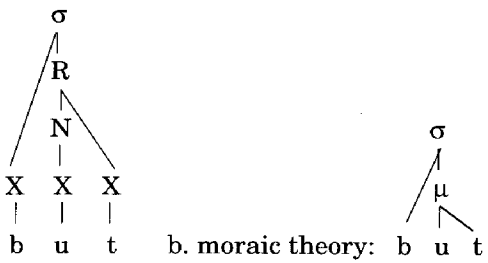
We close our discussion of syllabification with a summary of various strategies of dealing with extrasyllabic consonants. [51]

(40) a. *C becomes syllabic: Sonorant Syllabification (10) in English *little* and *button*
b. *C is deleted: /n/-Deletion in *condemn*, *condemns*, *condemned* versus *condemnation* [52]
c. *C is rescued from Stray Erasure by vowel insertion: Brazilian Portuguese [ra.pi.so]*dia* in (29)
d. *C is subject to adjunction (this section) [53]

### 3. Syllable Constituency

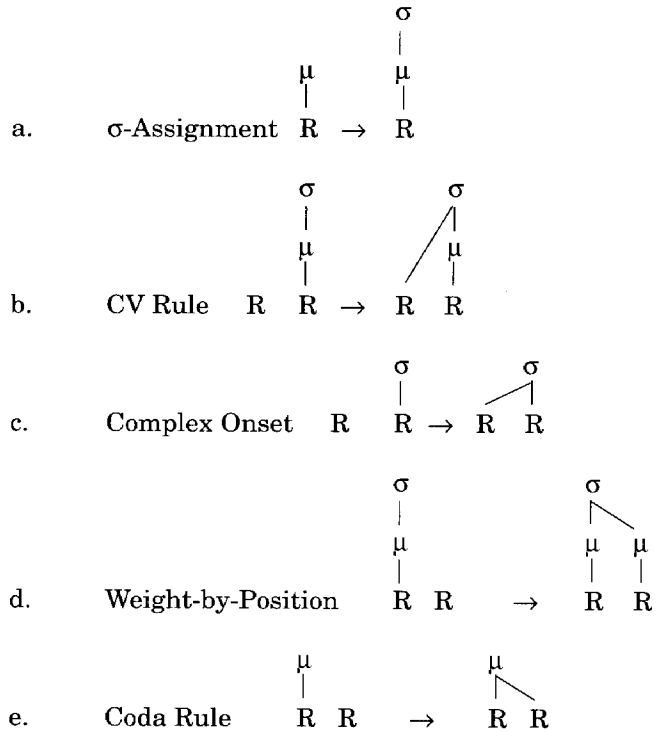
In this section we consider two most widely accepted types of syllable structure from the point of view of its constituency: the X-skeletal onset-rhyme syllables and the moraic onset-mora syllables. [54] To exemplify the difference between them, we look at the representation of the Polish word *but* 'shoe' (Polish is weight-insensitive: no long vowels, no moraic consonants.)

(41) a. X-skeletal theory: b. moraic theory:




The moraic representation (Hock 1986, Hyman 1985, McCarthy & Prince 1986, Hayes 1989) has less structure that the X-skeletal representation and therefore is attractive. [55] It is derived by an algorithm that bears similarity to the X-skeletal algorithm but is not identical to it (note: R means 'root node').

(42) Moraic Syllable Structure Algorithm (based on Hayes 1989)




In this theory syllabification rules have access to the melodic tier and thus they operate not only on moras but also on root nodes

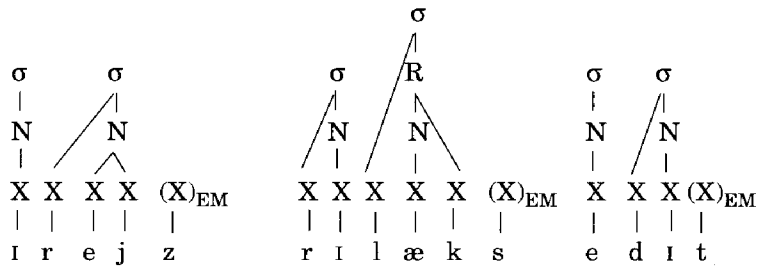




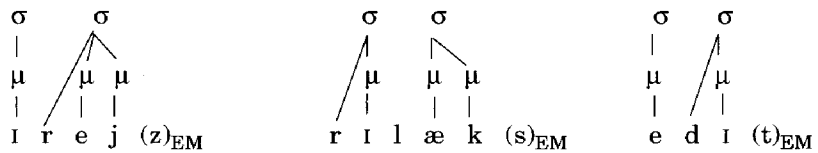
directly. The distinction Coda Rule – Complex Coda, familiar from (12), is replaced by the distinction Weight-by-Position – Coda Rule in (42). Weight-by-Position is active in languages that treat VC syllables as heavy and thus parallel to /V:/ syllables. To capture this parallelism, the C in VC is assigned a mora. The vowel of VC has a mora of its own and therefore /VC/ and /V:/ have exactly the same weight (two moras). A simple example from English can illustrate the difference between the X-skeletal syllables and the moraic syllables in their function of expressing weight.

Stress is attracted to heavy syllables in English. These can have either a complex nucleus (*erase*) or a complex coda (*relax*). Both contrast with light syllables, which do not take stress: *carry*, *edit*. It is standardly assumed that the word-final C does not count for weight; that is, it is extrametrical and, consequently, invisible to the rules of syllabification (Hayes 1982). [56] The algorithms in (12) and (42) generate the following representations for *erase*, *relax* and *edit*.

(43) a. X-skeletal theory




b. Moraic theory




In the X-skeletal theory, a heavy syllable is defined as branching in the rhyme: be it at the nucleus (*erase*) or at the rhyme node itself (*relax*). The moraic equivalent is the presence of two moras. Thus, both theories can define heavy syllables, but the determination is simpler and more elegant in the moraic theory than in the X-skeletal theory (due to less structure). However, glides are a problem for the moraic theory, as the data from Slovak suggest. [57]

Slovak is interesting, because it is weight-sensitive in one sense of this term only: complex nuclei (long vowels and diphthongs) count as heavy but VC syllables do not. A fruitful test here is the operation of the Rhythmic Law, a rule that shortens vowels if the preceding syllable is heavy. Consider (44), where the accent over the vowel means length and [ie] is a rising diphthong.

(44)

| | nom.sg.dat.pl. | |
|---|---|---|
| a. No Rhythmic Law: | noh+a 'leg' | - noh+ám |
| b. Rhythmic Law: | vlád+a 'authority' | - vlád+am |
| | riek+a 'river' | - riek+am |
| c. No Rhythmic Law: | sekund+a 'second' | - sekund+ám |
| | Alp+y 'Alps' | - Alp+ám |

The dative plural suffix //a:m// shortens after complex nuclei in (44b) but not after VC syllables in (44c): [se.kun.da:m], [al.pa:m]. Consequently, Slovak does not have Weight-by-Position. With this background in mind, we look at the behaviour of [ij] syllables.

Slovak has words such as *kyj* 'stick' which are pronounced [kij]. [58] The evidence for [ij] rather than simply [i:] comes from two sources. First, native speakers perceive the final syllable of *sladký* [slatki:] 'sweet' as different from the [ij] in *kyj* (Martin Votruba, p.c.). The latter has an offglide while the former does not. Second, the Rhythmic Law (shortening after a long vowel or a diphthong) treats [i:] and [ij] differently: it is triggered by the former (45a) but not the latter (45b).

(45) a. mal+ý [i:], UR //i:// 'small' *vs.* čír+y [či:r+i], UR //či:r+i:// 'clear'
noh+ám [a:m], UR //a:m// 'leg' (dat.pl.) *vs.* mín+am [mi:n+am], UR //mi:n+a:m// 'mine' (dat.pl.)

b. režij+n+ý [režij+n+i:] 'staging' (Adj,), zmijk+ám [zmijk+a:m] 'viper' (dimin., dat.pl.)

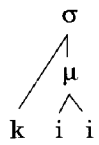
The word *ázij+sk+ý* 'Asian' is a particularly telling example. It shows that */ij/* neither triggers (like the words in 45b) nor undergoes the Rhythmic Law, since */ij/* is not shortened to */i/* after */á/*. We conclude that [ij] is not a diphthong or a long vowel but a combination of [i] in the nuclear position and [j] in the coda. Representing this structure is problematic for the moraic theory.

The moraic theory mandates that the nonmoraic coda consonant be attached to the mora of the vowel, as shown in (41b). But then we obtain the representation in (46) for *kyj* [kij] 'stick'. Let us add that,





given the autosegmental theory, the glide [j] is indistinguishable from the vowel [i] at the melodic tier. The distinction must be made at the syllabic tier, but this cannot be done for [kij]. [59]

(46)


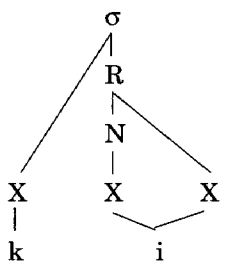

This representation is problematic in two ways. First, it does not distinguish [i] from [j], which runs afoul of native speaker intuitions. To remedy the situation, we could adopt a convention that it is the leftmost [i] melody that corresponds to the vowel [i]. However, adopting this convention is a complication and, more importantly, such a convention is particularly infelicitous for Slovak, which has rising diphthongs (the rightmost and not the leftmost vocalic segment is the head of the diphthong). Second, (46) violates the Obligatory Contour Principle that prohibits two identical melodic segments (Leben 1973). This is a problem, because, as shown by Rubach (1993), the Obligatory Contour Principle is active in Slovak. Notice that adhering to the Obligatory Contour Principle is not an option for (46) because the representation would then be as follows.

(47)



But this is incorrect, since [ij] contrasts with [i] in Slovak: *kyj* [kij] 'stick' is not equivalent to the last syllable in *boky* [boki] 'sides'.

The X-skeletal theory does not encounter any of these difficulties. The representation of *kyj* is straightforward.

(48)


At the melodic tier, we have one segment (feature tree) for [i], and thus the Obligatory Contour Principle is adhered to. The [i] is connected to two X-slots at the skeletal tier. This means that it counts as two segments. (In accordance with the assumptions of three-tiered representations, segmentation is reflected at the skeletal tier, not at the melodic tier.) The fact that one of these segments is the vowel /i/ and the other is the glide /j/ follows from the representation at the syllable tier: one X-slot is linked to the nucleus while the other X-slot is linked to the rhyme. We conclude that the X-skeletal theory can attend better to the facts of Slovak than the moraic theory can. [60]

## 4. *Optimality Theory*

Optimality Theory (Prince & Smolensky 1993) is believed to be a radical departure from the generative tradition of the past thirty years. This is undoubtedly true with regard to the basic assumptions: no rules but constraints only, no derivations but output-based evaluation (plus correspondence evaluation, McCarthy & Prince 1995), all constraints are universal, languages can differ solely by different ranking (ordering) of constraints, constraints can be violable, and so forth. However, from the point of view of capturing syllable-based generalizations, the difference between the traditional generative phonology and the Optimality Theory is smaller than one might expect. (This is true if we discount the radical change of the terminology and the technical ways of stating generalizations.) We shall argue, however, that such a difference exists and that Optimality Theory has a slight advantage over earlier generative theories. We begin by demonstrating that the basic syllabification patterns generated by the earlier theories can be successfully accounted for in Optimality Theory (OT, henceforth).

OT differs from the earlier frameworks by requiring that generalizations be stated as constraints (negative or positive) rather than as rules. The basic constraint system for syllabification closely parallels the rule system given earlier in (12).

(49) a. Harmonic Nucleus (HNuc): Most harmonic (that is, most sonorous) segments are syllable peaks
b. Onset (Ons): Syllables must have onsets
c. No Coda (*Coda): Syllables may not have codas
d. No Complex Onset (*$\text{Complex}_{\text{ONS}}$): Onsets cannot be complex





e. No Complex Coda (*$\text{Complex}_{\text{CODA}}$): Codas cannot be complex

Note: (d) and (e) are assumed to be instantiations of the superordinate (parent) constraint *Complex.

Harmonic Nucleus, which corresponds to N-Placement, is based on the insight drawn from Dell & Elmedlaoui (1985) that syllable nuclei are erected in accordance with the sonority hierarchy. Thus, low vowels are the best nuclei. Then follow mid and high vowels. Moving further down on the sonority scale, the next best nuclei are liquids, then nasals, fricatives and stops. [61]

Onset (49b) is a direct descendant of the CV Rule but the parameter setting over the first X-slot (see (12b) above) has been rationalized. In a language such as Hua, that permits CV syllables but not V syllables, Onset is undominated. If both CV and V syllables are possible, as in Polish or English, then V syllables incur Onset violations. However, this does not mean that such syllables cannot exist. They do exist if the faithfulness constraints (Max/Dep, that is, Maximality/Dependence, prohibiting deletion/insertion) dominate Onset. This highlights an essential novelty of OT: constraints are violable.

No Coda (49c) corresponds to Coda Rule (12d), albeit in an indirect way. In the rule system, a language that does not permit codas designates the Coda Rule as inactive, that is, such a language does not "have" the Coda Rule. In OT terms, this means that No Coda is an undominated constraint.

No Complex Onset (49d) corresponds to Complex Onset (12c), but the relationship is the same as that between No Coda and the Coda Rule. Instead of designating Complex Onset as inactive, we say that No Complex Onset is undominated. A fully parallel relationship holds between No Complex Coda (49e) and Complex Coda (12e).

Typological differences between languages derived by different orderings of the rules in (12), such as those between Polish and Slovak (CV.CCV and CVC.CV, respectively), are expressed in OT as language-specific rankings of the constraints in (49). Thus, the ranking for Polish is Onset >> *$\text{Complex}_{\text{ONS}}$ while for Slovak it is reversed: *$\text{Complex}_{\text{ONS}}$ >> Onset. [62] (We illustrate this point later.) Finally, the option iterative versus noniterative Complex Onset and Complex Coda in the rule system is reflected in OT as the parameter setting gradual versus binary (Prince and Smolensky 1993). [63] At this point there is a potential difference between the two theories. When permitted to iterate, Complex Onset (or, equivalently, Complex Coda)

cannot distinguish between CCCV and CCCCV syllables (or any other syllables with a larger onset).[64] The reason is that there is no way of stopping the iteration after one or more applications of Complex Onset. An OT analysis can make finer distinctions than the rule-based analysis. With No Complex Onset set at the gradual parameter, CCCV incurs two while CCCCV three violations. To the extent that such distinctions are relevant, OT has an advantage over the rule system.

We summarize the most important points of our discussion in (50), where DT (Derivational Theory) refers to the rule system and OT (Optimality Theory) to the 'constraint only' system of syllabification. Only the relevant constraints are mentioned. Thus, for example, in Hua (50a) Onset is undominated. Given that Hua has only CVCV types of strings, it follows that also *Coda and the other constraints referring to codas and onsets are undominated.

(50) a. CV but no other syllables (for example, Hua)
DT: the parameter over (X) in the CV Rule has been set as X (that is, X is obligatory); other syllabification rules are inactive[65]
OT: undominated Onset

b. CV or V syllables but no other syllables (Cayuvava)
DT: the CV Rule with its optional (X); other rules are inactive
OT: *Coda is undominated; Onset is violable

c. CV, V and CCV but no CVC, CCVC, CVCC (Mazateco)
DT: the CV Rule (X), Complex Onset; other rules are inactive
OT: *Coda is undominated; Onset and $*\text{Complex}_{\text{ONS}}$ are violable

d. CV, V, CVC, VC but no other syllables (Mokilese)
DT: the CV Rule (X), the Coda Rule; other rules are inactive
OT: $*\text{Complex}_{\text{ONS}}$ and $*\text{Complex}_{\text{CODA}}$ are undominated; Onset and *Coda are violable

e. CV, V, CVC, VC, CVCC, VCC but no CCV (Finnish)
DT: all rules are active except Complex Onset
OT: $*\text{Complex}_{\text{ONS}}$ undominated; other constraints are violable

f. CV, V, CCV, CVC, VC but no CVCC (Italian)
DT: all rules are active except Complex Coda
OT: $*\text{Complex}_{\text{CODA}}$ undominated; other constraints are violable

g. VC, VCC, VCCC, VCCCC but no CV (Oykangand: Blevins 1995, based on Sommer 1981)
DT: the (X) segment of the CV Rule has been set at its zero option (no X)
OT: an impossible language





The final example, Oykangand in (50g) looks odd, because it contradicts Jakobson's universal that all languages must minimally have CV syllables. If Blevins (1995) is right and such languages may be not as unusual as we have believed, then, apparently, DT has an advantage over OT, since DT can but OT (in its current version) cannot account for such languages. Since, however, there is currently no theory of what constitutes an impossible constraint, OT could, with no difficulty, be amended to include Coda, a constraint that would be a mirror image of Onset and that would say "syllables must have codas". Then, Oykangand can be accounted for: Coda >> Onset, which says that it is more important to have a consonant in the coda than to avoid an onsetless syllable.[66]

There are two further issues that need to be addressed. First, how do DT constraints in section 2.2 function in OT? And, second, if OT and DT are so similar in their handling of syllabification, then is there any reason to prefer one theory to the other?

The answer to the first query is simple: OT takes over *verbatim* or with little modification the constraint part of DT, most of which has long been known (for example, SSG dates back to Sievers 1881). We illustrate this point by looking at the evaluation of the verb *contract* [kən.trækt]. This example is interesting, since it shows how SSG controls the maximization of onsets in English and how adjunction works in OT. All the constraints are familiar with the exception of Max which prohibits deletion.[67] The idea in (51) is to illustrate the operation of all potentially applicable constraints from the set introduced in this article. In fact, the selection of the optimal candidate (indicated by an arrow) is made by two constraints: SSG and Max (no deletion). The other constraints are not relevant, a fact that is shown by the shading. Note also that an exclamation mark means that the violation is fatal and that the candidate has been rejected. Given that we consider just one word, it is not possible to establish all the rankings (ranking, that is, domination is marked by a solid line). The analysis in (51) is thus, of necessity, incomplete.

(51) //kəntrækt//

| | SSG | Max | *Plateau | *Coda | Onset | *Complex$_{CODA}$ | *Complex$_{ONS}$ |
|---|---|---|---|---|---|---|---|
| ⇒1. kən.trækt | | | * | ** | | * | * |
| 2. kə.ntrækt | *! | | * | * | | * | ** |
| 3. kə.trækt | | *! | * | * | | * | * |
| 4. kən.træk | | *! | | ** | | | * |
| 5. kən.træ | | **! | | * | | | * |
| 6. ən.trækt | | *! | * | ** | * | * | * |

In general, *Coda dominates *Complex$_{ONS}$, because English maximizes onsets. Furthermore, Max >> *Plateau, as in (51), is necessary to give preference to candidate (1) over (4). Also, SSG must dominate *Coda or else (1) and (2) would tie (lack of resolution). An alternative is to assume that *Complex$_{ONS}$ is gradient and then candidate (1) wins over (2) because the latter has two violations of *Complex$_{ONS}$.

Finally, we address the question of whether OT has an advantage over DT in the area of syllabification. An instructive example here is the treatment of /CiV/ strings in Polish and Slovak.

In spite of their impressive similarities, Polish and Slovak have quite different strategies of dealing with /CiV/ strings. The words in (52) look identical, yet they show a systematic difference in syllabification.

(52)

| | Polish | Slovak | gloss |
|---|---|---|---|
| a. | [ja] | [ja] | 'I' |
| | [je.den] | [je.den] | 'one' |
| b. | [kjosk] | [ki.osk] | 'stand' |
| | [dja.lekt] | [di.a.lekt] | 'dialect' |

These facts have been analysed by Rubach and Booij (1990a) for Polish and Rubach (1993) for Slovak. The analysis is as follows.

Core syllabification derived by the Syllable Structure Algorithm in (12) makes all [-cons] segments syllabic. Therefore *ja* and *jeden* in (52a) are /i.a/ and /i.e.den/. Gliding, a rule that is shared by Polish and Slovak, turns /i/ into [j] before a vowel; more accurately, /i/ is syllabified into the onset. [68] For Polish, nothing further needs to be said.





For Slovak, Rubach (1993) postulates an onset constraint that prohibits Gliding after consonants: */Cj-/, which blocks Gliding in (52b). [69]

This analysis can be revised in OT with a significant gain of insight. The difference between Polish and Slovak lies in the ranking of Onset and No Complex Onset: Onset >> *Complex$_{ONS}$ in Polish and *Complex$_{ONS}$ >> Onset in Slovak. [70] In (53) we look at the analysis of *kiosk* 'stand' in Slovak.

(53) //kiosk//

| | *Complex$_{ONS}$ | Onset |
|---|---|---|
| ⇒ 1. ki.osk | | * |
| 2. kjosk | * | |

Onset is violated in candidate (1) because *osk* has no onset. In candidate (2), the onset has two segments [kj-], which is a violation of *Complex$_{ONS}$. If *Complex$_{ONS}$ is dominant, then candidate (1) is the winner, which is correct for Slovak. On the other hand, if Onset is ranked higher than *Complex$_{ONS}$, then candidate (2) is the winner, which is correct for Polish. For the words in (52a), the analysis is the same in Polish and Slovak. *Complex$_{ONS}$ has no role to play and Onset selects [ja] over [i.a] 'I'.

In sum, the advantage of the OT analysis is that */Cj-/ as a constraint specific to Slovak is no longer necessary. The difference between Polish and Slovak is a matter of different ranking of universal constraints.

## 5. *Conclusion*

We have reviewed a number of different generalizations and assumptions relating to the concept of the syllable in phonological analysis. Some of them are well over a hundred years old (SSG), others are very recent (constraint violability in OT). We have looked at the standard derivational theory and at the currently practised Optimality Theory. With regard to syllabification, the two theories are not as different as the radical difference in the formalism might suggest. However, OT has an edge of advantage over DT (/*i*/ ~ /*j*/ in Slovak) and is more consistent than DT in that it assumes that all

and not only some syllabification mechanisms are universal: there are no language-specific rules and constraints, all constraints are universal but their effects in particular languages can be different, because constraints are violable and ranked on a language-particular basis.

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*Notes*

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1 An accent over a vowel means that the vowel is long.

2 I use double slashes for underlying representation, single slashes for intermediate representations and the standard square brackets for phonetic representation.

3 Stray Erasure (Steriade 1982) is a convention that deletes prosodically unlicensed segments, that is, segments that are not included in prosodic structure (Itô 1986).

4 Slovak, like Polish, suspends the sonority distance in the class of obstruents (see Obstruent Sequencing Suspension in section 2.2).

5 In the SPE framework, the rule 'dark *l* → clear *l*' would require a disjunction in the environment: before a vowel or before /j/, which is not much better than (7). This environment cannot be generalized to [-cons] segments (vowels and glides), because *l* is dark before *w*. An attempt to rationalize the occurrence of the dark *l* by appealing to the [+back] quality of the glide cannot succeed, since the *l* is clear before back vowels, as in *balloon*.

6 The occurrence of [j] is optional. The tendency to drop [j] after [l] in *lubricate* and *allure* is a reflex of a widespread generalization stating that [j] is deleted after coronal consonants in stressed syllables. This generalization is best illustrated by the East Coast dialect of American English which has [u] rather than [ju] in words such as *tune*, *due*, *sue*, *enthusiasm* and *annuity* (versus *annual*, with [j] because the syllable is unstressed). Received Pronunciation has [ju] in these words but it shares with American English the [u] rather than the [ju] after /r/: *rude*. The tendency to delete [j] in *lubricate* and *allure* can thus be seen as a generalization of the rule to the context of liquids (both /r/ and /l/).





7 The data come from Received Pronunciation, unless indicated otherwise.

8 It is a widely accepted understanding that SPE word boundary suffixes, known as class 2 suffixes in later research, do not preclude the application of Sonorant Syllabification, for example, [[*battl*]*ing*].

9 Attention should be drawn to Blevins (1995), which is an excellent overview of issues in syllable theory. In order to minimize overlap with Blevins's article, I will focus primarily on analysis and its tools (rules and constraints) rather than on syllable theories.

10 A non-derivational approach of Optimality Theory is discussed in section 4.

11 I know of no good reasons for underspecifying the skeleton in order to predict the occurrence of X-slots.

12 Goldsmith (1990) has an excellent review of such cases.

13 In order to surface phonetically, floating X-slots and floating segments must receive the missing part of the structure (a melodic content and an X-slot, respectively) as a result of phonological processes, because incomplete structures are subject to Stray Erasure.

14 The moraic version of the Syllable Structure Algorithm is discussed in section 3.

15 By convention, two X-slots linked to a single [-cons] melody, as is the case with long vowels, receive one N (nuclear node). Diphthongs are derived from long vowels by inserting a glide. Some languages show contrasts between diphthongs and vowel sequences with identical melodic representations, for example, Slovak (Rubach 1993). In these languages, diphthongs are specified underlyingly as two melodic segments linked to a single N.

16 Another option is to make N-Placement sensitive to the Sonority Sequencing Generalization (see below), along the lines suggested by Dell & Elmedlaoui (1985). Then, Gliding (for example, /i/ → /j/ / —- V) and creation of syllabic consonants would follow from N-Placement directly rather than from language-specific rules. A language-specific matter would be how to set the parameter on the Sonority Sequencing Generalization so that the correct class of segments undergoes N-Placement. For example, for English the parameter would be vowels, liquids and nasals; for Slovak, vowels and liquids; for Polish, which has no syllabic consonants, vowels only. See the discussion of Harmonic Nucleus in section 4.

17 One example is Hua (Blevins 1995, based on Haiman 1980).

18 This is the reason why N-Placement and the CV Rule are sometimes assumed to constitute one derivational step (Steriade 1982). The difference between this approach and the one presented in (12) is the treatment of glides, as we explain in section 4.

19 The operation of the Syllable Structure Algorithm is restricted by various constraints that I discuss later. The effect of these constraints is that not all structures that in principle could be derived by the Syllable Structure Algorithm are actually found in languages.

20 For a comprehensive typological review, see Blevins (1995).

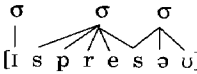
21 Some of these languages (Mokilese, Finnish and Italian) show edge effects. That is, word-initial/word-final onsets/codas admit clusters that do not occur word-medially. The offending segments are syllabified by rules of adjunction (see below).

22 Two segment onsets and codas are derived by Complex Onset and Complex Coda, respectively, and thus do not require iteration.

23 Sievers clearly speaks about syllables rather than about sounds being 'vowel-like', as Whitney does.

24 He makes no explicit statement about the sonority of glides but merely notes that liquids are a lower sonority class than vowels (p. 185).

[25] This principle was introduced into the current generative literature by Selkirk (1984).
[26] The second *s* is actually ambisyllabic, that is, it is both in the onset and in the coda. Schematically:




[ɪ s p r e s ə ʊ]. This first *s* is not ambisyllabic, since ambisyllabicity is blocked if the following vowel (*e* in this instance) is stressed. For reasons of space, I shall not be able to present an account of ambisyllabicity in English, but see a brief discussion in section 2.3 below and a comprehensive coverage in Rubach (1996).
[27] The conclusion that *s* forms a onset with a stop consonant is supported also by other types of evidence such as language games, see the discussion of Pig Latin in Steriade (1982).
[28] The occurrence of *s* in the coda (for example *miss*) is forced by the fact that English prohibits vowel insertion as a rescue strategy for unysillabified consonants. That is, Dep, the constraint prohibiting insertion (known earlier as Fill), dominates *s*-Onset. See Rubach (1997a) for a discussion of English syllabification, including the treatment of [ʃr-] onsets, as in *shrink*.
[29] Extrasyllabic consonants are those that cannot be syllabified due to the Syllable Structure Algorithm. The restriction (or constraint) that is relevant here is SSG (sonority), since *l*, a liquid, cannot be further away from the nucleus than *g*, a stop; see (16).
[30] False geminates are sequences of identical consonants that do not behave as a unit.
[31] Languages with word-initial or word-final geminates, such as Norwegian (see Kristoffersen, 1997) or Icelandic, must therefore have adjunction rules; see section 2.4.
[32] The prohibition on */tl-/, */dl-/* onsets is not as parochial as it might seem. For example, it is found in German and Italian (Wiese 1996:262).
[33] For the traditional view, see, for example, Jespersen (1904). A generative treatment of collocational constraints in English is best presented in Clements & Keyser (1983).
[34] Notice that */tl-/, /gn-/*, etc. are well-formed onsets from the point of view of SSG: the less sonorous stop is further away from the nucleus than the liquid/nasal.
[35] Itô's interpretation is different. The reason why an obstruent may appear in the coda is that Coda Condition refers to singly linked segments, which excludes geminates (they have double linking).
[36] I would like to thank Michele Loporcaro and Maria Helena Mateus for their help with the Italian and the Portuguese data, respectively. See Mateus & d'Andrade (1996).
[37] The idea of sonority distance within the generative paradigm of syllable structure goes back to Steriade (1982); see also van der Hulst (1984). For Italian and Portuguese, this distance is defined as two intervals on the sonority scale. That is, stop plus liquid onsets are well-formed, but stop plus fricative (no distance) or stop plus nasal onsets (one interval: that of the fricatives) are ill-formed. A diversion from this pattern occurs in word-initial onsets if the preceding word does not end in a vowel. See the discussion of word boundary effects in 2.3 and adjunction in 2.4.
[38] See Clements (1990) for an interesting proposal of a general theory (demisyllables) that encompasses Syllable Contact as well as SSG.
[39] This is the reasoning in Optimality Theory, see section 4. The overriding constraints in question are the collocation restriction on sonority distance (hence */ps/* must be heterosyllabic) and Dep (no insertion).





[40] This way of looking at syllabification is not always fully explicit in the derivational theory, but it certainly is the practice of many authors. Optimality Theory carries this line of reasoning to its logical end: all generalizations are constraints and they can compete with one another, see section 4.
[41] McCarthy (1993) discusses the dialect of Eastern New England, but the facts of *r*-deletion are the same as in Received Pronunciation. (Other facts are not the same: Eastern New England does not have Tapping.)
[42] Whitney says that the */n/* of *any* "belongs as much to the one syllable as to the other" (p. 295), but he provides no further examples or generalizations.
[43] Schematically: the structure AB is changed into AC only to be changed back into AB at a later derivational stage.
[44] For lack of space, I will not develop these objections here, but see Rubach (1996). Let me add one point, however. Resyllabification is incompatible with the understanding that *r* - zero alternations are a matter of *r*-licensing in the onset. If *courage* can go through the stages *cou.rage* → *cour.age*, then the *r* is not licensed at the *cour.age* stage. To avoid *r*-deletion, Stray Erasure would have to be ordered before Resyllabification in a counterfeeding fashion. But this cannot be done, since Stray Erasure is a convention rather than an ordinary phonological rule.
[45] This across-the-word-boundary rule is, naturally, not limited to /r/ but applies to all consonants (see Kahn 1976 & Rubach 1996).
[46] 'Resyllabification' may be an infelicitous term. For the purposes of this typology, it does not matter whether we have word level syllabification and then phrase level *re*syllabification or whether syllabification is first carried out at the phrase level.
[47] This syllabification is based not only on native speaker intuitions but also on the evidence drawn from the operation of phonological rules. Loporcaro makes a compelling case for his syllabification by investigating the role of closed and open syllables in a variety of Italian vernacular dialects.
[48] There is substantial literature on the syllabification of final coronals in English, see Fudge (1969), Fujimura and Lovins (1978), Halle and Vergnaud (1980) and others.
[49] This is supported independently by native speaker intuitions. Tests run by Rubach & Booij (1990b) have shown that native speakers are unable to decide whether the *r* in words such as *Jędrka* 'Andy' (gen.sg.) belongs to the first or to the second syllable. This uncertainty is understandable if *r* is linked to PW (see (39) below) as then it does not belong to any syllable.
[50] This is a standard assumption because the voicing of sonorants is entirely predictable and thus is not specified in underlying representations.
[51] For an impressive analysis of extrasyllabicity in Klamath, see Clements & Keyser (1983).
[52] The deletion of */n/* is by a rule that applies after nasals; elsewhere */n/* becomes syllabic: *button*. Adjunction is not an option because in English, unlike in Polish, Adjunction is limited to obstruents (more precisely: to coronal obstruents, see 37).
[53] A fifth strategy (which we cannot discuss for lack of space) is to change the feature content of *C in such a way that *C becomes syllabifiable and is therefore syllabified. See the analysis of *r* → *ž* Obstruentization in Rubach & Booij (1990a).
[54] Blevins (1995) reviews other types of syllable constituency. She argues, as we will do, for the X-skeletal onset-rhyme structure. For lack of space her arguments will not be summarized here.
[55] Authors differ on the details of moraic representation. The structure in (41b) is based on McCarthy & Prince (1986) and Hayes (1989).
[56] Extrametricality and extrasyllabicity are two different concepts. As indicated

earlier, extrasyllabicity is an effect of the Syllable Structure Algorithm and the constraints that restrict its application. Consonants are extrasyllabic if they cannot be syllabified. Different languages solve extrasyllabicity in different ways, as explained in (40). In contrast, Final Extrametricality has nothing to do with the ability of a segment to be syllabified. It is a convention that designates a word-final consonant as inaccessible to syllabification or adjunction. Extrametricality is erased at a later derivational stage, typically at the end of a component, such as the lexical (word level) component or the postlexical (sentence level) component. After the extrametricality has been erased, the consonant is open to syllabification and the regular Syllable Structure Algorithm takes effect. If the consonant happens to be of the type that cannot be syllabified (extrasyllabicity), then the strategies for dealing with extrasyllabic consonants in (40) become operative.

[57] The facts of Slovak reported here and in section 4 are based on standard sources such as Král' (1988) and Sabol (1989); see Rubach (1993) and the references therein. I would like to thank Martin Votruba for his consultation and help with the data.

[58] The vowel [i] is represented in the spelling either by *i* or *y*. The former is used to express the fact that the preceding consonant is palatalized; the latter denotes the absence of palatalization.

[59] The possibility exploited by Hyman (1985) and Hayes (1989) that some languages have [+cons] glides is not an option. The Slovak [j] is clearly related to the vowel [i], as shown by the variation.

[60] For further discussion, see Rubach (1998).

[61] As shown by Dell & Elmedlaoui (1985), all of these options are exploited as syllable peaks in the Imdlawn Tashlhiyt dialect of Berber, but other languages restrict the permissible nuclei in more severe ways. For example, English permits all vowels, as well as liquids and nasals, as syllabic nuclei. Slovak is like English but differs from it by prohibiting syllabic nasals. See Blevins (1995) for a typology of admissible nuclei.

[62] See (53) below and footnote 70.

[63] For example, designating $*\text{Complex}_{\text{ONS}}$ as 'binary' means that both CCV and CCCV are evaluated as the same (one violation) because 'binary' refers to the presence or the absence of a violation. With the designation 'gradual', CCV incurs one violation of $*\text{Complex}_{\text{ONS}}$ and CCCV incurs two violations of $*\text{Complex}_{\text{ONS}}$, since every C in clusters larger than CV counts as a violation.

[64] However, CCV and CCCV syllables are distinguished. The former is derived by Complex Onset (noniterative) and the latter by Complex Onset (iterative).

[65] This does not refer to N-Placement which must always be active, as there cannot be syllables without syllable nuclei. The OT equivalent is the requirement to choose one of the subconstraints of HNuc.

[66] As pointed out to me by a reviewer, the alternative would be to introduce *Onset ("syllables may not have onsets"). Both the positive Coda and the negative *Onset look odd, given the fact that the theory has also their mirror images: the negative *Coda and the positive Onset.

[67] Max is a correspondence constraint (McCarthy & Prince 1995). For the case considered in (51), it is required that the output segments correspond to the input segment. Consequently, all instances of deletion are a violation of Max. Note: in the correspondence version of OT (McCarthy & Prince 1995), unlike in the earlier version (Prince & Smolensky 1993), there is no possibility for an unparsed (that is, unprosodified) segment to exist in the output representation. Such segments are automatically deleted (Stray Erasure). In other words, inability to be included into prosodic structure is equivalent to deletion.

[68] The use of Gliding was standard in both the X-skeletal theory and the moraic theory. Since Gliding did not have to be part of core syllabification, it was possible to hold it off until later stages of the derivation and make it interact with regular phonological rules (see Rubach & Booij 1990a). In the moraic theory, high vowels were assigned moras (that is, they became syllabic) but they could subsequently undergo Gliding. This possibility was exploited particularly by languages with Compensatory Lengthening. The floating mora (an effect of Gliding) would link to the neighbouring vowel, which explained why Compensatory Lengthening took place (Hayes 1989).

[69] Rubach (1993) shows that *Cj- cannot follow from a more general constraint prohibiting complex onsets.

[70] In word-internal syllabification, No Coda also plays a role. The Polish V.CCV pattern is derived by No Coda >>$*\text{Complex}_{\text{ONS}}$ while the Slovak VC.CV pattern by $*\text{Complex}_{\text{ONS}}$ >> No Coda.





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