Syllables and Segments
A. Bell and J.B. Hooper, eds.

THE SYLLABLE IN PHONOLOGICAL AND PROSODIC STRUCTURE

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1. Syllabic Constraints on Phonetic Representation

Although in some languages there are phonological distinctions between syllabic and nonsyllabic segments, and between accented and unaccented segments, there is reason to believe that neither syllables nor accent-groups (measures) are present in the phonological representations of words in permanent memory. Syllables and other prosodic structures are characteristically predictable from segmental phonological representation and grammatical boundaries. They are, therefore, nondistinctive. Like other derivative, nondistinctive characteristics of speech, they are less readily "available to consciousness" (Sapir, 1921) than basic, distinctive characteristics. And, unlike phonological segments, they are rarely accurately reflected in writing systems, either in so-called syllabic orthographies like *kana* and *devanagari*, or in di-vi-sions of words in alphabetic orthographies. For these reasons we assume that the prosodic organization of segments into syllables and syllables into measures arises in the phonological processing of ongoing speech.

There is, furthermore, evidence that the *means* of this organization exists in whatever part of the central nervous system it is that carries out phonological processing. Specifically, there is evidence that prosodic structure is *re*-adjusted in response to processes which alter other aspects of a representation in the course of phonological processing.

An interesting example of syllable readjustment occurs in Lardil, an Australian language (Hale, 1973). Hale expresses puzzlement over the fact that [r], which becomes [n] optionally before a nasal, becomes [n] obligatorily before a *deleted* nasal (439, fn.) Thus /karmukarmu/ 'skinny' (compare the nonfuture [karmukarmu-n] ~ [kanmukanmu-n]) has an uninflected form, with final vowel apocope and consonant cluster simplification, pronounced [karmukan] or [kanmukan]--never with final [r]. But let us simply assume that this optional assimilation of [r] is obligatory *within syllables*. Then [kar.mu.kar.mu] after apocope must be [kar.mu.karm]. At this point assimilation must affect the tautosyllabic [rm] sequence even if it does not affect the heterosyllable sequence, giving [kar.mu.kanm]. With simplification this yields [karmukan].

Hale notes other puzzling examples, e.g. the palatalization of [n] to [ɲ] before a palatal consonant *only* if it is deleted, e.g. [puɳʈuɲ] 'tree species' from /puɳʈunča/ (compare nonfuture [puɳʈunča-n]). To explain this, we need only assume that palatalization is obligatory within syllables and inapplicable in larger domains. Only the apocopated form [puɳʈunč] meets these conditions: hence [puɳʈuɲč], and with simplification, [puɳʈuɲ]. These examples provide evidence of an intermediate syllabication

(after apocope) which is distinct from either underlying or superficial syllabications.

Examples like these (see also Stampe, 1973; Vennemann, 1972; Bailey, 1978) show clearly that prosodic organization may be imposed in phonological processing, and not just on the output of processing but also on nonterminal stages. It *could*, judging from this, be entirely derivative.

2. Syllabic Constraints on Phonological Representation

However, it has long been recognized that phonological representations, as well as phonetic ones, conform to canons of syllable structure. From this some have concluded that syllables must be in phonological representation after all. This is not a necessary conclusion. Constraints on phonetic representation, according to evidence cited by Stampe (1973) are systematically imposed on the phonological representations of *nonalternating* segments. (There are other provisos.) For example, there is a constraint in English (and most other languages) against sequences of alveolar stop followed by a stop of any other point of articulation. This constraint is imposed in the form of a process which assimilates the alveolar to the nonalveolar stop, under further conditions we will examine later: e.g. [ĩn'bold.ɾ̩] ~ [ĩm'bold.ɾ̩] *in Boulder*, [ĩn˛kʰɑl.ə'rɑɾ.o] ~ [ĩŋ˛kʰɑl.ə'rɑɾ.o] *in Colorado*. In nonalternating sequences of nasal stop plus stop, e.g. *jump*, *drink* [ŋk], *timber*, *Django* [ŋg], *handkerchief* [ŋk], etc., this amounts to a constraint on phonological representation: /mp/ does not contrast with */np/ in such forms.

We see no reason to believe that syllabication or other prosodic constraints that organize phonetic representation do not, likewise, also impose constraints on phonological representation. We can say that a phonological form is admissible, ceteris paribus, if it conforms, without changes, to an admissible syllabication. Without changes, because there are natural adaptations which can make virtually *any* form admissible: */bnɪk/ becomes /bə'nɪk], */ǰʌnp/ becomes [ǰʌ̃mp.], etc.

There is, however, one further question. If phonological */bnɪk/ is inadmissible because it does not conform to an admissible syllabication, how is it that phonetic representations like [bni:θ], a variant of [bə'ni:θ] *beneath*, can arise in English? There is a similar problem regarding segments: there are, clearly, constraints in English against phonological segments (phonemes) like nasal vowels, labiodental nasals, etc. Yet these arise assimilatively in, for example, [bæ̃ɱf] *Banff*.

There are indeed English constraints against phonemes like /æ̃/ (denasalization, as any teacher of French or Hindi to English speakers can attest) and /ɱ/ (de-dentalization, as we can attest from people's imitations of our daughter Elizabeth's invented name for her blanket, /ɱɨ-ɱɨ/, as ['mʌ˛mʌ]), just as there is a constraint against */bnɪk/ (epenthesis, as in [bə'nɪk]). But these constraints, manifested as strengthening or epenthetic processes, are subject to a universal and absolute order restric-

tion: they may not apply to the output of weakening or assimilative processes. (See Donegan and Stampe (to appear) under "Fortition First, Lenition Last.") Since the apparently problematic forms [bæ̃ŋ̊f], [bni:θ] arise as a result of "lenitions," they are not subject to "fortitions" like denasalization, dedentalization, or epenthesis. But when an English speaker aims directly at Hindi /hæ̃/, or Elizabethan /ŋ̊i-ŋ̊i/, or */bnɪk/, which are *not* the output of lenitions, then the fortitions apply. And since these "foreign" forms do not conform, without changes, to the requirements of these obligatory fortitions, we have an explanation of their phonological inadmissibility.

3. Rules and Processes

We have so far been speaking of "natural processes" which reflect phonetic constraints. In much phonological literature these are labeled "rules" and lumped together with morphological and morphophonological conventions which lack synchronic phonetic motivations. For example, the negative prefix *in- (inalienable)* participates in a number of obligatory, apparently assimilative alternations *(impractical, irrelevant, illicit, immoral)*. But when we compare the negative prefix *un- (unalterable)*, we find that it is not subject to any of these obligatory changes *(unpaid, unrelated, unlawful, unmentionable)*, but only to the optional changes described above as alveolar stop assimilation ([ɪ̃n'bold.ɾ̪] ~ [ɪ̃m'bold.ɾ̪]). Such discrepancies indicate that the alternations of *in-* are not synchronically assimilative at all, but merely conventional. See Donegan and Stampe (to appear) for further discussion.

We have argued that phonological representations are segmental rather than prosodic. It also appears that conventional rules manipulate phonological segments (phonemes) rather than prosodic constituents. (The reason *in-* before velar does not obligatorily become /ŋ/ in e.g. *incompetent* is that this was not a phoneme when the rule was borrowed into English with French and Latin vocabulary.) The prefix *con-* takes conventional /m/, obligatorily, before /b/ as in *cómbine* (noun), *combíne* (verb) regardless of their prosodic patterns. But it takes natural [ŋ] obligatorily only within an accentual measure: *cóngress* ['kʰɑ̃ŋ.grəs] versus *congréssional* [kɔ̃n.'grɛš.n.l], where it is only optional (Chomsky and Halle, 1968; Wojcik, n.d.).

Rules precede processes in speech production, and their outputs, like phonological representations, are phonologically admissible according to the criteria of Section 2 (Donegan and Stampe, to appear). If rules are insensitive to syllabic and accentual structures, this is further evidence that these structures arise in the (natural) phonological processing of speech.

4. The Asegmental Domains of Processes

We have described stop assimilation as obligatory within an accentual measure, which, roughly speaking, extends from a primary or secondary stress to the end of the word or up to the next stress. Since prosodic domains are hierarchic, and since assi-

milation is retarded by their boundaries, the process is obligatory also within syllables. It should be inapplicable or optional within domains larger than the measure. In fact it is optional, and this good luck gives us enlightening variants: *sandman* ['sæ̃:nd,mæ̃:n] ~ ['sæ̃:mb,mæ̃:n], but not *['sæ̃:nb,mæ̃:n], demonstrates its obligatoriness in the domain syllable. And *shouldn't go* ['šʊd.n̥t'gɔ̰ʊ̰] ~ ['šʊg.ŋk'gɔ̰ʊ̰], but not *['šʊd.ŋk'gɔ̰ʊ̰], demonstrates its obligatoriness in the domain measure.

The hierarchy of prosodic domains is reversed where their boundaries condition rather than impede a process. "Demarcative" features (Trubetzkoy, 1939), like glottalization of initial vowels, apply in wider domains if they apply in narrower ones. In Hawaiian this process has just the domain sentence, e.g. [ʔ]*aloha!* (Pukui et al., 1975); in English it has the domain phrase, e.g. [ʔ]*apples or* [ʔ]*oranges*, and thus also the wider domain sentence; in German, it has the domain measure, e.g. *Ver*[ʔ]*éin* 'union', and thus the wider domains phrase and sentence. We cannot, unfortunately, do justice here to the interactions of these domains with grammatical structure.

In English, sonorants are nasalized adjacent to a nasal, both regressively and progressively. The two are not quite symmetrical in our speech, because only regressive nasalization affects stressed sonorants: ['hæ̃m.ə̃,fɔ̃ʊ̃n] *homophone* but [hə̃'mɑf.ə̃.nĩ] *homophony*. The regressive domain is obligatorily the syllable and optionally the measure: ['ɑe̞r.l̃ə̃(n)d] ~ ['ɑ̃ẽr̃.l̃ə̃(n)d] *Ireland*, ['wɪl.j̃ə̃m] ~ ['w̃ĩl̃.j̃ə̃m] *William*, ['bɑr.ə.w̃ĩŋ] ~ ['bɑ̃r̃.ə̃.w̃ĩŋ] *borrowing*, [də'lɪr.i.ə̃m] ~ [də'l̃ĩr̃.ĩ.ə̃m] *delirium*. The progressive domain is obligatorily the measure: [kə̃n'tʰĩn.j̃ə̃.w̃ə̃.l̃ĩ] *continually*, contrast [kə̃n,tʰĩn.j̃ə̃'weš.n̥]. No partial domains occur: *['bɑr.ə̃.w̃ĩŋ] (a part-measure), *[bɑr̃.ə̃.w̃ĩŋ] (a part-syllable).

We have not found a process limited to the domain segment. We believe that segments *per se* play no role whatever in natural phonological processing. There is already evidence that they are not even the *minimal* domain of processes--that parts of segments as well as wholes are subject to most processes (Stampe, 1972; Donegan, 1973, 1976, 1978; cf. Andersen, 1972, and several others).

It is possible to understand the processes cited as applying simultaneously to the entire stretch of phonetic representation having the stated feature(s), within the bounds of the stated prosodic domain. With various grammatical addenda, this interpretation seems adequate for all nonprosodic processes.

5. Prosodic and Nonprosodic Features

The choice of nasalization as an example in Section 4 responds to a long tradition of "suprasegmental" and even "prosodic" treatment of this and other features which tend to take wide domains (Harris, 1951; Firth, 1948; Leben, 1973; Goldsmith, 1976a; Clements, 1977). In juxtaposing nasalization with ordinary consonant point-of-articulation we hope to suggest that nasaliza-

tion is not formally different from other articulatory or phonatory features: all these features are governed by processes whose domains are prosodic constituents.

Nasality covers many more segments than point-of-articulation, to be sure. But recall that the process governing regressive nasalization has an obligatory domain of a syllable only, while that governing point-of-articulation has an obligatory domain of a measure. The difference in segmental coverage has less to do with the difference between nasality and point-of-articulation than with the different kinds of segments covered: sonorants can occur in endless succession (*lalala...*), but a sequence of four stops (*shoul[dn't g]o*) is rather a rarity.

Nasalization and most other articulatory and phonatory features have in common a tendency to be assimilated which distinguishes them from, rather than allies them with, the truly prosodic features. Except for tone, whose manifold functions we cannot do justice to here, the prosodic features--syllabicity, stress, and duration--are not subject to assimilation at all.

Prosodic features are perceived relatively, mainly in terms of the relative contrast between neighboring segments, syllables, etc. (Lehiste, 1970a). Nonprosodic features are perceived absolutely, presumably because the nonlinear relation between their genesis and its acoustic result partitions "phonetic space" into discrete categories. Intensity, duration, and pitch have a linear relationship, and thus a nondiscrete and relative character.

But the primary distinction of the prosodic features is in their relationship with the rhythmic organization of speech, and, for that matter, of verse and music. The more prominent values of intensity, duration, and pitch may serve as the nuclei of syllables and measures which are spoken at regular time intervals, usually in a rhythmic alternation with less prominent elements. None of the nonprosodic features ever have nuclear, temporal, or rhythmic value.

6. Putting the Words to the Music

To bring out these characteristics of prosodic features more vividly, let us consider some syllabications of a word like *freedom*. We say this is a two-syllable word, ['friɾ.m̃], but in fact it can be spoken, given some lenitive processing, as one syllable, ['fr̃ĩm̃]; or with fortitive processing, as three [fɽ'riɾ.m̃]. It can be put into Pig Latin as ['iɾ.m̃,frɛi̯] or into Idig as ['friɾ.ə.gi,dɾɾ.ə.gm̃]. It can be sung to the tune of "Yankee Doodle Came to Town" as ['fri.i,i.i'i.i,dɑ̃m]. What does all this mean? Obviously, no *particular* syllabication is in the segmental representation of the word. Nor is any in (for example) the tune of Yankee Doodle. The tune gives us a certain number of syllables (notes) with a certain accent pattern, but not the segments of the word *freedom* or even, given that word, precisely the syllabication above. We *could* sing ['fɽ.ɾ,ɾ.ɾ'i.i,dɑ̃m], or even ['f.f,ɾ.ɾ'i.i,dɑ̃m]. What *is* syllabication, then? Clearly, it is the *mapping* of a segmental representation

onto a prosodic pattern. It is not the words or the music; to use what now should not seem merely to be a metaphor, it is the way the words are put to the music.

7. Syllable Structure

7.1. Sonority. Some syllabications are more natural than others. Of the above renditions of the word *freedom* to the tune of Yankee Doodle, the original one was clearly the most natural. This is not an absolute matter; it is relative to what phonetic difficulties our language has made us overcome. To the Japanese speaker, *freedom* would not be pronounceable as ['friɾ.ə̃m] but only as something like [ɸu'ɾi.do.mu]. Phonetic difficulties, however, do fall into various hierarchies, and we now turn to some which govern syllabication.

Let us regard syllables as having two "slopes," one (the "rise") including everything up through the syllabic, and the other (the "fall") including the syllabic and everything which follows it. For example, the rise and fall of [klaɔ̯nz] are [kla] and [aɔ̯nz], respectively. The reason for including the syllabic in both slopes is simply that the principles governing both slopes include the syllabic. We remark here that there is little to recommend any particular internal analysis of syllables: virtually any linear breakdown of a syllable can be found in the evidence of alliteration, rhyme, secret languages, singing Yankee Doodle, etc.

The best known principle is that the rise and the fall optimally contain segment sequences which increase and decrease, respectively, in relative sonority (intrinsic perceptual prominence--cf. Donegan, 1978); the fall [ə̃e̯ɚ̃nz] *irons* may be monosyllabic, but if its segments are scrambled the fall breaks up: [e̯ə̃ɚ̃nz] *(yarns?)*, ['ɑe̯n.ɚ̃z] *(Einar's)*, etc. (Stampe, 1973).

Some speakers break up *irons* into ['ə̃e̯.ɚ̃nz]. This is because the preferred slope is *steep* (Schambach, 1978); note that the optimal rise is the "universal" syllable [pɑ], consisting of minimal and maximal sonorant. This is a form of the principle of the attraction of opposites. Since the syllable bond consists in the subordination of less-prominent to more-prominent segments, the greater the contrast, the greater the subordination. Put this way, the sonority hierarchy can account not only for preferred word beginnings and endings, but also, word-internally, for preferred syllabic divisions.

Let us look at this in some detail. The onsets of prosodic sequences are intrinsically stronger in articulation (hence more perceptually prominent) than the offsets. This means that, ceteris paribus, a consonant is more likely to go with a vocalism to its right than one to its left: hence VCV is syllabified V.CV. But VC_1C_2V will be syllabified $VC_1.C_2V$, with C_1 bonded to V rather than to C_2, because C_2 is less prominent than V. Finally, VrdnV and VndrV will be syllabified Vrd.nV and Vn.drV, respectively, because [r] is more prominent than [n].

A slope which is accepted externally, e.g. the Vnd of *hand*, may be rejected internally--['hæ̃n.di] *handy*, even ['hæ̃n.dɫ] *handle*--where a more sonorant bond is available. The variation ['hænd ˌaʊt] ~ ['hæ̃nˌdaʊt] *hand-out* is due to the intermediate morphological domain compound as opposed to simple word *(hand, handy)*. This interplay of grammatical domains with the sonority hierarchy is richly illustrated by Allen's (1973) treatment of syllabication in Greek and Latin poetry.

The principle of maximal prominence contrast also helps govern phonological processing and change. It is apparent in such dissimilative developments as Lat. [januarium] *januarĭum*, Fr. [ʒɑ̃vi̯e] *janvier*, Port. [ʒɐnei̯ɾo] *janeiro*, Ital. [ʤennai̯o] *gennaio* 'January'; Germanic **ward-*, Romance **g*ʷ*ard-*, Fr. [gaʀd] *garde* 'guard'; Lat. [wi:were] *vivere*, Fr. [vivʀ] *vivre*, Span. [biβiɾ] *vivir*, and so forth. It is implemented in vowels in dissimilations like MEng. [hwi̯i̯t] (Nottingham Charters *hwuyt*), Canadian and Mid-Atlantic [(h)wʌi̯t], elsewhere [(h)wɑi̯t] *white;* and in syllabicity reversals like early Fr. [rɔe̯], later [rwɛ] *roi* 'king'; Old Swed. [se̯ɑ] *sea* beside Icel. [sjɑ:] *sjá* 'to see'; MEng. [uɑ̯n] > [wʌn] *one*, etc. (see Donegan, 1976, 1978).

7.2. Accent. Extrinsic prominence (accent) can override intrinsic prominence (sonority), as shown by syllabications like [ə'tʰɑ̃m.ɪ̃k] *atomic* beside ['æɾ.ə̃m] *atom*, [ˌɛ̃n'tʰɑe̯ɾ] *entire* beside ['ɛ̃ɾ̃.ə̃.ɾi] *entity*, and others cited in Section 4. (The syllabications are clearly delineated by nasalization--see Section 4--and, in particular, by the nasalization of the flap, which resists nasalization in domains larger than the syllable.) Words like *entity, camping* ['kʰæ̃p.ɪ̃ŋ], etc., illustrate the intersection of accent with sonority contrast; compare the distinct syllabication of voiced stops in ['hæ̃n.di] *handy*, ['æ̃m.bɻ] *amber*.

On the basis of intrinsic prominence alone, we would expect diphthongs like /iu/ to be pronounced as rising [ju] rather than as falling [iu̯] (according to the more-prominent onset principle cited in 7.1), and where the second element is more sonorant than the first, as in /ɒɑ/. But accent on the first element preserves [iu̯] in [siu̯] *sue*, [diu̯] *due* in many English dialects. (Contrast the unaccented development of /iu/ in ['ɪs.ju] ~ ['ɪš.u] *issue*, ['ɑɾd.ju.əs] ~ ['ɑɾ̆.u.əs] *arduous*.) Likewise, [ɒɑ̯] remains in general U.S. [sɒɑ̯] *saw*, urban [soɑ̯] *saw*, southern [ɒɑ̯l] *oil* (cf. its occasional reversal in unaccented *goin'* [gõɑ̯̃n] ~ [gw̃ɑ̃n]).

7.3. Quality. The attraction-of-opposites principle extends to quality as well as prominence. Sounds with similar timbres repel each other. Greek accepted word-initial [pt], [kt] but not *[tt]; [pn], [kn], but not *[tn]; [pl], [kl], but not *[tl]. Many languages reject homorganic glide-vowel rises; they either delete the glide, e.g. [tu:] for *[twu:] *two*, dialectal [ist] for [jist] *yeast*, or they re-syllabify, as in the Japanese borrowed words [i'e.su] 'Jesus' (from ['je.su]), and [u'o.tsu.kɑ] 'vodka' (as if from ['wɒt.kɑ]). The same repellence accounts for timbre dissimilations, as in dialectal [gɔu̯] ~ [gʌu̯] ~ [gɛu̯] *go*, or the Romance developments implicit in Span. [rɛi̯] *rey*,

OFr. [rɔi̯] *roi* 'king'; numerous examples are given by Donegan (1973, 1978).

7.4. Exceptions. The above principles find various exceptions, due to the intersection of conflicting principles. There are systematic exceptions to the principle of maximal contrast due to assimilative phonological processes and changes which, for articulatory reasons, reverse the dissimilative, polarizing tendencies mentioned. And there are exceptions to the increasing-decreasing sonority curve in the classic definition of the syllable, which amounts to a claim that all sonority peaks are syllabic. While the claim is true in many languages and, in fact, states an obviously *optimal* pattern, it confronts many exceptions. For example, there are nonsyllabic sonority peaks (italicized) in Ger. [štumpf] *stumpf* 'blunt', in Fr. [te'ɑtʀ] *théâtre* 'theater', in Icel. [vatn] *vatn* 'water' and [tʰagl] 'tail'--even arising by dissimilation in [kʰarl] ~ [kʰa(r)dl] *Karl* and [hɔrn] ~ [hɔ(r)dn] *horn* 'horn' (Einarsson, 1945)--and of course in nonsyllabic prenasalized obstruents in many languages, e.g. Fijian. One may cite the tendency of nonsyllabic peaks to reduce their sonority (e.g. by devoicing in French and Icelandic), or to be deleted (e.g. Fr. Canadian [te'ɑt]), or to become syllabic (e.g. *langur* 'long' from OIcel. *langr*). But the exceptions remain.

But if, as we claimed in Section 6, the syllable consists in a mapping of segments onto a prosodic pattern, there is no reason to expect that any purely segmental pattern for the syllable, like the sonority curve, should be universally adequate. The fact that it "works" for many languages is a reflection of the universal preference for minimal sonority in nonsyllabics and maximal sonority in syllabics. While we marvel that the Icelander pronounces *vatn* and *tagl* as monosyllables, he might well marvel that we pronounce *button* and *toggle* as disyllables, since his language permits no sounds with such low sonority as [n] or [l] to be treated as syllabic. Indeed, English does not permit these either, as *stressed* syllabics. The differences are a matter of degree.

Yet it should be noted that the "exceptional" non-syllabic peaks are limited to phonemes with some intrinsic independence: most are continuants, and the most widespread one, [s], is readily pronounceable as an isolated syllable and possesses a high degree of intrinsic audibility, if not much carrying power. This is necessary because, as peaks, these sounds are cut off by less sonorant sounds from the articulatory and perceptual support of the sonorous syllabic.

8. Timing

The regular prosodic pattern of speech imposes isochrony on prosodic constituents: on syllables, as in isosyllabic languages like French or Spanish, or on measures, as in iso-accentual languages like English. Where there are distinctions of syllable duration, as in Japanese, there is isochrony among short syllables and isochrony among long ones, and rhythmic regularity forces the shorts and longs into a simple mutual ratio such as 1:2 ("isomoric" rhythm).

Isochrony exists, of course, in the intention and perception of speech rather than in its actuation. There is clever experimental evidence that, although inequities in the number and quality of segments in prosodically equivalent utterances introduce inequities in their timing, the intended (Kozhevnikov and Chistovich, 1965) and perceived (Lehiste, 1977d) timings are in fact equal. Grammatical structure introduces another sort of "irregularity." Since perception is, in essence, causal analysis (Donegan and Stampe, to appear), the listener, discounting segmentally caused irregularities, can analyze others as reflecting the grammatical intent of the speaker.

The fundamental tempo of speech seems to vary little from language to language, and we suppose it is set at the rate of comfortable articulation of typical syllables. We find impressive differences in the rate at which we can repeat different articulations, and we suspect that this is the reason behind a number of constraints on syllable structure. The most general constraint we find is that within a slope, most feature values switch only once; reversals of voicing (*[zkɑ]), nasality (*[mjũ]), timbre (*[ɑe̯w]), etc., are rare or nonexistent. Presumably the tendency of certain features to extend their domain is, at least in part, due to temporal constraints. If nasality is apt to spread over adjacent sonorants, this is surely not unrelated to the markedly slower tempo at which nasality values can be switched in sonorants [ɑãɑã...] than in nonsonorants [dndn...]. We suspect, further, that dissimilative constraints against certain consonant re-articulations within a syllable, e.g. aspiration as in Grassman's Law; glottalization, exemplified by root structure constraints in Caucasian (Catford, 1977); and voicing, e.g. Dahl's Law in Bantu (Kimenyi, 1977); etc. are due to similar timing constraints.

9. Length

We close this phonetic-prosodic account of the nature of syllables with a few remarks on length. Quantitative verse is based on the length of syllables, never just the length of their constituent segments, and the same is true of speech prosody. Although a syllable with a long syllabic is always long, there are long syllables without long segments, e.g. *ar* and *rum* in the dactyls (–◡◡) of the *Aeneid:* |*Ar.ma vi*|*rum.que ca*|*nō*. It has been customary in phonology to treat length as a property of segments. We believe there is much evidence against this, but cite only one example here: compensatory length adjustment.

The common analysis of vowel lengthening in examples like OEng. *mægden* > *mǣden* 'maiden' as a segmental reflex of assimilation, [æg] > [ææ̯] = [æ:], is not satisfactory in some cases. One type is Old English *hōlhes* > *hōles* 'hole's', where the lost segment and the compensated segment are not adjacent. We believe that the correct analysis assigns *hōlhes* a syllabication *hōlh.es* (this can be established by other facts, mainly concerning vowel breaking before l, in Old English; cf. Campbell, 1959), and the first syllable a long duration (i.e. more than one beat of the prosodic pattern). When [h] is "deleted," the rest of the

syllable, and particularly the vowel--the most extendable segment--is simultaneously lengthened to conform to its prosodic matrix.

Another type of example with similar implications is the change of a falling diphthong to a rising one with simultaneous lengthening of the second segment, as in MEng. *spiwen* > Mod. [spju:] *spew*. The common appearance of length in such syllabicity reversals is not generally thought of as compensatory lengthening, but in fact the length appears only when the original diphthong was long. When the same /iu/ diphthong was reversed in unstressed, hence short, syllables in English, as in ['ɪs.ju] *issue*, the syllabic of the rising diphthong was *not* lengthened. When [iu̯] becomes [ju], the first segment loses its prosodic value because the onset of a syllable does not figure in its duration. (No vowel is ever lengthened to compensate for the deletion of a *preceding* consonant.) The lengthening of the second segment of the reversed diphthong occurs, we believe, to maintain the long prosodic value onto which the original diphthong was mapped in the prosodic matrix.

This approach to length may provide a way of understanding why languages sometimes undergo across-the-board changes in syllable quantity and structure which simultaneously involve many apparently unrelated processes. The vowel shortenings, deletions of final consonants, monophthongizations and reversals of diphthongs, metatheses, and change of vowel-nasal sequences into nasalized vowels which occurred in the histories of Romance, Slavic, and other languages (Martinet, 1955; Shevelov and Chew, 1959) might find a unified explanation beginning with a simple change in prosodic mapping. In these instances, the shift would have involved a change from a mapping in which syllables with long vowels or with consonantal closures, formerly mapped onto a double beat, were now mapped, like other syllables, onto single beats in the rhythm of speech. The segmental phonological processes would then eliminate long vowels, postvocalic consonants, and falling diphthongs--all of which would be difficult to pronounce in the time allotted a short syllable. If this approach is correct, it suggests that the syllable, which has not enjoyed a very solid place in linguistic theory, may in fact be the basic element in the relationship of language and speech.

ACKNOWLEDGMENTS

We wish to thank Alan Bell and Greg Lee for insightful discussions of the issues covered here. Part of the research reported here was supported by grants from the Ohio State University Graduate School and College of Humanities.