The Empty Node in Phonology: An Analysis of Epenthesis*

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In several recent papers, Singh (1980 and 1981a, b, and c) has argued that certain phonological processes are more appropriately seen as repair strategies. They are, according to him, invoked to fix up violations of well-formedness conditions (WFCs) that are defined over prosodic domains such as the syllable, the foot, and the word. He isolates four such strategies: (i) Resyllabification, (ii) Assimilation, (iii) Deletion, and (iv) Epenthesis. Whenever a WFC is violated, he claims, one of these strategies is called upon to repair it. His discussion of these strategies assumes certain principles of metrical organization that he does not discuss in detail. In the absence of a detailed discussion of these principles, the strategies in question could be perceived as primitives.

The purpose of this paper is to take one of these strategies ---Epenthesis---and to argue that it must not be regarded as a primitive since its execution and its effects follow from certain properties of syllable structures and some very general principles. Epenthesis, we shall argue, is a consequence of these properties and principles and not a primitive term in phonological theory. A detailed attempt to derive the effects of epenthesis was made in Piggott (1981), where the assumptions about metrical organization were similar to Singh's. The present paper represents an attempt to articulate more fully the assumptions that underlie the proposals in question and to refine and reformulate those proposals in order to outline what may be called an explanation of epenthesis.

The paper is organized in the following way. In section 1, we identify the phenomenon of epenthesis, summarize the difficulties in capturing generalizations about it within a linear model of phonology and review some proposals within a metrical framework. In section 2, we outline our conception of

syllable structure and examine some of the consequences and implications of our assumptions. Section 3 contains an elaboration of principles of syllabification and the interaction with epenthesis. In section 4, we indicate what we think we have managed to explain and point out some of the significance of our explanation. Finally, in section 5, we try to link our work to some long-held views about the relationship of rules to constraints.

1. The Phenomenon of Epenthesis.

Phonological theory has generally permitted descriptions of languages which contain rules that insert segments in specific positions in phonological representations. In a model of phonology such as that outlined in Chomsky and Halle (1968) (hereafter SPE) in which phonological representations are linear sequences of segments and boundaries, the phenomenon of epenthesis is presented as a process of inserting a segment between two segments or between a segment and a boundary. Such a process would normally be represented by a rule of the form of (1).

(1) $\emptyset \longrightarrow A / X \_\_\_ Y$

This type of rule usually inserts a single segment rather than a sequence of segments in the appropriate context.

The phenomenon of epenthesis is fairly common in both diachronic and synchronic descriptions of languages. However, the form of the rules that have been proposed indicates that processes of epenthesis are highly constrained. The following is a listing of the constraints which seem to apply to rules of the form of (1) above.

(2) a. If the inserted segment (A) is a vowel, then either X or Y or both are non-syllabic segments.

b. If A is a vowel and X is a boundary, then Y is a sequence of non-syllabic segments.

c. If X and Y are both vowels, then A is a non-syllabic segment, usually a glide.

d. If A is a consonant and X and Y are also consonants, then X is normally a sonorant or s.

e. When condition (d) above is met, the inserted segment A is normally a stop which is homorganic with the preceding sonorant.

In addition to the observations made in (2) above, it is often noted that the sequences into which epenthetic segments are inserted do not occur phonetically. This has led to the claim that rules of epenthesis are linked, in some way, to the phonotactic constraints of a language in that they function to block the surface occurrence of certain impermissible sequences. Brief reviews of some relatively well-known cases of consonant and vowel epentheses may serve to underline some of their characteristics.

Consider, first, the case of vowel epenthesis attested in certain English plural forms such as buses, churches and roses. The generally, though not universally, accepted analysis of English plurals represents the morpheme as basically /-z/. Hence the final syllable of words such as buses [bʌsɨz] must be analyzed as containing an epenthetic vowel. In this case, the epenthetic vowel occurs between two strident, coronal consonants, a sequence of segments that does not occur word-finally or word-initially in English.

Another typical example of vowel epenthesis is illustrated in the analysis of some Lithuanian forms by Kenstowicz and Kisseberth (1971). Lithuanian is described as having a rule of regressive voicing assimilation which ensures that members of a sequence of obstruents are assigned the same value for the feature [voice]. Prefixes such as /ap-/ and /at-/ show the effects of this assimilation process in the data below.

(3)

arti	'plough'	ap-arti	'finish ploughing'
dirpti	'work'	ab-dirpti	'work through'
eiti	'go'	at-eiti	'arrive'
gimti	'be born'	ad-gimti	'be born again'

However, when a combination of morphemes produces a sequence of homorganic stops, the process of assimilation does not apply. Instead, an epenthetic vowel [i] appears between the homorganic stops, as is revealed in the data below.

(4)

puti	'rot'	apiputi	'grow rotten'
bekti	'run'	apibekti	'run around'
teisti	'judge'	atiteisti	'adjudicate'
duoti	'give'	atiduoti	'give back'

In Lithuanian, there are apparently no phonetic sequences of homorganic stops.

The two cases of vowel epenthesis cited so far conform to the general constraints outlined in (2) above. Another case which provides additional confirmation of the validity of the constraints is the process of epenthesis attested in several dialects of Old English (OE). Dresher (1978) attributes the presence of the vowel e in the final syllables of the nominative and accusative singular and plural forms in a paradigm such as the following one to the application of the vowel insertion rule.

(5)

	Sing.	Plur.
Nom.	weter	weter
Acc.	weter	weter
Gen.	wetres	wetra
Dat.	wetre	wetrum

Most analyses of Old English in the SPE framework also treat the vowel in the final syllable of the following forms as epenthetic.

(6)

bremel	'bramble'
þymel	'thimble'
spinel	'spindle'
þonor	'thunder'

Consider, next, a few cases of consonant-epenthesis, all of which are consistent with the constraints outlined in (2d) and (2e). The first is a diachronic process that determined, in part, the development of words such as those cited in (6). Jones (1976:124-125) provides the following examples of consonant-epenthesis as it is manifested in some Middle English (ME) reflexes of Old English (OE) forms.

(7)

	OE	ME	
a.	sceamol	schambel	'stool'
b.	þymel	þimble	'thimble'
c.	nemnan	nempne	'to name'
d.	æmtig	empti	'empty'
e.	þonor	þunder	'thunder'
f.	spinel	spindel	'spindle'
g.	ealra	alder	'all of them'

In examples (7a-7d) the inserted consonant appears as [b] or [p] and is preceded by a bilabial nasal; in examples (7e-7g), epenthetic [d] is preceded by a homorganic nasal or liquid. Crucially, the segment proceding the epenthetic stop is a sonorant.

The pattern illustrated by these data from the history of English is typical of this type of consonant-epenthesis. A similar process in Old French (OF) has been the subject of some discussion recently (Walker 1978, 1981; Singh 1980; Morin 1980). Walker (1978:66) cites the data given in (8) as evidence for some synchronic process of stop-epenthesis. Notice that the forms in the first column are transparently related to those in the second one.

(8)	a.	graindre	graignour	'larger'
		mendre	menour	'smaller'
		attaindre	attaignons	'attain'
		prendre	prenons	'take'
		raiembre	raemons	'buy back'
	b.	coildra	collir	'gather'
		doldra	doleir	'pain'
		faldra	failir	'fail, lack'
		valdra	valeir	'be worth'
	c.	ancestre	ancessour	'ancester'
		cosdre	cousons	'sew'
		naistre	naissons	'be born'
		paroistre	paroissons	'appear'
		istra	issir	'go out'

The forms in (8c) introduce a feature not reflected in the Old English data: the inserted consonant [t] (or [d]) may be preceded by [s] (or [z]). Other non-sonorant consonants are not attested in a similar position in relation to an epenthetic stop. The fricative s thus appears to occupy a special status, since it patterns with sonorants in serving as part of the context for consonant insertion.

As a final case of consonant-epenthesis, we point to the familiar situation in certain dialects of English, in which the surface occurrence of the sequence [ns] seems to be blocked under certain conditions. Instead of this cluster, the sequence [nts] occurs. Examples such as those in (9) are considered to be illustrative of this:

(9)	'fence'	[fɛnts]
	'hence'	[hɛnts]
	'tense'	[tɛnts]

The epenthetic [t] in this case occurs under conditions not significantly different from the conditions under which stop-insertion occurs in Old English and Old French.

The cases of epenthesis discussed above were reviewed in order to show that there are general characteristics which are not associated with the specific properties of a given language. We have already identified some of these non-language particular characteristics in (2). An explanatory theory of phonology must distinguish language-specific properties from those properties that are shared by all grammars under similar conditions. Non-language particular properties should be derivable from principles of the theory of phonology. For example, in the case of consonant-epenthesis (of the type discussed) individual grammars vary with respect to the different types of sonorants that may precede the epenthetic stop. Whether or not the segment s serves as a part of the context is also an idiosyncratic property of grammars. However, phonological theory must provide some basis for explaining why sonorants (and sometimes s) but no other consonants may precede the epenthetic segment. One might also expect phonological theory to predict the variation in the shape of the epenthetic stop, which is invariably homorganic with the preceding segment. Finally, the fact that the epenthetic segment is invariably a stop should also be derivable from some universal principle(s).

Language-particular properties associated with processes of vowel-epenthesis would include identification of the inserted vowel (i.e. whether it is [i] or [ə] or some other vowel) and the specification of the class(es) of consonants that serve as context(s) for epenthesis. No universal principle should be expected to account for the fact that the epenthetic vowel in Lithuanian occurs between homorganic stops, while, in English, a similar type of vowel occurs between strident, coronal consonants. But we must demand of the theory of phonology that it should provide an explanation for the fact that an epenthetic vowel, when it arises, is always inserted between two consonants or between a consonant and a boundary.

We have mentioned earlier that processes of epenthesis seem to function as devices or mechanisms that block the surface occurrence of certain sequences of segments. This feature of this class of rules has been remarked upon, and there is a generally accepted view that such rules are to be related to the phonotactic constraints of the language. This means, of course, that an adequate theory of phonology must make formally explicit whatever link there is between rules of epenthesis and language-particular or universal constraints on sequences of segments.

Descriptions of processes of epenthesis in the SPE framework fail to embody any explanations for those features that are not language-specific. In this framework, every rule of epenthesis must be expressed in the form of (1) and, in each instance, the context of the inserted segment must be specified. As pointed out in Kaye and Lowenstamm (1981b) this requirement of rules of

epenthesis follows from the assumption, within a linear theory such as SPE, that the null element (Ø) is everywhere, hence between any pair of adjacent segments. Since it is assumed that the function of a rule of epenthesis is to replace a null element with a segment, it is absolutely necessary that the rule indicate unambiguously which null element is to be replaced.

The fact that standard phonological descriptions of processes of epenthesis fail to illuminate the phenomenon suggests that the SPE-type theory is fundamentally flawed. Nor does it seem likely that the generalizations referred to earlier can be captured by minor adjustments or additions to the standard theory. It is now generally accepted that the inadequacy of the standard theory lies in the characterization of phonological representations as linear sequences of segments and boundaries.

Much of the recent work in phonology has been conducted in a framework significantly different from SPE. One approach, represented by the work of Liberman and Prince (1977), Halle and Vergnaud (1979) and several others, characterizes phonological representations as hierarchical structures organized in terms of binary branching trees. The properties of such trees, referred to as 'metrical trees' are determined by a set of principles, some of which are outlined in Halle and Vergnaud (1979) and Hayes (1981).

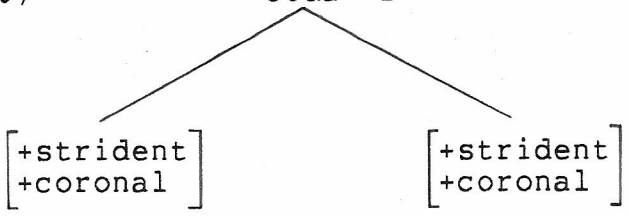
Metrical phonology assumes that the segments of a language are organized into syllables; syllables are organized into units called feet and feet are organized into word trees. This theory has been the basis of significant insights into the variety of phonological phenomena. For example, we now seem to have a much greater understanding of and more satisfying explanations for stress patterns and harmony processes. It is therefore not surprising that there have been attempts to explain other phenomena including epenthesis in the metrical framework.

Halle (1978) notes that vowel epenthesis "frequently arises as an attempt to impose the syllable structure of the rest of the words of the language on agglomerations of consonants that arise through consecutive affixation of consonantal affixes or through operation of vowel elision" and that the rule of vowel epenthesis supplies an epenthetic vowel to replace the empty node of minimal syllables set up to accomodate stranded consonants. Since his paper is chiefly concerned with a general theory of metrical structure, he does not go into the details of the phenomenon of epenthesis. It does, however, clearly suggest that vowel epenthesis may be entirely derivable inasmuch as it is merely the filling of an empty node.

Singh (1981a) attempts to account for the epenthetic vowel in English plurals such as /bɔsɨz/ by setting up /z/ as the plural marker and treating it as a degenerate syllable that later

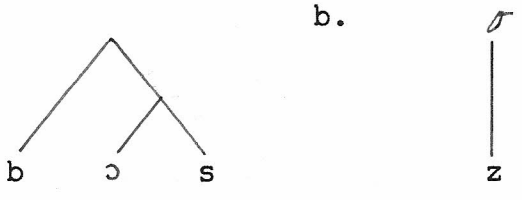
picks up a vocalic nucleus. The consonantal suffix /z/ is set up as a degenerate syllable because the WFC given in (10) would result in its being stranded.

(10) * coda <1>



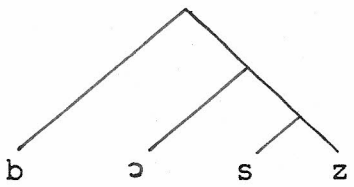
Singh attributes the ill-formedness of a sequence like /bɔsz/, the underlying representation of bosses, to the consonantal suffix /z/ since, according to him, it is the /z/ that is not syllabifiable, given (10). The assumptions, only some of which are fully articulated in the paper in question, on which Singh's analysis of the Ø-vowel alternation in English plurals is based are: (i) there is a stage or level of representation at which the plural marker /z/ is in fact part of the same syllable as the preceding segment, (ii) vowel insertion is a repair strategy, rather than a rule, motivated by the WFC given in (10), (iii) given a choice between a structure-preserving and structure-changing repair strategy, the former is preferred, and (iv) only one repair-strategy is used in any given case. <2> The degenerate syllable he sets up (11b below) picks up the epenthetic vowel because /z/ has the same sonority as the stem-final /s/.

(11) a. b.



Singh insists, however, that there are no null elements in (11b) are not part of the lexical representation of the plural morpheme /z/ and that insistence makes sense only under the assumption that a sequence like /bɔsz/ is at some point analyzed as in (12).

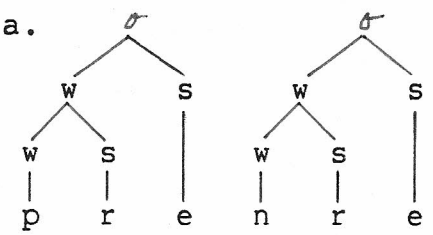
(12)



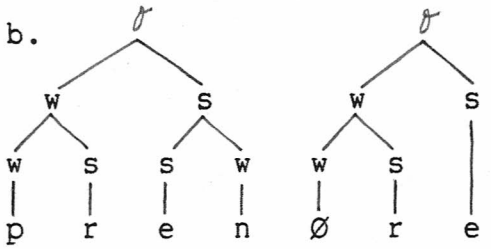
In Singh (1980), he proposes a similar analysis for Old French (OF) consonantal epenthesis. He argues that the epenthetic consonant in examples such as (8) is simply a slot-filler, and the slot is the structural hole or empty-node left by the assignment of the sonorant, including /s/, to the preceding syllable. He notes that the sequences that engender the insertion of an epenthetic stop immediately before the /r/ are all w(eak)-s(trong) sequences.<3> He then argues that intervocalic ws sequences, arising through the concatenation of morphemes or through syncope, are first analysed as XV$wsVY and then as XVw$sVY (where $=syllable boundary), if the ws sequences in question are not allowed as onsets in OF. This reanalysis is presented as a language particular re-adjustment, and the nature of the readjustment is described as movement of the w(eak) segment into the preceding syllable.

One example presented by Singh should serve to clarify the analysis he proposed. The sequence /prenere/ is first syncopated to /prenre/, which is initially syllabified as in (13a). This syllabification, however, cannot be sustained, since, at this stage, /nr/ is not a possible onset. The structure must, accordingly, be modified as in (13b). The epenthetic consonant /d/ simply replaces the null element in the second syllable (13c).

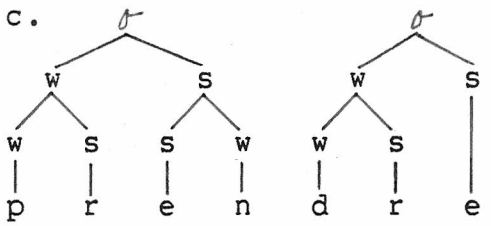
(13) a.



b.



c.



Although it is clear from the resumé just provided that Singh sees initial syllabification as exhaustively assigning segments to syllables governed by the principle of maximization of onsets, he is not clear about where the w(eak) segment (i.e. the /n/ in /prenre/) is moved to. Nor does he explore the circumstances under which a segment would move from a position in a syllable leaving an empty slot and those under which movement or readjustment does not leave such a slot.

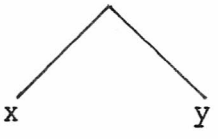
The proposed analyses of English plural and OF consonant epenthesis imply that the empty positions that are filled by epenthetic segments arise during the course of derivations, but Singh does not fully exploit this derivability of epenthesis, nor does he relate consonantal and vocalic epenthesis. Although one gathers from his formulation of the OF rule of consonant epenthesis that an empty position dominated by a w is filled by a consonant, all that he says about the epenthetic vowel in English plurals like bosses is that it is inserted before a segment that has the same or higher sonority than that of the segment it is adjacent to.

Piggott (1981) takes a position very similar to that of Singh in that he is essentially concerned with showing that epenthesis arises as an automatic consequence of certain manipulations of syllable structure. He proposes what he refers to as a principle of Dislocation which is responsible for changes in those structures that violate the well-formedness conditions of a language. Dislocation is intended here to cover either of two strategies. It may require that one of the terminal elements (i.e. segments) of an ill-formed structure must move, leaving an empty position or that both terminal elements (and the dominating

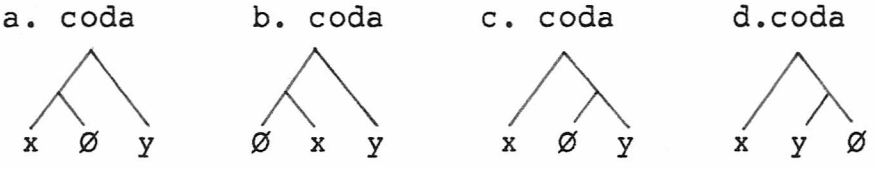
node) be 'pruned' from the syllable. The latter would always result in reconstruction of a new syllable for the dislocated pair of segments and this new syllable would contain an empty position into which an epenthetic vowel would be inserted. The former (i.e. moving one segment) could, it was claimed, lead to consonant epenthesis.

The problem with the analysis proposed by Piggott (1981) is that it fails to capture the fact that consonant epenthesis is strongly associated with the presence of sonorants in the structures that give rise to the epenthesis. A second failing is that it allows for a number of possible configurations resulting from the dislocation of one or the other of a pair of segments and does not provide a principled basis for choosing the correct configuration. For example, given that the structure in (14) is ill-formed, dislocation of a segment may produce either of the four possibilities in (15).

(14)



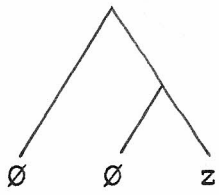
(15)



If, following Kiparsky (1979), we assume that the coda must be a right-branching structure, then structures like (15a) and (15b) may be eliminated because they are left-branching. However, both (15c) and (15d) would be possible and neither could be eliminated without being merely stipulative. We will later claim that the principle of dislocation does not result in the movement of single segments at all, but removes the entire ill-formed part of a syllable structure without leaving an empty position.

Another attempt to account for epenthesis in a metrical framework is that of Kaye and Lowenstamm (1981b). They attempt to derive vocalic and consonantal epenthesis by postulating null elements in the underlying representations of morphemes. They provide the following representation for the English plural marker /z/, for example:

(16)



Epenthesis is seen by them as the replacing of null elements that have not been eliminated by resyllabification. Null elements dominated by nuclei are replaced by the unmarked vowel and those dominated by onset and coda presumably by the unmarked consonant. While their approach accounts for the automaticity of epenthetic processes, it does not explicitly relate them to WFC's that can be said to trigger them.

The review of some previous attempts to explain the phenomenon of epenthesis in the metrical framework reveals that the focus is on features of the syllable. We believe that these approaches are fundamentally correct, even though flawed in various ways. The new analysis to be presented below will illustrate that processes of epenthesis can be explained in terms of properties of syllable structure together with a small number of general principles and rules of syllabification. Specifically we will argue that epenthetic segments arise automatically to fill empty structural positions that are created in the course of syllabification. We take the position that these empty structural slots are created through the interaction of certain general and/or language-specific principles of syllabification, the well-formedness conditions or phonotactic constraints of a given language and certain strategies to repair syllable structures that are not well-formed. It is to these structurally well-defined empty slots and not to the ubiquitous null element that rules of epenthesis make reference. Exactly what we mean by an empty slot/position will be made clear in our discussion of syllable structure to follow and in our later analysis of syllabification.

There are some far-reaching consequences of our analysis of epenthesis. If the empty structural positions arise automatically and if they must also be filled automatically, then there is no need to recognize language-specific rules of epenthesis. In fact, there is no need to recognize a <u>rule</u> of epenthesis at all. In seeking to explain processes of epenthesis we would have succeeded in eliminating such rules from grammars. We find such results particularly satisfying, since they represent a new approach to phonology more in line with recent approaches to the study of syntax within which greater emphasis is placed on principles rather than on rules as a basis for explaining linguistic phenomena. The approach to phonology which we expound is strongly reflected in a number of recent studies by

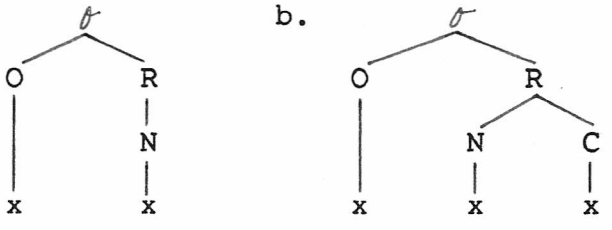
Kaye and Lowenstamm, though we differ from them in our conception of syllabification. Acceptance of our analysis depends crucially on acceptance of our views on syllabification and our proposals for the structure of syllables. It is to the latter two concerns that we turn next.

2. Syllable Structure.

We assume that every syllable (σ) has the two obligatory constituents, the onset (O) and the rime (R).<4> In addition, the rime has an obligatory constituent, the nucleus (N) and it may also contain a second (optional) constituent, the coda (C). We also assume that the terminal nodes of syllabic trees are not segments themselves but a set of skeletal slots or points to which segments are linked. Occasionally, however, we might refer to segments as constituents of the onset, coda or nucleus. The skeletal points to which segments are linked are specified in slightly different, but not irreconcilable, ways by McCarthy (1979) and Kaye (1983). We borrow the notation from Kaye (1983) and identify the elements of the skeletal structure by a series of x's.

The above assumptions provide for the following basic types of syllable structure.

(17) a. b.



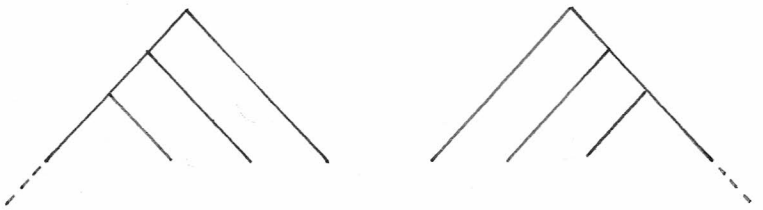
Of these, (17a) is obviously the minimal structure that a syllable can have. It is the appropriate structure for open syllables of the familiar CV and V types. Surface syllables consisting of just a vowel (i.e. the V type) are those in which a skeletal slot dominated by O is linked to an empty segment [e]. The difference between an empty segment and an empty structural position will be made clear below and during the discussion on syllabification.

Each of the nodes labeled O, N and C may branch, allowing for syllable structures of greater complexity that those shown in (17). Structures with branching onsets and codas would be required for syllables with consonant clusters in these positions and a branching nucleus would be an appropriate characterization of a long vowel or a diphthong (both in its traditional and, as we shall see later, modified sense). There are obviously likely to be universal and language-specific constraints on what

segments may be associated with terminal elements of the onset or coda. There are also likely to be constraints on the complexity of structures with branching onsets, nuclei and codas. Some consideration is given to such restrictions by Kaye and Lowenstamm (1981a, 1981b).

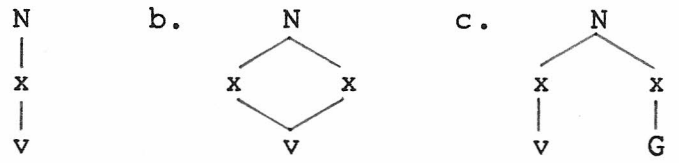
Since the onset and coda may dominate a number of skeletal points, it is appropriate to consider how these syllabic constituents are organized internally. We take the position, based on a proposal by Kiparsky (1979), that the internal structure of the onset and of the coda is organized in accordance with the general principles that govern the geometry of all metrical trees. The onset is analyzed as a left-branching structure and the coda is right-branching, as is illustrated in (18).

(18) a. O b. C



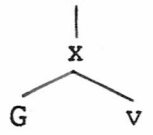
In contrast with the onset and the coda, the nucleus seems to be limited to fairly simple structures. It appears that, universally, the number of skeletal points that may be dominated by the nucleus must be limited to two. A short vowel would be represented as a single vowel (v) linked to one point (19a); long vowels would be analyzed as instances of a single vowel (v) linked to two points (19b); and diphthongs consisting of a vowel (v) followed by a glide (G) would be represented as in (19c).

(19) a. b. c.

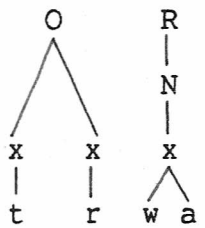


The structure (19c) is considered to be the appropriate representation of the familiar type of diphthong. Kaye (1983) refers to this type as a heavy diphthong, and he distinguishes it from another type, the light diphthong, consisting of a glide (G) followed by a vowel (v) linked to a single skeletal point. The structure of a light diphthong is shown in (20a), and the French word trois 'three' represented in (20b) provides an example of such a diphthong.

(20) a.



b.



Kaye (1983) contains an additional proposal limiting the number of segments that may be linked to a skeletal point to a maximum of two. However, even with such a restriction, the structures that are permitted in the nucleus appear to be rich enough to accommodate more complex nuclei such as so-called triphthongs.

The one-to-many and many-to-one relationships that hold between skeletal points of the nucleus and segments reflected in the description of light diphthongs and long vowels, respectively, extend to the description of other phenomena. For example, affricates and prenasalized consonants are similar to light diphthongs in that they (the former) are instances of two consonants linked to a single skeletal point. Instances of two skeletal points linked to a single segment include not only long vowels but also geminate consonants.

In addition to the strictly geometrical properties of syllable structure which we have discussed so far, there are certain substantive constraints on structure that will figure crucially in our analysis of epenthesis. By substantive constraints, we are referring to restrictions on the segments that may be associated with the terminal elements of the nodes labelled O, N and C. Proposals of this sort are discussed in Kaye and Lowenstamm (1981b). They propose, for example, that the segments that appear in the nucleus must all be specified [+vocalic]. Since vowels, glides, liquids and nasals are all segments that may be associated with the nucleus, the members of these classes are all arbitrarily specified as [+vocalic] segments by Kaye and Lowenstamm. We opt for a more conventional position and regard these segments as sonorants. However we propose that the nucleus may dominate [+sonorant] consonants, at least in some languages one of which is English. The qualification of the last statement is intended to allow for the possibility that languages may vary in terms of what segments may be linked to terminal elements of the nodes labeled O, N and C.

Given that any [+sonorant] segments can appear in the nucleus, we would like to propose that the distribution of nasals and liquids is parallel to the distribution of glides and vowels. Kaye and Lowenstamm (1981b) argue that the non-laryngeal glides

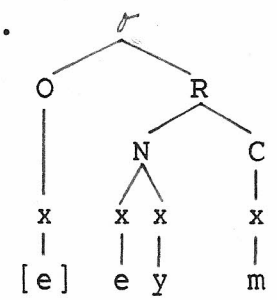
(i.e. the sonorant glides) are merely positional variants of the corresponding high vowel (e.g. [y] vs [i], [w] vs [u]). In a language like English, the position occupied by vowels is a possible position for nasals and liquids, since syllabic nasals and liquids occur in words such as 'sudden' [sʌdn̩], 'bottom' [batm̩], 'little' [litl̩] and 'letter' [lɛtr̩].<5> It is also clear that nasals and liquids share with the non-syllabic variant of vowels (i.e. with glides) the property of being possible constituents of the onset or of the coda. The only position that glides occupy that is not generally regarded as a possible position for an nasal or liquid is as a member of a diphthong. We claim that this restriction on nasals and liquids is untenable. We propose that nasals and liquids may appear as the second (i.e. the right-most) constituent of a nucleus. Thus a branching nucleus may characterize either a long vowel, a diphthong or a sequence of vowel followed by a nasal or liquid. We will later suggest that the fricative [s] may also appear as a constituent of the nucleus.

The feature of syllable structure that is probably the most crucial to our analysis of epenthesis is what we have been referring to as the empty slot or position (hereafter referred to as the empty node). The definition (21) below makes clear what the concept of the empty node entails.

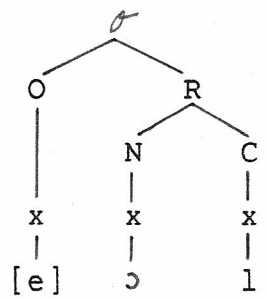
(21) An empty node is a skeletal point which is not associated with a segment.

The empty node must be distinguished from cases in which a skeletal point is associated with an abstract segmental element which we identify as the empty segment [e]. We consider the empty segment to be a segment that lacks phonetic specification. It is our contention that the empty segment is one of a limited number of elements that can fill an empty node. According to our analysis of syllable structure, the empty segment occurs at the beginning of English vowel-initial words such as <u>aim</u> and <u>all</u>, represented in (22a) and (22b), respectively.

(22) a.



b.



The distribution of the empty segment is highly restricted. It must be associated with a skeletal point which is the sole constituent of an onset. Both the existence of the empty segment and the restriction on its distribution can be derived from other properties of syllable structure and from the process of syllabification. Consider, first, the consequences of the requirement that every well-formed syllable must consist of an onset and a nuclues. This means that, since the terminal elements of syllable structure are skeletal points, there must minimally be two points in any syllable. Universally, the relation between points in the nucleus and segments is governed by the following principle:

(23) The nucleus of a syllable must dominate a [+sonorant] segment.

Particular languages may place even greater restriction on nuclear segments, for example, excluding sonorant consonants. However, as a consequence of a principle such as (23), there is only one point in the minimal syllable that could be associated with an empty segment if such a segment were postulated. We will claim later that, in certain cases, syllabification does require postulation of a point in the onset which is not associated with a segment. A well-formedness condition to be spelled out later requires that this empty node must be linked to a segment without phonetic content (i.e. an empty segment).

Accounting for the distribution of the empty segment might be approached from a different perspective. It is now fairly well established that the rime is the dominant constituent of the syllable. This is reflected, for example, in the theory of markedness proposed in Kaye and Lowenstamm (1981a). Since the nucleus is the only obligatory constituent of the rime, it does not appear to be unreasonable to propose that the head of the syllable must be contained within the nucleus. A recent proposal by Lowenstamm and Kaye (1983) actually defines the head of the syllable as the leftmost point of skeletal structure dominated by the nucleus. Based on this assumption they then propose (24) below as a principle of Prosodic Government to define a relation between the head of the syllable and the constituents of the rime.

(24) The head of the syllable must govern other constituents of the rime.

Government is defined in terms of the notion of c-command.

(25) α governs β if α c-commands β .

The version of c-command which they assume is as follows:

(26) α c-commands β if the first branching node dominating α also dominates β .

We are not concerned here with the phenomena that the principle of Prosodic Government is considered to account for. It suffices to note that the principle is assumed to hold only within the rime. What this principle appears to be reflecting is the fact that there are relations that hold internally to the rime and which are quite different from the relation between the onset and (any constituent of) the rime. Principle (24) suggests that the head of the syllable can influence or affect other constituents of the rime in ways in which it cannot influence or affect constituents of the onset. This may be attributed to the fact that in relation to the head the onset is ungoverned. Following the line of reasoning developed above, we might propose principle (27) below to account for the fact the empty segment must appear in the onset and can never appear in the rime.

(27) [e] must be ungoverned.

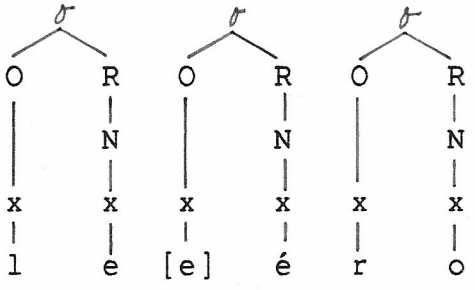
The combination of (24) and (27) would ensure that the empty segment could not be associated with a point in the coda of a syllable.

If it is correct to assume that government holds only within the rime, which is a sort of 'maximal projection', then the onset must be an ungoverned position. However, one might wish to consider the onset to be a governing category, i.e. a category within which government can be defined (Chomsky (1981)). Assuming such a possibility, principle (27) would then have the effect of restricting the empty segment to appearing in syllables in which it is linked to the only skeletal point dominated by the onset. This would be the only position within the two obligatory constituents of a syllable that would always be ungoverned.

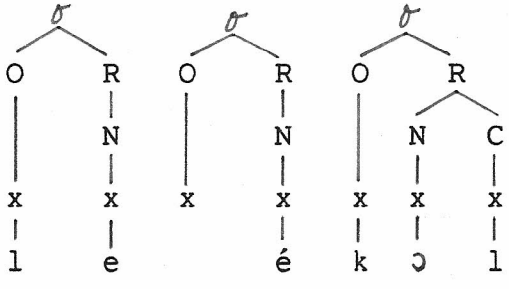
If the theory of syllable structure recognizes the existence of the empty segment as distinct from the empty node, it would lead to fairly interesting and revealing analyses of certain phenomena including the phonological behavior of the so-called 'h-aspiré' words in French. These phonetically vowel-initial words (e.g. (le) héros) pattern with consonant-initial words (e.g. (le) chien) in that an immediately preceding vowel such as

that in the definite article (le/la) does not elide. The 'h-aspiré' words differ from other phonetically vowel-initial words in that the latter provides a context for vowel elision (e.g. (l') école). The difference in the behavior of the two types of phonetically vowel-initial words can be accounted for if we postulate that the onset of the initial syllable of 'h-aspiré' words dominates a point that is linked to an empty segment. The representation of le héros (28a) and l'école (28b) illustrates the difference before vowel-elision occurs.

(28) a.



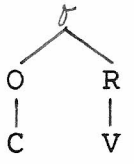
b.

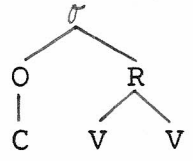


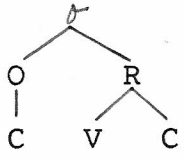
It is transparent in (28b) that two vowels are adjacent and therefore the conditions for vowel elision to occur are satisfied. In (28a) no two vowels are adjacent. To arrive at the difference between (28a) and (28b), we must assume that all 'h-aspiré' words are lexically represented with an initial skeletal point that is linked to an empty segment. The representation in (28b) contains an empty node which must ultimately be filled.

The fact that empty nodes may arise in the course of syllabification is crucial to our analysis of epenthesis. Equally important is the formal recognition of a distinction between the nucleus and the coda as constituents of the rime. Though we are not alone in recognizing such constituents, the structures proposed in (17) are hardly universally accepted. An alternative position is that the syllable has only two labeled constituents, the onset and the rime. The evidence is in the form of the general observation that the stress systems of many languages are determined by the structure of the rime. Halle and

Vergnaud (1979), McCarthy (1979), Hayes (1981) and many others have shown that stress systems are sensitive to the distinction between light (C_0V) syllables and heavy (C_0VV or C_0VC) syllables. The former are open syllables with short vowels, the latter include syllables with long vowels, diphthongs or short vowels followed by at least one consonant. This distinction can be captured directly if syllables are assumed to be organized as in (29). (The symbols C and V are equivalent to the points of a skeletal structure already recognized.)

(29) a. 

b. 

c. 

Given structures such as (29) in a theory in which stress rules apply on the projection of rimes, CVV and CVC syllables can be seen to be similar in that they both have branching rimes.

Notice, now, that if long vowels are analysed as branching nuclei, as is proposed earlier, there would be less of a similarity between CVV and CVC syllables. This would appear to undermine our proposal to analyse the syllable as in (17). However, Hayes (1981) and others have pointed out that there are stress systems that are sensitive to the distinctions identified in (30).

(30) a. Syllables with long vowel or diphthongs versus those with short vowels.

b. Closed versus open syllables.

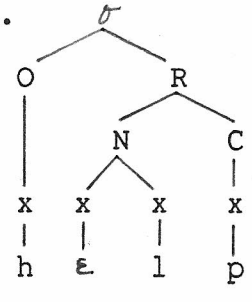
Contrasts such as those cited above are not directly reflected in the structures in (29) and cannot be. Hayes suggests that alternative proposals by Safir (1979) and Pesetsky (1979) seem more appropriate. These alternative representations of the syllable are exactly those allowed for (17). If the rime has labeled constituent structure, then the contrast in (30a) can be expressed as the difference between a branching and a non-branching nucleus, while (30b) reflects the difference between a branching and a non-branching rime. Given syllable structures as in (17), it would still be possible to capture the distinction between light (CV) syllables and heavy (CVV or CVC) syllables. The difference is readily characterized in terms of whether or not the rime or either of its constituents branches.

Even though there appears to be reasonably strong support

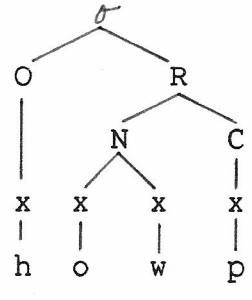
for the hypothesis that syllable structure may contain a nucleus and a coda, Harris (1983) argues strongly against the appropriateness of such an analysis for Spanish syllables. If Harris' claim is valid, it would seem to present phonological theory with a real paradox. We suggest that the paradox is only apparent. Phonological theory should permit languages to vary between having syllable structures like (17) and those as in (29). Such variation could be determined by the different setting of some parameter(s), allowing for syllables with onsets, rimes, nuclei and codas or syllables with just onsets and rimes. Perhaps, it is even appropriate to regard the unmarked syllable structure as one in which the rime does not contain labeled constituents. The fact that the coda is an optional constituent of the rime may be taken as evidence for this proposal for an unmarked rime structure. Syllable structures with a coda would only be postulated when the data force such an analysis. The approach to syllabification which is sketched in the next section is consistent with these views.

Before we proceed to outline our approach to syllabification, it would seem appropriate to point out some of the interesting results that may be derived from one of the proposals that will play an important role in our analysis of epenthesis, namely the proposal that nasals and liquids may appear as the second constituent of the nucleus. We believe that this assumption can serve as a basis for explaining a number of otherwise inexplicable facts about the behaviours of sonorant consonants in English and in other languages. Consider, first, a difference in the pronunciation of words such as help and milk in certain dialects of English. These are sometimes realized as [hɛwp] and [miwk], respectively. The difference from the standard pronunciation may be described as the result of a substitution of the glide [w] for [l], but the theory of syllable structure which we have adopted illuminates the process. We propose that the structure of a word such as help is as in (31a), at least for some dialects of English, and parallels the structure of a word such as hope (31b).

(31) a.



b.



Given (31a), the substitution process involves the replacement of a constituent of the nucleus by another possible constituent of

the nucleus. The appearance of liquids and nasals in the nucleus, especially as the rightmost constituent of the nucleus, appears to be marked relative to the occurrence of glides in a similar position. The evidence suggests that some language-specific stipulations are required to permit liquids and nasals to occupy positions in the nucleus. If a liquid is syllabified as the rightmost constituent of a nucleus, the substitution of a glide for such a liquid can readily be interpreted as an unmarked or natural process.

The formal and substantive properties of syllable structure which we have adopted also point to a possible explanation for the effects of sonorants on the stress patterns of English. There are two situations in which sonorants play some role in determining the stressing of English words. One of these has been the focus of attention by Nanni (1977) and, recently, by Travis (1982). Both authors attempt to provide an explanation for certain differences between sets of words containing the adjectival suffix -ative. For example, the words in (32a) are stressed differently from the words in (32b).

(32)

a.	b.
nóminative	límitàtive
imáginative	quálitàtive
génerative	intérpretàtive
íterative	invéstigàtive
cúmulative	législàtive
ejáculative	inhábitàtive

Nanni and Travis both point out that the first vowel of the suffix -ative is normally unstressed in the forms of (32a), but is stressed in the forms of (32b). Moreover, this unstressed vowel is subject to vowel reduction, just as is the corresponding vowel in the forms of (33) below.

(33)
accúsative
infórmative
provócative
consérvative

In the theory of stress outlined in Hayes (1981), the occurrence of stress in a word such as provócative is determined by the interaction of various rules which include the following.

(34)

a. A rule that designates the final suffix of an adjective as extrametrical (Adj. Ex.).

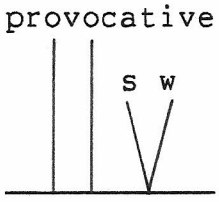
b. A rule that assigns the final syllable of a word such as provoke, which contains a long vowel, to an independent foot (LVS).

c. The English Stress Rule (ESR) that constructs a maximally binary foot at the right edge of word, labeled sw, the right node being non-branching.

d. The rule of Strong Retraction (SR) which applies iteratively from right to left, constructing maximally binary feet, labeled sw, the nodes being free to branch or not.

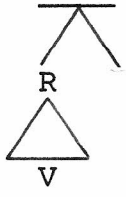
Application of this set of rules to a word like provocative would produce the following representation at the relevant point in the derivation. (For details, see Hayes (1981)).

(35)



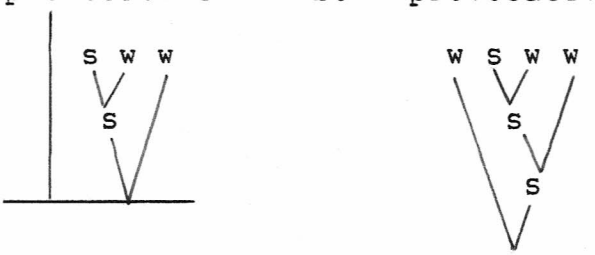
A representation like (35) satisfies the conditions for the application of the rule of Poststress Destressing (PSD) given in (36) below.

(36) "F" ---> Ø / F



The rule deletes a binary foot if the first syllable of that foot is open and there is an immediately preceding non-branching foot. The effect of the application of (36) to (35) is the obvious loss of foot structure associated with the suffix -ative. By the general convention of Stray Syllable Adjunction (SSA) syllables without foot structure are adjoined as a weak member of an adjacent foot. The result of the application of SSA to the output of PSD is the representation in (37a) which is adjusted to (37b) by other rules of destressing and word tree construction.

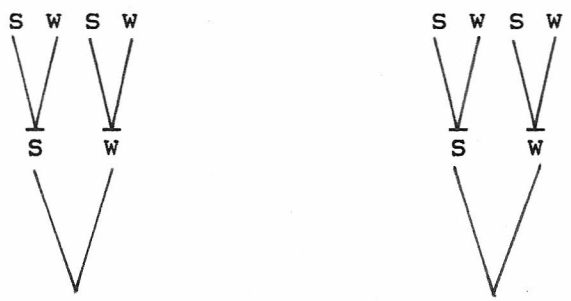
(37) a. provocative b. provocative



Notice that in (37b) the first vowel of the suffix -ative is in a weak metrical position and may undergo vowel reduction to schwa.

Since the vowel reduction manifested in the forms of (32a) is similar to that in the word provocative , one would expect that the pattern of derivation that holds for the latter word would be reflected in that which applies to the words in (32a). However, application of the rules in (34) together with other generally accepted rules and conventions would produce no difference between a word like nominative and a word like limitative.

(38) a. * nóminàtive b. límitàtive



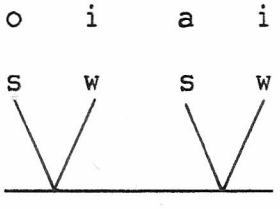
In the representations in (38) the first vowel of the suffix -ative is in a strong metrical position and thus would not be subject to vowel reduction. We must therefore motivate a different analysis for nominative and the other words of (32a).

A noticeable feature of the words in (32a) is the occurrence of a sonorant consonant immediately preceding the suffix -ative. It is reasonable to expect that this feature would play a role in the analysis of these forms. Indeed, both Nanni (1977) and Travis (1982) propose descriptions in which rules make reference to the presence of the sonorant consonant in these words. However, neither proposal embodies an explanation as to why sonorants and no other consonants should have the effect that they do.

We believe that an explanation may be offered, based, in part, on the conception of syllable structure that we have outlined above. Our proposed explanation follows.

Following Hayes (1981), we assume that after the rules of stress placement the representation of nominative would be as in (39). (Note that only the nucleus or rime projection is shown.)

(39)



We would now like to make two proposals which, together with other accepted principles, provide a straightforward account of the stressing of the words in (32). One of these proposals is partly specific to English; the other is intended to be a general convention.

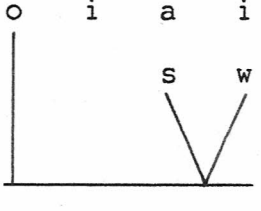
(40) Assign a sonorant to the nucleus of the syllable to its left.

(41) Whenever there is a change in the structure of a rime or a nucleus, the branch of the foot which dominates this rime or nucleus is automatically deleted.

A convention such as (41) seems entirely plausible. It simply permits changes in syllable structure to lead to possible changes in foot structure.

The effect of the application of (40) and (41) to a representation such as (39) is to delete the right branch of the first foot, leaving an independent foot on the first syllable of the word, illustrated in (42).

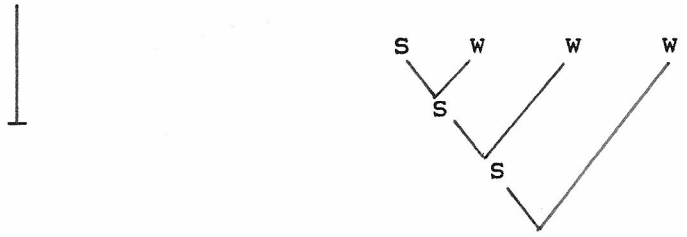
(42)



The derived structure in (42) is exactly that to which rule (36),

Poststress Destressing, applies. To ensure that PSD applies to (42) at this point in the derivation, it would seem to be necessary to stipulate that Stray Syllable Adjunction cannot apply. Application of SSA before PSD would simply have the effect of reconstructing a binary foot on the first two syllables of the word. However, there seems to be a universal constraint that SSA must apply after all of the rules that are applicable in a given domain. Thus, SSA can never block the application of a rule. Application of PSD to (42) produces (43a), and SSA would subsequently yield the representation in (43b).

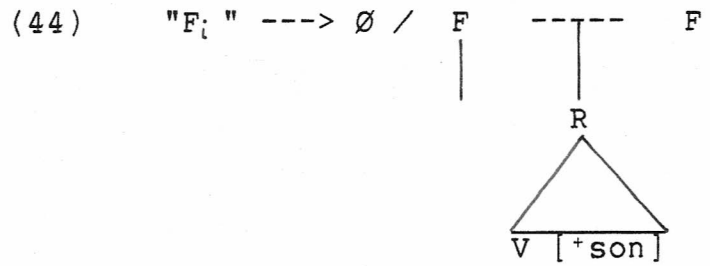
(43) a. o i a i b. o i a i



It is obvious that (43b) captures stress on words that are similar to nóminative and reflects the condition under which vowel reduction may apply to the first vowel of the suffix -ative.

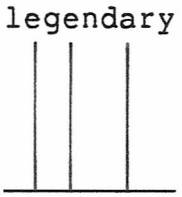
It should be apparent that if the theory of phonology does not recognize the nucleus as a constituent of the syllable, a rule such as (40) could hardly be justified. If, instead of rule (40), one were to propose that the sonorant consonant is re-assigned to the adjacent rime, one would then have to explain why sonorants and not stops or any other consonant are re-assigned. In our analysis, the difference between the behaviour of sonorants and other consonants is determined by the fact that sonorants have a privileged status as possible constituents of nuclei. Rule (40) may be considered to be one instance of a rule that moves sonorants. We claim that whenever a sonorant is moved it is assigned to a position in the nucleus.

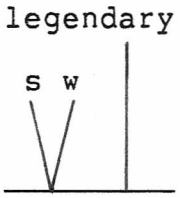
Another instance in English of the rule which moves a sonorant appears to be the defooting process known as Sonorant Destressing. Hayes (1982: 253) represents this rule as in (44).

(44) 

Condition: Fi is not dominated by S

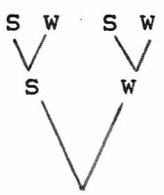
This rule deletes a non-branching foot containing a closed syllable that ends in a sonorant if there is a preceding non-branching foot and a following foot. The process is intended to account for the stress on words such as légendàry, mómentàry, désultòry, and répertòry. Words such as these have the main stress on the second syllable preceding the suffix -ary / -ory and not on the syllable immediately preceding this suffix as in trajéctory and valedíctory. It is generally assumed that in the derivation of stress on the word légendàry the representation (45a) is modified by application of Sonorant Destressing and Stray Syllable Adjunction to (45b).

(45) a. 

b. 

Application of other rules, including the construction of the word-tree, yields (46).

(46) légendàry



A rule like (44) appears to be descriptively adequate, but neither the original proposal of Kiparsky (1979) nor the recent analysis of Hayes (1982) explains why sonorants should trigger defooting in these cases. That is, there is no attempt to relate the behaviour of sonorants in these cases to any general property of this class of segments. We would like to propose that there

is no rule like (44) at all. Rather the defooting process is triggered by the movement of the sonorant into the nucleus of the syllable. Convention (41) predicts defooting after the sonorant is assigned to the nucleus. Thus, the destressing process that occurs in the derivation of words like nóminative is linked to destressing in words like légendàry. A similar attempt to unify the description of destressing in these two classes of words is made by Travis (1982).

We have shown how a theory of syllable structure which recognizes the nucleus as a component of the syllable and which permits sonorants to appear as constituents of the nucleus can provide rather illuminating explanations of aspects of English stress and of the well-known liquid-glide variation attested for words like milk and help. Our analysis of certain processes of destressing in English is clearly incomplete. It should be viewed as an alternative approach to the investigation of the phenomena. A complete analysis along the lines we have suggested would have to account for the stress on words such as èleméntary and demónstrative. However, further investigations of English stress fall outside of the scope of this paper. In the sections to follow, we return to the central issue, i.e. the explanation of vowel and consonant epenthesis in terms of aspects of the theory of syllable structure which we have adopted.

3. Syllabification.

We said earlier that our analysis of epenthesis depends crucially on our conception of syllabification. Syllabification is a set of strategies/principles by which all the points of the skeleton and the segments to which they are linked are (exhaustively) assigned to well-formed syllables. Among the strategies is a principle which applies relatively freely, determining an initial set of syllable structures. This initial syllabification principle (ISP) which is stated roughly in (47) is mediated by a set of principles which include those cited in (48).

(47) Every skeletal slot is assigned to a position in a syllable, maximizing onsets (ISP).

(48) a. Every node of syllable structure must dominate at least one skeletal slot.

b. A vowel is associated with at least one nucleus.

c. A segment must be associated with a slot in the nucleus if it is specified [+vocalic].

d. A slot which is linked to a segment unspecified for the feature [vocalic] must be associated with a nucleus unless it precedes a slot linked to a [+vocalic] segment, in which case the former is assigned to the onset.

e. A [-vocalic] segment cannot be associated with the nucleus.

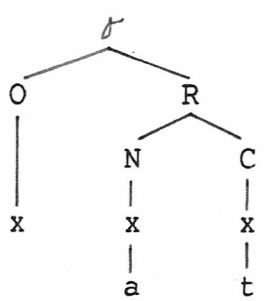
The initial set of syllables constructed in accordance with (47) and (48) must, of course, conform to the geometry of syllable structure which we have outlined earlier. Notice that (47) and (48) would construct syllables which could not have a coda as constituents, except when a syllable was the last one in the word. We may infer from this that the coda is a marked constituent of syllable structure.

The theory of syllabification which we adopt presupposes that the lexical representation of a word consists in part of a sequence of skeletal points which are linked to segments. For example, the English words <u>at</u> and <u>hat</u> would be represented as in (49a) and (49b), respectively.

(49) a.
```
x x
| |
a t
```
b.
```
x x x
| | |
h a t
```

Obviously, when syllabification applies to a representation such as (49a) a well formed syllable could only be constructed if a skeletal slot or point were posited under the onset. The requirements of syllable structure would be satisfied by the following:

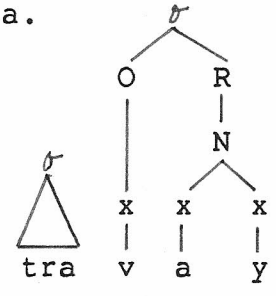
(50)



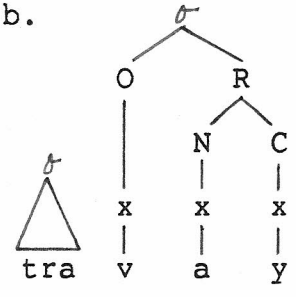
Thus, we must allow for skeletal slots to be added in the course of the derivation of syllable structure. This empty skeletal point (an empty node) will, of course, be automatically linked to the empty segment [e].

We assume with Kaye and Lowenstamm (1981b) that at the level of underlying representation the high vowels and corresponding high glides are not distinguished. We claim that they are unspecified for the feature [vocalic]. All other vowels are specified [+vocalic]. Principles (48c) and (48d) guarantee that long vowels and 'heavy diphthongs' will be initially analyzed as branching nuclei. If Kaye and Lowenstamm are correct in claiming that in French the glide in the final syllable of a word such as travail [travay] is assigned to the coda rather than to the nucleus, this would be regarded as a marked option triggered by a specific feature or constraint of French.<6> We could maintain that ISP associates the glide with the nucleus, giving a structure such as (51a) and that resyllabification reassigns the final glide to a coda (51b).

(51) a.



b.



Resyllabification is viewed as a set of strategies by which slots are reassigned to different positions in syllables if ISP creates structures that violate some substantive constraint, either universal or language-specific. For example, ISP would assign the sequence mb in a word like combat to the onset of the second syllable of the word. Since this sequence mb cannot appear in an onset in English, resyllabification will reassign the nasal to a position in the preceding syllable.

The principles of syllabification presented in (47) and (48) do not initially permit sonorant consonants to appear in the nucleus. It would seem that the appearance of such consonants in the nucleus is the manifestation of another marked option which is specifically permitted by a language particular rule or principle. Sonorant consonants may be assigned to the nucleus through one of two devices. A given language may include among the set of resyllabification strategies a principle such as (52).

(52) A [-vocalic] segment is associated with the nucleus iff it is also [+sonorant].

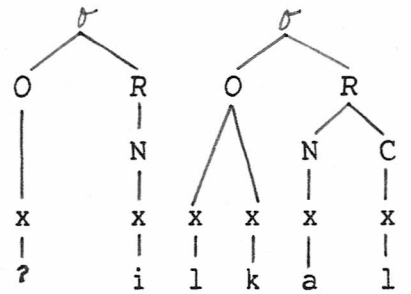
Alternatively, a language may undergo the rule which moves a sonorant into the nucleus. Crucially, application of the rule which moves a sonorant follows resyllabification. Both principle (52) and the rule which moves a sonorant are constrained by restrictions on which position in the nucleus sonorant consonants may occupy. We assume that in the unmarked case the sonorant appears as the righthand constituent of a nucleus. The sonorant consonant would, therefore, normally be associated with the non-head position.

Note carefully that principle (52) has a different status from the rule which moves a sonorant. The latter always leaves an empty node in the position vacated by the moved sonorant. On the other hand, principle (52) as one of the strategies of resyllabification does not create empty nodes. A further constraint on resyllabification strategies is that they cannot remove all the segments from the onset of the syllable.

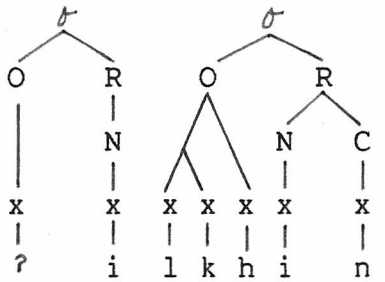
To summarize, we have argued that the skeletal slot and associated segments of a language are organized into syllables in the following stages. First, an initial set of syllables are constructed in accordance with the principles outlined in (47) and (48). These structures are then checked against the well-formedness conditions (or phonotactic constraints) of a given language and resyllabification strategies are applied to repair some or all the ill-formed structures. After resyllabification, a language may undergo the rule which moves a sonorant into the nucleus of a syllable, leaving an empty node.

Before considering what happens to the empty node created by the rule Move Sonorant it is instructive to see what happens when resyllabification cannot repair a violation of a well-formedness condition. An example of such a situation is provided by the Yawelmani dialect of Yokuts (Kisseberth 1970; Kenstowicz and Kisseberth 1977). This dialect is described as having a constraint against the occurrence of clusters of three consonants. Actually, the relevant constraint seems to be against a tautosyllabic cluster. The initial syllabification of the words ʔilk-al 'might sing' and ʔilk-hin 'sings' clearly results in violations of the constraint as it has just been reformulated.

(53)a.

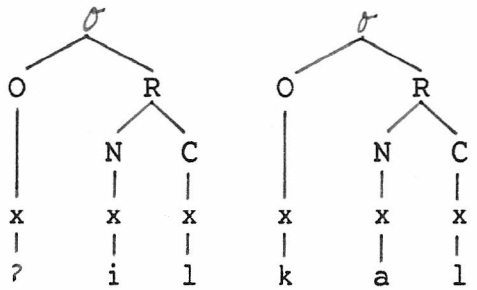


b.



Resyllabification of (53a) would produce the well-formed sequence of syllables in (54).

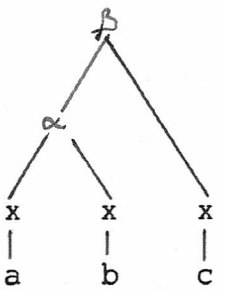
(54)



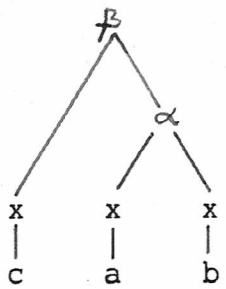
But it is impossible to reassign the segments in (53b) in such a way as to avoid violating the constraint against a tautosyllabic cluster. Whenever a situation such as this arises, the process which we refer to as Dislocation is triggered.

Dislocation removes that part of a syllable that contains the ill-formed structure. What is left must always be a well-formed syllable. The process does not simply remove segments, but actually prunes the branches and nodes associated with the segment or segments involved. Consider the application of Dislocation to structures like (55a) and (55b), where α and β are arbitrary labels for nodes and a, b, and c are segments.

(55) a.

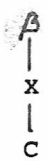


b.



If the ill-formedness in both cases result from the fact that a and b are sister constituents, the node α would, in most cases, be dislocated and the remaining structure would be as in (56) for both of the above.

(56)

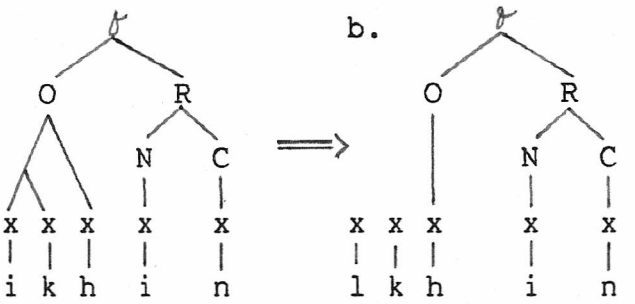


There is only one condition under which the entire node cannot be dislocated. When in a structure such as (55a) α is equivalent to the onset, then α cannot be dislocated. In such cases only the node dominating a is dislocated.

The restriction that Dislocation cannot prune the node Onset does not have to be stipulated, because it can be derived from another principle. It was pointed out earlier that the application of Dislocation, must leave behind a well-formed syllable. According to our conception of syllable structure a well-formed syllable must have an onset. Hence, Dislocation could never remove the onset from the syllable. On the other hand, the coda can and often is eliminated through application of the process of Dislocation, and this is consistent with the contention that the coda is only an optional constituent of the syllable.

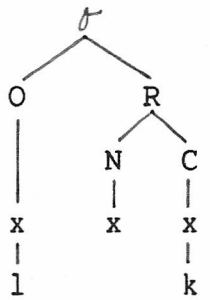
Returning now to our consideration of (53b), we see that after initial syllabification the second syllable of the word contains a violation of the constraint against a tautosyllabic cluster. Resyllabification would fail to repair the violation. Hence, the process of Dislocation must remove part of the onset of the second syllable. The immediate results are reflected in (57a) and (57b) (where only the second syllable is shown).

(57) a. b.



At this point in a derivation a general requirement, reflected in part in principle (47), that every skeletal point must be assigned to a position in syllable structure comes into play. The slots linked to the segments l and k are assigned to a new syllable. The mininal structure within which the constraint against tautosyllabic clusters would not be violated is (58).

(58)



According to the analysis of the Yawelmani dialect given in Kisseberth (1970), the underlying representation ʔilk-hin 'sings' undergoes a process of epenthesis which insert the vowel i , resulting in a surface form ʔilikhin. Notice, now, that under the analysis we have just motivated, this epenthetic i would be naturally assigned to the nucleus in a structure such as (58). We are now at the point where our explanation of vowel and consonant epenthesis can be presented.

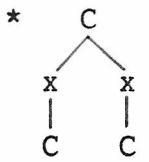
4. Explaining Epenthesis.

Our aim in this paper is to show that epenthetic consonants and vowels arise automatically to fill empty structural positions (i.e. empty nodes) that are created during the construction of syllables. We have just established that these empty nodes arise in two ways, either by moving a sonorant into the nucleus or by reconstructing a syllable after Dislocation has applied. We may now consider the representative cases of epenthesis introduced earlier in this paper. The derivation of epenthetic [ɨ] in the final syllable of the English word [bʌsɨz] buses follows Dislocation which is triggered by violation of the constraint

against a tautosyllabic sequence of strident, coronal consonants. Epenthesis in Lithuanian is similarly accounted for, the relevant constraint need not concern us at this stage.

The derivation of the epenthetic vowel in the final syllable of the Old English word /þymel/ 'thimble' may be used to demonstrate how our analysis works. We must assume the following constraint to be operative in Old English.

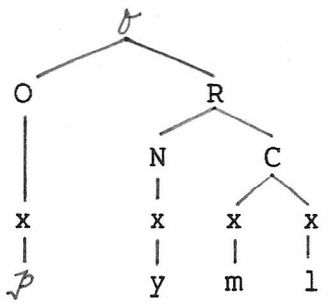
(59)



[+son]

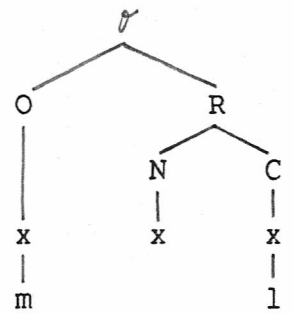
Thus there could be no well-formed syllable in which the coda contained a consonant clusters the second member of which was a sonorant. Given that the underlying representation of this word is /þyml/, application of initial syllabification strategies would produce the representation in (60).

(60)



Clearly, (60) contains a violation of (59) which cannot be repaired by resyllabification. (We are assuming, of course, that Old English does not allow sonorant consonants to appear in the nucleus.) Dislocation must therefore apply in order to remove the coda. The minimal structure required to accommodate the dislocated consonants m and l is (61).

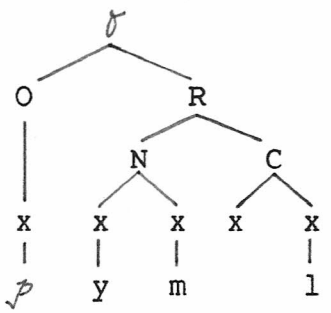
(61)



We have, thus, derived a structure with an empty slot in the nucleus which is filled by the vowel e , producing pymel.

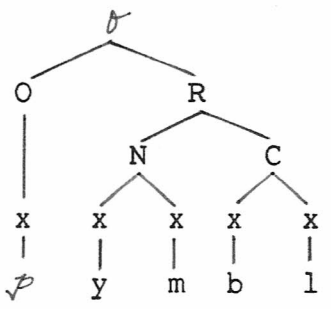
The historical change of pymel to pimble is illustrative of how consonant epenthesis is triggered. The crucial diachronic change is the innovation of the rule that moves a sonorant into the nucleus of a syllable. This rule always applies before Dislocation and would therefore change a representation such as (60) into (62) below.

(62)



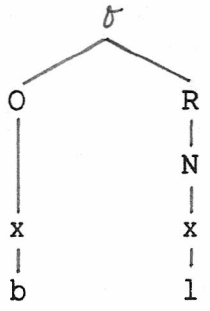
The empty node in the coda must automatically be filled and by a consonant, since vowels cannot appear in this position. Hence (62) must be changed as indicated in (63).

(63)



Dislocation which is applicable at this stage of the derivation removes the ill-formed coda, and a new syllable is constructed having the form of (64).

(64)



The structure in (64) is justified by the fact that, at this stage in the history of English, sonorants are permitted in the nucleus. Thus, the segment l would be the only segment in the nucleus and would be realized as syllabic. This historical analysis of the epenthetic consonant in a word such as þimble 'thimble' is applicable to the forms cited in (7). Of course, some of these forms also underwent Dislocation.

Turning now to the Old French data in (8), it is clear that the analysis which accounts for consonant-epenthesis in Old English may also be applied to the Old French forms in the first column of (8a) and (8b). One must postulate that Old French has a rule that moves the sonorant. The sonorant is initially assigned to the onset of a syllable and is subsequently reassigned to the coda by resyllabification. At this point in the derivation, the rule Move Sonorant applies, placing the sonorant into the nucleus and leaving an empty node in the coda. The appropriate analysis of the forms in (8c) is perhaps not immediately obvious. If the epenthetic t/d is to be accounted for in a manner appropriate to other instances of consonant-epenthesis, we would have to adopt one of two proposals: either the segment s is to be analysed as a sonorant or there is another rule that moves s into the nucleus. We wish to adopt the former proposal and regard s as a sonorant fricative. It appears that such a characterization of s can form a basis for explaining various aspects of the behaviour of this segment (and its voiced counterpart) in many languages.<7>

There is, fortunately, independent evidence which shows that Old French itself is one such language. Old French Apocope, Cluster-Simplification, and Early Syncope treat /s/ as if it were a sonorant. The patterning of /s/ with sonorants with respect to these rules is discussed in Reighard (1975). Old French Apocope is constrained from deleting final vowels preceded by consonantal clusters if the cluster contains a segment other than a sonorant

followed by an obstruent. It is, however, not blocked when the obstruent is preceded by a sonorant or /s/. Cluster-Simplification also treats /s/ like a sonorant as the examples below illustrate.

(65) rupta > route
testa > teste
porta > porte

The cluster is simplified in rupta but left untouched in testa and porta.

With respect to the early rule of syncope, /s/ also patterns with sonorants. The rule deletes a word-internal unstressed vowel between consonants provided one of the consonants is a sonorant or s. For example, praepósitu becomes prevost, but tépidu does not change to *tepdu. Similarly, cómite and mérula become comte and merle, respectively.

It should now be apparent that consonant-epenthesis is invariably associated with the moving of a sonorant, while vowel-epenthesis is linked to Dislocation. These correlations follow naturally from the position in which the empty nodes created after Dislocation and by movement are found. A non-sonorant consonant could not fill a position in the nucleus and a vowel would not appear in a position dominated by the coda. What is left to be explained is why epenthesis occurs, i.e. why the empty nodes must be filled.

We believe that this follows from a well-formedness condition which governs the relationship between segments and skeletal slots. This well-formedness condition is stated as (66) below.

(66) Every segment must be associated with a skeletal slot and every skeletal slot must be associated with a segment.

Given condition (66), it is obvious that an empty node that arises during a derivation could not remain unfilled.

We have actually suggested three ways in which empty nodes are filled. An empty segment is inserted under an onset; a consonant (t/d) is linked to a slot in the coda; or a vowel is inserted into the nucleus. The contexts are clearly complementary. The complementarity can be accommodated by assuming that at the point in derivation when empty slots are to be filled, the empty segment is first inserted wherever it can

be. It is, of course, limited to a single slot in the onset. After the onset is filled, the consonant (t/d) and the vowel are inserted under the coda and nucleus, respectively. A principle with an effect similar to (66) is given in Selkirk (1981:216) as the Syllable Completeness Condition.

Earlier we argued that a truly explanatory theory of phonology must distinguish those language-particular features or 'processes' of epenthesis from the more general ones. At this point, it is appropriate to evaluate our analysis in terms of how it succeeds in reflecting this distinction. Consider, first, the phenomenon of consonant epenthesis. The requirement that the inserted consonant must invariably be preceded by a sonorant follows from the fact that it is only a sonorant consonant that can move into the nucleus, thus leaving a structural position for the inserted consonant. That this inserted consonant is normally followed by another consonant can be attributed to the fact that the rule Move Sonorant, though a marked option, is linked to the strategies by which languages repair violations of phonotactic constraints involving sequences of segments (i.e. certain segments as sister constituents). In our analysis, we could account for the fact that the epenthetic consonant is invariably homorganic with the preceding sonorant by proposing as a universal principle that whenever an obstruent and a preceding sonorant are tautosyllabic they are invariably homorganic (i.e. assimilation is triggered). All that a particular grammar need state about consonant-epenthesis is the identity of the inserted consonant. But even this is not obviously necessary. It does seem possible to predict universally that the inserted consonant must be a non-continuant obstruent. If this could be firmly established, then the grammar of a particular language would say nothing at all about consonant-epenthesis.

With regard to vowel-epenthesis, we have established that the process of Dislocation with which the phenomenon is associated is triggered by a violation of a phonotactic constraint. These constraints are normally expressed as constraints on co-occurrence of consonants in certain structural configurations. Since Dislocation of a pair of consonants always results in reconstruction of a syllable in which one consonant is assigned to the onset and the other appears somewhere in the rime, usually in the coda, vowels must be inserted between consonants.<8> Unlike the situation with epenthetic consonants, it does appear that particular grammars must identify the vowel to be inserted, since the quality of this vowel seems to vary unpredictably. The statement of identification, if one is needed, could simply be a reference to some "minimal" vowel in that language.

If our analysis is accepted, then, the phenomenon of epenthesis reduces to the rule, Insert $\propto$, as Kaye and Lowenstamm (1981b) also conclude. This rule would be a part of

Universal Grammar. But it is probably inappropriate to characterize Insert ∝ as a rule, since it is entirely predictable from the well-formedness condition (66). It is an elementary operation that does not have to be learned. All that has to be learned is the set of conditions under which the learner has to move a sonorant or dislocate. The rest happens not because of a rule but because of a principle.

5. Conclusions.

We have argued that epenthesis, both consonantal and vocalic, is more appropriately seen as an automatic consequence of certain types of readjustments of metrical structure necessitated by violations of WFC's. One of the most obvious implications of our analysis of epenthesis is that putative cases of epenthesis that cannot be so derived cannot be properly regarded as epenthesis.

Morin (1982) provides an excellent example from French. The alternation ə - Ø found in the infinitive and the future conditional forms of some verbs, exemplified by forms like fonder [fɔ̃ndə] and fonderiez [fɔ̃dərje], has sometimes been analyzed as the result of a rule of epenthesis. The opposition, he argues, cannot be so analyzed semantically because of the existence of forms like fondre 'to melt' whose conditional is [fɔ̃drije]. Commenting on Bazylko's (1981) analysis of the alternation in question, he observes: "One does not need to look very far to find out that the free phonetic variation" observed by Bazylko is limited to two specific verb endings. Had it been a true phonological property of the language, one would see it elsewhere in the language. It is not possible to regard these alternations as examples of free phonetic variation, as Bazylko suggests, since the sort of free variation predicted by him just doesn't exist.

Neither Bazylko's analysis of / ə / as an epenthetic segment everywhere nor Klausenburger's (1980) analysis of the / ə / found in future conditional verbs as an epenthetic segment can be maintained. A simple case against the epenthetic analysis of at least some future conditional / ə / is, Morin argues, provided by the optional [ə] found after many verbs ending with two consonants as in (il) porterait. It cannot be an epenthetic vowel as it is not permitted in words such as portrait [pɔrtrɛ]. (The form *[pɔrtərɛ] is not a possible realization of this word.) Morin correctly concludes his discussion of the problem by observing that the / ə / in forms such as [fɔ̃dərje] must be regarded as a part of the lexical representations of such words.

Notice that what makes the vowel in English forms such as [bɔsɨz] an epenthetic vowel is the fact that it also occurs in other cases such as the past tense forms of verbs and possessive forms of nouns. One finds it in all and only the cases where

some specific WFC is violated during the course of a phonological derivation. The French case is different since the presence of the / ə / is not related to any global WFC of French.

Having discussed the difference between the English plural and the French future conditional case, we must point out that our analysis of consonantal epenthesis in OF and OE would not be tenable if it turns out that the WFC's we have postulated for these grammars do not hold "across-the-board" (cf. Singh:1982). If the segments in question are inserted only in specific morphological contexts and not globally, the appearance of these segments must be analyzed morphologically, i.e. as part of the lexical representation of the forms in which they are found. The point we would like to reiterate is that epenthesis is a consequence of specific readjustments under specific conditions despite the possibility that one (or more) of the cases we discuss may turn out to involve morphologization.

Our work is to be situated within the context of current work on metrical structure, but it is also an attempt to examine some of the questions raised by what Sommerstein (1977) calls the theory of phonotactics. Although phonotactically motivated phonological rules can often be simplified if they are formulated with reference to the WFC's that govern them, the primary objective of the theory of phonotactics is, according to Sommerstein, "to explicate the relationship between phonotactic constraints and phonological rules" (p.198). This relationship, we have argued, is of a rather abstract sort inasmuch as the phonological rules of epenthesis are mere consequences of certain metrical readjustments made necessary by violations of phonotactic constraints. There is, in other words, no direct relationship between the 'rule' and the constraint. The rule is merely a description of the result of the metrical readjustment and the consequent application of general, hopefully universal, principles. Although our explanation of epenthesis underlines the fact that a superficial theory of phonotactics is not likely to go far, they also point to the fact that standard generative phonology, following Postal's (1968) influential dicta, has erred in not assigning WFCs more than a heuristic role. The cases of epenthesis discussed in this paper provide systematic evidence for the centrality of phonotactic constraints.

If these constraints are duly accorded the centrality we wish to give them, phonological processes may have to be looked at a bit differently. Consider, for example, the proposal by Clements and Keyser (1981) regarding the syllabic structure of Klamath. They think that, apart from the characteristics stated in their syllabic template and a disambiguation rule for Klamath, there are no significant constraints on syllable structure that cannot be explained as consequences of the independently required rules of the phonology which insert and delete segments and otherwise simplify complex morphophonemic combinations. What we

have argued for is, in fact, quite the opposite. In other words, there may be no independently required rules of insertion.

Our analysis of epenthesis also partially confirms Schane's (1972) pretheoretical insight that "rules which delete or insert segments can only be of the syllable structure type" (211). One of the tasks left unaccomplished, though duly noted, by Schane was the formulation of precise conditions under which these processes take place. We hope to have formulated conditions under which one type of syllable structure 'rule' becomes operative.

Notes

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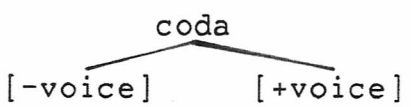
1. This and other constituents of syllable structure will be discussed later.

2. Singh considers the third principle to be necessary to account for the fact that the plural of cat is not /kætɪz/, given that the /z/ in /kætz/ is as unsyllabifiable as the /z/ in /bɔsz/. The WFC relevant to the former is:



The fourth principle is necessary to avoid derivations like /bɔsz/ ---> /bɔsɪs/.

3. Singh assumes, following Kiparsky (1979), that the nodes of syllable structure are labeled s or w, according to which labeling a segment dominated by s is relatively more sonorous than a segment dominated by w.

4. There is some evidence that the syllable has another (optional) constituent, the appendix. This will not figure in discussion of epenthesis and will therefore be ignored in this paper.

5. Notice that it would not be appropriate, as pointed out by Rubach (1977), to derive words such as /bʌtn̩/ 'button' from /bʌtən/.

6. Kaye (personal communication) suggests that this analysis of French "diphthongs" is a consequence of the fact that French does not permit the nucleus to branch.

7. It appears that /s/ is not the only fricative that, under certain conditions, behaves like a sonorant. Daniels (1972) and Beames (1836) argue that the development of /v/ as /w/ in Southern Russian and Pali, respectively, can be explained under the assumption that, in these cases, /v/ is a sonorant.

8. For the purpose of this presentation we will ignore prothetic vowels.

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