Nuclear Phonology and Aspiration and Flapping in English*

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1.0 The element of unpredictability in syllable structure

Linguists have long been preoccupied with the idea of proposing universal principles of syllable structure that would, in particular, predict the position of the nucleus and the syllable boundaries in a given sequence of segments. Various approaches to this problem have been proposed including those based on the relative phonological strength of the segments (cf. Hooper 1976) and the distributional approach which attempts to relate word internal syllable boundaries with word initial and word final boundaries (cf. Kuryłowicz 1960).

The difficulties involved in the former type of approach, which attempts to state universal rules of syllable boundary placement in terms of segmental strength hierarchies such as (1), are readily apparent.

(1) Glides Liquids Nasals Fricatives Stops
——————————————————>

Given an intervocalic sequence C_iC_j, where i and j refer to the strength of the C's on the Consonantal Strength Scale, it does seem to be the case that (2a) generally (universally?) holds; i.e., heterosyllabication is evident. However, in the event that the strength relation between the two C's is reversed, the syllable boundary cannot be placed by any universal rule, as shown in (2b). In this case, language specific variation prevails. Even closely related dialects such as Icelandic and Faroese can vary in subtle ways as shown in (2c) (cf. Vennemann 1972, and Murray and Vennemann 1983):

(2a) If VC_iC_jV and $i \leq j$ then $VC_i\$C_jV$ (e.g. *aɹ\$ta, ar\$ta, ak\$ta* etc.)
b) If VC_iC_jV and $i > j$ then $V\$C_iC_jV$ (e.g. *a\$tra*)
OR $VC_i\$C_jV$ (e.g. *at\$ra*)
c) Faroese *ē\$pli*, Icelandic *ep\$li*

Bell (1976) discusses a number of claims made by proponents of the distributional approach and clearly demonstrates that all proposals to date have counterexamples. For example, one of the most sweeping genera-

lizations made by those accepting the view that a distributional definition of the syllable is possible is formulated by Bell (1976:225) as in (3):

(3) If an intersyllabic sequence of consonants is analyzable into permissible word-initial and word-final clusters, then the syllable boundary does not fall between non-permissible clusters.

Although Bell (1976) notes that the principle in many cases holds true, counterexamples can be found. He discusses the case of Huichol which has word initial *pt-, pk-,* and *mt-* and no word final consonants. These clusters also occur word internally between vowels and, contrary to (3), the word internal clusters are syllabified *VptV, VpkV,* and *Vm$tV* (cf. McIntosh 1945):

(4) Counterexamples to 3
a) word intial: *pt-, kt-, mt-*
b) word final: NO CONSONANTS
c) word medial: *-pt-, -kt-, -mt-*
d) syllable structure: *VptV, VktV, Vm$tV*
e) *pti$ü$kʷa$i* 'he ate'
peptakʷi$ka 'you will sing'

The heterosyllabication of word internal clusters results in syllable structures which do not occur word finally (i.e. *-C$*) in contradiction to the general principle in (3).

Although some recent studies continue to assume the validity of the distributional approach to syllable structure (e.g. Kahn 1976, Kiparsky 1981, Selkirk 1982), they do not show signs of improving on the traditional approaches. Indeed, Bell (1976) concluded that all attempts to define the syllable in terms of the distributional properties of segments are doomed to failure. Bell's conclusion is inevitable if one accepts the arguments in Vennemann (1987) where it is proposed that an identical sequence of segments, even within the same language, may vary in three different ways according to syllable structure:

(5 a) positioning of the nucleus: e.g. a sequence *Crn* may be *C̩rn* or *Crn̩*, /lantr̩n/ vs. /eprn̩/ (*lantern, apron*)

b) number of syllables; in some dialects the difference between *peddling* and *pedaling* is one of syllable structure; cf. disyllabic /pɛdlɪŋ/ vs. trisyllabic /pɛdl̩ɪŋ/

c) placement of syllable boundary; e.g. the sequence *VkV* may be divided *V$kV* or *Vk$V* in German; cf. *e$klɪç* for *eklig* 'disgusting' but *jek$lɪç* for *jeglich* 'each'. (In the latter division, the syllable boundary corresponds with an assumed morpheme boundary.)

Accordingly, although tendencies cannot be denied, it must be concluded that syllable structure is not totally predictable on the basis of universal principles relating word initial/final cluster possibilities with word internal syllable boundaries, nor in terms of segmental strength hierarchies.

2.0 Syllable structure and ambisyllabicity

It might be argued that the aspects of syllable structure discussed in section 1 do not justify the outright rejection of approaches to segmental organization based on the placement of syllable boundaries. Rather, it is only necessary in a given sequence of segments to mark the nucleus and specify the syllable boundaries with (partially) language specific rules. It is, however, more complicated than that. Vennemann (1987) demonstrates that in any such approach, it is necessary, at least for some languages such as Standard German (and probably English), to introduce the notion of ambisyllabicity.

The introduction of ambisyllabic segments into phonological analyses has frequently bothered linguists. For example, Picard (1984:56) states:

> Ambisyllabicity is simply one of those ad hoc devices which seem to pop up once in a while albeit in slightly different guises, and which, much like the so-called sonority hierarchy, appears to have little or no substance.

Although some linguists have argued that the notion of ambisyllabicity need not be introduced into syllabic phonology (e.g. Selkirk 1982), Vennemann (1987) cites clear evidence indicating the necessity of postulating ambisyllabic segments in German. In this language, lax vowels can only occur in closed syllables:

(6 a) *Rock* /rɔk/ 'skirt'
b) *Roggen* /rɔgən/ 'rye'

It would seem, at first glance, that a *VC'$ V* structure must be posited for German to account for the open lax vowel in *Roggen* /rɔgən/ 'rye'; viz. /rɔg$ən/. However, this language also has a syllable final devoicing rule. Accordingly, a structure such as *Vg$(V)* should be susceptible to the process:

(7 a) /tag/ › [tak]
b) /rɔg$ən/ › *[rɔkən]

In assuming ambisyllabicity, however, it can be stated that the /g/ in *Roggen* both closes the first syllable (thus allowing /ɔ/) and begins the following syllable (and is accordingly not subject to devoicing). German, then, seems to present a strong case in favour of ambisyllabicity.

Consequently, if one accepts the idea of introducing syllable boundaries in order to make generalizations about a language or language in general, it would seem that the concept of ambisyllabicity necessarily follows, at least for some languages. But, as Vennemann (1987) asks, does it make sense to state within a syllabic phonology that a segment is, at the same time, in weak offset position and strong onset position of the syllable?

3.0 Syllable structure, prosody, and bonding

In the above two sections, we have discussed two characteristics of syllable structure which have disturbed linguists; the element of unpredictability in the placement of syllable boundaries and the necessity of introducing segments with ambisyllabic status. Furthermore, it should be noted that syllable boundaries are notoriously difficult to pin down; they can vary significantly, particularly in relation to speech tempo (cf. Bailey 1978, Kahn 1976). Stress, for example, has the effect (at least in stress timed languages) of drawing marginal segments towards the peak; cf. *t* in *entire* vs. *entity* with aspiration in the former and possible flapping in the latter. Is this to be accounted for on the basis of syllable boundaries, and if so, where are they to be placed? Given the difficulties involved in theories based on syllable boundaries, it would seem desirable for linguists to begin developing new approaches to segmental organization. One possible approach would be to express the organization much more directly in terms of the cohesion relations holding among segments. In such an approach,

syllable structure would be epiphenomenal to the cohesion relations of the language.

The foundations of such a theory are found in Bell (1979) and in Kreitmair (1984) (cf. also the discussion in Vennemann 1987). Kreitmair's approach, the most developed of the two, can be summarized as follows. He introduces five types of bonding:

(8a) segment sequence bond denoted by (-); this bond defines the sequence of segments; e.g. b-U-k, *book*.

b) complex segment bond denoted by (=); this bond binds a segment sequence into complex segments such as affricates or diphthongs, e.g. German d-a-m-p=f, *Dampf*.

c) nucleus bond denoted by (⌐¬); this bond binds segments into complex nuclei. It may play a role in the equivalence of $\breve{V}(=\breve{V}\ \breve{V})$ and $\breve{V}C$ as constituting heavy syllables regardless of the number of segments which follow;

e.g. $\breve{V}\breve{C} = \bar{V}$ (cf. also Clements and Keyser 1983).

d) syllabic bond denoted by (.); this bond binds segments into syllabic complexes, e.g. a+k+a+w+n+t, *account*.

e) body bond denoted by (`); this bond accounts for the greater cohesion of segments in the body of the syllable (i.e. the nucleus plus preceding segments) as evidenced by coarticulation phenomena as opposed to the rhyme of the syllable (i.e. the nucleus plus following segments), e.g. b+l+ɪ¬n¬k., *blink*.

He also assumes the following affinities which are responsible for the presence or absence of bonds:

(9 a) peak affinity
b) peak environment affinity
c) sequence affinities
i) onset affinity
ii) offset affinity

In Vennemann's (1987:27) discussion of Kreitmair's approach, he summarizes the characteristics of these affinities as follows:

> Peak affinity is the affinity between syllable peaks and the other segments bonded to it by the syllabic bond... Peak environment affinity is the affinity between syllable bonded segments standing before and after the peak; this affinity is responsible for the degree of compatibility of onset and offset types. Sequence affinities are the affinities between contiguous segments within onsets and within offsets.

Vennemann labels theories of segmental organization based directly on such relations Nuclear Phonologies. In a Nuclear Phonology only the placement of the nucleus would have to be given (although in certain individual cases as mentioned above, other syllable structure information might have to be supplied, e.g. Germ. (/e$klɪç/ vs. /jek$lɪç/) and all bonding relations would follow from the affinities. It seems to me that such an approach can be applied fruitfully to recalcitrant problems in English phonology.

4.0 Previous treatments of aspiration and flapping in English

The set of problems to be dealt with is that of flapping and aspiration in English as these are clearly related to various bonding relations. Previous treatments have encountered a number of difficulties. For example, Kahn's approach to the difference in aspiration of p in words such as *capon* and *depart* can be summarized as follows (cf. Picard, 1984: 48):

> "/p,t,k/ are aspirated if and only if they are both syllable-initial and non-syllable final."

Thus, the ambisyllabic *p* in *capon* (*capon*) is not aspirated, whereas the syllable initial *p* in *depart* (*de$part*) is.

There are at least two major problems with Kahn's approach as Picard notes. First of all, Kahn's syllable structure assignment rules would generate the following structures (for details, cf. Kahn, 1976: 32f.):

$
(10 a) after
$
b) Boston
$
c) bodkin
$
d) napkin

Since, however, there is no evidence of ambisyllabicity in the latter two cases, Kahn must introduce arbitrary conventions to yield what he believes are the correct syllable structures. (10c) is blocked by assuming that *dk-* belongs to a class of universally prohibited clusters. (10d), however, (a relatively frequent cluster) must be blocked by assuming that it is a highly marked one. It is unclear, however, if this cluster is in any way more marked than *ft-* in (10a). Accordingly, Kahn's introduction of heterosyllabication of *bod$kin* and *nap$kin* is somewhat arbitrary.

Secondly, as Picard also notes, the analysis is observationally inadequate. On the basis of Kahn's syllable structure assignment rules, structures such as *pal$try* and *coun$try* result. In these forms, however, the *t* is not aspirated or, at least, shows less aspiration than *t* preceding a stressed vowel; cf. *páltry* vs. *poltroon* This difference in aspiration can not be accounted for in Kahn's approach.

5.0 A nuclear treatment

In this section, I would like to provide a bare sketch of a a nuclear treatment of aspiration and flapping in English. The discussion here will be limited to *t* only, on the assumption that the treatment of *p* and *k* parallels that of *t* Furthermore, *sC* sequences are not considered as they appear to show no variation whether word initial or word internal. In both cases an unaspirated variant is found; cf. *still* and *distill* The data to be considered are found in (11):

(11) Aspiration
a) Tom
b) atomic
c) attribute
d) artistic

No Aspiration (No Flapping)
e) cat
f) attribute

Flapping
g) atom
h) artist

Let us note first of all the interrelationship of stress and peak affinity. Previous studies have noted that stress has the effect of attracting marginal segments to the peak of the syllable. For example, Bailey (1978) accounts for the nasal assimilation in (12a), contrasted with the lack of assimilation in (12b), in terms of a differential syllabication based on the different stress pattern:

(12 a) *cóŋg$ress*
b) *con$gréssional*

He assumes the syllable structure *ŋg$r*, which he offers as the basis for the assimilation, to be a consequence of the effect of the immediately preceding stress. According to Bailey, consonants are attracted to a stressed nucleus in a stress timed language such as English. As Bell (1979) however points out, similar assimilations also occur in syllable timed languages where such syllable structures could not be motivated. Furthermore, it is clear that an explanation in terms of syllable boundary placement alone cannot account for the fact that at faster speech tempos nasal assimilation **DOES** occur in *congressional* Indeed, it would appear that approaches based on syllable boundaries would have to assume that in faster speech tempos, the consonants would be attracted to a preceding **UNSTRESSED** nucleus; slow *con$gréssional* > fast *coŋg$réssional* In a nuclear phonology, the "attraction" of marginal segments to a stressed peak is accounted for in terms of the increase in peak affinity induced by stress which results in syllabic bonding:

(13 a) k+á+ŋ+g+r+ɛ+s
b) k+ə+n+g+r+é+š...

Assuming that besides stress, proximity (of a segment to a peak) also plays a crucial role, we can state the following two general characteristics of peak affinity:

(14) Peak Affinity

a) The peak affinity of a (marginal) segment increases when the peak is stressed.

b) The peak affinity of a (marginal) segment increases with proximity (linear closeness) to a peak.

Assuming further that:

(15 a) the stressed peak has primacy over the unstressed peak.

b) segments to the left of the peak are more susceptible to bonding than segments to the right of the peak (in recognition of coarticulation phenomena) and,

c) peak affinity can only bond sequences that have onset/offset affinity,

then the following bonding relations can be proposed:

(16) Bonding relations

a) Stressed Peak (Maximal body and syllabic bonding)

All (marginal) segments/sequences compatible with the onset/offset affinities are bonded to a stressed peak.

b) Unstressed Peak (Minimal body and syllabic bonding)

1) The immediately preceding (marginal) segment (and only this segment) is body/syllabic bonded with an unstressed peak.

2) All unbonded (marginal) sequences are syllabic bonded to the closest (unstressed) peak.

There is then a tentative hierarchy here; viz. (16a) has priority over (16b1) which, in turn, has priority over (16b2). The hierarchy is intended to reflect a) the primacy of stressed peaks over unstressed peaks and b) the tighter bonding to the peak of segments to the left of the peak than of segments to the right (cf. (15) above).

Focusing on only relevant portions of the data in (11), we have the body and syllabic bondings in (17). All sequences compatible with the onset/offset affinities are bonded to the stressed nucleus.

(17) Stressed Peak (Maximal body and syllabic bonding)

a) t+á+m (Tom)
b) ...t+á+m... (atomic)
c) ...t+r+í+b... (attribute)
d) ...t+í+s... (artistic)
e) ...ǽ+t (cat)
f) ǽ+t... (attribute)
g) ǽ+t... (atom)
h) á+r+t... (artist)

In accordance with (16b1), we have the body bonding in (18a-c); i.e., the segment preceding the unstressed nucleus is bonded to it:

(18) Unstressed Peak (Minimal body bonding)

a) ...r+i̯... (attribute) (cf. 11f, 17f)
b) ...t+ə̯... (atom) (cf.11g, 17g)
c) ...t+i̯... (artist) (cf. 11h, 17h)

In accordance with (16b2), the unbonded liquid is bonded to the unstressed nucleus:

(19) å+r... (artistic) (cf. 11d, 17d)

In summary, we have the following bonding relations:

(20 a) Tom t+á+m
b) atomic ə-t+á+m...
c) attribute ə-t+r+í+b...
d) artistic ə+r-t+í+s...
e) cat k+ǽ+t
f) attribute ǽ+t-r+ɪ...
g) atom ǽ+t+ə+m
h) artist á+r+t+ɪ...

I would like now to formulate three constraints to account for the distribution of the aspirated, unaspirated, and flapped *t* observed above. Before I do that, however, it is necessary to introduce two definitions to facilitate the statement of the conditions:

(21) Definitions
a) a free segment: absence of left-syllabic bonding
b) a tied segment: presence of left-syllabic bonding

We can now formulate three constraints for a nuclear phonology of English. These apply at a regular or regular to fast speech tempo.

(22) Positive constraints (for regular to fast speech tempo)
a) a free *t* is aspirated
b) a tied *t* is not aspirated
c) a tied body-bonded *t* is flapped

Finally, it should be noted that the lack of aspiration in forms such as *Atlantic* (vs. aspiration in *attribute*) requires no special treatment. A *tl* sequence cannot be body bonded since there is no onset affinity of *t* and *l* in English. The *t* is not free in *Atlantic* but is rather bonded to the previous unstressed nucleus. Accordingly, a necessary precondition for aspiration is not met. Furthermore, the lack of flapping in forms such as *after, actor,* etc. (vs. flapping in *artist*) also requires no special treatment in the phonology of English since the lack of flapping is a consequence of the following universal (cf. Perry 1977, Murray 1987):

Voicing cannot be turned off and then on again in the same syllable.

Consequently, flapping is impossible in æ÷f÷t÷ɾ (*after*) and æ÷k÷t÷ɾ (*actor*) since f÷D and k÷D are in violation of the universal but possible in ɑ÷r÷t÷ɪ÷s÷t (*artist*) since r÷D would not be blocked by the universal.

6.0 Conclusion

One reaction to Nuclear Phonology will probably be: Doesn't it raise more questions than it answers? That should not be a major concern. First of all, it is in a very early stage of development. Secondly, by enabling us to at least pose questions which have never been asked before, it will I believe prove to be a useful tool in our exploration of the intricacies of segmental organization. For example, it was mentioned above that approaches based on syllable boundaries would have difficulty accounting for the assimilation in fast speech *congressional* (with [ŋ] vs. slow speech *congressional* (with [n]. Would it be assumed that the segments are attracted to the **UNSTRESSED** peak in faster tempos; slow *con* $ *gressional* fast *coŋg* $ *ressional* In a nuclear phonology, such assimilations are not problematic. Bonding strength increases with speech tempo and assimilation is an expected consequence of such tightly bonded structures.

At least three goals of future reseach can be outlined:

a) to provide in-depth analyses of the bonding relations and affinities evident in individual languages

b) to determine the extent and in which ways the language specific bonding relations can deviate from unmarked or preferred syllable structure; e.g. in English body bonding of *trV-* may occur but not of *rtV-*. Such body bonds reflect relatively preferred syllable structures in accordance with a markedness theory relating the organization of segments within the syllable in terms of relative phonological strength

c) to determine the role of the various bonding relations in sound change; e.g., a difference in bonding may be the source of differential developments such as Spanish *gordo* 'fat' with [ð] but *mondo* 'world' with [d].

Notes

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