33. Syllable-internal Structure

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There is no simple discovery procedure for determining phonological syllable structure (which, like phonological representations in general, may not be in a one-to-one relationship with systematic phonetic syllabification, and which may not necessarily conform to native speaker intuitions about syllable division). The nature of the mechanism which assigns syllabification (defines possible syllables) for a given language is an empirical hypothesis, whose confirmation depends on the extent to which linguistically significant generalizations can be expressed under it (**Feinstein 1979**: 255).

1 Introduction

Although the syllable has been used by generations of linguists both in language description and in phonological theory, it is still surprising to see the variety of opinions and arguments on the topic. As Einar Haugen expostulated as early as 1956, "everyone talks about syllables, but no one seems to do anything about defining them" (**Haugen 1956**: 196). Since that time we have had fifty years or more of attempts to outline and define the syllable and its constituents, perhaps without coming much closer to solid agreement. Although the terms syllable, onset, rhyme, nucleus, and coda remain in common usage among phonologists, we cannot yet point to invariant acoustic or articulatory evidence for these constituents. As Haugen continues, "the only real basis for assuming their existence is that speakers of the language can utter them separately, dividing utterances into sequences that seem natural when pronounced alone." We point to this evidence again and again as certain proof that there is "something" called the syllable; perhaps the everyday linguistic knowledge of the speaker is the single constant throughout phonological research on syllable structure. And yet, as Feinstein emphasizes in the quote appended above, we also draw a certain distinction between the "speaker's syllable" and the "phonological syllable." The phonological syllable is defined empirically by "linguistically significant generalizations," while the speaker's syllable is defined simply and automatically (when the decision is indeed simple and automatic) in careful speech, or by a number of – also empirical – experimental methods exploring external evidence, such as language games and other speaker behavior (**CHAPTER 96**: EXPERIMENTAL APPROACHES IN THEORETICAL PHONOLOGY).

As **Goldsmith (1990)** points out, there are at least two competing, or perhaps parallel, views of the syllable that have influenced phonological theory over the past century or more: just as light can behave as both wave and particle, the syllable too has been shown to demonstrate both a wave-like property based on sonority (**CHAPTER 49**: SONORITY), and a piece-like, or chunk-like, division into smaller constituents, such as onset and rhyme. While there are still good reasons to hold on to a wave-shaped understanding of the syllable, defining the syllable and its properties with reference to the peaks and valleys of sonority shaping each one, the present chapter will nonetheless focus exclusively on theories of the syllable which specifically

address the question of constituent structure. The question of syllable structure can be understood as a question about the nature of linguistic representation (cf. **Anderson 1985**); as Anderson claims, "most of the history of twentieth-century phonology is the history of theories of representations, devoted to questions such as 'What is the nature of the phoneme, morphophoneme, morpheme, etc?'" (**Anderson 1985**: 9), to which we might add the question that concerns us here: "What is the nature of the syllable?" This chapter begins with a brief historical sketch tracing the early arguments in favor of different representations of syllable structure, followed by an overview of different models of the internal structure of the syllable. A final section reviews the conclusions of experimental studies as they adduce evidence for or against internal constituents of the syllable. (See also CHAPTER 109: POLISH SYLLABLE STRUCTURE; CHAPTER 115: CHINESE SYLLABLE STRUCTURE; CHAPTER 56: SIGN SYLLABLES.)

2 Early twentieth-century discussions of syllable-internal structure

Early twentieth-century linguists asked themselves the same question, "what is the nature of the syllable?" Saussure proposes an impressionistic account of the syllable as composed of a succession of explosive and implosive articulatory movements; while all speech consists of an alternating series of these movements, the syllable boundary itself is marked by "the passage from an implosion to an explosion in a chain of sounds" (**Saussure 1922**). Arguing for the syllable as a unit of phonology, he reasons that "the regular coincidence of a mechanical principle and a definite acoustical effect assures the implosive-explosive combination of a right to existence in phonology" (1922: 57). Saussure goes so far as to claim that these opening and closing articulatory motions, which he distinguishes from acoustic sonority, are themselves the irreducible units of the syllable; further, a close examination of Saussure's diagrams demonstrates that he considers the vocalic peak to form a part of the implosion, hinting at something like a rhyme: "Whenever a particular phoneme is more open than the following one, the impression of continuity persists; … an implosive link, like an explosive one, obviously can include more than two elements if each has wider aperture than the following one" (**Saussure 1922**: 56). Saussure's footnote demonstrating the syllabification of the word *particularly* is noteworthy, presenting an early sketch of an onset-rhyme division within the syllable: a vowel and following tautosyllabic consonant are both "implosive," according to Saussure's terminology, while the prevocalic consonants are "explosive." (Superscript arrow-heads indicating explosion [<] and implosion [>] are placed immediately above each alphabetic graph in Saussure's text.)

(1)   <>> <>> <> <>> <>
      [par tik iu lar li]

Kuryłowicz develops a notion of syllable structure which was clearly influenced by Saussure, referring to "the initial (explosive) consonant group and the final (implosive) consonant group as they relate to the vocalic center"[1] (**Kuryłowicz 1949**). Here Kuryłowicz quite explicitly associates the structure of both "semantic" and "phonic" systems, presenting a "table of correspondence," or equivalence, which presages hierarchical structure within the syllable, as in (2), in parallel with the semantic functions of subject, predicate, etc.

(2)   *Table of correspondence* (Kuryłowicz 1949, reprinted in Hamp *et al.* 1966: 230, translated A. R. K. Bosch)

semantic system	phonic system
proposition	syllable
predicate	vowel
subject	initial consonant group
additional information	final consonant group, etc.

That is, just as a proposition consists of subject, predicate, and additional information, a syllable can be seen to consist of initial consonant group, vowel, and final consonant group. Peak and coda are grouped into a constituent in **Kuryłowicz (1948)**, on the basis of co-occurrence restrictions which are found between peak and coda, but not between onset and peak.

Although the term "vocalic peak" is already in use by the time of Saussure's writing, **Selkirk (1982)** credits **Hockett (1955)** with the terms "onset" and "coda"; the use of "rhyme" to refer to the conjunction of peak and coda is attributed to **Fudge (1969)**, although of course the informal usage of this term to describe poetic form dates from the seventeenth century.[2]

3 Evidence for constituents within the syllable

Reviewing arguments for syllable-internal structure from Saussure onward, we find that evidence for structure within the syllable is typically modeled on evidence for the syllable itself; in a comprehensive overview of syllable theories, **Blevins (1995)** outlines four traditional arguments in favor of the syllable itself as a constituent. She notes that (a) the syllable has been employed as the domain within which phonological processes or constraints may apply; (b) the syllable edge is identified as the locus for the application of processes or constraints; (c) the syllable itself may be picked out as a "target structure," e.g. for the application of language games or for the assignment of stress or tone; and finally (d) field linguists

recount that native speakers can express intuitions regarding the number of syllables per word or utterance. So, for example, nasalization may spread within a syllable (a); a syllable-final consonant may be devoiced (b); syllables may be independently manipulated in language games such as the French Verlan (c); finally, field linguists commonly report formal and informal studies of speakers who are easily able to count syllables, or who pause between syllables when exaggerating slow and careful speech (d).

All these are common examples of the utility of the constituent "syllable"; however, not all of these arguments provide evidence for sub-syllabic constituents. Upon closer examination, only (a) and (c) usefully apply in evaluating syllable-internal constituents. First, as argued in (a), the constituents onset or rhyme have been argued to serve as phonological domains: **Davis (1992)** argues from Italian that the choice of the article (*il* or *lo*) depends on the constituent structure of the following onset (CHAPTER 55: ONSETS; CHAPTER 38: THE REPRESENTATION OF SC CLUSTERS). And the constituent structure of the rhyme – short vowel, long vowel, or vowel + consonant – may play a crucial role in stress assignment in quantity-sensitive languages. In addition (as argued in (c)), the separate constituents onset and rhyme may be singled out as "target structures" for the application of language games. In the American children's game "ubby dubby," popularized by the 1970s television show *Zoom!*, the sequence [əb] is inserted between each onset and rhyme: *hello* becomes [həbɛləbou]. Numerous language games play on the identification of onset and rhyme as target structures, and studies suggest that speech errors may operate on onset and rhyme sequences as single units (see discussion of experimental evidence, below). Thus evidence for sub-syllabic constituents derives primarily from data suggesting that onset and rhyme function as phonological domains or as target structures for other linguistic behavior. However, when we return to examine common evidence for the syllable as a constituent, parallel arguments for syllable-internal structure are not as convincing. Evidence such as (b) that refers to syllable-edges as targets (e.g. devoicing a syllable-final obstruent; CHAPTER 69: FINAL DEVOICING AND FINAL LARYNGEAL NEUTRALIZATION) in fact says nothing about syllable-internal structure per se: a syllable boundary, without reference to constituent structure, could identify this position (see **Steriade 1999**, for example). And finally, evidence in (d) from slow or careful speech by native speakers may provide clues as to syllable count or syllable boundaries, but generally provides little insight into sub-syllabic constituents, without additional manipulations such as we find in studies of language games, etc.

Nonetheless, we frequently uncover parallels between discussions of syllable structure and discussions of syllable-internal structure. This is made explicit within the framework of prosodic phonology (**Selkirk 1982**; **Nespor and Vogel 1986**): here the internal structure of the syllable is seen as a natural extension of the higher-level prosodic structure, to which the syllable naturally belongs (see CHAPTER 40: THE FOOT; CHAPTER 51: THE PHONOLOGICAL WORD; CHAPTER 84: CLITICS; CHAPTER 50: TONAL ALIGNMENT). After laying out arguments for the syllable as a constituent, Selkirk goes on to conclude that:

> The same three reasons leading to the postulation of the syllable can be shown to motivate the existence of privileged groupings of segments within the syllable which must be thought of as constituent-like linguistic units themselves … an internally-structured tree quite analogous to a tree representing syntactic structure (**Selkirk 1982**: 237).

3.1 "Flat" models of syllable-internal structure

Various models of syllable-internal structure have been proposed over the past century of linguistic study, from an entirely flat structure consisting primarily of syllable boundary markers to a more highly articulated hierarchical structure. **Kahn (1980)**, for example, proposes the simplest two-tier flat structure consisting of syllable nodes (σ_1, σ_2, etc.) on one tier, associated directly with the segments of phonetic (or phonological) representation, as in (3).

(3)   *No internal constituent structure* (e.g. **Kahn 1980**)
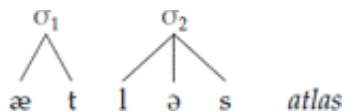
For Kahn, the discrete segments are "associated" with the syllable node, and among his syllable-building principles is one akin to the no-crossing constraint of **Goldsmith's (1976)** autosegmental phonology; "given the way the term 'syllable' is understood, it would seem nonsensical to speak of discontinuous syllables" (**Kahn 1980**: 36). Kahn explicitly cites Goldsmith manuscripts from 1974 and 1975, and in a footnote outlines his claim that he himself is working in an autosegmental framework, "because all theories of the syllable, including my own, are 'autosegmental' in that they involve parallel analyses of phonological material into (traditional) segments and syllables" (**Kahn 1980**: 61; see also CHAPTER 14: AUTOSEGMENTS).

A contemporary version of Kahn's flat structure is echoed in a recent textbook, **Hayes (2009)**. Hayes takes a non-committal position on the internal structure of the syllable: while he prefers constituent (tree) structure to the simple use of boundary symbols to identify syllables, he makes no claim about constituency within the syllable. Introducing the terms onset, coda, and nucleus, he explains that

> In some theories, the onset, nucleus, and coda are described as constituents (they are daughters of the

syllable node σ, and dominate segments). This book will use "onset," "nucleus," and "coda" merely as useful descriptive terminology (**Hayes 2009**: 251).

In diagrams throughout this textbook, as in **Kahn (1980)**, segments are dominated directly by the syllable node itself, without intervening structure.

A related flat structure with an intervening CV tier is proposed by **Clements and Keyser (1983)** in (4) (see also CHAPTER 54: THE SKELETON).

(4)   *Syllable with intervening* CV *tier* (e.g. **Clements and Keyser 1983**)
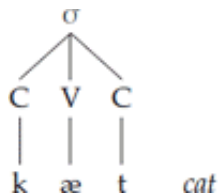
Among the options that do incorporate some representation of internal structure, however, ternary branching structure represents perhaps the simplest option, incorporating the nodes onset, peak, and coda, as in (5). The primary distinction between the examples in (3) and (5) lies in the use of the constituents onset, peak, and coda to function as hierarchical nodes of the syllable in the latter example; more than one segment may occur within a single constituent in (5), for example.

(5)   *Ternary branching, with internal structure* (e.g. **Hockett 1955**)
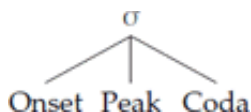
While Kahn's flat structure in (3) appears comparable to the ternary branching flat structure in (5), as employed by **Hockett (1955)** and others, the differences are considerable. Hockett presents an internal structure to the syllable, labeling the constituents onset, peak, and coda (he leaves the door open to other types of internal structure as well). In contrast to Hockett, Kahn simply refers to syllable-initial position, or syllable-final position, when stating phonotactic constraints defined by syllable positions. Thus, for Kahn, the [p] in *support* [səpʰort] is syllable-initial; we know this because the syllable-initial voiceless stop is aspirated [pʰ]. In contrast, the unaspirated [p] in *asparagus* is not syllable-initial, since the [s] is the first consonant of the syllable in the case of the vegetable: [ə.spæ.rə.gəs] (**Kahn 1980**: 73). The aspiration of voiceless stops in English is precisely the type of evidence Kahn requires, as the syllable boundary alone can provide the environment for aspiration. An analysis which allows for internal constituent structure, such as that in (5), would place the [p] of *asparagus* in the syllable onset, of course, even if it is not syllable-initial (see also CHAPTER 38: THE REPRESENTATION OF SC CLUSTERS).

While Hockett proposes the syllable structure in (5), he also allows for a wide variety of different syllable models, suggesting in a "survey of syllable types" (**Hockett 1955**: 51ff.) that languages may employ different syllables and differing syllable "systems" according to the requirements of each system. He cites Bella Coola as an example of a language demonstrating the "onset type," for example, since "while every (or almost every) syllable has a distinctive onset, many syllables contain no other syllable-element distinctively" (**Hockett 1955**: 57).

As American linguists of the mid-twentieth century developed a taxonomic or distributional approach to language categories, the informal use of the syllable became commonplace as one means by which the distribution of phonemes could be expressed most economically;[3] this was and remains today perhaps the primary use of the syllable as a unit in phonological theory and description. The constituents onset and coda played such a role for **Pike and Pike's (1947)** analysis of Mazateco, demonstrating what Selkirk calls the "immediate constituent" principle of phonotactics: that the constraints that hold between positions within the syllable are more tightly bound when those positions themselves form a constituent. Thus the constituents onset, peak, and coda – for Pike and Pike – are precisely those constituents within which we can describe such constraints. Similarly, Pike argues here and elsewhere (**Pike and Pike 1947**; **Pike 1975a, 1975b**) that phonological processes will refer to syllable constituents, rather than to individual segments; thus pitch and stress in Mazateco are defined with reference to the syllable peak. For example, in Mazateco contrastive tone is "limited exclusively" to the nucleus of the syllable; while tone will spread within the nucleus, it never spreads to the consonants in the "margins" of the syllable.

Haugen's (1956) analysis of the syllable in Kutenai details possible initial and final consonant clusters in that language, and elaborates whether medial clusters (the "interlude") can properly be determined on the basis of permitted onset and coda clusters alone. **Rand's (1968)** analysis of Alabaman syllables is specific in the disclaimer that "the syllable in Alabaman cannot be identified by any physical boundary feature." Indeed, making use of both the wave model and hierarchical structure, he first defines the syllable in terms of sonority: there are as many syllables as there are peaks; "the determination of what occurs as peak is based on phonetics." Later, however, he relies on hierarchical structure: "Stated another way, the syllable is an endocentric construction of two layers of immediate constituents, head (the vowel) and satellite (the consonant)" (**1968**: 97).

Two different hierarchically structured binary–branching syllable types have been suggested, as in (6) and (7) below; by far the more conventional type is (6), in which the syllable consists of the constituents onset and rhyme, and the rhyme is formed by nucleus and coda. Arguments in favor of (7) have been proposed for languages such as Korean and Mandarin Chinese (**McCarthy 1979**; **Yoon and Derwing 2001**; **Wang and Cheng 2008**); in these examples the syllable is seen to consist of body + coda; the body forms a unit composed of onset and nucleus together.[4]

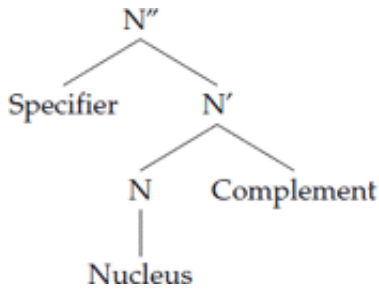(6)　　*Binary branching with rhyme* (e.g. from **Pike and Pike 1947** onwards)

```
            Syllable
           /        \
        Onset       Rhyme
                   /      \
               Nucleus    Coda
```
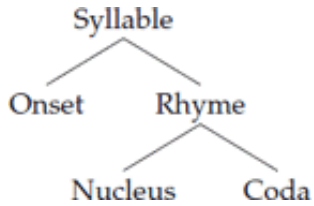
(7)　　*Binary branching with body* (e.g. **Yoon and Derwing 2001**)

```
            Syllable
           /        \
         Body       Coda
        /    \
    Onset   Nucleus
```
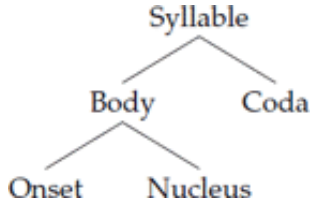
Levin (1985) proposed a variation of the branching structure in (6), a metrical theory of syllabic structure in which the syllable is a projection of the category "nucleus," or N, illustrated in (8). Here the coda is represented as the complement, or right sister, of N, dominated by the first projection N'. The onset is the specifier of the syllable, dominated by the second projection N".

(8)　　*Metrical theory of syllable structure* (**Levin 1985**)

```
               N"
              /   \
       Specifier   N'
                  /   \
                 N    Complement
                 |
              Nucleus
```

Finally, it should be noted that government phonology, as described by **Kaye *et al.* (1990)** and employed in **Kaye (1990)**, **Harris (1994)**, **Botma *et al.* (2008)**, and various chapters in **van der Hulst and Ritter (1999)**, makes use of syllable structure without the syllable, so to speak. The "syllabic constituents" onset (O) and rhyme (R) are not united into a single constituent (the syllable) in this analysis. The nucleus (N) is a constituent of the rhyme, but neither the coda nor the syllable is recognized as a constituent in government phonology. (Some versions of government phonology require CV syllables throughout, and posit an empty V where needed; see e.g. **Scheer 2004**.)

(9)　　*Syllable structure without the syllable* (**Kaye *et al.* 1985**)

```
         R
        / \
   O    N  \
   |    |   \
   x    x    x
```

3.3 Development of models of internal structure, from Fudge through Selkirk

In his influential article on the syllable, **Fudge (1969)** argues that the syllable has two primary functions as a linguistic universal: first, the syllable plays a role in the location of suprasegmental phenomena such as stress and tone; and second, it serves as the most appropriate unit for the formulation of phonotactic constraints. For Fudge, the internal structure of the syllable plays a key role. Fudge presents an analysis of the syllable in RP English, based in part on prior work on Chinese syllable structure (**Firth and Rogers 1937**; **Hockett 1947**). According to Fudge, the internal structure of the syllable,

along with a detailed set of "collocational restrictions," "clearly accounts in an appropriate way for the majority of the systematic restrictions on sound-sequences" (1969: 266ff.), or surface phonotactic constraints. The syllable consists of a hierarchical branching structure; below the labeled nodes onset, peak, and coda are numbered positions which play a role in the formulation of co-occurrence restrictions, as in (10). The phoneme inventory is specified according to what is possible, or permitted, for each syllable position. Thus, onset position 1 may include sC clusters as well as any of the non-syllabic phonemes of English; position 2 only allows the sonorants [w l r m n].

In addition to the sub-syllabic constituents onset and rhyme, Fudge argues for a "termination" node, which forms a part of word-final syllables only, and which permits only a small subset of segments, primarily morphemes such as past tense or nominative plural, and [-st] or [θ].[5] Later phonologists have also employed some version of a termination, or appendix, at word edges (see various articles in **Féry and van de Vijver 2003**), as discussed further below.

(10)   *The English syllable* (**Fudge 1969**: 268)
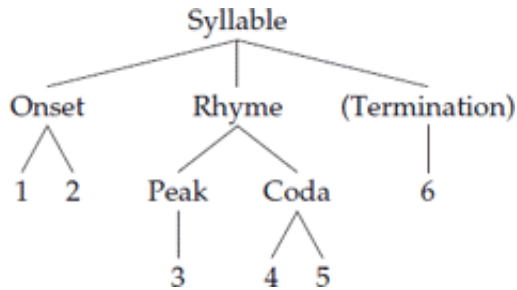
Like **Kuryłowicz (1948)**, Fudge argues against a flat syllable "on the basis that there is no means of stating relations between peak and coda, which we wish to do, while there is no such constraint between onset and peak" (1969: 273). So, for example, he details a number of constraints holding between positions 1 and 2 (i.e. within the onset); 4 and 5 (within the coda); and 3 and 4 (holding across peak and coda, within the rhyme). Paraphrased examples of Fudge's collocational restrictions are given below (from **Fudge 1969**).

(11)   *Examples of phonotactic rules governing onsets*

   a.   Within the onset, if the second position consists of [m] or [n], the first position can consist only of [s].

   b.   If the second position consists of [l], the first position may not consist of an alveolar (no [tl-, dl-, stl-, θl-]), except [s-].

(12)   *Example of phonotactic rules governing final clusters* (paraphrased)

        Nasals form final clusters only with plosives and voiceless fricatives.

Fudge's detailed elaboration of the phonotactic constraints of RP, based on syllable constituents, provided a model for later phonologists such as **Selkirk (1982)** and **Goldsmith (1990)**. Nonetheless, hierarchical structure within the syllable has gone in and out of favor over the past fifty years. A number of articles throughout the 1970s argue for the importance of the syllable as a unit, but are not concerned with internal syllable structure (e.g. **Hoard 1971**; **Hooper 1972**; **Vennemann 1972**; **Kahn 1980**). **Feinstein (1979)**, presenting a syllable-based analysis of prenasalized consonants in Sinhalese, employs the terms onset and coda, and yet remains explicitly neutral on the subject of syllable-internal structure. Instead, his analysis relies on identifying syllable boundaries only, without any more elaborate constituent structure. He employs "a phonological syllabification mechanism in which syllable structure is defined in terms of a discrete boundary within the linear string of segments," although he admits that "other structural definitions may be more appropriate" (**1979**: 246). A range of essays from this period do not generally present specific evidence to support syllable-internal structure, though they make frequent use of the terms onset, rhyme, and coda, at least informally.

Any argument which identifies a phonological syllable requires some means of identifying syllable boundaries, however, and

in so doing we also confront evidence for permitted onset or coda clusters, almost by necessity. Arguments that attempt to lay out principles of syllable division in a particular language are at least implicitly arguments in favor of a particular syllable shape, VC–CVC *vs.* V–CCVC, for example. These have been taken to be arguments demonstrating internal syllable constituencies, such as arguments for a particular structure of the rhyme. If a specific intervocalic sequence of consonants is not a permissible onset cluster, one consonant may be forced into the coda of the previous syllable. Syllable structure thus regularly plays a role in analyses of quantity–sensitive metrical structure (CHAPTER 57: QUANTITY–SENSITIVITY). For example, Kenstowicz (1994) points to differences in the syllabification of certain internal consonant clusters to explain certain facts of English stress patterns. Secondary stress falls on the first syllable of the words in (13a), while the words in (13b) show no stress on the initial syllable:

(13)   *English stress pattern differences* (Kenstowicz 1994: 251)

|						
a.	*Montana*	ˌmon.ˈtana		b.	*America*	a.ˈmerica
	arcade	ˌar.ˈcade			*Nebraska*	ne.ˈbraska
	Atlantic	ˌat.ˈlantic			*atrocious*	a.ˈtrocious
	arthritic	ˌar.ˈthritic			*astronomy*	a.ˈstronomy

The difference in patterns of secondary stress between the words in (a) and (b) above depends crucially on the fact that the word–initial syllables in (a) all terminate in a coda consonant, and therefore receive some stress; the word–initial syllables in (b) are open and thus unstressed. The consonant cluster "interludes" in (a) cannot form permissible word–initial clusters, and therefore it is claimed a syllable boundary must divide them. Thus what can count as a "possible onset" is ultimately defined in terms of what can serve as a possible word–initial cluster. This is essentially what Venneman (1972) terms the "Law of Initials": that "medial syllable–initial clusters should be possible word–initial clusters" (Venneman 1972: 11); or what Bell (1976) terms "the Kuryłowicz condition," that "initial and final clusters of medial syllables conform to the same constraints as those in initial and final syllables" (Bell 1976: 255).[6]

On the other hand, there are languages which place more restrictions on word–internal consonant clusters, and allow extra consonants at word edges, such as Polish (Kenstowicz 1994: 262ff.). A number of chapters in Féry and van de Vijver (2003) tease out just these inconsistencies between word–internal clusters and clusters found in either word–initial or word–final position (Cho and King 2003; Green 2003; Kiparsky 2003; Wiltshire 2003). See also Dixon (1970) and many others, as well as CHAPTER 36: FINAL CONSONANTS.

3.4 Moraic phonology and syllable–internal structure

While the syllable itself has been in wide use throughout the past century or more, clear arguments providing evidence of the internal structure of the syllable are less common than one might expect. Many arguments which state a convincing case for the syllable as a phonological unit in fact fail to motivate syllable–internal structure. The constituent structure of onset, rhyme, nucleus, and coda intersects in complex ways with a moraic theory of syllable organization, as sketched in (14) below. While a moraic analysis often appears to supersede one employing syllable structure, in fact the notion of moraic weight is interwoven with an understanding of syllable structure, in particular the structure of the rhyme.

(14)   *The mora in the prosodic hierarchy*

Prosodic Word
|
Foot
|
Syllable
|
Mora
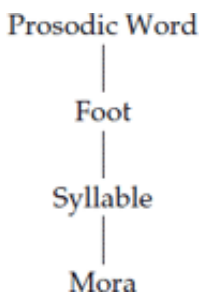
The mora provides a useful means of representing syllable weight, in quantity–sensitive languages where this is required. In languages such as English or Latin, a syllable with a short vowel is monomoraic, while syllables with a long vowel (VV), or vowel + coda consonant (VC), are bimoraic. We note, however, that only consonants in the rhyme may be moraic; onset consonants never contribute to syllable weight (CHAPTER 47: INITIAL GEMINATES; CHAPTER 55; ONSETS). Thus we return to some notion of constituent structure within the syllable, if only to identify the domain in which moras are projected. Furthermore, whether the mora truly serves as a "constituent" is unclear; while the syllabic nucleus is typically affiliated with a mora, the affiliations of onset and non-moraic coda consonants are less clear. Non–moraic elements are sometimes associated with the syllable node directly, or sometimes argued to share the mora with the nuclear vowel. Essays in Ziolkowski *et al.* (1990) demonstrate the range of arguments regarding moraic structure within the syllable. Hyman (1985) originally suggested that a syllable–initial consonant links to the mora of the following vowel, creating what looks like a "body-coda" structure. More commonly, the syllable–initial consonant is assumed to associate directly to the syllable node, as in Hayes (1989) and many others. For a more recent position favoring the mora, Yip argues explicitly that the evidence in favor of the constituents

onset and rhyme "is scanty and inconsistent" (**Yip 2003**: 779), and relies on a moraic model of the syllable to account for the behavior of pre-nuclear glides in English and Mandarin Chinese. I leave it to other contributors to this *Companion* to tease out the intricacies of moraic phonology in more detail (see CHAPTER 39: STRESS: PHONOTACTIC AND PHONETIC EVIDENCE; CHAPTER 40: THE FOOT; CHAPTER 41: THE REPRESENTATION OF WORD STRESS).

4 Experimental studies

Experimental studies, both of acoustic properties of speech and of human behavioral responses to syllabification tasks, have also been constructed to explore this question of the nature of the syllable. The great majority of experimental work over the past fifty years involves studies of simple syllabification, with a view to accounting for syllable boundaries. Most of these studies place a particular focus on the syllabification of an intervocalic consonant or consonants; see for example studies on Dutch, Finnish, German, French, Japanese, and English (e.g. **Fallows 1981**; **Gillis and DeSchutter 1996**; **Schiller *et al.* 1997**; **Berg and Niemi 2000**; **Content *et al.* 2001**; **Goslin and Frauenfelder 2001**; **Ishikawa 2002**; **Redford and Randall 2005**). Still, a number of experimental studies have been adduced to test the validity of the internal constituents of the syllable; the majority of these studies focus on the primary constituents of onset and rhyme. Evidence regarding hierarchical structure within the syllable is mixed, with arguments drawn from language games (both "traditional" and invented/experimental), slips of the tongue, perceptual studies, investigations with children, and other experimental paradigms (CHAPTER 96: EXPERIMENTAL APPROACHES IN THEORETICAL PHONOLOGY) to investigate whether onset, rhyme, nucleus, and coda are or are not syllable constituents.

A series of experiments by Treiman and co-authors argue in favor of an onset-rhyme structure, based on subjects' performance on various word games (**Treiman 1986**; **Fowler *et al.* 1993**; **Treiman *et al.* 1994**; **Treiman *et al.* 1995**). Most recently, **Kapatsinski (2009)** claims to show from an experimental study that English speakers are able to learn rhyme-affix associations more easily than body-affix associations, basing this argument on the claim that associations should be easier to learn within rather than across constituents, given a hierarchical structure to the syllable. However, **Pierrehumbert and Nair (1995)** replicate Treiman's word game paradigm (**Treiman 1983**) and conclude that flat models of the syllable are sufficient to account for the results; see **Treiman and Kessler (1995)** for a response.

Although few experimental studies look for evidence for constituent structure within the rhyme, one study by **Hindson and Byrne (1997)** found that children had less difficulty learning a word game which kept the final consonant cluster intact compared to one which broke it up. They conclude that these results support a model "which attributes internal hierarchical structure to the rime, with the coda as a constituent" (**Hindson and Byrne 1997**). Also focusing on constituent structure within the rhyme, **Hayes *et al.* (2009)** examine the ability of 9-month-old infants to detect change in vowel, in coda, or in both, based on the head-turn procedure. One experiment suggests that infants detect a difference most easily when both vowel and coda are altered – perhaps an unsurprising conclusion. However, the authors argue that pre-verbal 9-month-olds do parse syllables into units smaller than just onset and rhyme, presumably those of nucleus and coda.

An additional area of research focuses on the relation between syllables, syllable constituency, and literacy (e.g. **Derwing 1992**). It is argued variously that syllable constituents may assist in visual word recognition (**Álvarez *et al.* 2004**) and the development of literacy; and that literacy itself influences phonological judgments about syllable structure (**Treiman *et al.* 2002**). Orthography was found to influence onset-rhyme segmentation in Portuguese, for example, in a CVC blending task: "the C/VC segmentation of pseudo-words and homophones was much more frequent in a context of words spelled CVC than in a context of mute-e-words" (**Ventura *et al.* 2001**). Orthography was also found to influence Pig Latin production by adult English speakers, when speakers trained on singleton and true cluster onsets extended their production to Cj- and sC(C)- clusters (**Barlow 2001**). Handwriting production tasks by French schoolchildren also indicated the influence of orthography on syllabification, again in particular where "silent e" is orthographically employed (**Kandel *et al.* 2009**).

Criticism has occasionally been voiced that some of the experimental work cited above is methodologically flawed. **Davis (1989)** points out that many of these studies are based on speech errors or word games that involve only monosyllabic words; when polysyllabic words are considered, we find evidence not for an onset-rhyme distinction, but for a distinction between onset and "the remainder of the word," or onset *vs.* "everything else." Davis aims this criticism in particular at studies by **Treiman (1983, 1986)**, who investigates language game productivity, and **Fudge (1987)**, who argues for internal syllable structure primarily drawing on evidence from monosyllabic speech-error blends. Other studies have not found relevant distinctions between onset and rhyme under experimental contexts. Geudens and Sandra (**Geudens and Sandra 2003**; **Geudens *et al.* 2005**) conducted four experiments with Dutch children, both pre-readers and young readers, concluding that their subjects "did not treat onsets and rimes as cohesive units of the syllable."

Recent articulatory studies based on gestural analyses of speech in fact call into question the evidence for syllable constituents based on speech error and slip-of-the-tongue data. These criticisms target methods of data collection for speech error studies – transcription-based methods that have changed little since studies in the 1970s specifically termed them "field studies" (e.g. **Fromkin 1973** and others). Laboratory-based studies, such as the gestural studies of speech errors as described in **Pouplier (2007, 2008)** seem to indicate that many errors are not merely substitutions of segmental units – errors in "selection" – but instead may be examples of gestural intrusion or mis-timing (**Pouplier and Goldstein 2005**).

Various studies conducted on languages other than English appear to show that if there is an onset-rhyme distinction it may

be a language-specific one; experiments with native speakers of Korean indicate that Korean syllables "contain a cohesive CV or body unit, in contrast to the VC or rhyme unit of English" (**Yoon and Derwing 2001**); one of the five experiments described here studied preliter- ate children, indicating that literacy could not be a confounding factor. A study involving Chinese-English bilingual children found "a preference for matching body over rime in Chinese, and for matching rime over body in English," concluding that there must be cross-language differences in processing spoken syllables (**Wang and Cheng 2008**).

Acoustic studies have examined timing relationships within the syllable to identify syllable constituents. Conducting an acoustic study on English disyllables and casual speech vowel reduction, in triplets of words such as *support/sport/s'pport* (reduced *support*) **Fokes and Bond (1993)** conclude that there were no invariant acoustic cues determining syllabicity. While the authors concede that *sport* and *s'pport* may in fact be phonetically distinct, the study found no invariant cues to distinguish them. Certainly, attempts to isolate acoustic or articulatory invariants of the syllable date from as early as **Stetson's (1928)** "chest pulse" theory; however, there is no current consensus on either acoustic or articulatory definitions of the syllable, let alone of structure internal to the syllable. While **Selkirk (1982**: 340) set the stage for a good deal of ensuing research with her note that "other phonological, or shall we say phonetic, phenomena such as duration and closeness of transition between segments might also be taken as revealing of the immediate constituent structure of the syllable," we still find very little clear evidence of any invariant property pointing to syllable-internal hierarchical structure.

5 Conclusion

Despite the lack of phonetic evidence for invariant acoustic or articulatory measures of syllable structure, research in this area too continues apace. As Ladefoged noted:

> There is no single muscular gesture marking each syllable … (but) there is evidence … that speakers organize the sequences of complex muscular events that make up utterances in terms of a hierarchy of units, one of which is the size of a syllable; and it is certainly true that speakers usually know how many syllables there are in an utterance. We will therefore assume that a neurophysiological definition is possible, even if one cannot at the moment state it in any way (**Ladefoged 1971**: 81).

Even those who argue against the use of syllable structure to account for phonotactics acknowledge the usefulness of the terms referring to syllable-internal structure: onset, peak, coda, and even rhyme. "Syllable structure, whether directly perceived or inferred, is an undeniable aspect of phonological representations," claims **Steriade (1999)**, although she goes on to argue against employing syllable constituents in a phonological analysis, concluding that syllable position "does not condition segment realization." Steriade argues instead that knowledge of syllable structure, and syllable edges in particular, derives from or is founded on the speaker's perception of word-based phonotactic regularities. Her claim is essentially that we have put the cart before the horse in arguing that phonotactic constraints are built upon syllable structure; instead, these phonotactic regularities may be precisely what allow us to identify syllable position.

In any case, the labels we use to identify internal constituents of the syllable -onset, coda, and rhyme – remain convenient terminology, and seem likely to remain in common usage. Nevertheless, it also seems clear that a conservative view of linguistic structure – a view shaped by Occam's razor, perhaps – would concede that these terms, while useful, may not be supported by empirical evidence. Acoustic and experimental studies offer only mixed results, while language-specific phonological studies continue to differ widely in their use of (and claims for) some particular organization of syllable-internal structure. How we use syllable structure to represent the patterns and organization of human language will differ depending on the questions we ask and the problems we confront in the specific languages we investigate. Syllable structure may turn out to be an organizational tool, rather than an object available for independent manipulation.

Notes

1   "le groupe consonantique initial (explosif) et le groupe consonantique final (implosif) par rapport au centre vocalique" [translation A. R. K. Bosch].

2   The *Oxford English Dictionary* cites **Samuel Butler (1663)**, "For Rhime the Rudder is of Verses, With which like Ships they stear their courses."

3   Compare Fischer-Jørgensen's comment: "it may nevertheless be due to Bloomfield's influence that most American linguists, even in short phonemic descriptions (such as the numerous descriptions of American Indian languages in the *International Journal of American Linguistics*), give a rather detailed statement of the syllabic structure of the language, and in this way present the material on the basis of which the phoneme categories may be established" (**Fisher-Jørgensen 1952**, reprinted in **Hamp** *et al.* **1966**: 300).

4   A reviewer points out that this appears to contradict the traditional description of Chinese syllables in terms of "initials" and "finals" (cf. also **Blevins 1995**: 212; CHAPTER 115: CHINESE SYLLABLE STRUCTURE).

5   Note that Fudge does not require his collocational restrictions to apply without exception; for a certain rule he also adds

a footnote: "exceptions to this rule are not lacking (…). This does not detract from the value of stating the rule – even an '80% rule' is well worth stating, provided that the exceptions to it are indicated" (**Fudge 1969**: 271).

6   Recall that in this article Bell argues against "the distributional syllable." Nevertheless, he does not entirely conclude that phonology can do without the syllable: "Let us, however, guard against too narrow a view, against confusing a tool with the problem. 'Defining the syllable' and 'proving the existence of the syllable' are pseudo-problems. Segment organization is the problem. If assumption of a syllabic unit leads to explanation of regularities of segment organization, so much the better. If not, we will be awaiting a more general theory of organization, and the syllable may enter the museum's Hall of Scientific Constructs, taking its place beside ether, the noble savage, and the like" (**Bell 1976**: 261).

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