ISSUES AND EVIDENCE IN SYLLABIC PHONOLOGY

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1. Scope

_Syllables and Segments_ deals with the properties of speech events that are not satisfactorily accounted for in terms of simple sequences of segments. In most cases, the phenomena discussed in the following articles relate to a unit of phonological organization between the segment and the word, that is, to the syllable, but a number of them also deal with the organization of segments in terms of larger and smaller units. They are mainly studies which concentrate on the evidence for different types of segment organization. Traditionally, much of this evidence is phonological: it is evidence concerning distributional constraints on segment sequences, synchronic and diachronic processes determined by segment position, harmony of features over segment sequences, and the characteristics of tonal, accentual and rhythmic systems. This is the major source of evidence that has shaped the views of segment organization found in current phonological thinking, but there are other sources of evidence that cannot be neglected in the formulation of a general theory. One of these is experimental phonetics, which provides evidence concerning the complex coarticulation of speech segments, the relative timing of articulatory gestures, and the perception of speech. Evidence about the psychological organization of segments can be gained from the study of writing systems, poetic forms, secret languages, speech errors, speech pathologies, and from experiments that require speakers to manipulate speech samples. Bridging both the psychological and the physical phonetic are the phenomena from child language. This volume includes evidence from most of these sources.

Our purpose in bringing these studies together was to exemplify the range of phenomena that a theory of syllables or of segment organization must account for. They go beyond arguments about the existence of the syllable and its definition that fills so much of past writings. In many cases the work is exploratory; but throughout, the theme of bringing together insights from several sources will be found. We could not at the same time cover the parallel research activity in phonological theory, intimately related as the two areas are. Phonological theory must turn to evidence beyond the strictly phonological to resolve the issues it uncovers; and conversely, further development of phonological theory is essential to the eventual understanding of the relations among the varied phenomena associated with the syllable.

The following discussion can serve as background for the articles included in this volume. In Section 2, we sketch some prominent issues in phonological theory concerning the explicit representation of segment organization. Evidence from the syn-
chrony and diachrony of phonological systems is treated in Section 3, and Section 4 covers the evidence from other sources. In these last two sections, the main findings of the studies that follow are placed in a general perspective.

2. The Theoretical Background

The syllable has a long and troubled history in the development of phonology. While the evidence for the syllable as a unit for segment organization exists all around in great abundance, the various aspects of the syllable that have been investigated are kaleidoscopic and the pieces have not fallen into place. The numerous attempts to give the syllable a rigorous phonetic and/or phonological definition (Stetson, 1951; Hjemslev, 1939; Haugen, 1956; Hálá, 1961; Rosetti, 1962, O'Connor and Trim, 1953; Pulgram, 1970) have not been entirely successful in accounting for the wide range of data associated with the syllable. The relationships among the phenomena in question are too complex to admit of explanation by simple schemes, which has sometimes led phonologists to ignore or avoid the problem altogether and not recognize any unit of organization between the segment and the word, e.g. Chomsky and Halle (1968).

A more usual reaction has been to set up the syllable as a (quasi-) dependent construct defined in terms of the properties of segments and words. This approach is possible because within a word the same series of segments seem always to have the same syllabication, differences in style and tempo aside. Contrasting phonetic syllabifications arise only across syntactic boundaries. For instance, the phonetic contrast between night rate and nitrate is accounted for by the presence of the syntactic boundary (night##rate) versus the absence of a boundary (in nitrate).

There are three types of theories, which differ according to the relative priority that they accord to the segment and the syllable. The most usual theory assumes that segments, fixed in sequence are given. The basic mechanism in this approach is a procedure for placing syllable boundaries around words and among the segments of words. Proposals of this sort are advanced by Kuryłowicz (1948), Haugen (1956), Pulgram (1970), Hoard (1971a), Hooper (1972), Vennemann (1972), Stampe (1973), Anderson and Jones (1974), Basbøll (1974), and Kahn (1976). Another type of theory does not assume that syllables can be defined or located in terms of existing segments and words, but rather takes the syllable, like the segment, to be an independent construct which is a part of the representation of an utterance. Under this view syllable structure is basic, and the sequencing of segments, along with some of the phonetic properties of segments, are predictable from this basic structure (Fudge, 1969; Hooper, 1976).

A third class of theories of segment organization does not insist upon syllables at all. It hypothesizes merely that there are bonds among segments which constitute their organization. In one sense, this simply turns the syllable model inside out. Segments with a common bond can be said to belong to the same
syllable; two consecutive unbonded segments can be said to lie across a syllable boundary. Schematically, instead of SS or CVC.CV we might write C V C V. For many conceivable states of language, this could lead to exactly the same conclusions as a syllabic model. On the other hand, since there are many conceivable inventories of bonds with different inherent properties, it allows a wider range of hypotheses. In particular, it has more potential for achieving a general account of coherence across the levels of the segment (where constructs of segment, complex segment, and transition are now used), the syllable (including the phenomena lumped under the rubric of the internal structure of the syllable), the vocalic or consonantal sequence, the disyllable, and the word and phrase. Of current varieties of phonological theory, autosegmental theory, whose most recent statement is Goldsmith (1976b), is most compatible with this point of view. A segment bond model would allow us to consider structures such as C V C V as integral, as the contribution of Lehiste suggests; or to admit the possibility of unbonded consonants, schematically C V C C C for example, as alternatives, which is related to the proposal of syllabic affixes by Fuji-mura and Lovins.

However conceptualized, all such phonological theories must resolve in one form or another the same fundamental questions about the representation of syllable structure. In the remainder of this section, we outline briefly five of these important questions.

It is now generally agreed that the syllability of segments must be specified in underlying representations by the feature SYLLABIC or an equivalent. Any segment class may apparently be [+syllabic] at the phonetic level (Bell, 1978), but it does not appear to be generally predictable from segment sequences (Section 3.1), and the extent of the privilege of syllability in underlying representations is still unknown. Hoard’s discussion of the syllabic stops of Northwest Coast Indian languages and Anderson’s analysis of the "vowelless" languages of the Northwest Caucasus suggest new and innovative approaches to this issue.

The issues concerning the proper assignment of segments to syllables, or syllabication, are much more hotly debated. We take it to be noncontroversial that the input to the phonetically motivated processes must include syllabication. Whether or not underlying representations are syllabified is not so clear. The question is addressed by Donegan and Stampe in Chapter 2.

An argument against lexical representation of syllabication is simply that it is never contrastive. Of course, if it were found to be contrastive, that would settle the issue. As it is, arguments for lexical representation hinge on whether there are constraints on the underlying composition of syntactic units that must be expressed in terms of syllables. (Donegan and Stampe’s argument against a lexical—or "mental"—representation of syllables is exceptional in the attempt to move beyond distributional evidence.) Fisher-Jørgensen (1952) and Haugen (1956) proposed that the syllable was the proper domain for dis-
tibutional constraints. For the more abstract representations of generative phonology, Halle (1959) and Stanley (1967) proposed that the constraints on segment sequences be stated in terms of morpheme structure conditions which apply to lexical representations. Hooper (1975) argues that the morpheme is not the proper unit for the expression of such phonotactic constraints, but rather that the syllable is their proper domain, since this permits the statement of constraints that on the one hand are both stronger and more directly represent pronouncability. Similar arguments can be made for combinations of the syllable and the word. This rules out a lexicon of morphemes to which sequence structure constraints, and hence syllabication, apply. Possible alternatives are to express phonotactic constraints at another level (Hooper, 1975) or to list full words in the lexicon (Vennemann, 1974).

While it is generally accepted that syllabication is not ad hoc language by language, how and to what extent universal principles of syllabication are to be incorporated into phonological descriptions has so far resisted determined attempts at a solution. The strongest hypothesis about a descriptive theory is of course that no language-particular statements are necessary. There are two principal characteristics of the syllable that have been used by investigators to implement this hypothesis in whole or in part. One much used approach capitalizes on the striking similarity in any language of word-medial consonant sequences and combinations of word-final and word-initial clusters. Proposals based in some way on this similarity are found in Kuryłowicz (1948), Pulgram (1970), Hoard (1971), Anderson and Jones (1974), Babsøll (1974), and Kahn (1976). Bell (1977a) has argued that such theories which admit no language-particular statements unless based on this similarity of distribution, e.g. the first three above, are unsuccessful when applied beyond phonotactic criteria. Their shortcoming is that, in giving interior sequences a derivative status, they do not incorporate any hypothesis about substance that holds for both interior and exterior sequences.

The second principle, which was noted by Sievers (1893), is that the sequence of segments within the syllable depends upon an inherent hierarchical scale of sonority or strength, which can be independently determined by their universal phonological properties, or, as it now appears necessary, by a combination of universal and specific ones. Jespersen (1904), Saussure (1915), Vennemann (1972), Hooper (1976), and Rudes (1977) are among those whose theories incorporate this insight.

The difference between these two approaches raises the question of whether it is their distribution at word boundaries or the inherent properties of segments that determine their syllabication (e.g. Babsøll, 1974). Hooper (1976) argues that the latter must be taken as fundamental, for sequences across word boundaries are not arbitrary, but in general conform to the same constraints as sequences within the word across syllable boundaries. In Section 3 we return to a discussion of the principles upon which the distributional and sonority approaches are based.
The distinction between a phonetic and a phonological syllable is a traditional one. (See Kloster Jensen, 1963, for a survey of the discussion of this issue.) In part, this has been a divorce de convenance, which permitted one to assume a phonetic basis for the syllable on one hand, while using it independently to account for phonological phenomena on the other. Pike (1967) exemplifies this pragmatic position. Within a generative framework, the question may be phrased as whether different rules of syllabication can apply at different points in a derivation: It appears that all such cases that have been proposed assume the sensitivity to syllabication of rules that are non-productive, opaque, and/or morphosyntactically restricted, such as English Velar Softening (Bailey, 1978), Danish Consonant Gradation (Babøll, 1974), and Seneca Stress Placement and Vowel Lengthening (Chafe, 1977). There is no reason to expect such rules to be phonetically natural, and in fact they are usually not (Vennemann, 1971; Stampe, 1973; Hooper, 1976). Thus, while it is clear, both from such cases and from dialect variation, that principles of syllabication can change historically, and that traces of former syllabication are sometimes found in the alternations of a language, no evidence for different productive syllabifications has been found, except where distinct speech styles or tempos are involved.

The fourth issue concerns the possibility of syllabifications which assign segments to more than one syllable ("ambisyllabity") or which leave them unassigned ("interludes"). The crucial observation in this regard is that there appear to exist no cases where three distinct assignments of a marginal segment are needed, i.e. to the preceding syllable, to both syllables, and to the following syllable (Hoard, pers. comm.). This suggests that treating the medial consonants in attic, any, apple, which are phonetically quite different from the pre-stress consonants in attack, anneal, and appall, as ambisyllabic or syllable-final may be equivalent in some sense. However, see Hoard (1971) and Bailey (1978) for the syllable-final analysis, and Pulgram (1970), Anderson and Jones (1974), Kahn (1976), Rudes (1977), and Stampe (1973) for the ambisyllabic approach. The problem is more complex for longer intervocalic sequences. Babøll (1974:68) suggests that assignment be "partly indeterminate" in, for example, the cases where the only relevant distinction is between open and closed syllables and whether the syllable is closed by one consonant or more than one does not matter.

The fifth issue concerns the delimitation of the role of the syllable as a domain for phonological processes. We will not review here the arguments for taking the syllable or larger units to be the proper domain of stress, accent, and tone; brief discussions appear in Sections 3.2, 3.3. There are similar advantages for treating other features as specified over domains greater than the segment. In addition to the numerous "prosodic" analyses of the London School, such analyses are given by Babøll (1974) for the Danish stød, Lehn (1963) for-emphasis in Cairo Arabic, Hooper (1977) for nasality in American English, to name a few. It is worth noting, in view of the parallel with Anderson's analysis of Kabardian in Chapter 3, that the differ-
ences between the analyses of Nupe by Hyman (1970), Harms (1973a), and Hooper (1976) become much less dramatic if Nupe syllables are taken to be either palatalized, labialized, or plain. So far, however, the question of whether some features obligatorily, optionally, or never have a syllabic domain remains to be answered.

3. Phonological Evidence

Much of this section concerns the most basic and most available phonological evidence, the phonotactic distribution of segments. In spite of its relative familiarity, it is misinterpreted surprisingly often. We concentrate, therefore, on identifying what we feel to be the principal generalizations, attempting to indicate their validity and significance. We have less to say about phonological processes. This reflects our much less complete knowledge about them, rather than their importance, for we, like many others, feel that their evidence speaks more directly to the heart of theories of segment organization than do phonological structures. Brief discussions of rhythmic structures, indeterminacy, and stylistic variation conclude the section.

3.1. Segment Sequences and the Internal Structure of Segments. It is a common assumption that syllables of the form CV have a special status. There is less appreciation for the complex basis for this privileged distributional status, which when examined closely, shows that categorizing the CV syllable type as "unmarked" is a misleading simplification of a number of more significant generalizations.

The fundamental pattern of segment sequencing is an alternation of consonant and vowel. We observe from (1) - (4) that in general sequences of consonant and vowel are not constrained, whereas any sequence of either class may well be constrained. The following typological facts are stated with reference to the section, which is roughly the phonological word (Pulgram, 1970).

(1) Within the section, VV sequences ("hiatus") are not permitted by about one-half of the world's languages, e.g. Berber.

(2) CC sequences are not permitted by about 10 to 15 percent of the world's languages, e.g. Fijian.

(3) No languages require that all sections with two or more vowels contain a hiatus, nor that those with two or more consonants contain a sequence of consonants.

(4) About 10 to 15 percent of the world's languages that permit consonant sequences within the section, permit none initially nor finally. Almost all of these are limited to no more than two consonants, with Kannada, which possesses medial -CCC- but no initial clusters nor final consonants, being the best known exception.

These generalizations form the basis for the representation of canonical forms as iterations of vowel-consonant combinations,
for example \((C_V^iV)^n\), \((C_V^iVC_V^i)^n\), etc. The first expression represents the section as an iteration of \(n\) CV's or V's; it may contain \(n\) vowels which may be separated by one consonant or none. The section represented by the second expression also has \(n\) V's, which however may be separated by two, one, or no consonants; the possible iterative elements are CV, V, VC, or CVC. This expression of the distribution of C and V captures the important fact that the syllabic portion is obligatory while the C portion is not. While contoids, even fricatives and stops, may be the only segments of an utterance, as in the Northwest Coast Indian languages described in Chapter 3 by Hoard, at least some of them must be syllabic.

We observe further that the alternating pattern is asymmetrical. The corresponding vowel-initial expressions such as \((VC_V^i)^n\) and \((VC_C^i)^n\) are not appropriate because of the following preferences:

(5) Sections must begin with a consonant in about 20 to 40 percent of the world's languages, e.g. Hottentot.

(6) Sections must end in a vowel in about 10 to 25 percent of the world's languages, e.g. Luganda.

(7) There are virtually no languages whose sections obligatorily begin with a vowel or end with a consonant.\(^4\)

The generalizations (1)-(7) conspire to afford a special status to the CV sequence. In this regard, note further that the existence of more complex consonant sequences implies the existence of simpler ones. If a language possesses forms with CCCC strings in initial, final or medial position, then it must possess forms with CCC, CC and C strings in that position. Initial position is special, however, in that there, forms without C (that is, forms beginning with V) only occur in languages that also have forms beginning with C. This follows from (7). Taken together, the result of these generalizations is that canonical formulas for syllable structure necessarily contain the sequence CV.\(^5\)

However, the widely accepted claim (e.g. by Jakobson and Halle, 1956) that some languages have only CV syllables has not been substantiated, although there are some near misses, of which Piro is perhaps the best example (Matteson, 1965).

The asymmetry between initial and final position, which is evident in (5), (6), and (7), is also a predominant characteristic of the constraints upon the occurrence of consonant combinations at the beginnings and ends of sections. In the following discussion we have largely relied upon Greenberg (1965) and Bell (1971), to which the reader is referred for further details. We begin with the two main global differences between initial and final clusters.

(8) Languages are more likely to have initial consonant clusters than final clusters. The world's languages are split about evenly between those with initial clusters and those without. But less than half, perhaps as few as one-quarter, have final clusters.\(^3\)

(9) In final position, the single consonants that may occur are a small subset of the total segment inventory in many lan-
guages; this does not appear to occur in initial position. For example, ʔ is the only final consonant in Burmese, n ŋ l are the only ones in Mandarin Chinese, p t s are the only ones in Hottentot (except for loans). It is of course commonplace for a few segments or a segment class to be forbidden in either final or initial position; in English ŋ and ʒ are not permitted initially, but all segments occur finally, for example.

The internal composition of consonant clusters permitted in initial and final positions has attracted much attention. What excites the beholder is that segments in both initial and final clusters tend to be ordered according to increasing sonority from the outside of the section toward the syllable peak (Siev- ers, 1893; Jespersen, 1904; Saussure, 1915). The result is certain regularities of patterning for the segment classes Glides (G), Liquids (L), Nasals (N), and Obstruents (O):

(10) Glides (nonsyllabic vocoids) are the most preferred interior segments.
In many languages, e.g. Luganda and Burmese, the only clusters are of the type C+y or C+w. No instances are known of clusters with voiced glides exterior to obstruents. A few cases of initial glide+resonant clusters do occur, e.g. Pasho wradz, wlar, but when they do, the language also has clusters with glides as interior elements.

(11) Liquids are preferred over nasals as interior segments.
The strongest pattern reflecting this preference would be for nasal+liquid clusters to be restricted to initial position, and for liquid+nasal clusters to be restricted to final position. But both orders do occur in both positions. However, some languages have only the preferred orders, whereas languages which have the reverse orders (initial liquid+nasal, final nasal+liquid) also possess the preferred ones except for some cases of voiceless liquids. The preference is also manifested in obstruent+resonant clusters. In initial position, for example, obstruent+liquid clusters are preferred to obstruent+nasal ones, the latter not known to occur without the former.

(12) Liquids are preferred over obstruents as interior segments.
Similarly, both obstruent+liquid clusters and liquid+obstruent clusters occur initially and finally. The first order is highly favored in initial position. The clusters of a language which has only one kind of initial cluster are most likely to be obstruent+liquid clusters, except perhaps Cw, Cy clusters. Again, some languages, like English (plum, frog) have only the preferred order; the languages which have clusters with the reverse order also have the preferred clusters. Russian is a typical example: prauda, ziæb, rta, tba, lsi. A similar preference for final liquid+obstruent clusters is found.

These patterns of occurrence of cluster types suggest a hierarchy of segment classes

(13) obstruent - nasal - liquid - glide
in order of increasing affinity with the adjacent vowel, which
is of course most sonorant of all. It should be noted that this is true even though the occurrence of every combination which violates this order is attested save one, initial glide-obstruent.

To this point we have discussed only section-initial and section-final sequences. Their regularities relate to constraints on order of medial consonant sequences in two ways. Each forms the basis for syllabication theories discussed in Section 2. First, even without referring to the intrinsic properties of segments, most medial sequences of consonants can be analyzed into combinations of permitted final consonants plus permitted initial consonants. There are a few medial sequences that cannot be broken up in one or more such ways in most languages, but when they can, syllable boundaries determined by other criteria almost never fall at another division. Known exceptions are Huichol and Alabama, where the syllabication of some medial sequences does not meet this condition (Bell, 1977a).

The other approach to syllabication also relies on the similarity of sequences within and between words, but considers this similarity to be due to the fact that section-initial and section-final sequences are merely special cases of syllable-initial and syllable-final sequences, and that the organizing principle that determines the order of segments in all positions depends on the sonority of the segments:

(14) Segments of a syllable must be arranged in such a way that their sonority increases from the onset to the nuclear peak, and decreases thereafter.

This principle relies on a ranking of segment types on a scale of sonority (or its converse, consonant strength), and predicts not just the organization of the consonantal onset and coda, but also predicts that the nuclear peak will contain the segment with the highest degree of sonority. Since we have already discussed the consonantal margins of syllables, let us now consider briefly the nucleus.

It is well known that syllable peaks are not limited to vocoids. Resonants, obstruents, even stops, are reported as syllabic peaks in a number of languages. In fact, syllabic peaks need not even be necessarily voiced, as shown by the variety of entirely voiceless and vocoidless utterances that occur in some Northwest Coast Indian languages discussed in Chapter 3 by Hoard. It is possible, however, to establish an order of preference for occurrence as syllabic peaks, namely

(15) stop - fricative - resonant - vowel

See Bell (1978) for further discussion. It is notable that the preference for liquids over nasals as interior elements does not extend to their occurrence as nuclei, a fact remarked by Sievers (1893).

If we combine (13), the order of vowel affinity, with (15), we are left with but three categories, obstruent-resonant-vowel. Even for this reduced set of categories, the scale unfortunately cannot predict universally whether a syllable peak occurs or not
for all sequences and of course the problem is even more difficult within the categories. A vocoid will be syllabic between obstruents, or preceding an obstruent initially, and obstruents are always nonsyllabic between two vowels, for example. But in most contexts, either syllabic or nonsyllabic segments may appear, as the following examples illustrate: Piro pérka vs. English parka; Serbocroatian krvi vs. Polish krwi, both meaning 'blood'; English kæsə vs. Norwegian avl; Piro ričmika vs. Russian xlep.

From these facts, and from the implicational, rather than absolute, nature of (10)-(12), we conclude that a universal scope for (14) is too strong. There are a number of ways, however, of further elaborating this general theory so that apparent and real violations may be explained.

One aspect that needs further elaboration is the basis for sonority ranking of segments. One cannot operate successfully with general categories such as obstruent, nasal, liquid and glide without knowing more of the details of the phonetic realization and phonological properties of the particular segment in the particular language. For instance, all r-like sounds cannot be placed at the same point on the scale, since there are so many varieties of r, ranging from sonorous retroflex approximants to nonsonorous apical and uvular trills and fricatives. Language-specific sonority rankings can be partially determined by examining assimilation processes, as proposed in Vennemann (1972). Hooper and Vennemann conjectured that with a language-specific sonority ranking, (14) would apply to all marginal segments and that their order within the syllable would be determined. This now appears to be too strong, particularly with respect to the order of sequences of obstruents. (Note that we did not include a statement about stops and fricatives analogous to (10)-(12).) Saib's description of the final consonant sequences of Berber illustrates the point. If this is so, it amounts to restricting (14) to sequences of segment classes. Basbøll (1974) proposes that principles such as (14) apply to the "hierarchical" features SYLLABIC, CONSONANTAL, SONORANT, and VOICE and that all other features are cross-classificatory with respect to sequence constraints. (Rather than language-specific sonority ranks he suggests that while no language may reverse the order of the hierarchy, some languages may not apply them. Thus by relaxation of the CONSONANTAL constraint, i.e. [+cons] is interior to [-cons], there occur wrada, ušar in Pashto, but initial rw and lw also occur.) One last conception of sonority that is so far little explored is that it is multidimensional rather than uni-dimensional in nature.

The segment's structure is crucial to (14). For example, although Basbøll (1974) takes VOICE to be a hierarchical feature, and Greenberg (1965) shows that voiced segments are far preferred as interior elements, there do exist tautosyllabic sequences of the sort ##(+voice) [-voice] V. Most of these are the common sequences of nasal+unvoiced stop, usually homorganic, which are sometimes described as clusters and sometimes as single segments. The concept of the complex segment, whose application is illustrated here by Anderson and Hoard, obviously sug-
gests itself as a possible explanation, since then the voicing adjustment which takes place would then be seen as a transitional laryngeal adjustment parallel to that which is part of the articulation of some types of "implosive" stops. The success of such an approach naturally depends on the discovery of general principles for assigning sequences to such structures.

One effect of the complex segment approach is that it restricts the domain of application of (14) to the more central part of the syllable. This can be done in other ways, too. We noted above that the hierarchy of preference for interior elements does not coincide exactly with that for syllabic ones, which suggests that somewhat different principles govern the nucleus and its margins. Balsbøll (1974) suggested that CONTINUANT is a hierarchical feature within the sonorant portion of the Danish syllable. He however did not indicate how the notion might be extended generally. Such an extension is one of the consequences of Fujimura and Lovins' proposal of "syllable affixes." They suggest that (14) or its equivalent does not apply to affixes, segments which on independent grounds can be shown to be loosely bonded to a syllable. Further extensions of this notion might reveal that languages fall into various phonological types, and those that allow "affixes" or complex consonant clustering might have other characteristics in common, e.g. widespread vowel deletion between consonants, while languages without affixes might exhibit more vowel insertions. (Cf. Isačenko's (1939) typology of "consonantal" and "vocalic" languages.)

To recapitulate at this point, a good deal is known about the internal organization of syllables, and from what is known a definite pattern emerges, such that there is a general harmony between the alternation of syllabic and nonsyllabic segments and the alternation of segments with more or less inherent sonority. But the specific nature of this pattern is complex, and while sonority theory is often useful and revealing, many questions remain to be answered.

3.2. Phonological Processes Determined by Position. Another interpretation of the generalizations expressed in the preceding section, including the sonority hypothesis (14), is that the properties of segments and their positions serve as active determiners of phonological processes which shape the syllabic structure of a language. For example, state (7) is best understood in terms of the equilibrium between the diachronic processes responsible for it. These are mainly vowel and consonant loss. Even ignoring the many complexities of the diachronic situation, the reader can see that the common loss of consonants in final positions, which exposes word-final vowels, is counterbalanced by vowel loss there, reestablishing closed syllables. But to achieve obligatorily closed syllables, a language must lose all its final vowels before losing any final consonants, which suggests that such languages are simply very very rare, not impossible, whether or not they are attested. Similarly, a more detailed knowledge of the diachronic sources of the typological bases of sonority hierarchies will be necessary before their full significance can be understood. The emphasis of Zwicky (1972), Vennemann (1972), Hooper (1976), and Hankamer
and Aissen (1974) on processual criteria for a language's sonority or strength hierarchy expresses the same priority on the synchronic plane.

It has been a major goal of the last decade's research in phonological theory to achieve a proper representation of the relation between constraints and processes, e.g. Stampe (1973), Hooper (1976). The problem in the phonology of children, where it is even more prominent, is considered in some detail below by Ingram and by Menn. As a step toward bridging the considerable gulf between adult phonologies and the phonologies of young children, Menn proposes parallel accounts of the relationships between constraints and processes in terms of a speech production model and a formal representation based on autosegmental phonology.

The syllable as a unit finds independent justification in a large number of phonological processes which depend on the segment's position in the syllable for application. Some examples that have been discussed are Spanish nasal assimilation in syllable-final position, and glide obstruentization in syllable-initial position (Hooper, 1972), and German syllable-final devoicing (Vennemann, 1972). These processes provide evidence concerning the inherent properties of syllables, since we find weakening, realized as assimilation, sonorization or deletion, to be common in syllable-final position, while strengthening, although never a common process, seems to be restricted to syllable-initial position. Similarly, vowel insertions usually break up longer consonant clusters before (or if) they break up shorter ones, and vowel deletions are often blocked if a complex syllable structure would result (Bell, 1971; Hooper, 1976, 1978).

Segmental processes are often conditioned by the distinction between an open and a closed syllable, notably those affecting length and quality of vowel, e.g. open syllable lengthening in Icelandic (Vennemann, 1972) and retraction of low vowels closed by velars and labials in Danish (Basbøll, 1974). Finnic consonant gradation, described by Lehiste below, was conditioned by closure of the following syllable, although this may have been part of a more general rhythmic pattern.

The domains of harmonic features, which spread from a segment inherently marked for the feature to neighboring segments, perhaps through intervening segments, until it is blocked by some condition, also reveal segment organization. The principal domains are strings of segments (characterized by (lack of) certain features), words, and syllables, with the first two being the most common. General principles for the interaction of the domain types are virtually nonexistent, even for such a common process as vowel nasalization, which Schourup (1973) claims to be favored before tautosyllabic nasals, but which Entenman (1977) argues with some force to be strictly sequence-conditioned, occurring before all nasals or none at all. We note also that tone spreading processes seem to be of this type (Hyman, 1973). Two domain types interact in the spreading of pharyngealization in Tamazight Berber analyzed by Saib in Chapter 3. One possible
statement of the process, which differs from Saibh's, is this: The word plays no role; the domain of pharyngealization is never less than a syllable; it spreads to the preceding and to the following syllable unless blocked by a sequence of two consonants.

The Otomanguean contrast between ballistic and controlled syllables, which Rensch describes, is a notable instance of a contrast over the domain of syllable. It affects the realization of a syllable's onset, coda, length, and pitch contour in a systematic way. While it is reminiscent of accentual features, its possible accentual function is not known, and it is an obvious candidate for instrumental phonetic study.

Because the domains of segments, syllables, and words interact and in many cases provide competing explanations of phonological processes, it would be desirable to obtain a general characterization of the types of segment strings that serve as domains. The formal attempts advanced so far, e.g. Howard's Crossover Constraint (1972) and Jensen's (1974) Relevancy Condition, are not generally satisfactory, but consideration of this question and that of syllable structure should prove mutually rewarding. The contributions of Gay and of Fujimura and Lovins in Chapter 4 are also pertinent here.

In this regard, it should be obvious that neither explanation of a process in terms of segment strings nor in terms of syllables is desirable a priori. The lenition of voiced stops in Spanish could be described as occurring in syllable-final position, given syllabifications of the type pad.re, huev.o, ai.dea, silb.o. Such syllabifications are not well-motivated, and the lenition is better explained by being blocked in phrase-initial position and following a homorganic sonorant (Harris, 1969). Similarly, there is no need to assume a shift in syllable boundary to explain the alleged assimilations of the nasal in English penguin, concret.e giving -ng-, -nk- versus lento forms with -ng-, -nk- (Bailey, 1975). The closer adhesion of segments at faster tempos suffices. A fortiori, to take such processes as the defining basis for the syllable (Skaličková, 1958; Smalley, 1961) does not seem supportable.

3.3. Rhythmic Structures. Accental systems are the most obvious examples of linguistic rhythmic structures, marking certain syllables as more prominent by some combination of prosodic features. Prominent syllables tend to separate one or more non-prominent ones, providing the same sort of alternation at the level of the syllable is characteristic of vowels and consonants. We also include here tonal and other systems, traditionally classed as prosodic, although their rhythmic function is not so evident.

Rules for the placement of accent are often sensitive to the distinction between heavy syllables, which typically are either closed by a C or contain a long (or full) V, and light syllables, which are open and contain a short (or reduced) V. This important topic is explored in three of the papers in the following chapters. Ohsiek, in Chapter 2, discusses the role of the
heavy/light distinction in stress systems and considers the relation between the two kinds of heavy syllables in terms of evidence from both experimental phonetics and typological comparison. In Chapter 5, Allen and Hawkins, noting that the syllables of very young children are typically all heavy, report their research on how children acquire light syllables. Lehiste's description of the Estonian contrast between short, long, and overlong syllables in Chapter 3 is also of interest here.

Restricting the domain of prosodic features to the segment(s) forming the syllable crest (Jakobson and Halle, 1956) is not tenable. Leben (1971) has shown that the conjecture that Woo (1969) drew from this hypothesis, that short vowels may never bear rising or falling tone, is incorrect. Rising and falling tones occur on short vowels in the West African language Mende (på 'kill', mbè 'owl') and doubtless in many other languages. One instance of the distinctive portion of tone extending over the initial onset has been reported in Lalana Chinantec, e.g. [b̥^2i³], by Rensch and Rensch (1966). For an illuminating view of the relationship of tonal structures to segmental structures, see Hyman (1975) and Leben (1973). It is of course necessary to admit larger structures than the syllable as domains of prosodic structures; the description of Estonian, in which Lehiste draws on considerable experimental phonetic study, presents a compelling case for the disyllable as a rhythmic unit.

3.4. Indeterminacy. The preceding discussions imply that syllabic divisions and the number of syllables per word are uniquely determinable. Unfortunately, just as with segments, this is not always the case. In this section we discuss briefly the cases of indeterminacy which are likely to be most troublesome.

Many linguists have claimed that native speakers can determine the number of syllables in any utterance in their language, often inviting the assumption that this is a fundamental justification for the unit. Most of the claims appear to imply not just that the utterances are countable but that there is agreement among speakers, that is, they are uniquely countable. It is known that this is not the case for some languages. Lebrun (1966) asked bilingual subjects to count the number of syllables in recorded French and Flemish sentences. The subjects were indeed able to count the number of syllables but they disagreed about the number. Furthermore, the disagreements were not resolved by discussions among the subjects and re-presentation of the sentences. All subjects agreed that the recorded sentences were perfectly understandable and were pronounced in an ordinary fashion. The results were confirmed for English, French, and Igbo by Bell (1975).

Vooids in contact with other vocoids are a major source of indeterminacy. Two vowels in succession may be pronounced as clearly as two syllables, or clearly as a single one. Since the process V.V > V:, VV, or VV is likely to be gradual, it will sometimes be difficult to decide at what point along the continuum the sequence ceases to be two syllables and becomes one. Resonants and obstruents, when they are separated from vowels, may also be indeterminate. Lebrun found that initial sequences
of French *le temps*, *le cavalier*, and *de la boue* were perceived differently by his subjects. In Kashmiri, the release of final consonants is indeterminate, being described by Varma (1964) as a 'vowel which "is not heard, though...definitely articulated,"' and by Kachru (1969) as not vocalic. For some dialects of American English, final /r/ sequences and glide-liquid sequences, such as *pearl*, *squirrel*, *dire*, *jewel*, *towel*, also seem indeterminate. Note that indeterminacy is not found where contoids and vocoids alternate, but occurs where segments of the same class are in contact. However, even in these contexts indeterminacy is not the usual case.

A more prevalent kind of indeterminacy is found in the perception of syllable boundaries. There are cases in which an inter-vocalic consonant or consonant cluster appears to belong equally to the preceding or following syllable, or else judgments of which one it belongs to vary widely. A notorious case is that of English consonants preceding an unstressed vowel, as in *attic* and *apple*, mentioned earlier. Although little is known for sure about the contexts which favor indeterminate perception of syllabication, our impression is that they at least include certain stress-timed rhythms, of which *attic* etc. are one example, and longer sequences of inter-vocalic consonants, a factor noted by Jones (1956) and Harms (1962).

3.5. Stylistic Variation. Stylistic and tempo variation interact in interesting ways with syllabic phenomena. Bailey (1975 [1978]), Stampe (1973), and Rudes (1976) describe differences in syllabication in English in different speech styles. The tendency is for stressed syllables to attract consonants and become heavier, while unstressed syllables become more and more reduced. Thus Bailey gives the example of lento syllabifications, *as.para-gus*, *Wis.cons-in*, *hucks.ter*, *mons.trous*, compared to allegro *a.sparagus*, *Wi.scons-in*, *huckst.ter*, and *monst.rous*. Other changes in syllabication affect syllable boundaries that mark syntactic boundaries in careful speech. In casual styles, these boundaries are relieved of their syntactic duties and allowed to find their natural phonological position.

Resyllabifications in casual styles are affected by the rhythmic type of the language. Bailey (1978) points out that careful speech in English is more syllable-timed than the heavily stress-timed casual speech in which the difference between stressed and unstressed syllables is exaggerated. Compare the slow, careful version of *I'm going to Buffalo* [æ.é.m.ˈgou.ɪŋ.ˈtu.ˈbaf.ɪ.ˈlu] to its most casual version [ˈɡŏʊn.ˈwɛntˈbaf.ɪ.ˈlu] (Rudes, 1976). In this extreme version all but the most strongly stressed syllables are lost.

In a strictly syllable-timed language, such as Spanish, casual speech processes tend toward the creation of open syllables. Vowels are not lost except in contact with other vowels, so that the syllables remain, at least impressionistically, approximately the same length. Consider this example of casual Spanish from Hutchinson (1974:184): *su amante vive en una casa* (h)umilde *swa.man.te.ʒi.ˈbe.nu.na.ka.su.mil.de* 'her lover lives in a modest house'.
Casual speech processes present certain problems for synchronic statements of canonical structure. While some casual speech processes simplify syllable structure which thus continues to conform to the canons based on careful speech (e.g. cluster simplification in contact and hand in English), others produce more complex segment sequences which do not. For example, pre-stress schwa-deletion in English produces consonant clusters such as /pt/ in potato, /mk/ in mechanic, /ft/ in fatality, /tn/ in tonight and so on in casual speech. These clusters all violate the syllable structure condition that is applicable in careful speech, but at the same time they are the consequence of the general rhythmic and syllabic structures of English (Hooper, 1978).

4. Beyond Phonological Evidence

Phonological evidence for how segments are organized has the disadvantage that the observer must take what is offered him by the language or languages studied. This is often enough inconclusive. Researchers have never given up hope that a key to the mysteries of the syllable might be found outside phonology, a hope that seemed fulfilled with Stetson's (1951) theory of chest-pulses, only to be quelled by later investigation (Ladefoged, 1958). Most researchers today have a more sophisticated appreciation of the unavoidable distortion of speech behavior that is the price of probing it outside its natural setting. Research in this area is thus simultaneously driven by the desire to find research paradigms that expose new or more detailed phenomena to view and by the need to find means to generalize the results beyond the observational context. Both questions are addressed in the following chapters.

The accumulating results of experimental phonetics have already made it clear that purely segmental models are inadequate to account for the processes of speech production and perception (Liberman et al., 1967; Studdert-Kennedy, 1975). It is thus a major task of experimental phonetics to explain the mechanisms for the extensive coarticulation of segments, the smearing of the gestures and the acoustic cues that correspond to their distinctive features over the surrounding segments.

Granting that it cannot be segments that are strung together at the phonetic level raises the following question: Can we account for the properties of the speech string in terms of a concatenation of some other unit? Drawing upon a wide range of evidence, Fujimura and Lovins respond to this question in Chapter 4 with an explicit model of syllable concatenation. They address the problem of coarticulation by distinguishing several types of assimilatory phenomena and proposing constraints on the domains of assimilation. Gay also addresses the issue of the domain of coarticulation, demonstrating the power of well-directed instrumental speech analysis. He obtained an indication of muscle commands by electromyography, observed the movement of articulators by x-ray cinemography, and was thus able to examine the coarticulation of vowel and consonant gestures in more detail than heretofore. In particular, he is able to
show that in forms such as /kipip/ or /kutup/, where the vowel gestures appear to be more or less continuous through the medial consonant, there are in fact two separate muscle commands, both for the tongue gesture and for the lip rounding gesture. He concludes that the domain of coarticulation in one sense is the string of preceding consonants for inherently vocalic features, and is limited to the neighboring vowels for inherently consonantal ones.

Although it is clear that the timing of articulatory gestures is organized over larger stretches than the segment, with some remarkably strong correlations (Lehiste, 1970a), no satisfactory overall account has emerged. Lisker, also in Chapter 4, examines carefully the effects of consonants on the duration of the vowel preceding them in English. Vowels are longer before voiced obstruents (cob) than before unvoiced obstruents (cop), a fact of English that has received much attention, at least in word final position. (See Lisker, 1974, and the references therein.) Can this temporal relationship indicate the syllabic allegiance of medial consonants in the "indeterminate" post-stress position as in cobby and copy? Lisker argues that the similarity of temporal coarticulation between the two positions does not justify this conclusion, when the whole pattern of temporal relations is considered.

At the other pole from the largely unconscious behavior studied in experimental phonetics, the structure of culturally based activities under the headings of language use, language play, and language art consistently show that segments are less accessible than the groups of segments that serve as prosodic domains and rhythmical units. The dominance of syllabaries in the development of writing systems is a celebrated instance. The isosyllabic line is one of the commonest devices of poetic prosody in the world (Lotz, 1960); segment-based poetic forms are quite rare, though attested, e.g. a Somali poetic form described by Greenberg (1960).

Lehiste's description of the meter of Estonian folk songs in Chapter 3 is an example of a poetic form that is syllable-based and provides a valuable complement to the accompanying account of the syllable's role in the language. Secret languages such as English Pig Latin are a potential source of information about a language's organization of its segments. Interpretation of evidence from all of these sources is complicated by the simultaneous involvement of a cultural code and the linguistic code. Distortion of the language code must also be allowed for; for example, Bailey (1978) remarks that secret languages, because they are usually heavily monitored and spoken with a syllable-timed rhythm, are dubious evidence for syllabication of a stress-timed language like English. Similarly, we are not yet in a position to interpret speakers' responses to tasks of marking parts of words or of dividing them in parts, even for the more ingenious tasks that attempt to reduce speakers' self-monitoring.

Occasionally word-formation processes such as reduplication offer a potential insight into segment organization; elicitation of forms beyond the more common ones to determine the conditions
of the process has qualities between secret languages and the
analysis of naturally occurring speech. A striking example of
this sort in English is expletive infixation. McCawley dem-on-
strates in Chapter 6 the value of probing this process to ex-
amine the interrelation between syllable boundaries and morpheme
boundaries.

The role of child phonology in the study of segment organization,
as in phonology generally, seems to be in transition. There is
an evident tendency to consider it as having the same relation
as diachronic phonology with phonology proper, although it is
usually still classed with speech dysfunctions and speech er-
rors. However, the deviations from adult speech found in these
three sources differ in nature, not just degree, as Blumstein
points out in Chapter 6. This indicates that any understanding
of these phenomena as stemming from common mechanisms will re-
quire further development of process models of the sort sketched
by Menn and MacKay.

In the early speech of children, the production constraints de-
scribed by Ingram and Menn seem to be in terms of the utterance
or the word (which may in some cases also be a syllable). The
child's sensitivity to the number of syllables in adult forms
is nevertheless revealed, as Ingram shows, by the rules that re-
late children's forms to the adult ones. Sensitivity to the
same parameter is reported in two other processes. In a kind
of speech error called nonsemantic malapropisms, the inappropri-
ate word that is produced nearly always has the same length as
the word it replaces, where length is not counted in segments
but in C\textsubscript{0}VC\textsubscript{0} combinations, e.g. \textit{review} for \textit{revise} (Fay and Cut-
tler, 1977). The "tip-of-the-tongue" study of incomplete lexi-
cal access by Brown and McNeill (1966) also reported number of
syllables of target words to be an accessible parameter by their
subjects. With regard to the discussion of lexical representa-
tion in Section 2, these facts would be most directly explained
by the lexical representation of words with their syllabic pat-
tern, perhaps as part of their rhythmic pattern, although other
explanations are of course possible. (Note that there is no
corresponding evidence for lexical representation of syllabica-
tion.)

MacKay (Chapter 6) reports on an experimental paradigm which un-
expectedly induced a large number of speech errors involving
more than one part of a syllable, a type that rarely occurs nor-
maally. Subjects were asked to repeat monosyllabic words, re-
placing a labial stop by its voiced or unvoiced counterpart,
e.g. \textit{big} \textasciitilde \textit{pigt}. More interesting than the errors in switching
the labial consonants were the many errors that occurred else-
where in the syllable, and their patterns, e.g. shift of voic-
ing of another consonant in harmony with target stop, e.g.
\textit{peaked} \textasciitilde \textit{beaged}. The task apparently creates production diffi-
culties for adults that are similar to those postulated by Menn
for very young children to explain forms such as /g\textsubscript{ak}/ for \textit{duck},
among other things. This kind of consonant harmony, which is
not at all common in adult phonology, is also one of the types
of errors in aphasic speech that Blumstein describes in Chapter
6. She notes that within a word the consonants involved in
such errors seem to obey a distance principle, never being separated by more than one syllable. Among other characteristics of consonant errors in aphasic speech, Blumstein notes that substitutions are rarer in clusters than in single consonants, indicating that they are a more cohesive articulatory sequence. We will have to wait for future research to answer the interesting question, raised by Fujimura and Lovins' proposal of syllable "affixes," whether such consonants behave more like single consonants or like members of a cluster in aphasic speech. One further regularity of aphasic substitutions is that contaminating and affected consonants appear in the same structural position of the word and syllable. As MacKay points out, this is of course one of the major characteristics of spoonerisms: thus we observe *magazine* for *magazine*, *fute meewing* for *feet moving*, *arg of the fewt* for *art of the fugue* (Fromkin, 1971).

Distorted speech also gives evidence for another characteristic of the syllable. Under a variety of conditions, the consonantal onset and the nucleus plus coda have been shown to be more tightly bonded internally than the two parts are to each other, suggesting an internal structure \( C_0 + VC_0 \). MacKay (1972) found that the most frequent type of transposition in speech errors created a break between onset and core; the distinction forms part of the model he presents in Chapter 6. The same distinction was proposed by Kuryłowicz (1948) on phonological grounds. (Pike and Pike (1947), to whom Hyman (1975) attributes the proposal, did not consider the status of the coda in their argument for an internal structure of the syllable.) The distinction of course conflicts with the view sketched in Kozhevnikov and Chis-tovich (1965) that the articulatory structure of syllables consists of CV elements. Kuryłowicz cited the heavy/light distinction, which makes no reference to the syllable's onset, and the domain of tonal contrast, which as we remarked earlier almost never extends into the onset. To these phonological facts can be added the asymmetry of co-occurrence constraints, which are far stronger between coda and nucleus than between onset and nucleus. Reduplications which retain the CV portion of a CVC syllable are not necessarily counterevidence, since the inherent weakness of syllable final position is probably a better explanation.

Coarticulation of course extends over the entire syllable and beyond, as the studies in Chapter 4 make clear; but, except for pitch, Lisker's results showing more coarticulation with the syllable of the coda than the onset are typical. The perceptual consequences of an internally structured syllable are not well explored, although the above hypothesis is consonant with the finding that English vowels are more accurately perceived in a VC context than in a CV context (Edman, Strange, and Jenkins, 1976).

It appears that the transposition and insertion rules of secret languages also tend to separate the onset (English *pig* + *ig-pay*, *popig*, *pegig*, *palfig*), although counterexamples are attested, e.g. Hanunóo *riguk* + *nugrik* (Conklin, 1964) and *hánko* + *konko hánttő*, etc. in the Finnish "knapsack" language (Campbell, 1976). The same asymmetry occurs in the metrics of poetry. It appears
that rhyme frequently demands that VC₀ sequences be similar, whereas alliteration is rarely based on C₀V sequences. The alliterative meter of the Finnish Kalevala (Kiparsky, 1968b) is the only such case known to us. Conclusions from these two sources remain necessarily tentative in the absence of systematic comparison.

We view this evidence for the C₀ + VC₀ structure, converging from many sources, more as signalling an important area for further research than as establishing a fact about the syllable. The example illustrates the power of bringing together diverse sources of evidence to direct us to areas where the search for underlying principles is likely to be fruitful. Other similar examples arise in the following chapters. It is our hope that the discussions we present here, which approach the subject from many different points of view, will provide the perspective necessary to approach a general theory of segment organization and the syllable.

NOTES

1 There is no general survey of the syllable and related phenomena that covers the last ten years' work, to our knowledge. Awedyk (1975), Chapter 9 of Pike (1967), and Kloster Jensen (1963) are all useful commentaries on earlier work, and Lotz (1966) is a preliminary bibliography.

2 O'Connor and Trim (1953) and Greenberg (1962) are attempts to provide a general characterization of syllabic and nonsyllabic segments. See Bell (1977a) for discussion.

3 This estimate is based on a classification in which consonant+glide combinations, e.g. εv, etc., and consonant+laryngeal combinations, e.g. kʰ, pʰ, etc., were counted as single segments, and would be somewhat lower if such sequences were considered to be clusters in some cases.

4 The Kunjen dialects of Australia are a possible exception to both parts of (7); see Sommer (1969) and Dixon (1970). Fischer-Jørgensen (1952) cites Keresan as a counterexample to the last part, based on Spencer (1946); for another analysis see Miller (1965). The Iroquoian languages Seneca and Mohawk are described by Chafe (1963) and Bonvillain (1973), respectively, to have final syllables that are closed either by an oral consonant or else ʔ or h. Seneca and Mohawk may indeed be true counterexamples, although in many cases one would rather consider a partial devoicing of a vowel, which the h represents here, as part of the syllable nucleus than its coda.

5 This condition cannot hold for Kunjen if it violates (7). Even so, it of course does not follow that Kunjen's canonical forms contain no CV.

6 We thank David Stampe for drawing our attention to the Campbell and Kiparsky reference.