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Generative Generative Phonology

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The syntactic component σ of a generative grammar G can be thought of as a 4-tuple (N, T, A, R), in which N is the nonterminal vocabulary, T the terminal vocabulary, A the axioms, and R the syntactic rules. It is often assumed that the elements of T, the words of a grammar, can simply be listed in a word-dictionary. However, they cannot, as elementary considerations of the productivity of the rules of word formation immediately show us. To take a very simple example, consider the process whereby the prefix *re* can be joined to English verbs, to form new, morphologically complex, verbs. That process is not only productive, in the sense that given practically any verb in English, a new verb can be formed from it by prefixing *re;* it is also recursive, since *re* can be added freely to verbs already containing the prefix. Thus we have, in English, such infinite sets of words as {analyze, reanalyze, re-reanalyze, re-re-reanalyze, . . .}. Consequently, the elements of T cannot simply be listed. They must be generated.[1]

To generate the elements of T, we set up a morphological component μ of G of the form (N', T', A', R'). The nonterminal vocabulary N' of μ consists of morphological categories, one member of which, we may suppose, is W (for 'word'), which is the axiom A' of μ. The members of R' are the morphotactic rules and the elements of T' are the morphemes. Again, it is often assumed that the elements of T' can simply be listed in a morpheme-dictionary, and again that assumption is false. As Halle (1962) shows, there are more morphemes in a language than those which are associated with particular meanings or which combine with other morphemes to form meaningful words. In any language there are also meaningless morphemes that combine with no other morphemes to form meaningful words. In order for a string of phonemes to qualify as a morpheme in a language, it simply has to obey the phonotactic conditions of that language.[2] Now consider a language, such as English, which imposes no limitation on the length of its morphemes (where the length of a morpheme is the number of phonemes in it).[3] In such a language, there is no longest morpheme, and the set of morphemes is infinite.

Thus the morphemes of a language, like its words, must be generated. To generate them, we postulate a phonological component ϕ of G of the form (N'', T'', A'', R'').[4] The nonterminal vocabulary N'' of ϕ consists of the categories of phonology, including the category M (for 'morpheme') that we take to be the axiom A'' of ϕ. The rules R'' are the phonotactic rules and the members of T'' are the phonemes.[5] In the remaining discussion, we examine some aspects of the phonological component of English.

Besides M, we consider the membership of N'' to include S^3 (syllable cluster), S^2(syllable), S^1 (sonant cluster), S^0 (sonant), C^1 (consonant cluster,), and C^0 (consonant). As the notation for representing these categories suggests, the internal structure of a morpheme is a 'projection' of the segmental categories S and C.[6] A consonant cluster is headed by a consonant, which may be flanked by other consonant clusters (typically, but not necessarily, made up of single consonants). A sonant cluster is headed by a sonant, which may be flanked by other sonant clusters (again typically, but not necessarily, made up of single sonants).

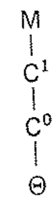
A syllable, in turn, is headed by a sonant cluster, which may be flanked by consonant clusters. The fact that a syllable is headed by a sonant cluster, which in turn is headed by a sonant, explains our use of S^2 as the category symbol for syllables. Syllables are projections, ultimately, of sonants. Finally, a syllable cluster is headed by a syllable, which may be flanked by syllable clusters.

A morpheme in English consists either of a consonant cluster, or of a syllable preceded by at most one syllable cluster and followed by at most two syllable clusters. Accordingly, the categorical rule schemata of the phonological component of English are those in (1):

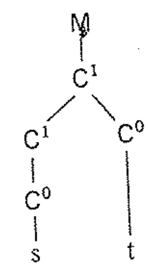
(1) a. $M \rightarrow \{C^1, (S^3)\ S^2\ (S^3\ (S^3))\}$
b. $S^3 \rightarrow (S^3)\ S^2\ (S^3)$
c. $S^2 \rightarrow (C^1)\ S^1\ (C^1)$
d. $S^1 \rightarrow (S^1)\ S^0\ (S^1)$
e. $C^1 \rightarrow (C^1)\ C^0\ (C^1)$

Like the categorical rules of the base subcomponent of the syntactic component, the categorical rules of the phonological component are context-free, and they associate with the terminal strings that are eventually generated structural descriptions in the form of tree diagrams or labeled bracketings. We illustrate this fact by diagramming in (2), (3), and (4) the structures that the schemata in (1) associate with various English morphemes, assuming the appropriate application of rules for inserting particular phonemes.[7]

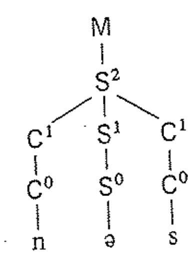
(2) a. *th*, /θ/



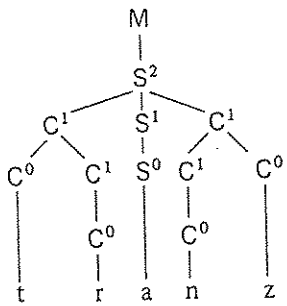
b. *st*, /st/



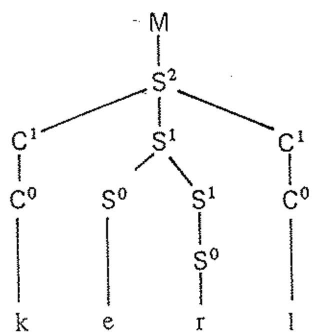
(3) a. *ness*, /nəs/



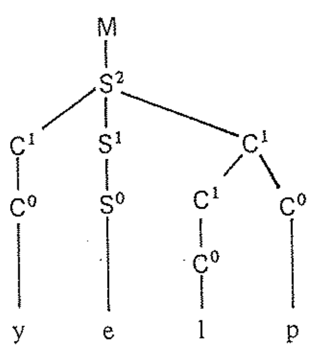
b. *trans*, /*tránz*/



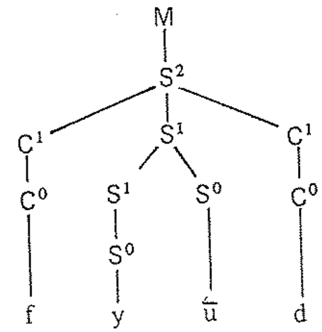
c. *curl*, /*kérl*/



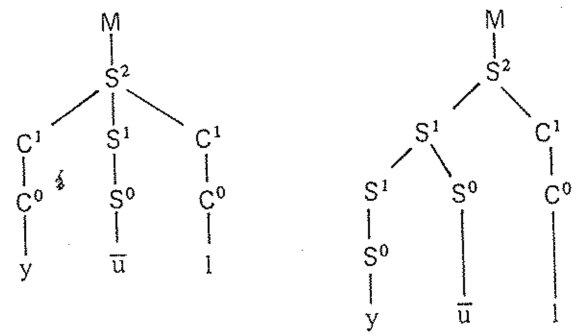
d. *yelp*, /*yélp*/



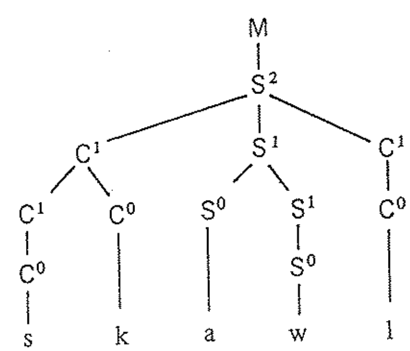
e. *feud*, /*fyūd*/



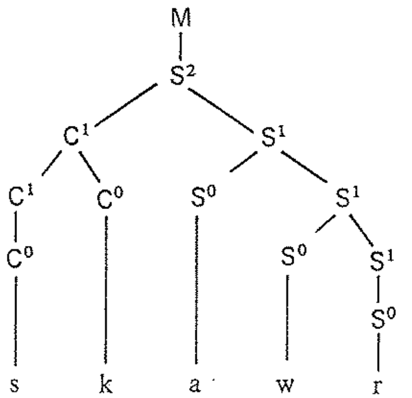
f. *yule*, /*yū́l*/



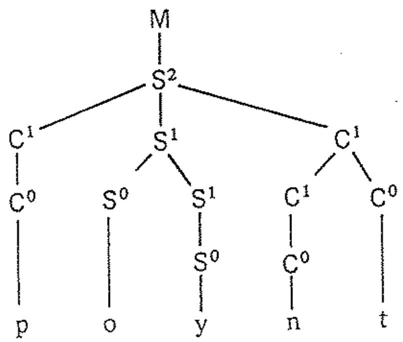
g. *scowl*, /*skául*/



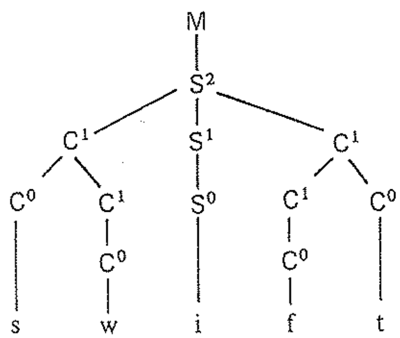
h. *scour, /skáwr/*



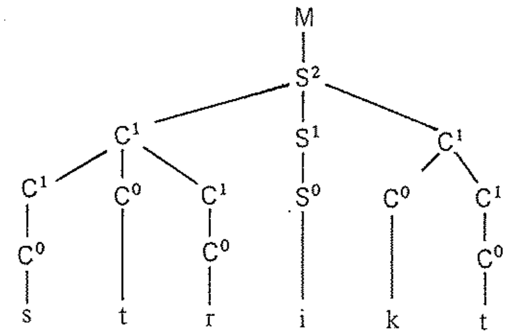
i. *point, /póynt/*



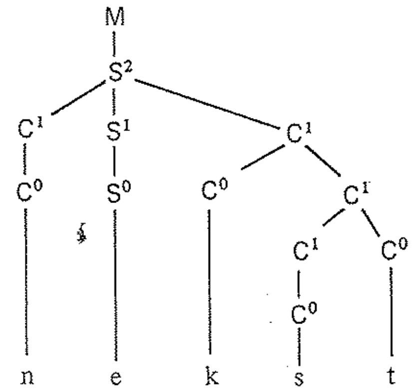
j. *swift, /swíft/*



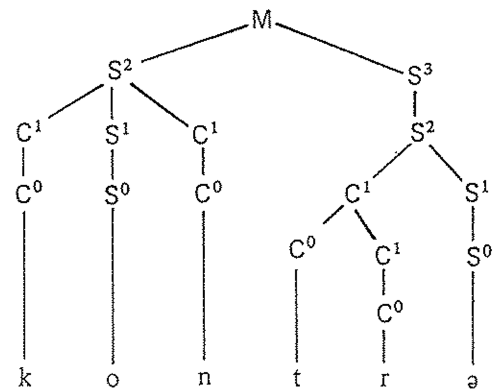
k. *strict, /stríkt/*



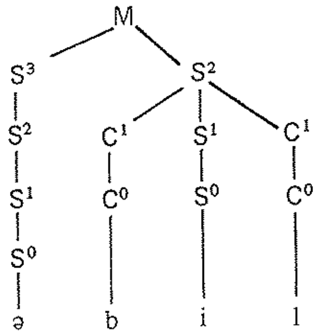
l. *next, /nékst/*



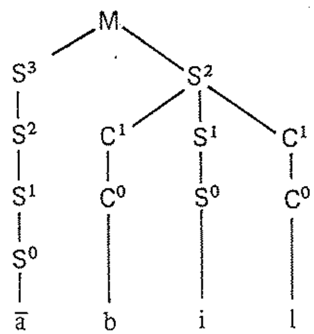
(4) a. *contra, /kóntrə/*



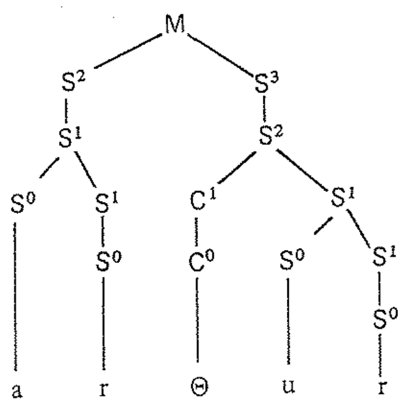
b. *able, /əbíl/*



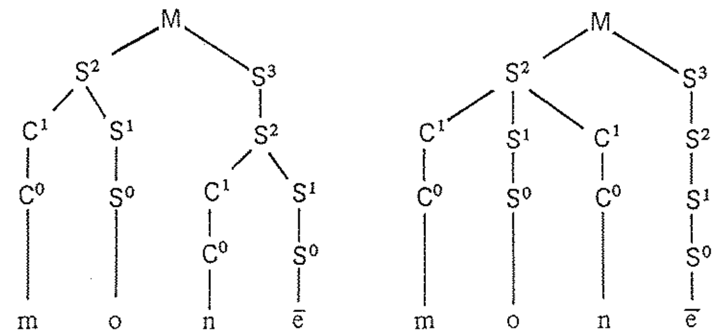
c. *able, /ā́bil/*



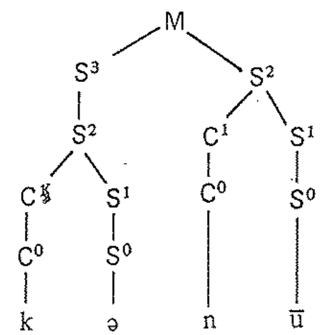
d. *Arthur, /árθur/*



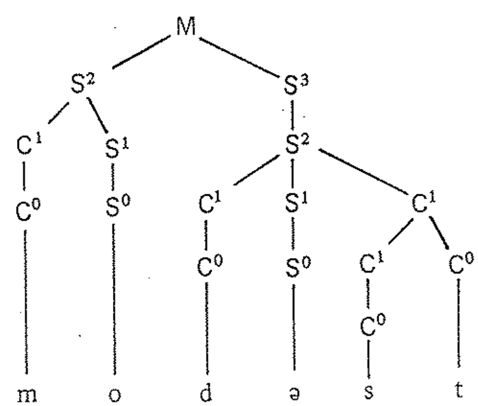
e. *money, /mónē/*



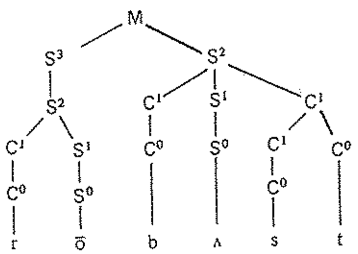
f. *canoe, /kənū́/*

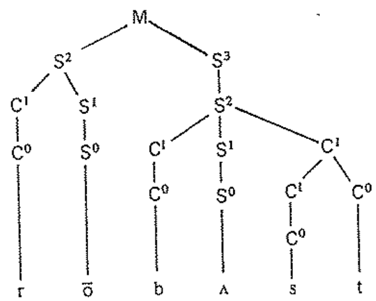


g. *modest, /mṓdəst/*

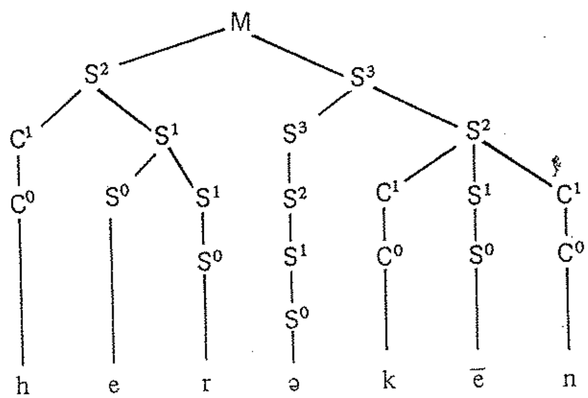


h. *robust*, /ròbʌ́st/ or /rṓbʌst/

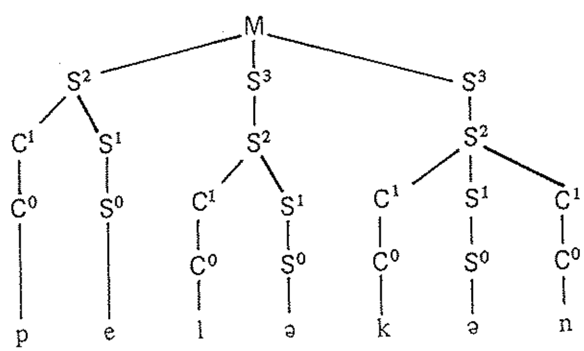




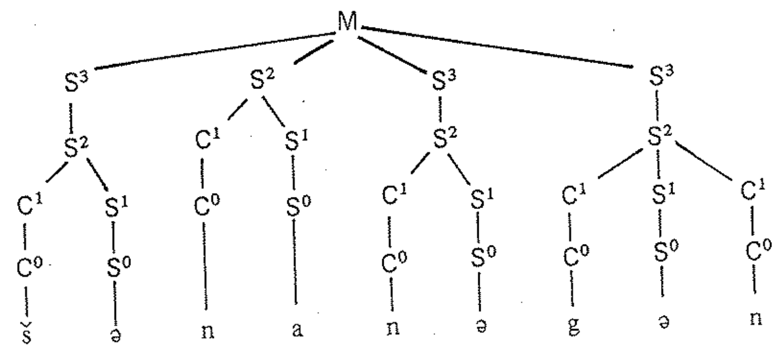
i. *hurricane*, /hérəkȅn/



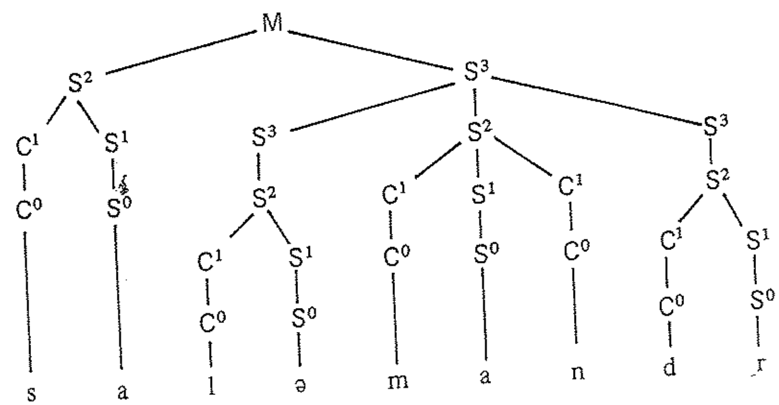
j. *pelican*, /péləkən/



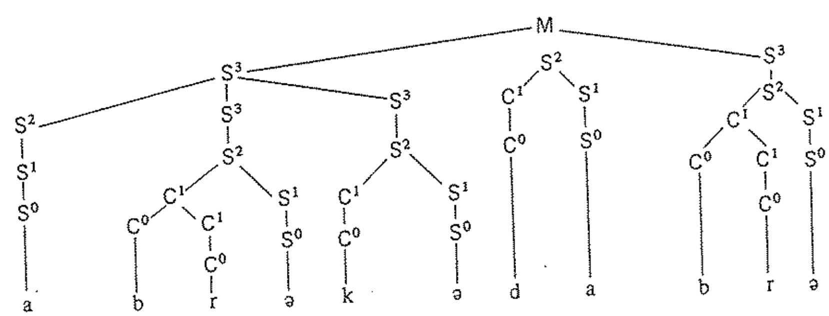
k. *schenanigan*, /šənánəgən/



l. *salamander*, /sáləmàndr/



m. *abracadabra*, ábrəkədábrə/



In English, morphemes consisting of a consonant cluster only, like those analyzed in (2), occur only as suffixes. The consonants that occur in them, however, must be (in the terminology of Chomsky & Halle, 1968) anterior coronals, since suffixal morphemes like *m* and *g* are impossible in English.[8]

The phonotactic structures of monosyllabic morphemes in English, like those analyzed in (3), have been studied by many investigators. Here we comment on some of the properties of those structures that are highlighted by the examples in (3). First, if the head sonant is not a full vowel, as in (3a), then it cannot be stressed and the morpheme must be a suffix. An English monosyllabic prefix, such as the one analyzed in (3b), must be headed by a stressed full vowel. Similarly, monosyllabic stems in English, as in (3c-1), must also be headed by stressed full vowels.

Second, certain phonemes, namely the glides *r*, *w*, and *y*, can occur either as sonants or as consonants. All three glides occur as sonants that follow a vowel within the head sonant cluster, forming a falling diphthong, as in (3c), (3g), and (3i). In some dialects, moreover, the glide *r* can also follow *w* within a sonant cluster to form a falling triphthong, as analyzed in (3h).[9] All three glides occur as consonants preceding the head sonant cluster, as in (3b), (3d), (3fi), (3j), and (3k); and both *r* and *w* (but not *y*) can combine with other head consonants in initial consonant clusters, as in (3b), (3j), and (3k). Finally, *y* can occur also as a sonant that precedes the vowel *ū* within the head sonant cluster, forming a rising diphthong, as in (3e) and (3fii). Accordingly, forms like /yélp/ and /fyūd/ are phonotactically unambiguous, as indicated in (3d) and (3e); whereas forms like /yū́l/ are phonotactically ambiguous, as indicated in (3f). In /yelp/, *y* must be analyzed as an initial consonant, since *y* does not form a rising diphthong with the head sonant *e*. In /fyūd/, on the other hand, *y* must be analyzed as a sonant, since *y* does not form initial consonant clusters with any other consonant. However, in /yūl/, *y* can be analyzed either as an initial consonant or as the first member of a rising diphthong.[10]

Third, the internal structure of the syllable establishes the order in which the segments are inserted. Consonants are inserted before sonants, and within clusters modifiers are inserted before heads. In this respect, segmental insertion in phonology is like lexical insertion in syntax.[11] As a result, the insertion of modifying consonants is the least constrained contextually, whereas the insertion of the head sonant is the most constrained. For example, the insertion of *s* in (3g), /skáwl/; (3h), /skáwr/; (3k), /stríkt/; and (3l), /nékst/ is unconstrained by the choice of the neighboring phonemes and is constrained only by its positions within the syllable structure (e.g., as the initial modifier of an initial consonant cluster, or as the initial modifier of the final modifier of a final consonant cluster). Indeed, in those positions, *s* is the only phoneme that can be chosen. On

the other hand, the insertion of *s* in (3j), /swíft/, is constrained by the choice of the following *w* (any of the phonemes *θ*, *s*, *t*, *d*, *k*, or *g* can occur as the head consonant of an initial consonant cluster when modified by a following *w*); if *r* had been chosen instead of *w*, then *s* could not have been inserted as the head of the initial consonant cluster (whereas any of the phonemes *p*, *b*, *f*, *θ*, *t*, *d*, *š*, *k*, or *g* could have been inserted).

Fourth, within a cluster, the choice of head is based on a principle of relative sonority, which states that the head of a sonant cluster may not be less sonorant than any of its modifiers (including consonantal modifiers) and that the head of a consonant cluster may not be more sonorant than any of its modifiers.[12] In case a cluster is made up of two segments of equal sonority, then the decision as to which is head is based on internal criteria. For example, in the cluster *kt* that appears in (3k), /stríkt/, we select *k* as the head and *t* as the modifier, since this choice makes for a simpler set of phonotactic rules. On the other hand, in the cluster *ft* that appears in (3j), /swíft/, *t* is the head and *f* is the modifier, since *f* is more sonorant than *t*. In most cases, including the one just mentioned, the decision to classify segments as heads or modifiers on the basis of the relative sonority principle results in the choice of the simplest set of phonotactic rules. One exception that I am aware of is the classification of *s* as the head of initial *sm* and *sn* clusters in such morphemes as *smear*, /smḗr/, and *sneer*, /snḗr/. If we were to take *m* and *n* as head and *s* as modifier in these clusters, contrary to the relative sonority principle, then we would have to mention the phonemes *m* and *n* in only one phonotactic rule schema having to do with initial consonant clusters (namely, one in which they are inserted as heads following a modifying *s*); whereas if we treat *s* as head and *m* and *n* as modifiers, in conformity with the relative sonority principle, then the phonemes *m* and *n* must be mentioned in two such phonotactic rule schemata (one in which they are inserted in modifier position following a head consonant, along with *l*, *r*, *w*, and *y*; and another in which *s* alone is inserted as head before *m*, *n*, *l*, or *w*). Despite the added complexity that results from treating *s* as head consonant in initial *sm* and *sn* clusters in English, I prefer that treatment to one which requires abandoning the relative sonority principle in this case.[13]

We turn finally to the polysyllabic morphemes that are analyzed in (4). Perhaps the most salient property of these analyses is their resemblance to the metrical trees of Liberman and Prince (1977). In particular, the symbol S^2 that occurs in them corresponds to Liberman and Prince's *S* (for 'strong'), and the symbol S^3 corresponds to their *W* (for 'weak'). This correspondence is not accidental, since we can consider the S^2s that are introduced by rule schemata (1a) and (1b) to be nuclear, that is metrically 'strong'; and the S^3s that are introduced by those schemata to be peripheral, that is metrically 'weak'.[14] However, unlike Liberman and

Prince's trees, the trees in (3) and (4) include ternary- and even quaternary-branching structures. The reason for our departure from Liberman and Prince's strict adherence to binary branching is our adoption of the principles of the $\overline{X}$-theory of constituent structure for phonotactics, which does not grant any special significance to binary branching.

As in Liberman and Prince's analysis of stress assignment, the relative stress prominence of a syllable in a polysyllabic morpheme can be determined by its position in the tree structure for that morpheme.[15]. Primary stress falls on the head sonant of that syllable in the morpheme that is immediately dominated by *M*. In general, the relative prominence of a syllable in a polysyllabic morpheme is inversely related to the number of occurrences of S^3 that intervene between it and *M* in the tree diagram for that morpheme. Thus, in the bisyllabic morphemes in (4a–h), the stressed syllable is immediately dominated by *M*, while the unstressed syllable is immediately dominated by S^3, which is immediately dominated by *M*. A similar situation holds for the trisyllabic morpheme (4j), /péləken/, and for the tetrasyllabic morpheme (4k), /šənánəgən/. In the morphemes (4i), /hérəkḕn/, and (4l), /sáləmàndr/, the primary-stressed syllables are immediately dominated by *M*, the secondary-stressed syllables are separated from *M* by exactly one occurrence of S^3, and the unstressed syllables are separated from *M* by exactly two occurrences of S^3. Finally, in (4m), /àbrə kədábrə/, we note that the stress pattern accords with the analysis, together with the principle that syllables that are not headed by full vowels are always unstressed (cf. note 14).[16]

As the two analyses of (4e), /mónē/, illustrate, there is a certain amount of ambiguity that arises because of different possibilities of syllable division within morphemes. This type of ambiguity is like the phonotactic ambiguity of morphemes like (3f), /yūl/, noted above, and requires no further discussion.[17] Another type of ambiguity can arise depending on which syllable is made head and which are made modifiers. As the analysis of (4h) illustrates, this ambiguity is reflected in the stress patterns that are assigned to the morphemes.

While the choice between /rṑbʌ́st/ and /rṓbʌ̀st/ is, in my dialect, completely free, not all such choices are as free as that. For example, the choice between *Tennessee*, /tènəsḗ/, and *Tennessee*, /ténəsḕ/, depends on whether the word consisting of this morpheme occurs as head of its phrase or not, as illustrated in (5).

(5) a. Arthur visited Tennessee (/tènəsḗ/).
b. Arthur visited the Tennessee (/ténəsḗ/) Valley.
c. Arthur visited Tennessee's (/ténəsḕ/) capital.

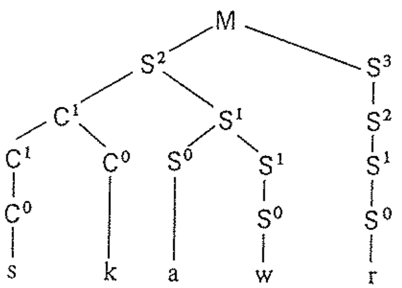
This patterning clearly shows that the two variants, /tènəsḗ/ and /ténəsḕ/, are indeed two different morphemes, and that a choice between them may be made on syntactic grounds.

I conclude this discussion of the analysis of English phonotactics by noting that the order in which segments are inserted into polysyllabic morphemes follows the same logic as the order of insertion of segments into monosyllabic or nonsyllabic morphemes. First the segments of the most deeply embedded modifying syllables are inserted (those with the least degree of stress), followed by the insertion of the segments of the next most deeply embedded modifying syllables, and so forth, until the head syllable is reached. Thus the insertion of the segments appearing in stressed syllables can be made dependent on the occurrence of segments in unstressed syllables, but not conversely. There is abundant evidence for the correctness of this assumption, but the discussion and analysis of that evidence must await another occasion.

NOTES

1. Not only the morphological structures, but also the semantic structures, of the elements of *T* must be generated. How this is done is beyond the scope of this essay; for discussion, see Langendoen (1982).
2. I assume that each morpheme has an underlying phonemic shape, which may be altered by application of morphophonemic rules, the discussion of which is also beyond the scope of this essay.
3. I take the claim that there is no phonotactic limitation on the length of English morphemes as not requiring detailed justification. There is, to be sure, a longest meaningful morpheme in English, but its length (whatever it is) is not a consequence of a phonotactic limitation.
4. Once again, we omit consideration of the semantic properties of morphemes. We may assume that one of the tasks of the semantic component of a generative grammar is to generate a set of semantic structures, a finite subset of which is associated with morphemes of the language by an arbitrary pairing.
5. The phonological component ϕ of *G* is thus very much like the 'phonological grammar' of Householder (1959).
6. The notation is that of the $\overline{X}$-theory of phrase-structure grammar, proposed originally by Chomsky (1970) and developed in detail by Jackendoff (1977).
7. We give the morphemes first as they are spelled in English and second in their underlying phonemic forms. Phonemic representations, when not given in tree-diagrammatic forms, are enclosed within solidi.
8. Note that this is a restriction of the underlying phonological forms of morphemes, not on their surface forms. The contracted form *m* (from *am*, /ăm/) is not coronal, and the contracted form *r* (from *are*, /ăr/) is not anterior.

9. In those dialects in which forms like *scour* are disyllabic, the analysis is as in (i):
   (i) scour, /skáwr/



10. The problem then arises of accounting for the fact that the morphemes represented by /yūl/ are associated with the same semantic structure. I assume that this is not a problem that requires a solution within English grammar but that it is a problem for linguistic theory. Essentially what is needed is a principle from which it follows that identical sequences of phonemes in a language receive the same pairings with semantic structures. We may presume that this principle (whatever it is) establishes the general range within which so-called 'free-variants' can vary both phonemically and phonotactically.
11. In syntax, nouns (like consonants) are inserted before verbs (like sonants), and modifiers are inserted before heads; cf. Chomsky (1965, chapter 2).
12. I am indebted to Janet Fodor for this insight. I assume that full vowels are more sonorant than reduced vowels, which are more sonorant than glides, which are more sonorant than liquids, which are more sonorant than nasals, which are more sonorant than aspirates, which are more sonorant than fricatives, which are more sonorant than affricates, which are more sonorant than stops.
13. One important consequence of the relative sonority principle is that initial consonant clusters like *str* in (3j), /stríkt/, and final consonant clusters like *mps* in *glimpse* /glímps/, must be analyzed as ternary-branching. Thus we predict that the insertion of certain head consonants may depend on the prior choice of both the modifier that precedes it and the modifier that follows it. As a case in point, consider the rule schema that inserts the head *t* in initial consonant clusters. If no modifier precedes, then either *r* or *w* can follow, as in (3b) /tránz/, and *twist*, /twíst/. However, if *s* precedes, then only *r* can follow (/stwíkt/ is not a possible English morpheme; at best it will be heard as a misrendering of /stríkt/).
14. Except that an S^2 that is headed by a sonant that is not a full vowel is necessarily metrically weak, as in (3a), /nəs/.
15. Liberman and Prince's trees actually analyze words, not morphemes. It is beyond the scope of this essay to consider the analysis of English word stress and metrical structure; see Langendoen (1982) for discussion.

16. We also assume the converse principle of Chomsky and Halle (1968), namely, that syllables headed by full vowels that fall in an unstressed position *in a word* are reduced. Thus, for example, the vowel *i* that heads the second syllable in (4b), /ā́bil/ is reduced in the word *able*. On the other hand, in the word *ability*, it is the vowel *ā* of the first syllable that reduces thanks to this principle.
17. Except to point out that certain investigators prefer to think that bisyllabic morphemes like (4e), /mónē/, have a single phonotactic analysis, in which the intervocalic consonant simultaneously belongs to both syllables (see Kahn, 1976, for a detailed justification of this position). Obviously, such a treatment cannot be accommodated within the framework presented here, since we assume that the phonotactic structures of morphemes are generated by constituent-structure grammars. In defense of our position, it may be noted that it treats the analysis of morphemes like /mónē/ on a par with the analysis of (3f), /yū́l/, and (4h), /rṑbʌ́st/ or /rṓbʌ̀st/, namely as falling within the scope of a principle of free variation (see note 10). This is a generalization that is not expressible in frameworks like Kahn's.

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