6. The Syllable in Phonological Theory

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0 Introduction

The role of the syllable in phonological theory has become more significant with each passing decade.[1] All major approaches to phonology, from the early Prague School through the London prosodicists and the American structuralists to modern generative approaches including autosegmental and metrical phonology, have recognized the syllable as a fundamental unit in phonological analysis.[2]

My goal in this chapter is to illustrate the important role played by the syllable in phonological theory. I first address the importance of recognizing the syllable as a phonological constituent (section 1). I then discuss how such constituents serve to organize segments in terms of sonority (section 2). In section 3, I present arguments bearing on the nature of syllable-internal structure, including the role of sonority and syllable weight in establishing constituency. This discussion is followed in section 4 by an overview of parametric variation in syllable types of the world's languages. In section 5, I consider the status of syllabification with respect to the phonological derivation – specifically, the question of how, and at what derivational point, syllable structure is assigned to strings, and respects in which certain phonological rules can be viewed as part of the syllabification process. Finally, in section 6, I take up several problems in current syllable theory, including the nature of coda constraints, questionable syllabifications, and mismatches between phonological and phonetic syllables.

Evidence for the syllable is plentiful, although much of it is dispersed among analyses from different schools and eras, and couched in disparate theoretical frameworks. My aim here will be to bring together a range of arguments and to extract from them the essence which any adequate phonological theory must capture.

What are syllables? Just as the feet of metrical theory supply rhythmic organization to phonological strings, syllables can be viewed as the structural units providing melodic organization to such strings. This melodic organization is based for the most part on the inherent sonority of phonological segments, where the sonority of a sound is roughly defined as its loudness relative to other sounds produced with the same input energy (i.e., with the same length, stress, pitch, velocity of airflow, muscular tension, etc.).[3] Hence, melodic organization of a phonological string into syllables will result in a characteristic sonority profile: segments will be organized into rising and falling sonority sequences, with each sonority peak defining a unique syllable. The syllable then is the phonological unit which organizes segmental melodies in terms of sonority; syllabic segments are equivalent to sonority peaks within these organizational units.

1 The Syllable as Phonological Constituent

While phonologists from a wide range of theoretical perspectives agree that the syllable plays an important role as a prosodic constituent, agreement is by no means universal concerning the precise nature of the syllable, nor for that matter the very existence of this constituent in phonology. In this section I will offer a range of arguments, both old and new, with the aim of providing a strong case for the importance of the syllable in phonology and a general foundation for the discussion to follow.

Arguments for constituency are traditionally based on the observation that a particular generalization, or group of generalizations, can be more succinctly stated in terms of the given constituents than without them. For instance, arguments for the familiar syntactic constituents NounPhrase and VerbPhrase are rooted in the position that distributional constraints and extraction phenomena are best stated in terms of such constituents. In this section I present four arguments of this sort for the syllable as a phonological constituent.

1.1 Syllable as Domain

The first argument for the syllable as a phonological constituent derives from the fact that there are phonological processes and/or constraints which take the syllable as their domain of application. Such rules and constraints are sensitive to a domain that is larger than the segment, smaller than the word, and contains exactly one sonority peak.[4]

One example of a process involving entire syllables is pharyngealization in Arabic and Berber dialects (Ali-Ani 1970; Ghazeli 1977; Saib 1978; Broselow 1979; Elmedlaoui 1985; Hoberman 1987). In these languages, the presence of an underlyingly pharyngealized or emphatic consonant gives rise to domains of pharyngealized segments which are larger than the individual segment, and often smaller than the entire word. In Cairene Arabic the smallest domain for pharyngealization is CV; this is also the minimal syllable type in this language. Broselow (1979) argues that the appropriate way to characterize pharyngealization alternations in Cairene is with reference to the syllable: pharyngealization spreads to all tautosyllabic segments, and its domain is thus the syllable.

Other phonological properties which take the syllable as their domain are stress and tone. At the phonetic level, stress and tone, like pharyngealization, are typically realized on multisegmental strings (Firth 1948; Pike 1962; Beckman 1986).

At the phonological level, there are many languages in which placement of predictable stress or tone requires "skipping" C_oVC_o sequences.[5] Such principles of stress assignment support the existence of syllables in that the candidates for stress assignment that are skipped over are always complete syllables. Furthermore, stress and tone languages fall into two general classes with respect to general assignment algorithms: those in which mappings of stress and tone differ for *heavy* and *light* syllables, and those in which such weight is irrelevant. In the first case, the mora, or weight unit, might be viewed as the stress/tone-bearing unit; in the second case, it seems necessary to recognize the syllable as the stress/tone-bearing unit. However, even in languages which show weight-sensitivity to stress assignment, recognition of syllables is necessary. Hayes (1991) observes that in all true stress languages, the syllable appears to be the stress-bearing unit, that is, there is no contrast between tautosyllabic v́v and vv́. In order to account for this, Hayes adopts a universal constraint which prohibits a single metrical foot from splitting syllables.[6] Without access to the construct "syllable", it is difficult to imagine how such a constraint would be formulated.

Another phenomenon which argues for the existence of the syllable as a phonological constituent derives from the presence of a contrast between so-called "ballistic" and "controlled" syllables in Otomanguean Amuzgo and Chinantecan languages (Robbins 1961; Merrifield 1963; Bauernschmidt 1965; Westley 1971; Foris 1973; Rensch 1978). In these languages, ballistic syllables have some or all of the following properties: aspiration (including fortis initial Cs, voiceless nuclear Vs, final voiceless sonorants, and syllable-final aspiration); rapid crescendo to peak intensity, with sudden decrescendo; accentuation of vowel length (long vowels are longer, and short vowels are shorter); tonal variants (higher level tones, upglides and downglides); tongue root retraction. Nonbllistic syllables are unaspirated, show even rise and falls of intensity, have normal vowel length contrasts, do not show tonal gliding, and have no tongue-root retraction. The group of properties distinguishing ballistic syllables all take domains larger than a single segment. Of particular relevance is the fact that aspiration is spread across the maximal $C_oV(V)C_o$ span, and that the distinct intensity patterns are also mapped over this domain. Treating ballisticity as anything other than a feature of the syllable leaves the range of properties noted and their multisegmental domains unexplained.[7] In sum, phonological properties with the syllable as their domain include pharyngealization, stress, tone, and ballisticity.[8]

1.2 Syllable Edge as Locus

Another argument for the syllable as phonological constituent is the existence of phonological rules that apply at syllable edges. In all languages, syllable edges correspond with word/utterance edges, so that without reference to the syllable, many such rules must be formulated to apply in the schematic environments/___{#, C} or / {#, C} ___. Such rules are problematic for the simple reason that boundary symbols and consonants do not form a natural class.[9] As a result, such rules are best interpreted as defining syllable-final and syllable-initial environments respectively. Aspiration is often associated with syllable boundries. For instance, in English (Kahn 1976) and Kunjen (Sommer 1981), syllable-initial obstruents are aspirated, while in Sierra Popoluca (Elson 1947) and Yucatec Mayan (Straight 1976), syllable-final obstruents are aspirated.

1.3 Syllables as Target Structures

In addition to rules which take the syllable as their domain of application, and those which affect segments at syllable edges, syllables can function as targets of language games (see chapter 23, this volume) or as prosodic targets in morphological processes (see chapter 9, this volume). Numerous language games have been described with reference to the syllable. For instance, White (1955) describes a language game in Luvale where /-ti/ is suffixed to each syllable of the word. Laycock's (1972) survey of language games (or “ludlings”) notes at least twenty cases where the syllable is the target of affixation, truncation, substitution, or movement.

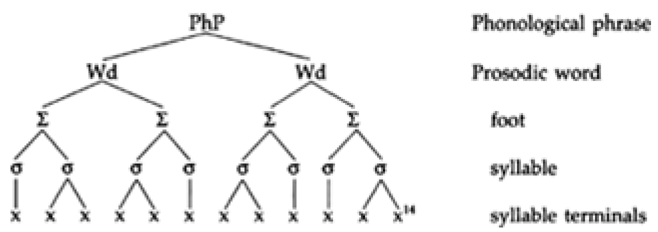
In addition to ludlings, syllables are also the prosodic targets of morphological processes like reduplication. Within the theory of prosodic morphology and phonology as developed by McCarthy and Prince (see chapter 9, this volume), reduplication involves affixation of a bare prosodic template to a base, where the segmental properties of the template are determined by those of the base. Four syllable types are recognized in prosodic morphology: (1) (maximal) syllable; (2) light (i.e., monomoraic) syllable; (3) heavy (i.e., bimoraic) syllable; and (4) core (i.e., CV) syllable. Only by the introduction of syllable templates can the invariant properties of such affixes and their restricted types cross-linguistically be captured.

1.4 Native Intuitions

In a number of languages, native speakers have clear intuitions regarding the number of syllables in a word or utterance, and in some of these, generally clear intuitions as to where syllable breaks occur. Many descriptive grammars contain references to native speakers' awareness of syllable breaks. For instance, in Schütz's (1985, p. 537) comprehensive grammar of Fijian, he notes that “native speakers seem to recognize the syllable as a unit: covertly in their occasional use of syllabic oral spelling; and overtly in their making syllable divisions in some material for language teachers.”[10] If phonology is in part the study of the mental representations of sound structure, then such intuitions support the view of the syllable as a plausible phonological constituent.[11]

Having shown how some languages require reference to syllabic constituents, the strongest theory (that is, the easiest theory to disprove) will posit syllables as substantive linguistic universals.[12] This is the theory I will adopt in the remainder of this chapter. In addition, I will assume that the syllable has a fixed position in the universal prosodic hierarchy as pictured in (1) below.[13]

(1) Universal Prosodic Hierarchy



2 Sonority

The relationship between syllables and sonority is one that has been recognized for a century or more. Jespersen (1904) points out that in each utterance, there are as many syllables as there are clear peaks of sonority, and Sievers (1881) observes that in general, between any member of a syllable and the syllable peak, only sounds of higher sonority are permitted. These and related observations are generally referred to as the Sonority Sequencing Generalization (or Sonority Sequencing Principle) a version of which is given in (2).[15]

(2) Sonority Sequencing Generalization (SSG)[16]
Between any member of a syllable and the syllable peak, a sonority rise or plateau must occur.

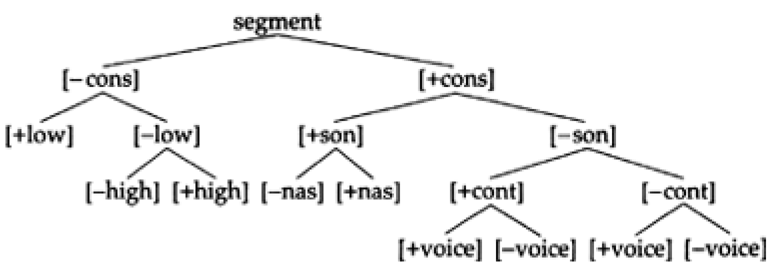
While most phonologists agree that some version of the SSG is to be intergrated into phonological theory, a range of questions arise concerning its status and implementation. Is the Sonority Sequencing Generalization an absolute condition on representations, or simply a preference condition expressing universal markedness values? On what basis is segmental sonority determined? Is sonority ranking universal or language specific?

There appear to be a fair number of exceptions to the Sonority Sequencing Generalization as presented in (2). As stated, it proposes that the presence of a prevolic C_1C_1 (C_1 □ C_2) sequence within the syllable implies the absence of a postvocalic C_1C_2 sequence and vice versa. However, in English, syllableinitial/ sp st sk/occur, and postvolic tautosyllabic / sp st sk/ are also found, and English is far from unique in this regard.[17] Such cross-linguistic facts have lead many researchers to adopt the Sonority Sequencing Generalization as a preference condition, a determinant of syllable markedness, or as a constraint on initial syllabification, which can later be violated by language-particular rules and/or constraints.[18]

Another question concerns how sonority is defined and on what measure it is based. A phonetic basis for sonority has been widely contested, though measurements based on acoustic intensity are often taken as a starting point for estimating the pereceptual saliency or loudness of a particular sound. Based on such measurements, Ladefoged (1982, p.222) presents the following partial sonority ranking for English: a > æ > ϵ > I > u > i > l > n > m > z > v > s > š > d > t > k >.

This particular scale conforms to most universal and language-particular phonological sonority scales proposed in the literature. Such scales come in a variety of types, with the major parameters of differentiation being feature-based vs. nonfeature based, binary vs. scalar, relative vs. absolute, and finegrained vs. not-so-fine-grained. Distinctive feature-based models, first advocated by BasbØll (1977), have the distinct advantage of categorizing segments on the same basis as other phonological rules and constraints.Using distinctive features, I summarize in (3) the sonority relations which, to my knowledge, have not been counter-exemplified in the phonological and /or phonetic literature.[19]

(3) A working universal sonority scale
For each node, the left branch is more sonorous than the right branch, and sonority relations for a given feature are only defined with respect to segments with the feature specification of the mother node.



The sonority scale in (3) is organized in terms of binary relationships, with the left branch more sonorous than the right branch. The relationships in this tree are intended to be absolute; thus, for example, we will find *no* language where non-low vowels are more sonorous than low vowels. The fine-grainedness of the scale is determined by available evidence; as far as I know, for instance, there are no languages which display clear sonority rankings for place of articulation features within the class of [+consonantal] segments.[20]

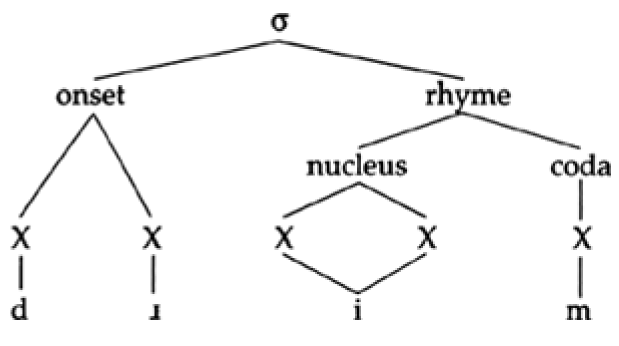
3 Syllable-internal Structure

We turn now to the question of syllable-internal structure, and the relation of syllable-internal structure to syllable weight. Many proposals have been made concerning the internal structure of syllables. Some current views are listed in (4).[21]

(4) Models of syllable-internal structure
(a) Flat structure (i.e., no subconstituents but the segments themselves) (Anderson 1969;Kahn 1976; Clements and Keyser 1983).
(b) Moraic approaches: $\sigma \rightarrow C_0 \mu (\mu) C_0$ (Hyman 1985; McCarthy and Prince 1986; Hayes 1989).
(c) Binary branching with Body: → σ → Body Coda;Body Onset Nucleus (McCarthy 1979; Vennemann 1984).
(d) Ternary branching:σ → Onset Nucleus Coda (Hockett 1955; Haugen 1956; Davis 1985).
(e) Binary branching with Rime: σ → Onset Rime; Rime → Nucleus Coda; (traditional Chinese scholars as represented, for instance, in the Song dynasty rhyme tables (dêngyùntú), and discussed at length in Chao 1941 and Karlgren 1954; Pike and Pike 1947; Kurylowicz 1948; Fudge 1969; Halle and vergnaud 1978; Selkirk 1982).

Evidenced for subsyllabic constituency falls into the same categories already used in justifying the syllable as a constituent. Particular emphas is usually on sonority-based, feature-based, and position-based phonotactic constraints, as these provide the strongest evidence for multisegmental domains within the syllable. Here the principle has been invoked that the presence of cooccurrence restrictions between two segment positions within a syllable is evidence that the two positions form a constituent. In this section, I present evidence in favor of the model in (4e), where the maximal syllable-internal structure is as shown in (5).

(5) Syllable-internal structure (English word *dream*)



I will present first what I believe is the strongest evidence for this model, and then demonstrate that other approaches (4a-d) cannot adequately account for such facts, at least not without substantial revision.

As outlined in section 2, there have been various proposals concerning how sonority values should be integrated into syllable theory. Most proposals attempt to account for the Sonority Sequencing Generalization (to the extent that it is valid) by ranking phones on a sonority scale like that suggested by Ladefoged (1982) for English. Using such scales, two aspects of sonority sequencing favour the division of syllable into onset, nucleus, and coda subdomains. First, while initial and final C clusters in $\#\#C_0V_1C_0\#\#$ may show a rigid internal adherence to sonority scales, the sonority value of prevocalic and postvocalic Cs is not determined in relation to the sonority value of adjacent Vs. Second, for many languages, the sonority sequencing constraints holding among prevocalic C-sequences are not simply the mirror image of those which constrain postvocalic C-sequences.

Both of these points can be illustrated with reference to English. In English, all word-initial C-clusters, excluding those composed of /s/ + obstruent, conform to the Sonority Sequencing Generalization: /pr br tr dr kr gr fr vr sr pl bl kl gl fl vl sl šl tw dw kw gw sw šw/. However, there is no case in which the sonority value of the second member of these clusters is determined by the following vowel: /swaum/ and /swan/ are both well-formed despite the fact that the sonority values of /w,u/ are much closer than those of /w, a/. In addition, while all the initial clusters above are well-formed in reverse order as postvocalic sequences, additional postvocalic clusters occur, including: /rl rm rn lm ln nd mp nk/. But despite the fact that all of these clusters obey the Sonority Sequencing generalization, none of them constitute well-formed syllable-initial clusters when their order is reversed: *lrV…,*mrV….,*nrV…,*mlV…, etc. Hence, any attempt to formalize the constraints on relative sonority of segments within the English syllable must (1) recognize that sonority scales are relevant within prevocalic and postvoclic clusters, but not across CV or VC; and (2) distinguish minimal sonority distances for initial and final clusters, as segments closer in sonority value are tolerated post-vocalically. Evidence for sonority sequencing constraints within a language can then be extended to become evidence for a division of the syllable into three distinct domains: onset, nucleus, and coda. As such evidence is consistent with the models in (4c, d, e) above, further arguments focus on the necessity of a rhyme constituent which is decomposed into nucleus and coda subconstituents.

The most robust evidence for the rhyme constituent is based on phenomena sensitive to syllable *weight*. In many languages, syllabus are divided into heavy and light, where heavy syllables are those which attract stress or allow two (as opposed to one) tones. In all but a very few cases, syllable weight is defined without reference to the prevocalic portion of the syllable [22].Further, as shown in (6), in languages that show a three-way weight distinction, the heaviest syllables are those which have the most sonorous rhymes. (Recall here that, all else being equal, long segments are more sonorous than short segments.)

(6) Cross-linguistic definitions of syllable weight[23]

	Light	Heavy	Heaviest	
Type 1	C_0V		C_0VX…	Sierra Miwok, Hausa, etc.
Type 2	C_0VC_0		C_0VV…	Huasteco, Hawaiian, etc.
Type 3	C_0V	C_0VC_1	C_0VV…	Klamath, Yupik
	C_0V	C_0VC_1	$C_0V(V, R)$…	Creek

In such languages as Sierra Miwok, both C_0VC and C_0VV syllables attract stress, while in Hausa, both of these syllable types count as heavy for the purposes of phonological and morphological processes. In Huasteco, stress falls on the last syllable in the word containing a long vowel, otherwise on the first syllable, with C_0VC syllables skipped; in Hawaiian all C_0VV syllables are stressed, but this language has no closed syllables. In Klamath, stress also falls on the last long vowel of the word; but in the absence of a long vowel, stress falls on the penult if it is closed, otherwise on the antepenult. In Yupik, syllables with long vowels attract stress, as do wordinitial closed syllables. Finally, in Creek, where a pitch accent system is in evidence, contour tones are found only on VV and VR sequences; however, predictable pitch accents in Creek are placed in accordance with quantity-sensitive binary feet which treat both CVV and CVC syllables as heavy.

The three languages types in (6) appear to exhaust the range of syllableweight distinctions that do not involve segments preceding the nuclear vowel. The fact that languages have at most a three-way weight distinction and variable definitions of heavy and light will then follow from the definitions of these categories in terms of the syllable subconstituents nucleus and rhyme, as shown in (7):

(7) Structural definitions of syllable weight[24]

Light Heavy Heaviest

Type 1	nonbranching rhyme		branching rhyme
Type 2	nonbranching nucleus		branching nucleus
Type 3	nonbranching rhyme	branching rhyme	branching nucleus

The syllable-internal structure posited in (4c, d) above must resort to conjunctive statements to account for the cross-linguistic weight classes in(7). For instance, the definition of “heavy” for type 1 within the body/coda approach would be as follows: heavy syllables are those which are branching and/or those with branching nuclei. Moraic approaches (4b) which lack syllable internal constituency have problems handling languages with three-way weight constrasts. In order to remedy such problems, Hayes (1991) has introduced various elaborations of moraic theory including context-sensitive weight-by-position rules, a distinction between strong and weak moras, and a prosodic grid on which extra-moraic sonority distinctions can be represented. While it would take us somewhat afield to argue the point in detail here, Hayes's emmendations can be interpreted as demonstrating that a moraic theory which eschews syllable-internal structure is forced to weaken itself to a point where the possibilities for defining distinct syllable weights are greater than those delineated by the model of annotated syllable structure summarized in (7).[25]

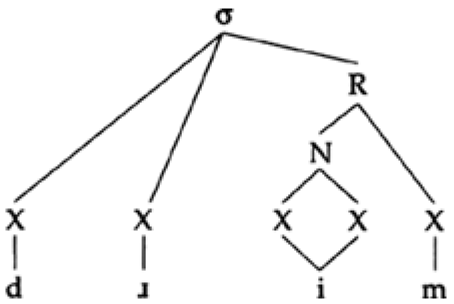
Other arguments for constituency focus on feature distribution and substiution classes within the syllable. Pike and Pike (1947) argue that the immediate constituents of Mazateco syllables are onsets (“margins”) and nuclei.(As all syllables in Mazateco are open, there is no distinction possible between nucleus and rhyme in this language.) This division is based on the distribution of tone and nasalization; contrastive tone and nasalization are features of the nucleus, and are not realized on prevocalic glides, which are members of the onset.[26] Hockett (1947) illustrates how the traditional view of the Chinese syllable accounts for systematic restrictions on sound sequences. Only consonantal elements occur as initials (onsets), only glides appear as medials (rhymeinitial elements), only vowels occur in the nucleus, and terminals (codas) are restricted on a language-specific basis. Fudge (1969,1987) also uses distributional evidence to support a view of the English syllable similar to that shown in (5).[27] For instance, the fact that only lax/short vowels are found before/-mp/ and /-nk/ is taken as an indication that nucleus and coda are more closely related than onset and nucleus are.

In other languages, evidence for the rhyme also takes the form of restrictions on the number of rhyme-internal segments: for instance, in Yokuts (Newman 1944), Afar (Bliese 1981), and Hausa (Newman 1972), no more than two segments can appear in the rhyme, with derived CVVC syllables surfacing as CVC; and in Turkish (Clements and Keyser 1983) and Spanish (Harris 1983) no more than three elements can occur within the syllable rhyme.[28] Such restrictions are difficult to formulate without reference to the rhyme itself.

Additional arguments for the rhyme as phonological constituent come from languages games. In addition to ludlings which affix/replace/move entire syllables, there are also numerous examples in Laycock (1972) where the syllable rhyme is the rule focus. In English “oppen-gloppen” the sentence “you are mad” is rendered as [y-op-u op-aŋ m-op-æd].[29]

Arguments for the onset as a constituent are hard to come by. Other than the fact that sonority sequencing constraints can be shown to hold within this domain, there are few indications that the onset is anything but what is left when the rhyme is taken away.[30] Likewise, other than sonority constraints, there are few convincing demonstrations of coda sequences defining an identifiable constituent. Given the lack of positive evidence for onset and coda constituents, the original model in (5) is modified to that shown in (8) below:

(8) Syllable-internal structure (based on positive evidence)



Within this model, sonority constraints holding within pre-vocalic and postvocalic clusters can still be defined with reference to syllable structure: onset elements are those dominated immediately by σ, and coda elements are those dominated immediately by R.

4 An Overview of Syllable Typology

In this section, I shall present a brief overview of syllable typology. The purpose of this is to demonstrate the extent to which syllable types vary cross linguistically, and to highlight cross-linguistic generalizations. Any theory of the syllable must be able to account for the wide range of syllable types that we find, and for aspects of syllable structure which remain constant across languages.[31] Variation among syllable types in the world's languages is considerable.

Table 6.1Cross-linguistic variation in syllable types*

	V	*CV*	*CVC*	*VC*	*CCV*	*CCVC*	*CVCC*	*VCC*	*CCVCC*	*CVCC*
Hua	no	yes	no	no	no	no	no	no	no	no
Cayuvava	yes	yes	no	no	no	no	no	no	no	no
Cairene	no	yes	yes	no	no	no	no	no	no	no
Mazateco	yes	yes	no	no	yes	no	no	no	no	no
Mokilese	yes	yes	yes	yes	no	no	no	no	no	no
Sedang	no	yes	yes	no	yes	yes	no	no	no	no
Klamath	no	yes	yes	no	no	no	yes	no	no	yes
Spanish	yes	yes	yes	yes	yes	yes	no	no	no	no
Finnish	yes	yes	yes	yes	no	no	yes	yes	no	no
Totonac	no	yes	yes	no	yes	yes	yes	no	yes	yes
English	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

***For language sources, see table 6.3. Note that V is used in this chart as a cover term for any nuclear sequence, i.e., both for short vowels, long vowels, and vowel sequences.**

Some languages, like Hua, have only one syllable type: CV.Other languages, like English, have more than ten basic syllable shapes.[32] Despite the range of variation, certain generalizations are apparent.First, all languages have CV syllables.[33] Second, all languages exhibit the following property: if clusters of *n* Cs are possible syllable-initially, then clusters of *n*-1 Cs are also possible syllable-initially, and if clusters of *n* Cs are possible syllable-finally, then clusters of *n*-1 Cs are also possible finally.[34] In addition, if a language does not allow syllables consisting solely of V, then it does not allow any V-initial syllables.Table 6.2 illustrates the extent to which languages can very in terms of tautosyllabic sequences of syllabic (or nuclear) elements.

Table 6.2Parametric variation in nuclear [-cons] sequences*

Language	*V*	*V:*	*V::*	*V:::*	V_1V_2	$V_1V_2V_3$	$V_1V_2V_3V_4$

Cayuvava	yes	no	no	no	no	no	no
Yokuts	yes	yes	no	no	no	no	no
El Paraíso Mixe	yes	yes	yes	no	no	no	no
Spanish	yes	no	no	no	yes	no	no
Witoto	yes	no	no	no	yes	yes	no
Finnish	yes	yes	no	no	yes	no	no
Estonian	yes	yes	yes	no	yes	yes	no

***Language sources include: Cayuvava (Key 1961); Yokuts (Newman 1944); El Paraiso Mixe (Van Haistma and Van Haistma 1976); Spanish (Harris 1983); Witoto (Minor 1956); Finnish (Keyser and Kiparsky 1984); Estonian (Prince 1980).**

Again, certain generalizations are apparent. Most notably, if a language allows tautosyllabic sequences of *n* Vs, then also allows sequences of *n*–1 Vs. No language appears to allow sequences of more than three Vs within a single syllable, and no language has more than a three-way contrast in vowel length. Though not apparent from this schematic table, within the nucleus domain, the SSG holds without fail.

In order to capture some of these generalizations, languages can be described in terms of a small set of binary-valued parameters which are defined over sub-syllabic domains onset (=Cs immediately dominated by the Syllable node), nucleus, and coda (=Cs immediately dominated by the rhyme node).

In Table 6.3, logical combinations of five binary-valued parameters are shown along with representative languages. The Complex Nucleus parameter specifies whether or not complex nuclei are well-formed (yes) or not (no).[35] In languages without complex nuclei, VV strings will constitute disyllabic sequences. The Obligatory Onset parameter determines whether an onset is obligatory (yes) or not (no). Languages like Totonac for which the setting is yes have no V-initial syllables. The Complex Onset parameter determines whether more than one segment is allowed in the onset (yes) or not (no). The Coda parameter is an indicator of whether (yes) or not (no) a language has closed syllables, while the parameter Complex Coda (CC) allows more than one segment within the coda (yes), or only one (no). In addition to these five parameters which result in a set of well-formed syllable types, some languages allow exceptional syllable types at the edge of the syllabification domain. For instance, in Klamath, word-initial syllables may begin with CC-clusters, but CC-initial syllables are not found word-internally. Such exceptionality is included in this chart under Edge Effect, with sub-settings I(nitial)/F(inal), for the sake of completeness. While settings for the first three parameters are independent, settings for Coda and Complex Coda are dependent: if the setting for Coda is “no,” then the settings for Complex Coda is also “no”. The resulting full matrix is 24 by 5, where each of the 24 rows defines a possible parameter setting for some natural language.

The parameter settings described above not only account for the generalizations noted above, but are also meant to encode markedness values, where “no” is the unmarked value and “yes” is the marked value. The unmarked case is that onsets are not obligatory; there are no complex onsets; there are no codas, and there are no systematic differences between word-internal and word-edge syllables. While it would take us somewhat afield to present a detailed justification of the syllable markedness values encoded here, the following observation are taken to be highly suggestive of such a ranking. (1) In the early stages of language development (early babbling), children appear to produce syllables in which onsets are not obligatory, there are no complex onsets, there are no codas and there are no systematic differences between word-internal and word-edge syllables (Vihman et. al. 1985). (2) In second language acquisition, speakers have little difficulty in shifting from a “yes” value to a “no” value for a given parameter, but do show difficulty in switching from a “no” value to a “yes” value (Anderson 1987). (3) All languages have CV syllables. (4) Perhaps most important, there are a variety of phonological processes which take marked syllable types to unmarked types (rules of epenthesis and segment deletion), but there are few if any rules which consistently result in obligatory codas, obligatory complex onsets, or obligatory complex codas.

Table 6.3Parametric variation in syllable type*

	Complex Nucleus	*Oblig.Onset*	*Complex Onset*	*Coda*	*Complex Coda*	*Edge Effect*
Totonac	yes	yes	yes	yes	yes	yes/F
Klamath	yes	yes	no	yes	yes	yes/I
English	yes	no	yes	yes	yes	yes/F
Nisqually	no	yes	yes	yes	yes	yes/F
Gilyak	no	no	yes	yes	yes	yes/F
Finnish	yes	no	no	yes	yes	no
Tunica	no	yes	no	yes	yes	no
Tamazight Berber	no	no	no	yes	yes	yes/F
Sedang	yes	yes	yes	yes	no	yes/I
Cairene	yes	yes	no	yes	no	yes/F
Spanish	yes	no	yes	yes	no	yes/F
Dakota	no	yes	yes	yes	no	yes/F
Italian	no	no	yes	yes	no	yes/IF
Mokilese	yes	no	no	yes	no	yes/F
Thargari	no	yes	no	yes	no	no
Cuna	no	no	no	yes	no	no
Arabela	yes	yes	yes	no	no	no
Siona**	yes	yes	no	no	no	no
Pirahã**	yes	no	yes	no	no	no
Piro**	no	yes	yes	yes	no	yes/I
Mazateco	no	no	yes	no	no	no
Fijian	yes	no	no	no	no	no
Hua**	no	yes	no	no	no	no
Cayuvava	no	no	no	no	no	no

***Language sources include: Totonac (Mackay 1991); Klamath (Barker 1963, 1964); Nisqually (Hoard 1978); Gilyak (Austerlitz 1956; Jakobson 1957); Finnish (Keyser and Kiparsky 1984; Prince 1984); Tunica (Haas 1946); Tamazight Berber (Saib 1978; Chung 1991); Sedang (Smith 1979); Cairene (Broselow 1979); Spanish (Harris 1983); Dakota (Shaw 1989); Italian (Basbɸll 1974); Mokilese (Harrison 1976); Thargari (Klokeid 1969); Cuna (Sherzer 1970, 1975); Arabela (Rich 1963); Siona (Wheeler and Wheeler 1962); Piraha (Everett and Everett 1984); Piro (Matteson 1965); Mazateco (Pike and Pike 1947); Fijian (Schütz 1985); Hua (Haiman, 1980); Cayuvava (Key 1961).**

****Aspects of syllabification in these languages are questionable. The above classification requires that (i) complex nuclei in Siona include V_1V_2 and V?; (ii) voiceless stops in Piraha be treated as tautosyllabic geminate onsets; (iii) all long vowels in Piro be derived from lengthening of V_1 in compensation of C_1–loss in...V.C_1C_2V... strings; (iv) that V? and V both constitute simple nuclei in Hua, where V? is a short glottalized vowel.**

Table 6.4Parametric variation in syllabic segments*

				Sonority			
Language	*A*	*I*	*R*	*L*	*N*	*S*	*T*
Kabardian	yes	no	no	no	no	no	no
Hawai'ian	yes	yes	–	–	no	–	no
Sanskrit	yes	(yes)	(yes)	no	no	no	no
Lendu	yes	(yes)	(yes)	(yes)	no	no	no
English	yes	(yes)	(yes)	(yes)	(yes)	no	no
Central Carrier	yes	(yes)	–	–	(yes)	(yes)	no

Imdlawn Tashlhiyt Berber	yes	(yes)	(yes)	(yes)	(yes)	(yes)	(yes)

*** Where A is [−high, −cons]; I is [+high, −cons]; R, L, N are rhotic, lateral, and nasal sonorants respectively; S is a [+cont] obstruent; and T is a [-cont] obstruent. "Yes" indicates that this segment type is an obligatory syllable nucleus in the language in question; (yes) indicates that the segment type is an optional syllable nucleus; "no" indicates that the segment type is an impossible syllable nucleus;– indicates that such segments are not found in the language in question.**

Language sources include: Kabardian (Kuipers 1960); Hawai'ian (Pukui and Elbert 1986); Sanskrit (Whitney 1889); Lendu (Tucker 1940); Central Carrier (Walker 1979); Imdlawn Tashlhiyt Berber (Dell and Elmedlaoui 1985; Elmedlaoui 1985).

In addition to the parameters shown in table 6.3, for each language a set of obligatory, possible, and impossible nuclei must by specified. Table 6.4. shows the range of syllabic segments cross-linguistically, where the horizontal axis is arranged from most sonorous segments on the left to least sonorous segments on the right.

From table 6.4 we see that there is a definite relationship between the sonority value of a segment and its potential as a syllable nucleus. Three concrete generaliazations emerge: (1) all languages have syllable containing non-high vocalic nuclei; (2) if a language allows a syllabic segment with sonority value *x*, then all segments with sonority values greater than *x* (i.e., more sonorous segments) are also potential syllabic nuclei; (3) within a language, optional nuclei are never more sonorous than obligatory nuclei.[36]

Parameters like those instantiated in table 6.3 coupled with the Sonority Sequencing Generalization and the three generalizations above go a long way toward defining the range of syllable types cross-linguistically.

5 Syllables and Syllabification

Having established the existence of phonological syllables, and aspects of their internal structure, we turn to the question of where syllables come from. Are they present in the lexicon, or are they somehow generated in the course of the phonological derivation? Three observations suggest that in the general case, syllable structure is not present in underlying representations: (1) minimal pairs distinguished by syllabification alone are rare, and are nonexistant in many languages; (2) segments in many languages exhibit syllabicity alternations which can be viewed as the simple result of derived syllabification; (3) individual morphemes often fail to conform to the possible syllable types of a given language, making lexical syllabification infelicitious.

With reference to the first point, consider the English near minimal pair [?áy.da] "Ida" vs. [?a.íy.da] "Aïda". In the general case, heteromorphemic /ai/ sequences are syllabified as complex nuclei: [ai] "I", [wai] "why", [?ail] or [áil] "aisle", etc. For this general case then, we can formulate a syllabification rule which will result in tautosyllabic /ai/ sequences. For exceptional forms like [?a.íy.da] we can assume that minimal structure is specified in the lexicon. In this case, it is sufficient to mark /i/ as a syllable nucleus in the UR: /a[i]$_N$ da/; this pre-specified syllable structure will bleed the regular rule assigning unsyllabified /ai/ sequences to a single nuclei.

Syllabicity alternations have been examined in numerous languages, and for the most part appear to be predictable and nondistinctive. Studies supporting the view of such alternations as the simple output of regular syllabification schemas include:Steriade (1982) for Latin and Ancient Greek;Noske (1982) for French;Sagey (1984) for Kinyarwanda;Steriade (1984) for Rumanian;Dell and Elmedlaoui (1985) for Imdlawn Tashlhiyt Berber; Guerssel (1986) for Ait Seghrouchen Berber; and Levin (1985) for Klamath. [37]

Perhaps the most striking analysis of this kind is that of Imdlawn Tashlhiyt Berber presented by Dell and Elmedlaoui (1985). In this language, all segments have syllabic and nonsyllabic allophones, with the exception of /a/ which surfaces consistently as a vowel. Syllabicity is predictable and nondistinctive (except for a set of morphemes containing high vocoids which are consistently [-syllablic]). As a result, Dell and Elmedlaoui start with unsyllabified underlying representaitons and propose a simple syllabification algorithm which predicts the syllabicity of segments based on their position and relative sonority within the string. Dell and Elmedlaoui adopt the following sonority scale for Imdlawn Tashlhiyt Berber:a>i, u> liquid>nasal>voiced fricative>voiceless fricative>voiced stop>voiceless stop. Their syllabification algorithm involves three steps: (1) Core syllabification:scanning from left to right in the string, associate a core syllable (i.e., a simple CV syllable constituent) to any sequence (Y) Z, where Y can be any segment not yet syllabified, and Z is a segment of type T, where T is a variable to be replaced by a set of feature specifications, in descending order, starting with the most sonorous elements on the sonority scale; (2) Coda rule: incorporate a single coda consonant; (3) Complex onset, complex coda: build complex onsets and/ or codas where necessary.[38]

If syllable structure is generally absent in underlying representations, how does it arise? As noted above, syllabification algorithms have been proposed for a variety of languages. Perhaps the most basic division between these algorithms is that distinguishing rule-based approaches like that of Steriade (1982), and template-matching approaches such as that implemented by Itô (1986). *Template-matching algorithms* for syllabification scan the segmental string in a fixed, language-particular direction (left to right, right to left), assigning successive segments to positions in a syllable template, always mapping to as many positions inside a given syllable template as possible. *Rule-based algo-rithms* posit an ordered set of structure-building rules which have similar status to that of other phonological rules:such rules may or may not apply directionally and do not require that syllable structure be maximalized in any sense from the start. While the two approaches overlap in many respects, two aspects of syllabification are most simply handled in rule-based syllabification algorithms: (1) in some languages rules of syllabification have been argued to apply in an ordered fashion to potential syllable nuclei, from most sonorous to least sonorous;(2) in some languages, there is evidence that structure-building rules of syllabification must be intrinsically ordered.

Both of these points are illustrated by the brief sketch of Dell and Elmedlaoui's analysis of Imdlawn Tashlhiyt Berber just presented. First, core syllabification applies in an ordered fashion from most sonorous to least sonorous potential nuclei; second, core syllabification precedes the formation of codas and complex onsets and codas. Another language where such ordering relationships have been argued for is Klamath (Clements and Keyser 1983; Levin 1985), where the maximal syllable is [CVVCCC]. In Klamath, on the basis of glide/vowel alternations, it has been argued that (1) non-high vowels are syllabified prior to high vowels, and (2) the first rule of syllabification creates [CVX] syllables, where this rule crucially feeds epenthesis. The analyses of Imdlawn Tashlhiyt Berber and of Klamath then present an immediate challenge for templatic models in which syllables are first maximalized, since such maximalization would bleed the necessary first-stage CV-/CVX rules, respectively, and derive ill-formed surface strings.[39]

While there might not be overt evidence for directional syllabification in all languages, those with vowel/glide alternations often provide evidence for directionality in the form of attested vs. unattested glide-vowel strings. For instance, in Lenakel (Lynch 1974) the distribution of high vowels and glides is complementary: high Vs [i, u] are found in C___C, C___#, and #___C environments, while glides [y, w] are found elsewhere, i.e.,___V, V___. Note the syllabicity alternations of the morpheme/-i-/ "first person" in the following verb forms:/i-ak-ol/yágɔl "I do it";/t-i-ak-ol/ tyágɔl "I will do it";/i-n-ol/ ínol "I have done it". The maximal syllable in Lenakel is [CVC].[40] In sequences of two or more high segments, the first is always syllabified as a glide:/iik/ yík (*iyk) "you, sg.";/uus/wús (*uws) "man, fellow";/uikar/wígar (*uygar) "seed";/kiukiu/kyúgyu (*kiwgiw)" to shake the body";/uiuou/wíwɔw (*uywɔw) "boil". Whether a rule-based or templatic approach is taken, the algorithm must apply directionally: in a rule-based approach, nucleus-placement must apply from right-to-left for high segments; [41] in a templatic approach, the template must be mapped from left-to-right to ensure glide-vowel as opposed to vowel-glide sequences.[42] In a case like this, the separation of template mapping into separate nucleus- and onset-building steps in the rule-based approach results in different directionality requirements: mapping to CV as a single step must be left to right; V mapping, with a subsequent onset formation is right to left. If directional syllabification has implications for other aspects of the phonology, then the distinct predictions of these two approaches could be tested against such phenomena. In fact, Itô (1989) has claimed that the directionality of syllabification predicts the position of epenthetic vowels in languages which have vowel epenthesis. Before evaluating this prosodic treatment of epenthesis, a short excursus on crosslinguistic strategies for dealing with stray segments is in order.

Underlying and intermediate phonological representations often do not constitute sequences of well-formed syllables within a given language. Where such violations occur at the edge of the syllabification domain, they are often tolerated on the surface, and aberrant strings result. For example, in Klamath, C_1C_2 sequences occur word-intially, though VCCCV strings are consistently syllabified as VCC.CV, attesting to the ill-formedness of complex onsets in this language. In Cairene Arabic, C_1C_2 sequences are found word-finally, though triconsonantal sequences are not found intervocalically (Broselow 1979, to appear). Here, VCCV strings are consistently syllabified as VC.CV, attesting to the ill-formedness of complex codas. In such cases, it has been useful to adopt the notion of extrametricality introduced by Liberman and Prince (1977:293) and developed by Hayes (1980) for metrical stress theory: *extrametrical* (or *extraprosodic*, or *extrasyllabic*) elements are (1) limited to the edge of the stress and syllabification domain, respectively, (2) invisible to the rules of constituent construction, and (3) are adjoined to existing metrical structure late in the derivation. Where the word is the domain of syllabification, then Klamath licenses extraprosodic segments initially, and Cairene Arabic licenses extra-prosodic segments finally. Rules of syllabification do not "see" such segments, and proceed accordingly; only late in the derivation are such segments adjoined to adjacent syllables.[43]

In other languages, segments which cannot be incorporated into well-formed syllables are deleted. This process, when affecting consonants, is commonly referred to as *Stray Erasure.* When affecting vowels, rules of closed syllable shortening may result. In either case, the general process can be stated as in (9):

(9) Stray Erasure: Unsyllabified segments are deleted.[44]

Stray Erasure has been claimed to account for consonant deletion in a number of languages, including Attic Greek (Steriade 1982), Diola Fogny (Steriade 1982), English (Borowsky 1986), French (Levin 1986), Icelandic (Itô 1986), Korean (Kim and Shibatani 1976), Lardil (Wilkinson 1988), and Turkish (Clements and Keyser 1983). In English, stem C/ø alternations as in *damn/damnation* and *hymn/hymnal* can be accounted for by recognizing that **mn* is an ill-formed coda sequence in English, and hence, the pre-surface representation of/dæmn/is/dæm.n′/ where C′ represents an unsyllabified C which is deleted by stray erasure, resulting in [dæm].[45]

Stray Erasure can also be viewed as the process involved in rules of closed syllable shortening in many languages. Rules of closed syllable shortening typically take [CVVC] to surface $[CVC]_\sigma$ by deletion or shortening of a nuclear vowel. Languages exhibiting regular closed syllable shortening include Afar (Bliese 1981), Hausa (Newman 1972), Kashaya (Buckley 1991), and Yokuts (Newman 1944; Noske 1984). In such languages maximal $[CVX]_\sigma$ syllables are typical:when a ...V_1 V_2 C_1 {C_2, #} ...string is syllabified, the syllable headed by V_1 takes C_1 (over V_2) as a post-nuclear element. for instance, in Afar, vowel shortening and glide loss both follow from constructing [CVX] syllables with priority of C over V in the post-nuclear position:/koo/[koo] "you, acc."vs./koo-t/[kot] "by you";/rakuub/[rakub] "camel, sg." vs./rakuub-a/[rakuuba] "camels";/oys-oome/[oysoome] "I caused to spoil" vs./oys-s-oome/[ossoome] "I caused to spoil for my benefit".[46]

Short of deleting a stray segment altogether, a segment may be altered by a feature-changing process, in conformity with language-specific syllable structure constraints. This type of process is most common with coda consonants, as such consonants are subject to featural restrictions in many languages (see section 6.1). For instance, in Korean, the feature [+lcontinuant] is not licensed on obstruents within the coda. As a result, / s s′ c^{čh}/ all are realized as [t′] in the syllable coda (Kim-Renaud 1977):/os/[ot′] "clothes",/os-kwa/[ot′ k′ wa] "clothes and",/os-in/[osin] "as for the clothes";/k′ o c ^{čh}/[k′ o t′] "flower",/k′ o c ^{čh}-kwa/[k′ o t′ k′ wa] "flower and",/k′ o ^{čh}-i/[k′ o ^{čh}i] "flower, subj."[47]

Having briefly reviewed these methods of dealing with underlying and intermediate phonological representations which do not constitute sequences of well-fromed syllables within a given language, I turn to perhaps the most well-established and well-studied mode of dealing with stray consonants, vowel epenthesis.[48] Prosodic treatments of vowel epenthesis are suggested in work of Firth (1948), Vennemann (1972), Giegerich (1981), Noske (1984), and Itô (1989), among others. The basic insight of these approaches is that epenthesis is a strategy for saving otherwise unsyllabifiable strings.

Whereas rule-based syllabification algorithms build well-formed syllables, and subsequently invoke rules of V-epenthesis triggered by unsyllabified syllable terminals, templatic approaches such as that proposed by Noske (1984) and Itô (1989) view epenthesis as an integral part of the syllabification process.

As noted above, Itô (1988) has claimed that the site of epenthetic vowels is a direct function of the directionality of syllabification: in languages with left-to-right syllabification, stray consonants will surface as syllable onsets, while right-to-left syllabification will incorporate stray Cs as coda segments. Itô (1988) illustrates such an approach with a near-minimal dialect pair:Cairene Arabic vs. Iraqi Arabic. In both languages, the maximal syllable (abstracting away from the effects of extraprosodicity) is $[CVX]_\sigma$. However, in Cairene, underlying/… VCCCV… /surfaces as[… VCCiCV…], whereas in Iraqi, underlying/… VCCCV … /surfaces as [… VCiCCV …]. In both languages/ … VCCCCV … / strings surface as [… VCCiCCV …]. Itô accounts for these facts by mapping $[CVX]_\sigma$ from left-to-right in Cairene, and from right-to-left in Iraqi. While this approach handles the epenthesis facts from these two Arabic dialects in an elegant and straightforward way, it meets with problems in other languages.[49]

One of these languages is Lenakel, discussed with respect to glide/vowel distribution above. Recall that, based on the distribution of syllabic segments, the prosodic and rule-based approaches are led to different directionality specifications: left-to-right and right-to-left respectively. The template-matching approach then predicts that epenthesis rule in Lenakel, as in Cairene, should result in stray segments syllabified as onsets, as opposed to codas. While this is true for initial (10a) and medial (10b) clusters, it is not the case for final CC clusters (10c), where a word-final C is syllabified as a coda.[50]

(10) Lenakel epenthesis (Lynch 1974)

(a)	/t-n-ak-ol/	tɨnágɔl	"you (sg.) will do it"
	/t-r-ep-ol/	tɨrɛ́bɔl	"he will then do it"
	/n-n-ol/	nɨ́nɔl	"you (sg.) have done it"
	/r-n-ol/	rɨ́nɔl	"he has done it"
(b)	/kam-n-m̃an-n/	kàmnɨm̃ánɨn	"for her brother"
	/ɔs-ət-pn-aan/	ɔ̀sidbənán	"don't go up there"
	/k-ar-(ə)pkom/	karbə́gɔm	"they are heavy"[51]
(c)	/əpk-əpk/	əbgə́bəkʰ	"to be pregnant"
	/apn-apn/	abnábən	"free"
	/ark-ark/	argárikʰ	"to growl"
	/r-əm-əŋn/	rɨmə́ŋən	"he was afraid"
	/n-əm-əpk/	nɨmə́bəkʰ	"you (sg.) took it"

While one might view such facts as calling for a slight emmendation to prosodic theories of epenthesis, facts from Chukchi (Bogoraz 1922; Kenstowicz 1979) support the view of epenthesis as independent of directional syllabification. In Chukchi, syllables are maximally [CVC], and onsets are not obligatory. The monomorphemic forms in (11a) are immediately problematic for template-mapping approaches, as unsyllabified/CCC/should surface as [vCCvC] under right-to-left syllabification, and as [CVCCV] under left-to-right syllabification (where v indicates an epenthetic vowel).[52] The forms in (11b) highlight the preferential treatment of word-initial stray Cs as onsets, while the forms in (11c) show that treatment of/ … VCCCV … / sequences in Chukchi depends on the position of the morpheme boundary:/ … CC-C … / surfaces as [… CCvC …] while / … C-CC … / surfaces as [… CvCC …].

(11) Chukchi epnthesis

(a)	/pnl/	pinil	"news"
	/kkl/	kukil	"one-eyed man"
(b)	/tke-rkin/	tikerkin	"thou smellest of"
	/mk-icin/	mukicin	"more numerous"
(c)	/...C-CC.../	...CvCC...	
	/mit-tmu-git/	mititmugit	"we killed thee"
	/nalvul-chin/	nalvulichin	"the herd"
	/n-np-qin/	ninpiqin	"the old one"
	/n-plu-qin/	nupluqin	"small one"
	/...CC-C.../	...CCvC...	
	/timk-leut/	timkileut	"hummockhead"
	/itc-pilintin/	itcipilintin	"precious metal"
	/itc-wil/	itcuwil	"precious ware"
	/iwl-walat/	iwluwalat	"long knives"
	/tumg-tum/	tumgitum	"companion"
	/pilh-pil/	pilhipil	"famine"

Such facts, coupled with those from Lenakel suggest that (1) rules of epenthesis preferentially take word-initial stray segments as onsets (despite the existence of onsetless syllables within a language); (2) rules of epenthesis preferentially take word-final stray segments as codas; (3) rules of epenthesis can be sensitive to morphological structure. In sum, epenthesis sites cannot be predicted by directional syllabification alone in all languages.[53]

The final issue to address in this section is at what point in the derivation syllabification takes place. A closely related question involves determining the morphological or phonological domains (stem, word, etc.) within which proper syllabification is required. In some languages, there is evidence of early cyclic syllabification. Because the prosodic hierarchy in example (1) requires that syllabification feed stress assignment, evidence of cyclic stress provides evidence for cyclic syllabification. For instance, in Palestinian Arabic (Brame 1974), where stress assignment is sensitive to syllable weight and stress is assigned cyclically, syllabification must also be cyclic.

In many languages there is no evidence for a domain of syllabification smaller than the word. For instance, in Yupik (Krauss 1985), word stress and related phonological processes provide no evidence for syllabification within a domain smaller than the word. This can also be the case in languages in which the phonological word is not the stress domain. For instance, in Yokuts (Newman, 1944; Archangeli, 1984), where stress falls on the penultimate syllable within the phonological phrase, rules of closed syllable shortening and epenthesis apply within the phonological word, providing evidence of word-level syllabification.

In still other languages, word-level syllabification is followed by later syllabification or resyllabification at the level of the phonological phrase. For instance, in Cairene Arabic, word-level syllabification is necessary for proper assignment of word-stress, but syncope, epenthesis, and spread of phrayngealization across word boundaries provides evidence for later (re-)syllabification at the level of the phonological phrase (Broselow, to appear).

In sum, rules of syllabification parallel other phonological rules in taking as their smallest domain the individual morpheme, and as their largest domain, the phonological phrase. In some languages there is evidence for cyclic syllabification, while in others the earliest evidence for syllabification is at the word level.

6 Problems in Syllable Theory

While there is a great deal of consensus on issues relating to syllable constituency, syllable typology, sonority and syllabification, other aspects of syllable structure are still debated within the phonological literature. In this section, I touch on four topics which could easily constitute whole chapters in themselves: coda constraints and their proper formulation (6.1), the syllabification of VCV strings (6.2), ambisyllabicity (6.3), and mismatches between phonological and phonetic syllables (6.4).

6.1 Coda Constraints

In addition to phonotactic constraints within the syllable which follow from sonority and syllabification, many languages have additional constraints on the featural content of segments in particular syllable-internal positions. While single member onsets appear to be unrestricted cross-linguistically,[54] many languages with single member codas allow only a small class of segments to occupy coda position. For instance, in Axininca Campa (Payne 1981), the only element which occupies coda position is /N/, an unspecified nasal segment which shares the place features of a following obstruent.

Many recent proposals have been made regarding the status of such coda constraints. Itô (1986) posits both negative and positive feature-based coda constraints which are purely phonological, and which are stated in such a way as to exempt full or partial geminates. Clements (1990) takes a more concrete view and suggests that in some cases, coda constraints instantiate the cross-linguistic preference for a sonority profile which "rises maximally towards the peak and falls minimally towards the end" (p.301).

While there are many languages in which the segments appearing in coda position are highly limited, it is not easy to determine in many cases whether such distributional facts reflect synchronic phonological constraints. For instance, in the Beijing dialect of Chinese, the only coda Cs are /n ŋ i/. The native phonology of Chinese provides little evidence as to whether other consonants are actually prohibited from the coda position, or whether the gaps in question are accidental. In this case, examination of loan-word phonology is revealing: Beijing speakers produce ní-kè-sōŋ, ní-kè-xùn or ní-kè-sūn for "Nixon", and^{v}jū-lī-yè or jū-lī-yè-de for "Juliette." Such forms seem to indicate that absence of obstruent-final syllables is not accidental. However, in other languages, loan-word phonology reveals that coda possibilities are more extensive than evidenced by the native vocabulary. For instance, in Italian, where the maximal syllable is CCVC, nongeminate coda consonants appear to be restricted to sonorants.[55] Based on this, Itô (1986, p. 38) proposes a coda condition that bars obstruents from the coda unless they are geminate. However, in loan words, obstruent codas of all sorts apoear both medially and finally: kakto, kaktus "cactus"; koftiko "Coptic"; kamčatka "Kamchatka"; fiat "Fiat"; vat "watt"; kopek "copeck"; etc. Given such facts, the gaps in the native vocabulary become suspect: are these representative of systematic constraints against nongeminate obstruent codas, or is the absence of such codas accidental? As with other aspects of syllable structure, distributional constraints comprise only one limited form of evidence. Wherever possible, coda constraints should be supported by positive evidence from native and loan phonology in the form of Stray Erasure, extraprosodicity, feature-changing rules, or epenthesis triggered by arguably illicit coda segments. Only in such cases is there positive evidence of the systematic nature of gaps in the coda inventory.

Itô's coda conditions for Japanese, Italian, and other languages are stated so as to exempt full or partial geminates by invoking Hayes's (1986) Linking Constraint, which requires that all association lines be interpreted exhaustively. For instance, the constraint in (12) is proposed for Japanese, where the only well-formed codas are nasals and the first C of a geminate structure (kappa "legendary being" is well-formed, but *kapka is not):

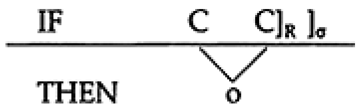
(12)

Japanese coda constraint   *** C]**
|
[-nas]

As stated, (12) will only apply to singlely linked instances of the feature [-nasal], exempting all geminates.[56] This theoretical innovation takes as its basis the observations of Prince (1984), that in many languages what are CVC syllables in skeletal terms, are really CV syllables melodically, as the melody of the coda segment is linked, or borrowed from a following heterosyllabic segment (see chapter 8 for additional discussion).

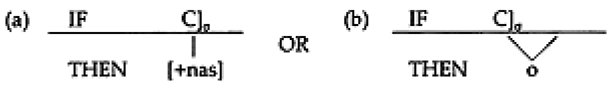
Chung (1991) points out that in Tamazight Berber, with maximal CVCC syllables, any single coda consonant is possible, but the only well-formed coda clusters are geminates: annli "brain" (*anlli); áaddratt "ear of corn" (*áadrratt); etc. While the parallelism between a "geminate-only" constraint for C_1C_2 in VC_1C_2V (for Japanese, Italian, etc.) and in $VC_1C_2C_3V$ (for Berber) is striking, Chung (1991) demonstrates that the constraint in Berber cannot be treated by invoking a version of the Linking Constraint; instead the geminate-only condition on complex codas in the language should be derived from positing a positive constraint like that shown in (13).

(13) Tamazight Berber Complex Coda Constraint



The existence of languages which require explicit reference to geminate structures in the statement of coda constraints leads one to question whether syllable structure constraints in Japanese might not be best represented by two distinct statements, as shown in (14):

(14) Japanese coda constraints (revised)[57]



There are good reasons to adopt the disjunction of coda constraints in (14). In referring positively to geminate structures, it highlights what I believe is the ultimate nonexplanation for the patterning of geminates seen above: geminate structures are often the only ones found in consonant clusters because place assimilation and total assimilation between C_1 and C_2 are common sound changes in the context VC_1C_2…, with straightforward acoustic-auditory explanations (Ohala 1990). That is, the fact that many languages exhibit only assimilated clusters is a fact about the pervasive nature of assimilation rules, and not a fact about preferred syllable types or coda types.[58]

The existence of languages like Japanese also weakens Clements (1990) view that coda constraints instantiate the cross-linguistic preference for a sonority profile which "rises maximally towards the peak and falls minimally towards the end" (p. 301). Given the possibility of geminate obstruents in the coda, Clements is forced to admit that "intersyllabic articulations involving a single place specification are simpler than those involving two (or more) place specifications. This principle must clearly take precedence over the sonority principles stated earlier (p. 321)." This reference to "intersyllabic articulations", like Itô's invocation of the Linking Constraint, also fails to relate the Berber facts to those in Japanese, Italian, etc. By adopting disjunctions like those in (14), the sonority profile suggested by Clements and the synchronic reflexes of well-understood sound change are independently instantiated.

In sum, while the nature of coda constraints is ultimately an empirical question, data amassed to this point suggests that within a single language such constraints can be representative both of preferred sonority profiles and of the idiosyncratic residue of historical sound change.

6.2 Syllabification of / … VCV …/ Sequences

Let us now turn to a second problem in the realm of syllabification. It has been claimed by many researchers that a / … VCV …/ string is universally syllabified as / … V.CV …/. In rule-based approaches, this generalization is known as the *CV-rule* or the *Maximal Onset Principle*, and has been claimed to hold only of initial syllabification where it follows from the ordering of onset formation (and under some approaches, onset maximization) before coda formation. In template-based approaches like that of Itô (1986), the constraint is stated independently, and is taken to hold at all levels of the phonology.

Several languages have been described in which even the weak form of this generalization is violated. Kunjen,[59] an Australian Aboriginal language of the Cape York Penninsula, is described by Sommer (1969, 1970, 1981) as having only vowel-initial syllables: the maximal syllable in Kunjen is claimed to be [VCCCC].[60] Sommer (1981) bases this on the fact that all Oykangand words are vowel-initial and consonant final:[61] [og ařŋg aŋguñang eŋkoriy uwal ay iŋun] "I gave (some) water to the young child in the shade". However, he is aware of the nonprobative nature of such facts: "Distributional criteria are admittedly successful in the syllabification of *some* languages … so the above criteria should not be altogether disregarded" (p. 233). A stronger argument for his syllabification of all / … VCV …/ sequences as / … VC.V …/ comes from partial reduplication, which marks the progressive or continuative aspect on verbs, and superlative/transcendent properties on adjectives and nouns. Some representative examples are given in (15).

(15) Oykangand partial reduplication (Sommer 1981)

Stem	Reduplicate	
/eder/	ededer	"rain", "heavy rain"
/igu/	igigun	"go", "keeps going"
/algal/	algalgal	"straight", "straight as a ramrod"
/elbmben/	elbmbelbmben	"red"

In Oykangand, it appears that the prosodic template prefixed in reduplication is simply σ, and that template satisfaction results in maximization of this template. Forms like *elbmbelbmben* "red" then suggest that [elbmb] is a possible syllable in Oykangand. While such facts are suggestive, template satisfaction does not bear on the syllabification of the reduplicative base: /σ+elbm.ben/ with the σ prefix realized as $[elbmb]_{\sigma}$ and subsequent resyllabification to elbm.belbm.ben is also possible. The real question then appears to be whether the maximal syllable in Kunjen is [CVCCCC] or [VCCCC].

Some evidence of syllable onsets in Kunjen does appear to exist. First, stress is realized both on vowels and on preceding consonants which are noticably fortis.[62] As the stress-bearing unit cross-linguistically is the syllable, prevocalic Cs would appear to constitute syllable onsets. Another piece of evidence for onsets is the distribution of aspiration. Aspirated plosives occur only in pre-vocalic position. If aspiration in Oykangand were viewed as a syllableedge rule, it would support the existence of onsets, since the pre-vocalic context would be equivalent to syllable-initial position under V.CV syllabification.[63] Finally, the peculiarities of a rule of utterance-initial reduction suggest the existence of onsets in Kunjen. The rule in question is formulated by Sommer (1981, p. 240) as in (16), with representative examples provided.

(16) Oykangand Reduction

$VC_0 \rightarrow \emptyset \ / \ [\#\#\_\_C\ldots]_{PhP}$

Unreduced	Reduced	Gloss	Deleted string
igigun	gigun	"keeps going"	[i]
ididař	didař	"kept eating"	[i]
amamaŋ	mamaŋ	"mother" (voc.)	[a]
eweweŋg	weweŋg	"evening"	[e]
uŋgul	gul	"there"	[uŋ]
elbmbelbmben	belbmben	"red"	[elbm]

Sommer's claim that reduction is a late phonetic rule is inconsistent with the fact that it is restricted to certain lexical items (an estimated twelve in the entire language.) In addition, the deleted string $[VC_0]$ preceding C… is equivalent to the first syllable of the word only if some version of the CV-rule is at work. Despite surface phonotactics, then, C-initial syllables appear to exist in Oykangand: the syllable is the stress-bearing unit, resulting in fortis onset consonants within stressed syllables;

syllable-initial voiceless stops are aspirated; and finally, a lexically determined reduction rule deletes the first syllable of a word, leaving the second C-initial syllable in phrase-initial position.

Another language in which it has been suggested that the initial syllabification of VCV is not V.CV but rather VC.V is the Barra dialect of Gaelic as described by Borgstøm (1937,1940) and analysed by Clements (1986).[64] Based on auditory observations and deliberate speech of native speakers ([fan. ak] “crow”) in which syllables are separated, Borgstrøm (1940, p. 55) concludes: “When a single consonant stands between two vowels the syllable division takes place as follows: (1) After a long vowel the consonant belongs to the second syllable, e.g., mo:-ran ‘much’; (2) after a short vowel the consonant normally belongs to the first syllable, e.g., bɔd-əx ‘old man’, ar-an ‘bread’, fal-u ‘empty’ …” Given this much, the CV-rule can be maintained in its weak version: all VCV strings are initially syllabified as V.CV, with resyllabification taking place if the preceding vowel is short.[65] This resyllabification must precede epenthesis in Barra, which takes underlying /… VRC …/ to /… VR$_V$C …/, with the sonorant syllabified as the onset of the syllable headed by the epenthetic vowel despite the presence of a preceding short vowel.[66] While this alternative account of Barra involves an abstract step of V.CV syllabification, with subsequent resyllabification to VC.V, stress-conditioned resyllabification rules which result in “heavier” syllables are not uncommon (see below). What does seem clear from this and other instances of resyllabification discussed below, is that VC.V syllabificction is possible in derived environments, that is, as the output of context-sensitive resyllabification rules.

6.3 Ambisyllabicity

Related to VCV syllabification is the question of ambisyllabicity. Ambisyllabic representations are those in which a single segment is affiliated with more than one syllable. Kahn (1976) and Clements and Keyser (1983) argue for such representations in analyses of English and Efik respectively. Kahn (1976) argues that ambisyllabicity is useful in English in capturing the distribution of consonantal allophones. He claims that aspirated allophones of /p, t, k / are exclusively syllable-initial, while flapped variants are just those consonants which are ambisyllabic.[67] Kahn's ambisyllabic segments are represented in (17a).

Borowsky (1986), following Hoard (1971), Stampe (1972), and others, argues that English flapping, as well as *h*-deletion, *y*-deletion, and palatalization, are the result of a stress-conditioned resyllabification rule. The rule of resyllabification is shown in (17b), which in English applies within the foot.

(17) Ambisyllabicity vs. Resyllabification

The output of (17b) violates the claimed universal V.CV syllabification discussed above. To the extent that such analyses are accurate, they provide further evidence against a universal condition requiring that all / … CV … /sequences be tautosyllabic.

Extending syllable theory to incorporate ambisyllabicity allows for systems in which a minimal three-way phonological distinction in intervocalic consonants is possible: these segments may belong exclusively to the second syllable (typical output of the CV-rule); exclusively to the first syllable (17b); or to both syllables (17a). However, as argued convincingly by Borowsky (1986) for English and by Fruchter (1988) for Efik, ambisyllabic representations are unnecessary when rules of resyllabification are invoked. One is led to conclude that until such minimal three-way phonological contrasts are demonstrated, a theory without access to ambisyllabic representations is to be preferred on grounds of restrictiveness.[68]

6.4 Mismatches

Finally, let us address the problem of mismatches between phonological representations and phonetic representations. Phonological representations provide input to the phonetic interpretive component.

As argued above, such representations include syllable structure, structure which organizes segments on the basis of relative sonority. However, due to the fact that undershoot is typical in the realization of phonetic targets, mismatches between phonological sonority peaks and phonetic sonority peaks are not uncommon. It is only with a clear view of the interaction between phonological syllables and phonetic rules that such mismatches are rendered nonproblematic.

For instance, many languages contain unstressed reduced vowels at the phonological level which are deleted optionally or in fast speech between adjacent identical consonants.[69] As a result, a phonological sonority peak is missing in the phonetic representation. McCarthy (1986) discusses such rules in Odawa, Modern Hebrew, English, and Japanese, and notes that the output strings of such apparent deletion rules are not subject to phonological principles (e.g., the Obligatory Contour Principle), nor to language-specific phonological rules (e.g., degemination in Modern Hebrew and English). For instance, English [