

The Organization of Phonology: from rule-based approaches to constraint-based approaches [2]

—The role of syllable structure and low-level phonetic alternations—

Takahiro IOROI

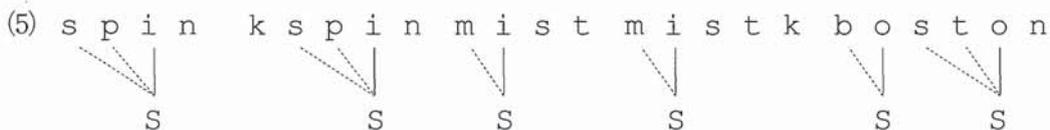
Table of Contents

0	Introduction
1	A review of previous studies on syllable structure
1.1	Kahn (1976)
1.2	Kiparsky (1979)
1.3	Problems
2	Syllabification in the theory of Lexical Phonology
2.1	The universal syllable template and the governing principle
2.2	Foot formation
2.3	Ambisyllabicity and the link between the Coda and the Onset
3	Consonant Laxing
4	Flapping
5	Aspiration
6	Glottalization
7	Consonant alternation and schwa deletion
8.	Assimilation
8.1	Nasalization
8.2	Palatalization
8.3	Rule Ordering of palatalization and other rules
8.4	<i>R</i> -coloring
8.5	Ordering of <i>r</i> -coloring
9.	Conclusion
	Bibliography

0 Introduction

As a continuation of Ioroi (1999), this paper tries to put the development of phonological theory in a historical perspective, focusing on the roles of rule ordering and syllable structure. The original text was written almost fifteen years ago, and the framework assumed and the proposals made herein are,

dashed lines, with the solid lines in each syllable having been drawn by Rule I):



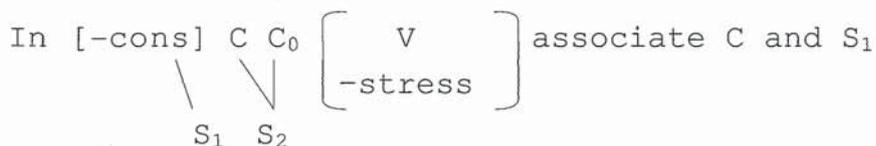
Applying Rule IIb to the sequences of segments in (5), we obtain the representations below:



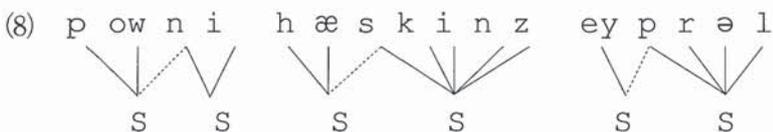
In (6), Rule II is unable to link the /k/ in **kspin* and **mistk* to any syllable because there is no word attested that would allow such consonant clusters. As a result, these hypothetical words are ruled out.

The third rule is formulated as follows:

(7) Syllable Structure Assignment Rule III (Kahn 1976:48)



Rule III syllabifies a given sequence of segments at the normal speed of speech and is responsible for the ambisyllabicity of segments. Note that this rule accounts for the alternations of consonants discussed below. For example, the syllable structures of *pony*, *Haskins* and *April* that are generated by Rule III are indicated with broken lines:

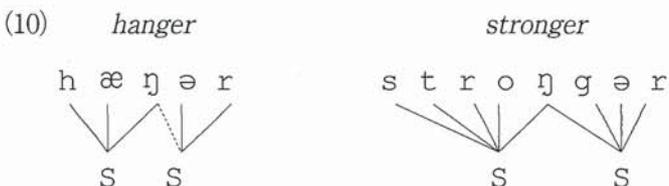


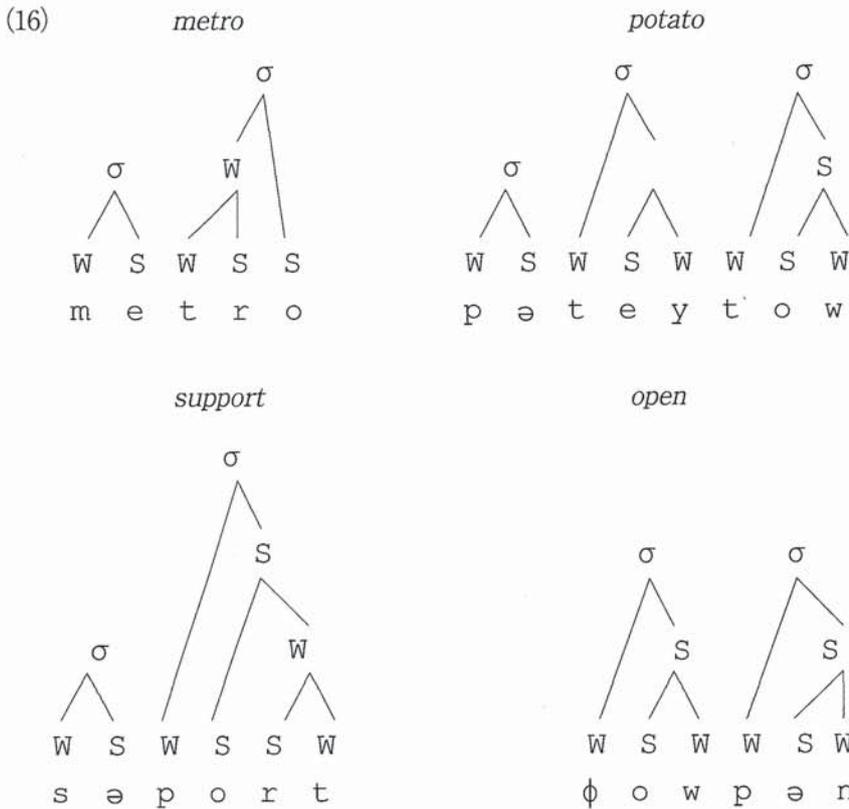
Kahn (1976) proposes another rule that accounts for the ambisyllabicity of segments. It is similar to Rule III but differs from it in that it operates leftward. He formulates the latter rule as follows:

(9) Syllable Structure Assignment Rule IV (Kahn 1976: 49)



In (10) are given some examples to which Rule IV applies. The broken lines represent the associations between syllables and segments (assuming that Rule I and II have been applied):

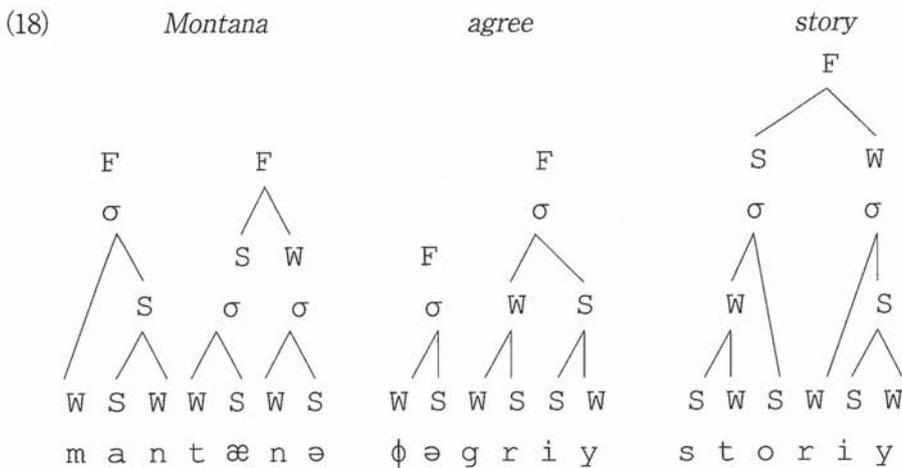




In Kiparsky's theory, it is the foot that plays the crucial role of determining the application of rules such as laxing, aspiration, flapping and glottalization. He defines the notion of the foot as follows:

(17) By the foot I mean a metrical entity constituting of a syllable followed by any number of unstressed syllables, which are dominated by a single metrical node.²

For example, *Montana*, *agree* and *story* has the following metrical structures, respectively:



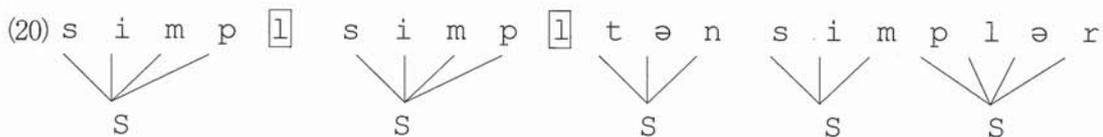
1.3 Problems

Note that the theories reviewed above are not immune to problems; in fact, there are flaws in both of them. Let us discuss them in order.

Consider the following examples:

- (19) a. *simple* [sɪmpəl] /sɪmpl/
 b. *simpleton* [sɪmpəl̩tən] /sɪmpl̩tən/
 c. *simpler* [sɪmpəl̩r] /sɪmpl̩r/ (l̩ = a syllabic l)

In Kahn's (1976) it was considered that a segment that has a specification [+syllabic] must be associated with only one syllable.



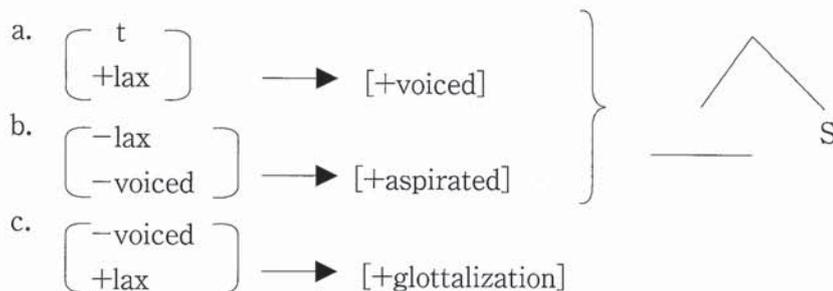
The problem is that no syllable can afford to pick up the /l/s of simple and simpleton due to the feature [+syllabic] on them.

Next, let us move on to the problem with Kiparsky's (1979) analysis. He proposed a rule to account for the weakening of consonants after a nonconsonantal segment in the same foot. This laxing rule provides a path to some of the postcyclic rules that account for the behavior of stop consonants. The rules he proposed are reproduced below:

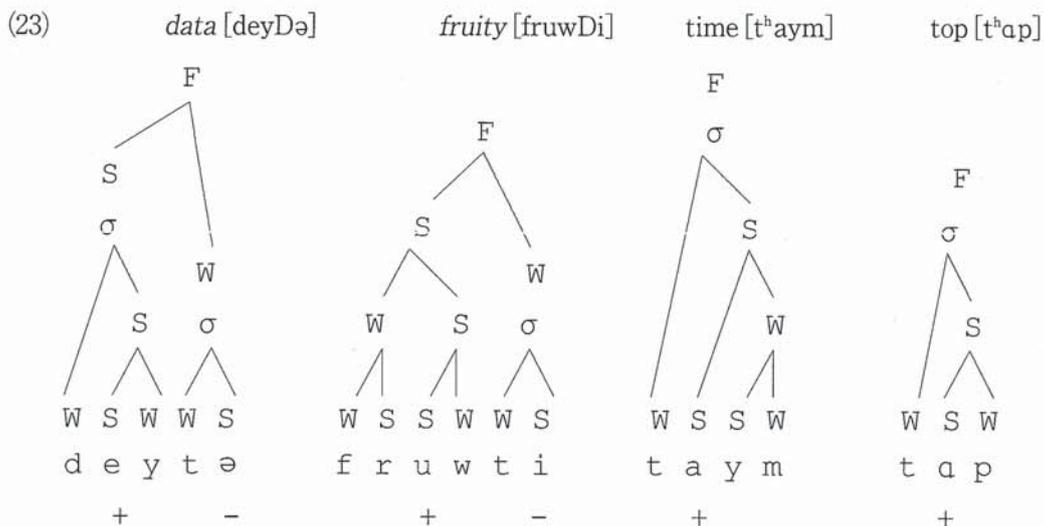
(21) Laxing

$$C \rightarrow [+lax] / \text{r}[\dots [-cons] ___ \dots]_F$$

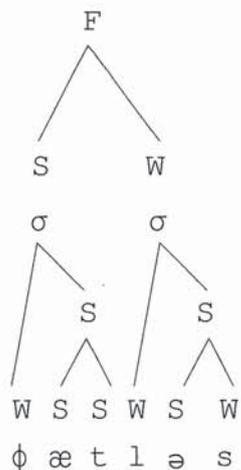
(22) Post cyclic rules



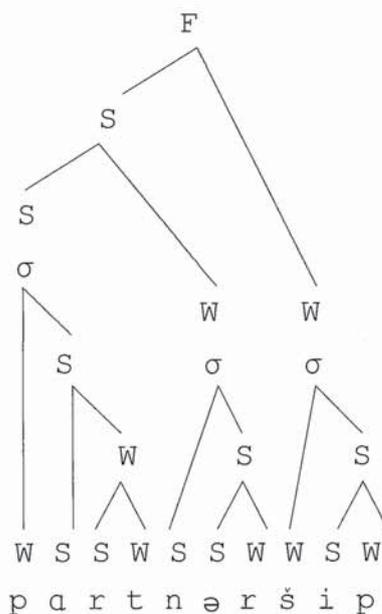
Rule (22a) makes a syllable initial /t/ voiced; rule (22b) aspirates a nonlax voiceless consonant; rule (22c) glottalizes a lax voiceless consonant. Some examples are given below:



atlas [æʔləs]

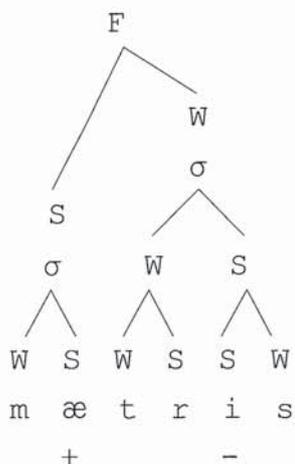


partnership [pʰɑrʔnəʃɪp]

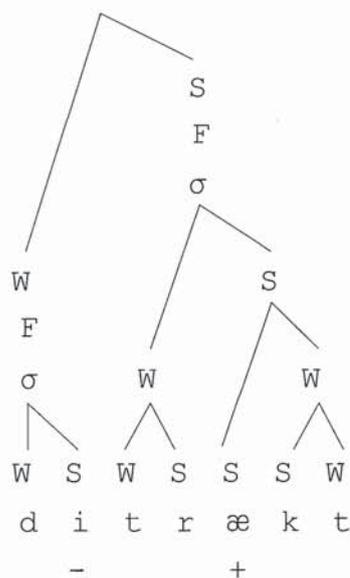


However, the following words raise a problem.

(24) *mattress*



detract



As far as the laxing rule is formulated as in (21), it assigns [+lax] not only to the /t/ of the words in (24) as well as those in (23). Kahn (1976) points out that the /t/ in *mattress* and *detract* is never flapped; however, Kiparsky's theory predicts that it will be realized as flap /D/.

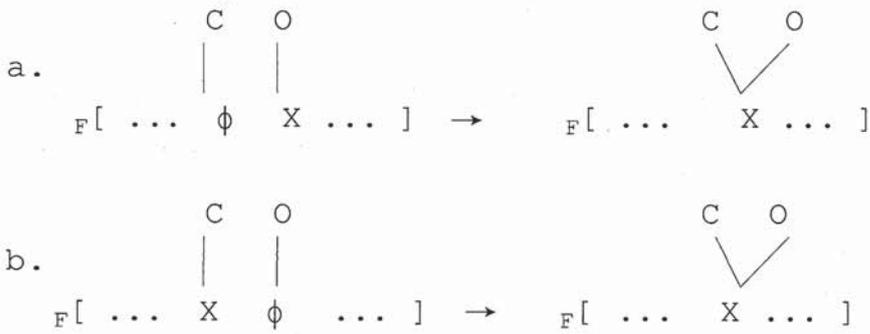
2 Syllabification in lexical phonology

2.1 The universal syllable template and convention

In this section we consider how syllabification processes are operated without suffering the difficulty Kahn (1976) and Kiparsky (1979) had to face.

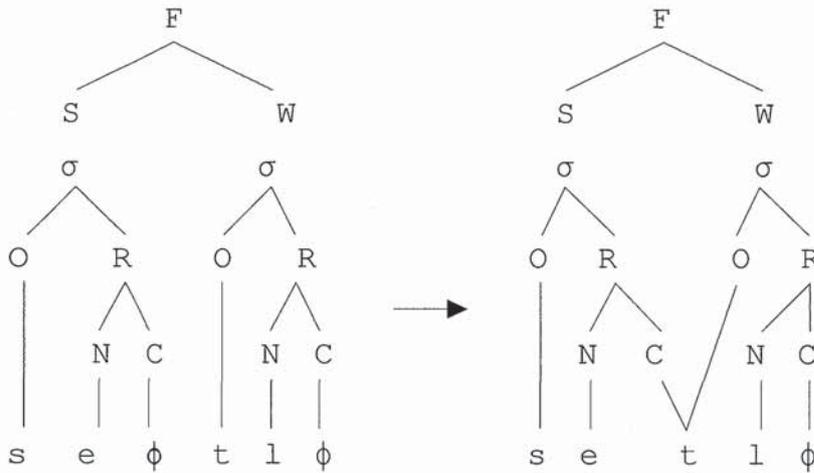
account for the status of ambisyllabic consonants.³ In the present analysis, let us posit the following rule:

(28) Coda-Onset Linking



For example, *settle* undergoes the following process:

(29) *settle*



3. Laxing Rule

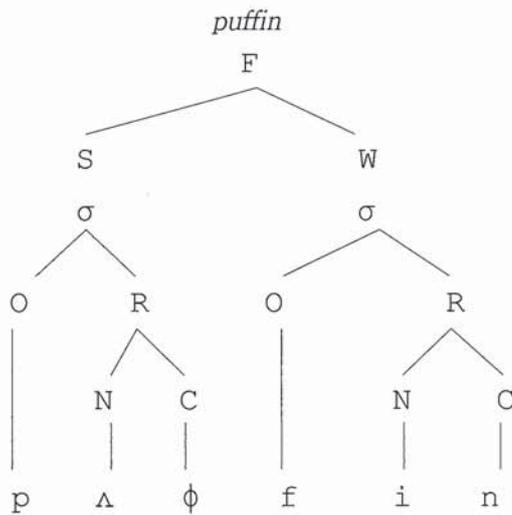
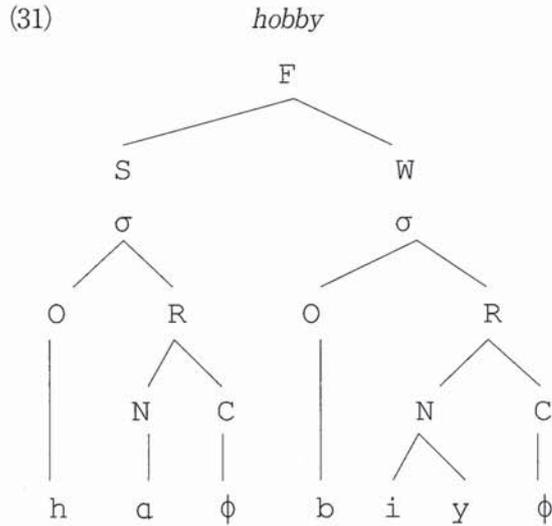
In (30) are presented a list of lax consonants that occur within a word:

(30) Lax medial consonants⁴

- /b/ *hobby, hobo, Sabbath*
- /d/ *caddy, ladder, bloody*
- /g/ *leggy, agate, spigot*
- /m/ *seminar, chroma, comma*
- /n/ *penny, funny, lanolin*
- /f/ *stuffy, fluffy, puffin, buffet, philosophy*
- /v/ *covey, covet, divot*
- /z/ *fusing, music, easy, dizzy*
- /ʃ/ *pushy, bushy, cushion, crucial*
- /ʒ/ *Asia, allusion, fusion*
- /j/ *magic, eulogy*

- /l/ *folly, silly, alley*
- /r/ *sorry, story, torrent*
- /θ/ *ether, ethic, method*
- /ð/ *rhythm, either*

Notice that all the lax consonants appear in an unstressed syllable. For example, *hobby*, and *puffin*, for example, are assigned the following representations by the template and convention in (25) and (26).

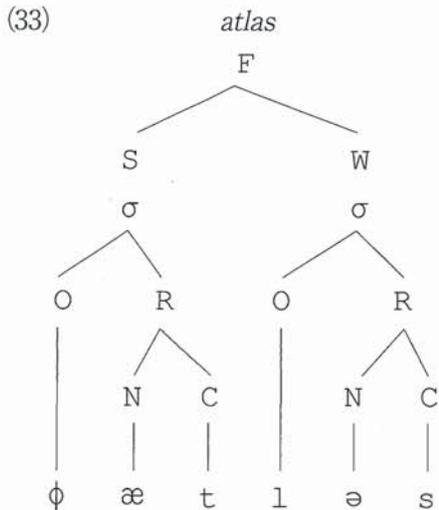


We see that it is at the Onset position of the second syllable in a foot that a lax consonant occurs. Let us posit the laxing rule in (32).

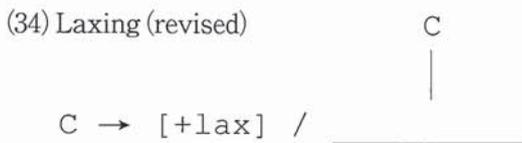
(32) Laxing (preliminary version)

$$C \rightarrow [+lax] / [F \dots X \overset{\sigma_1}{\mid} \overset{\sigma_2}{\mid} \dots]$$

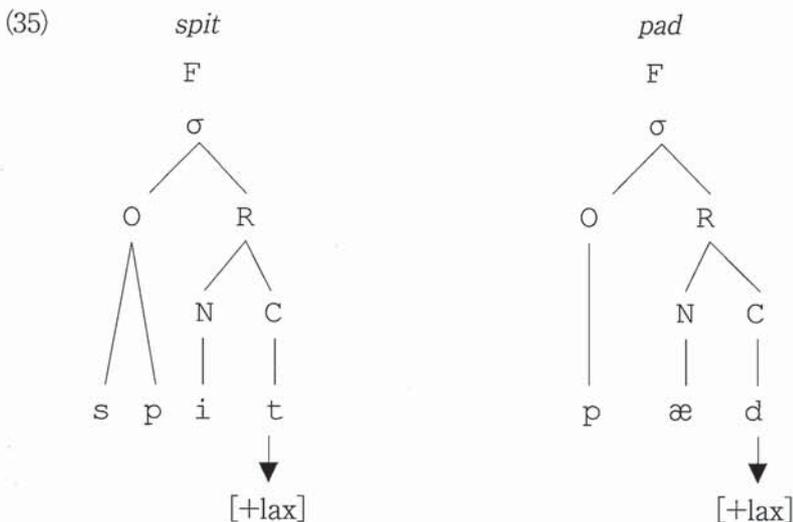
Actually, this rule is not sufficiently stated, because it fails to account for the /t/ in *atlas*, which turns out to be lax, as Kiparsky (1979) points out.



The lax consonants in (30) are all situated in the Onset position of a syllable that is preceded by a stressed syllable, whereas the /t/ in *atlas* holds a Coda position. As a result, we cannot apply Laxing in this case because it fails to meet the structural description of rule (32). However, this difficulty can be overcome with recourse to Coda-Onset Linking and a simplification of the laxing rule.



Rule (34) simply assigns [+lax] to any consonant in the Coda; accordingly, it applies not only word-internally but also word-finally, as the following examples illustrate:



Thus, given the assumption that Coda-Onset Linking applies at a certain stage earlier than laxing, there is no difficulty accounting for all the occurrences of lax consonants. In the following sections, we will consider some different types of low-level phonetic alternation in order.

3 Flapping

Flapping is a phenomenon that is often observed in the American varieties of English. Let us begin

with Kahn's (1976: 92) remark:

- (36) "Flap" refers to the characteristic motion of the tongue tip in articulating [D], which is quite different from normal stop articulation.

Flapped consonants occur at the word-initial and word-final positions as well as at the word-internal position. In (37) are listed the types of positions in which /t/ undergoes flapping.⁵

- (37) a. Word-internal

<i>later</i>	<i>dedicated</i>	<i>little</i>
<i>loiter</i>	<i>Marty</i>	<i>Beatles</i>
<i>shouting</i>	<i>artery</i>	<i>bottle</i>
<i>setting</i>	<i>watery</i>	<i>subtle</i>
<i>buttery</i>	<i>potato</i>	<i>title</i>
<i>flattery</i>	<i>city</i>	<i>cattle</i>
<i>data</i>	<i>fruity</i>	<i>kettle</i>

- b. Word-initial

...door to.. ...four to... I'll see you tomorrow.

- c. Word-final

...it a... ...plant it... built a... ...about a...

Examples of the flapped /d/ are:

- (38) a. Word-internal

<i>alre<u>ady</u></i>	<i>yeste<u>rd</u>ay</i>	<i>ra<u>d</u>io</i>
<i>bo<u>d</u>y</i>	<i>bla<u>dd</u>er</i>	

- b. Word-initial

...the detection... ...to do... ...I did...

- c. Word-final

...would if... ...side of... ...read about...
...could ever... ...good equipment...

Not also that /n/ may turn out to be nasalized flap /D/, as exemplified by the following cases:

- (39) a. Word-internal

<i>any<u>way</u></i>	<i>in<u>ner</u></i>	<i>mo<u>ney</u></i>
<i>electro<u>n</u>ics</i>	<i>refin<u>er</u>ies</i>	<i>ma<u>ny</u></i>

- b. Word-initial

...you know... ...or no.. ...car needs...

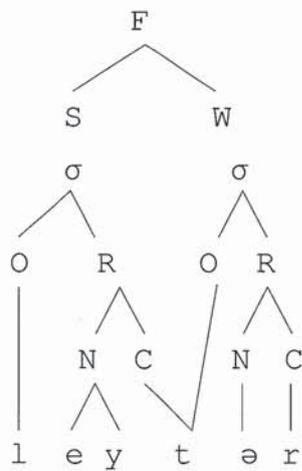
- c. Word-final

...on a... ...on his... ...run it...

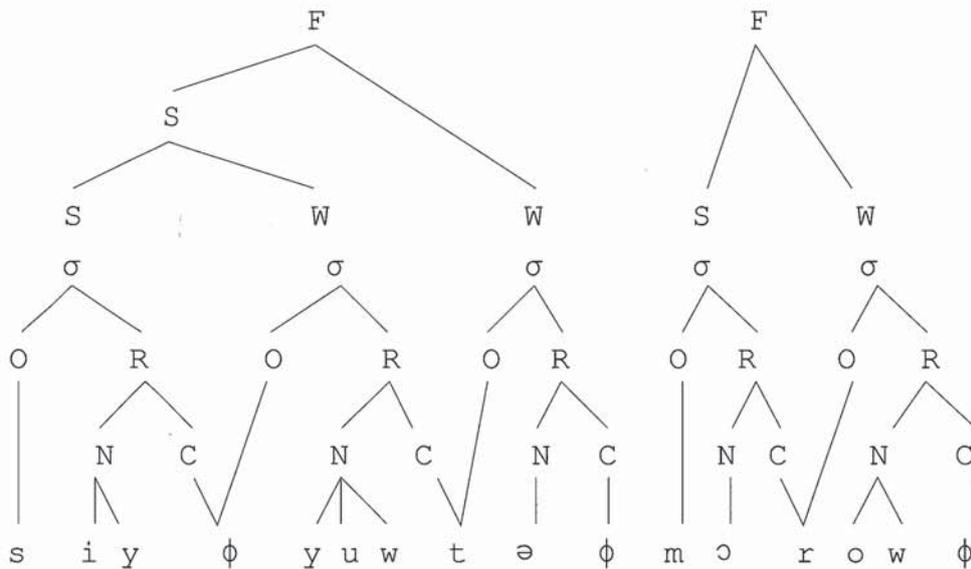
Applying Coda-Onset Linking to *later*, *...see you tomorrow*, *plant it*, for example, we obtain the

following representations:

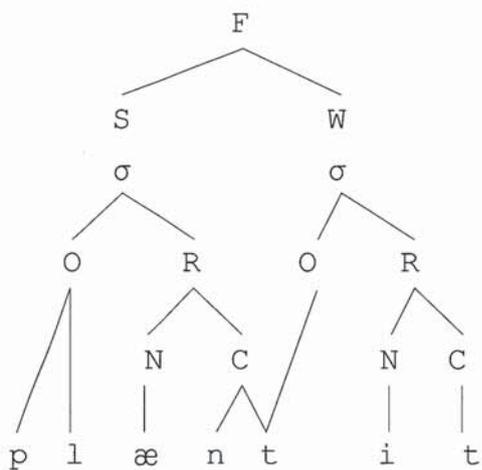
(40) *later*



See you tomorrow.

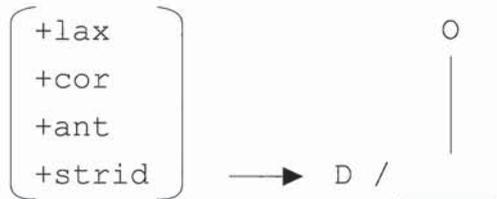


plant it



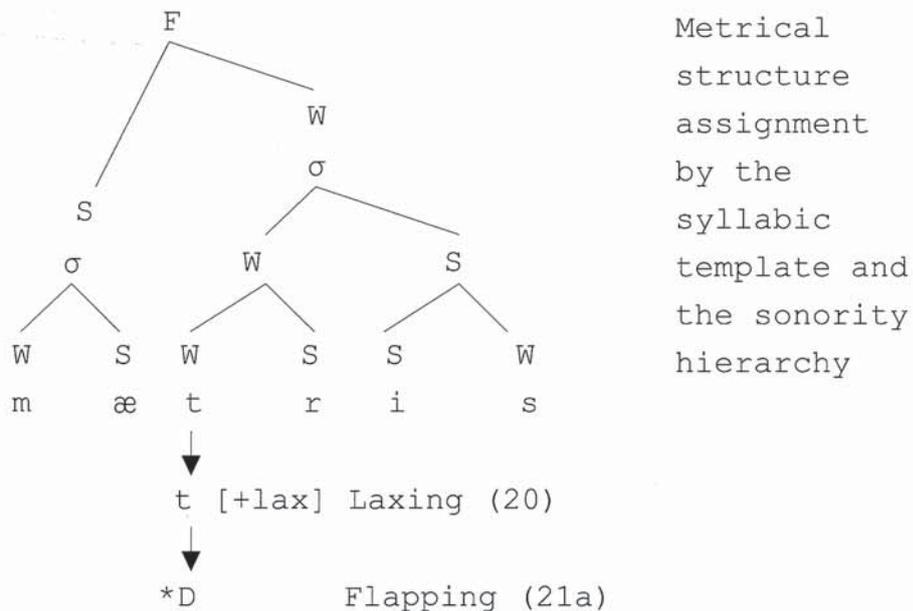
Flapping must be ordered after laxing. As we can see from the structures in (40), every flapped segment occupies the position that has been created by the Linking rule; consequently, note that /t/, /d/, and /n/, which undergo flapping, share [+coronal, +anterior, -strident] with each other. Taking this fact into consideration, we can formulate flapping as follows:

(41) Flapping (to be revised)



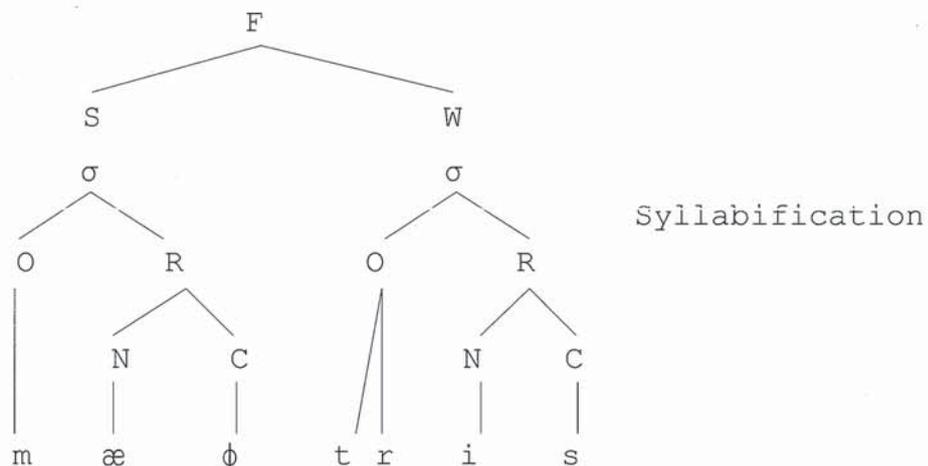
Notice that, in Kiparsky' (1979) metrical theory, words such as *mattress* and *citrus* are incorrectly derived, as illustrated in (42):

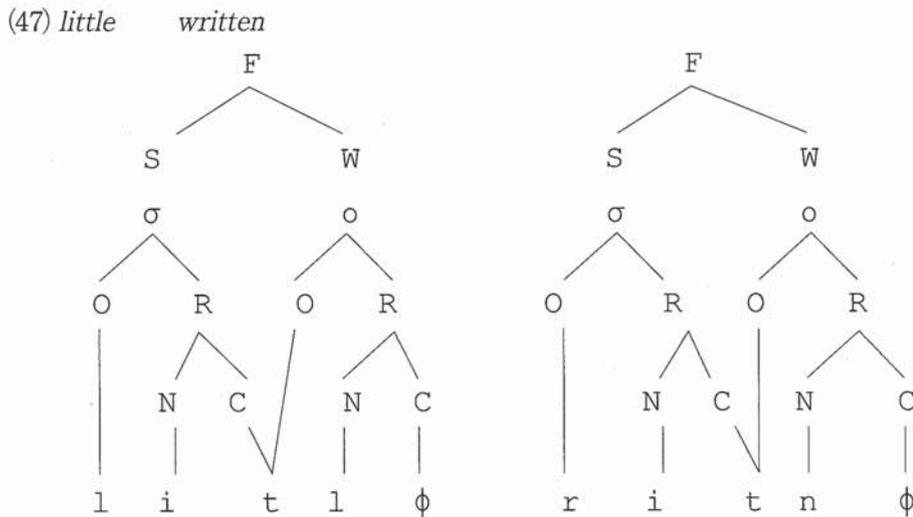
(42)



As Kahn points out, this /t/ is not in fact flapped. Kiparsky's theory, however, predicts that it will be realized as /D/. Let us consider the following derivation.

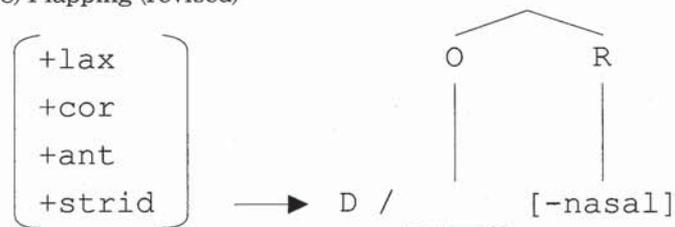
(43)





Thus, let us restate the rule as in (48) so as to prevent flapping from turning /t/ into /D/ phonetically.

(48) Flapping (revised)



4 Aspiration

Aspiration is a phonetic phenomenon that is observed when a voiceless stop is pronounced with an aspirate. Aspirated stops may occur at the word-initial position of *pie*, *time*, *kill*, etc., or the word-internal position of words like *suppose*, *capon* and *attach*:

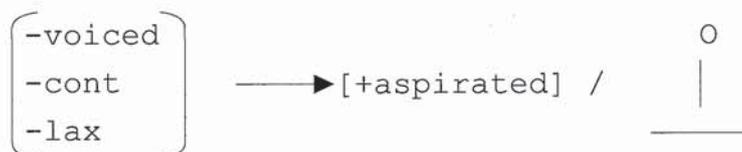
- (49) *pie* *time* *tuna* *pill* *team* *plantation* *pin*
came *attack* *part* *kill* *capon* *talk* *priorities*
suppose *professor* *planet* *latex*

However, aspirated stops do not appear in the words listed below:

- (50) *step* *spoon* *sketch* *spark* *skin* *shepherd* *happy*
heap *apple* *matter* *action* *motto*

A comparison of the words in (49) with those in (50) suggests that the aspirated segments in the former group have the status of the Onset of the initial syllable in a single foot, whereas the unaspirated stops in the latter group do not; they are to take on the feature [-lax]. This fact is imprinted on the structural description of rule (51).

(51) Aspiration⁶



The reason for specifying [-lax] is that if it were not for such a specification, every /p/, /t/ or /k/ at the Onset position is deemed to be aspirated. Thus, we maintain that there must be a bleeding relation between laxing and aspiration in order to capture the behavior of /p/, /t/ and /k/ by specifying [-lax] in the structural description of rule (51).

5 Glottalization

When a word like *mat* is pronounced, the vowel is terminated by cutting the airstream. With respect to the property of such an unreleased /t/, Heffner (1960: 136) remarks:

- (52) If the breath stream is wholly occluded by the vocal bands while it is also stopped at any one of the positions possible for the tongue or lips, the lingual or labial occlusion may be (a) compressed, (b) rarefied, or (c) merely confined.

Glottalized stops occur in the following words:

- | | | | |
|------|--------------|-------------|-------------|
| (53) | <i>leap</i> | <i>feet</i> | <i>leak</i> |
| | <i>rip</i> | <i>bit</i> | <i>lick</i> |
| | <i>sharp</i> | <i>cart</i> | <i>lark</i> |
| | <i>cup</i> | <i>cut</i> | <i>luck</i> |
| | <i>rope</i> | <i>boat</i> | <i>joke</i> |
| | <i>limp</i> | <i>went</i> | <i>bank</i> |
| | <i>help</i> | <i>belt</i> | <i>bulk</i> |
| | <i>lisp</i> | <i>list</i> | <i>risk</i> |
| | | <i>lift</i> | |

Glottalization takes place not only word-finally but also word-internally, as is illustrated below:

- | | | | | |
|------|------------------|-------------------|--------------------|------------------|
| (54) | <i>witness</i> | <i>nutmeg</i> | <i>Scotland</i> | <i>outset</i> |
| | <i>football</i> | <i>nutshell</i> | <i>gatepost</i> | <i>outright</i> |
| | <i>cat-call</i> | <i>cart-wheel</i> | <i>catgut</i> | <i>boathouse</i> |
| | <i>cap-badge</i> | <i>cup-full</i> | <i>back garden</i> | <i>capture</i> |
| | <i>upset</i> | <i>lecture</i> | <i>backdoor</i> | <i>breakfast</i> |
| | <i>output</i> | <i>partner</i> | | |

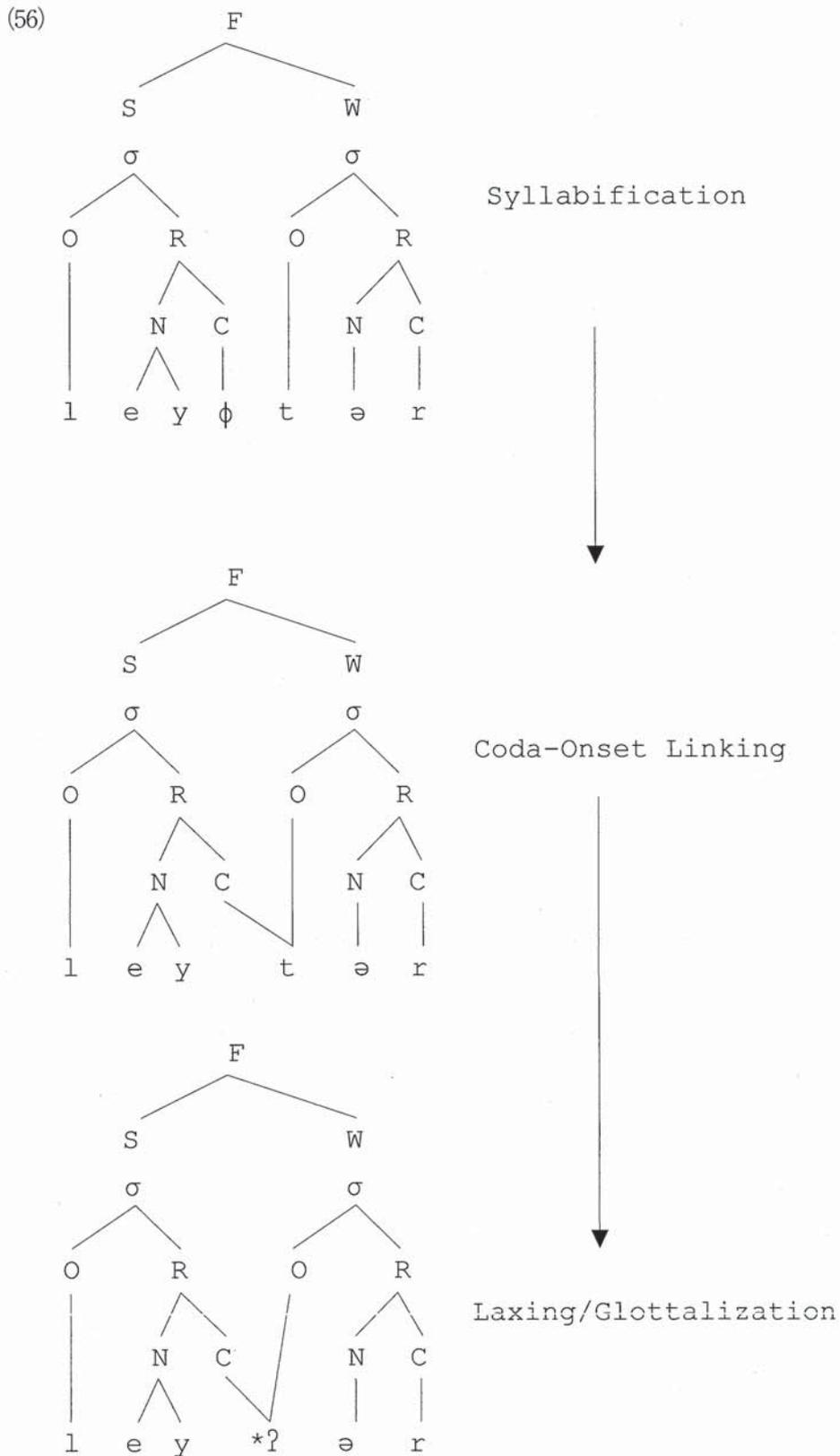
(55) Glottalization



6 Rule Ordering and the Elsewhere Condition

Though we have succeeded in formulating the rule of glottalization in the above discussion, there

remains a serious problem with this device. If we order glottalization prior to flapping, the theory would yield unwanted results. Consider the input *later*, for example:



At the normal rate of speech, the /t/ in *later* is not realized as [ʔ] but as [D]. In order to avoid the wrong outcome, it seems necessary to take into consideration the ordering of Flapping and

glottalization. In fact, we notice that the Elsewhere Condition plays a crucial role in securing the required result.

Note that the structural description of Flapping (48) includes that of glottalization (54). The Elsewhere Condition helps to determine their relative order. As for the case in question, flapping does not apply but glottalization does. This ordering relation further simplifies the grammar as well as predicts the correct account for the phonetic alternation of /t/.

7 Consonant alternation and schwa deletion

There are a number of words that are pronounced with the dropping of schwa. In the following discussion, we will fill in some further details of aspiration and glottalization in relation to schwa deletion.

Let us consider the following cases, in which there are two types of schwa deletion:⁷

(57) Post-stress schwa deletion

<i>separate</i>	<i>factory</i>
<i>misery</i>	<i>every</i>
<i>memory</i>	<i>mentally</i>
<i>easily</i>	<i>finally</i>
<i>personal</i>	<i>reckoning</i>

Pre-stress schwa deletion

<i>capacity</i>	<i>today</i>
<i>depend</i>	<i>debate</i>
<i>beginning</i>	<i>deceive</i>
<i>pacific</i>	<i>vicinity</i>
<i>Canadian</i>	<i>commercial</i>

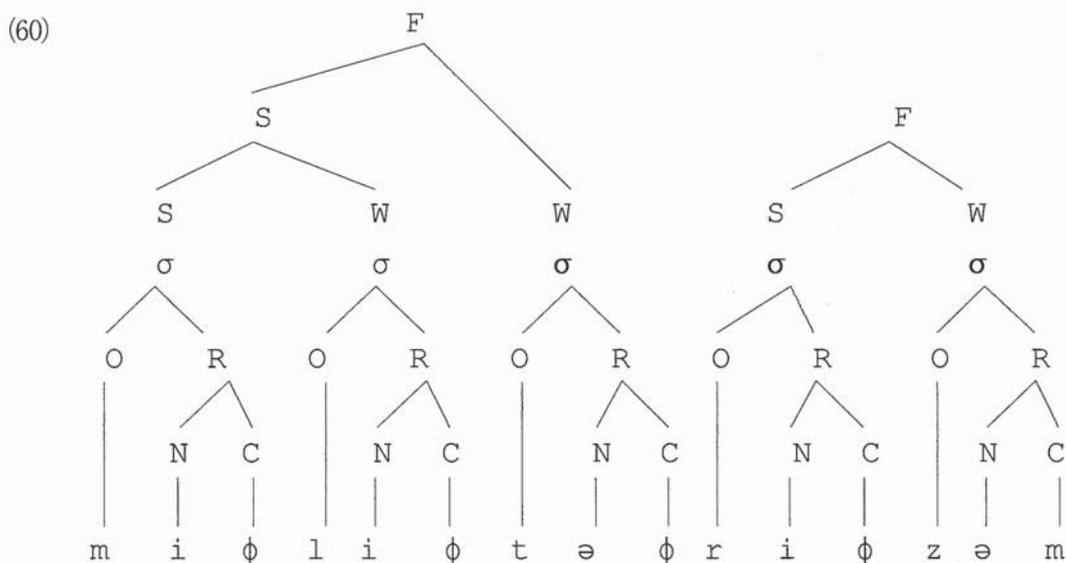
When the words in (58) are uttered without a schwa, the [+sonorant] consonants manifest themselves as syllabic:⁸

(58)	<i>cotton</i>	[katŋ]	[katən]
	<i>hidden</i>	[hɪdŋ]	[hɪdən]
	<i>little</i>	[lɪt]	[lɪtəl]
	<i>cradle</i>	[keyd]	[keydəl]
	<i>apple</i>	[æp]	[æpəl]
	<i>trouble</i>	[trʌb]	[trʌbəl]
	<i>prizm</i>	[prɪzŋ]	[prɪzəm]
	<i>album</i>	[ælbŋ]	[ælbəm]

To account for this fact, it is necessary to discover at which stage schwa deletion, schwa insertion and syllabification of liquids and nasals take place. Let us assume that the rules responsible for these operations apply before those that are responsible for consonant alternations. In (59) are given some pieces of evidence for the argument that schwa deletion takes place prior to Coda-Onset Linking and the rules that affect the phonetic realization of /t/.⁹

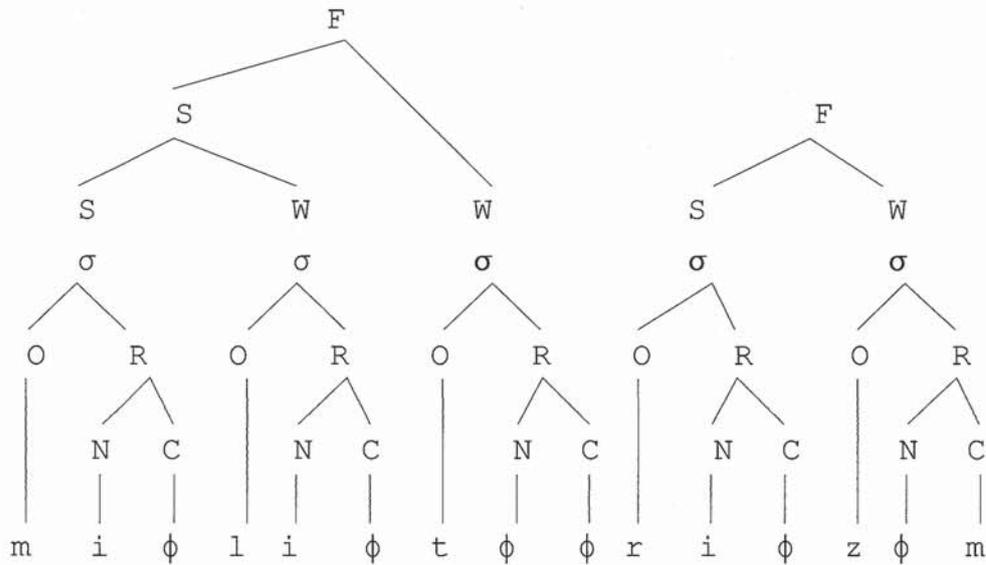
- (59) *gotten* [gʌʔn]
certain [səʔn]
mutton [mʌʔn]
written [rɪʔn]
militarism [mɪlɪtʰɪzɪzəm]

Militarism, for example, is considered to have the following syllable structures after vowel reduction has applied in the Lexicon:



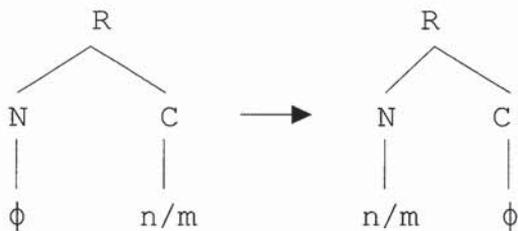
To secure the output form [mɪlɪtʰɪzɪzəm], we need schwa deletion, sonorant syllabification, resyllabification, and a rule dealing with the relevant consonant alternation. When schwa deletion applies, the representation in (61) results.

(61)



Subsequently, syllabification of /m/ and /n/ takes place. This is performed by the following rule:

(62) Sonorant syllabification

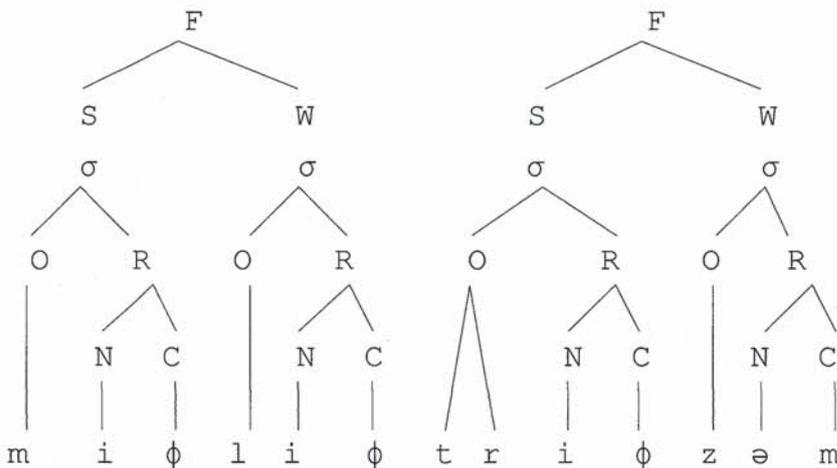


With respect to the structure of militarism, we notice that there is a syllable whose elements are all empty. It appears to be highly infeasible for any natural language to leave intact a syllable whose entire structure consists of null elements. This suggests that there needs to be a convention governing the shape of syllable structure:

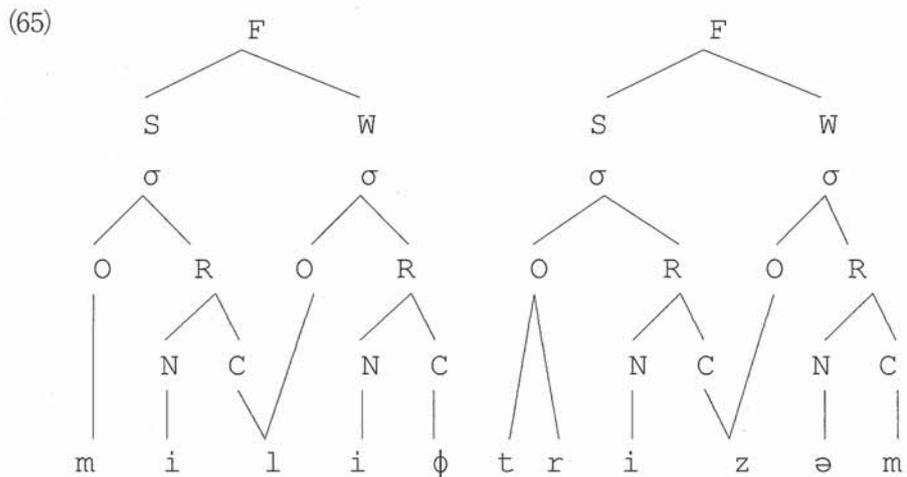
(63) If resyllabification results in a syllable with its constituents void of content, then erase the entire structure of the syllable.

Employing this convention, we obtain (64).

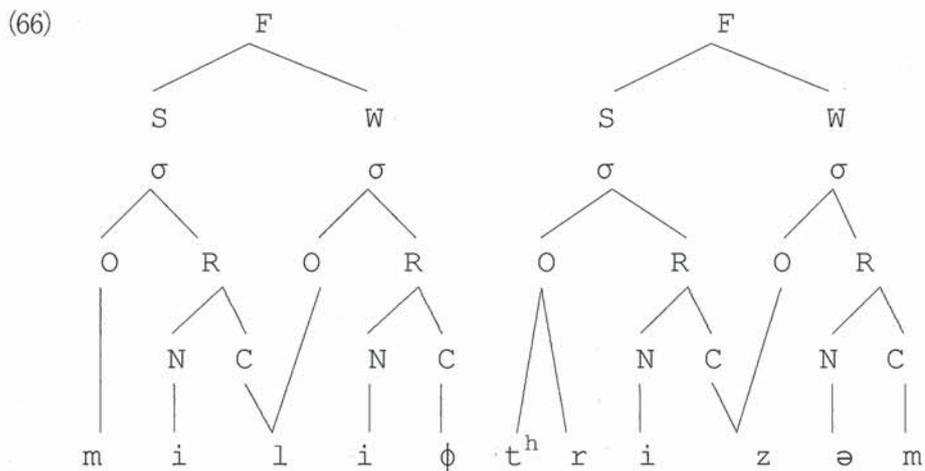
(64)



Then the Coda-Onset Linking rule gives rise to the representation in (65).



Finally, the desired representation [milit^hrɪz̥m] results by virtue of glottalization and aspiration.



Summing up the discussion so far, the rules that account for low-level phonetic alternations must be placed after schwa deletion, sonorant syllabification, and resyllabification. In the sections that follow, we will have a close look at different assimilatory processes observed in American English.

(The rest part of this article will appear in the next issue, with a list of references to be supplied.)

Notes

¹ See Kiparsky (1979: 432). The literature of phonetics includes Jespersen (1926: 191), Heffner (1960: 74-75), and Borsnahan (1970: 141-142) that have noted the notion of sonority. Jespersen (1926), for instance, presents the following description:

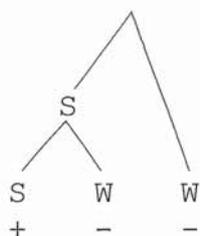
1) Stimmlose a) Verschlusslaute: [p, t, k]

- " b) Engelaute: [f, s, ç, x]
- 2) Stimmhate Verhulusslaute: [b, d, g]
- 3) " Engelaute: [v, z, ʒ]
- 4) " a) Nasale: [m, n, ŋ]
- " b) Seitenlaute: [l]
- 5) " r-Laute
- 6) " hohe Vokale: [y, u, i]
- 7) " mittelhohe " [ø, o, e]
- 8) " niedrige " [ɔ, æ, ɑ]

² Kiparsky (1979: 421) says that the formation of the structure above the foot takes the following steps:

a. Assign [(stress)]

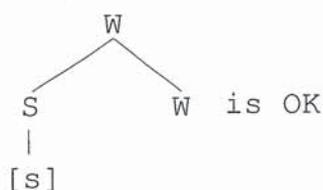
b. Assign "feet"



c. Connect remaining nodes

d. Label right branches S iff they are branching (at the relevant level)

In a sequence like /sp, st, sk/, the principle of sonority hierarchy is not observed, as the sonority of /s/ is greater than that of /p, t, k/. To handle this fact, Kiparsky (1979) states a language-particular syllabic template:



³ Recall that Kahn's (1976) Syllable Structure Assignment Rule IV was proposed to capture the behavior of the velar nasal /ŋ/, which occurs only at the word-final position. This kind of additional rule may lead to making the grammar unnecessarily complicated.

⁴ See Hoard (1971: 134-135). We will use the feature [±tense] for vowels and [±lax] for consonants to indicate the tenseness of segments. He adds that tense segments are long and lax segments are short.

⁵ The data are from Kahn (1976), Shockey (1973), Hooper (1976), Donegan and Stampe (1979), Halle and Mohanan (1985) and a tape of interviews by American announcers.

⁶ Concerning a discussion on the laxness of consonants and Aspiration, see Hoard (1971).

⁷ See Hooper (1978: 192, 199).

⁸ See Kenyon and Knott (1953).

⁹ The examples are from Shockey (1973), Jones (1956) and a tape recording by a speaker of American English.

(いおろい たかひろ・本学助教授)