Based on a non-linear framework of phonology, this article claims that English Vowel Lengthening is due to the reshaping of syllable structures which result from the affixation of certain types of suffixes. The paper also seeks to establish a general principle that governs different types of English Vowel Lengthening that have hitherto been considered distinct processes. Introducing the idea of Rime-Onset Alternation Principle, it is shown that vowel lengthening originates from the violation of the well-formedness condition of the syllable sequences.

1. **INTRODUCTION.** It is well-known that English Vowel lengthening is triggered by affixation of certain types of derivational suffixes. As illustrated in 1 and 2, vowels are regularly lengthened when the noun-forming suffix -e, or the suffixes -ian, -ious, -ial, -ia, -iate, etc. are attached.¹

(1) breath ~ breathe, bath ~ bathe
loss ~ lose, brass ~ braise

(2) a. æ (ə) ~ eɪ
Arab ~ Arabian, Panama ~ Panamanian,
Canada ~ Canadian, Jordan ~ Jordanian,
Caucasus ~ Caucasian, regal ~ regalia,
gymnastics ~ gymnasium,
courage ~ courageous, fallacy ~ fallacious,
mendacity ~ mendacious

¹ Notice that the suffixes which are adjoined in the examples in 1 and 2 are all affixes of Stratum I in the framework of Lexical Phonology.

* This is a revised version of the paper I read at the meeting of the Circle of English Phonology on Nov. 17, 1986. I am grateful to those people who gave me valuable comments and suggestions. I especially wish to thank Prof. S. Haraguchi for his insightful comments and advice on an earlier draft of this article. Needless to say, any mistake is strictly my own.
We will follow the practice of non-linear phonology and assume that the segments are long when mapped onto multiple (typically two) timing slots. We will also assume that a syllable universally has a hierarchical structure which consists of Onset and Rime. Therefore, the difference between long and short vowels in English is that the former has two timing slots (which we denote with X) while the latter has only one timing slot associated with the vowel. Thus, in abstract phonological representation, hypothetical words paa and pa are expressed as in 3.

Note that paa and pa are the same at the segmental tier but different at the Rime-Onset and timing tier; the former has a branching Rime and the latter has a non-branching one.

2. TENSING FOR VERB-FORMING

2.1. ASSUMPTION OF FINAL -E. Let us first examine the alternations shown in 1. The vowel tensing observed in these examples is due to the attachment of the verb-deriving suffix -e. We will assume that the vowels in bathe and lose are underlyingly short, but lengthened by the suffixation of -e as in bath ~ bathe ([bæθ] ~[beɪθ]), loss ~ lose ([lɔs] ~ [luːz]).
This suffix is indicated by the letter -e in orthography, but its phonological feature is unknown to us, since it is deleted in the course of derivation, and does not realize itself in the phonetic representation. We will assume that -e underlyingly consists of a certain vowel, which we shall provisionally denote with E hereafter.

Support for postulating an underlying E comes from the following arguments.

Notice that voiceless consonants become voiced when followed by the verb-forming suffix -e in bath [θ] ~ bathe [ð], loss [s] ~ lose [z]. These alternations are handled by the same rule that Halle-Mohanann (1985) postulated in order to account for the voicing alternations in Malthus ~ Malthusian, Caucasus ~ Caucasian, etc. They call it S-voicing and formalize it as follows.

\[
(4) \quad s \rightarrow z / [\text{-cons}] \quad [\text{-cons}] \\
\text{X} \quad \text{X} \quad \text{X} \\
\text{R}
\]

\quad (Halle and Mohanan (1985))

We should also add θ→ð, in order to account for the alternation in bath ~ bathe. We will simply call this “Consonant Voicing Rule” hereafter, and reformulate 4 as 5.

\[
(5) \quad \text{Consonant Voicing} \\
\begin{array}{c}
\text{+cons} \\
\text{-voice} \\
\text{+cont} \\
\text{+ant}
\end{array} \quad \rightarrow \quad [+\text{voice}] / [\text{-cons}] \quad [\text{-cons}] \\
\text{X} \quad \text{X} \quad \text{X} \\
\text{R}
\]

As is shown in 5, Consonant Voicing operates when there is at least one vowel following the consonant that undergoes this change. Notice that the final /s/ in precise, concise does not follow this rule, even though the preceding vowels are branching; this is because they are not followed by a vowel. This fact lends support to our assumption that there is an underlying vowel E at the word-final positions in breathe, lose, etc.

Further support for postulating an underlying E is found in the data relating to Velar Softening. The following examples suggest that the words produce and introduce contain /k/ in their underlying representations, and the phonetic [s] is derived from /k/ by Velar Softening.

\[
(6) \quad \text{produce} \sim \text{produce} \\
\text{introduction} \sim \text{introduce}
\]
Notice that the final consonants in *produce* and *introduce* cannot be /s/ underlingly, because we would get incorrect results *[prodůz], *[introduz]* if we assumed that they are derived from /s/, since underlying /s/ is subject to Consonant Voicing 5 as in *lose, braze*, etc. We may avoid this by assuming, in accordance with SPE, that they are /k/ underlingly. The underlying /k/ in *produce, introduce*, etc. will escape Consonant Voicing if we assume that Consonant Voicing (s→z) is extrinsically ordered before Velar Softening (k→s).

As noted in SPE (1968) and Halle and Mohanan (1985), the context in which Velar Softening applies should have [−low, −back] vowel to follow /k/ or /g/, as observed in the examples in 7.

(7)  

a.  

- critic ~ criticize,  
- medicate ~ medicine  
- matrix ~ matrices, reduction ~ reducent

b.  

- g ~ ɬ  
- fungus ~ fungi, analog ~ analogical  
- syrinx ~ syringes, larynx ~ laryngeal

Thus Velar Softening can be formalized as follows.

(8) Velar Softening

\[
\begin{array}{c}
k \rightarrow s \\
g \rightarrow ɬ \\
\end{array}
\]

Looking at *produce* and *introduce*, we have seen that the final consonant [s] in these examples is derived from underlying /k/ by Velar Softening. Therefore, we should assume that these words end with a vowel (possibly [−low, −back]) even though it does not appear on the surface representation.

To summarize, we have seen that the verb-forming suffix -e underlingly consists of a certain vowel which may be specified as [−low, −back]. This underlying vowel E is deleted word-finally by the following rule.

(9) Vowel Deletion

\[
[+\text{syll}] \rightarrow \phi / \underline{\text{—}} #
\]

Notice that this rule only operates in derived environments, since non-

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2 The vowel [ai] in *criticize* derived from the underlying /i/ by means of Vowel Shift. Because of this, Vowel Shift should be extrinsically ordered after Velar Softening.
derived words such as banana, hero, city, menu retain their word-final vowels. We will handle this difference, in the framework of Lexical Phonology, by assuming that rule 9 is a lexical rule which applies in Stratum I, where the suffix -e is attached.

2.2. TENSING FOR VERB-FORMING AS A COMPENSATORY VOWEL LENGTHENING.

Let us go back to the main issue of this article. This paper claims that Vowel Lenthening is triggered by requirements of syllable structures. I would like to propose that there is a universal condition called Rime-Onset Alternation Principle stipulated below.

(10) Rime-Onset Alternation Principle

Rime and Onset should alternately appear in a linear string of syllables.

This principle states that a phonological string is "well-formed" when Rimes and Onsets alternate. It suggests that some phonological operations are motivated in order to eliminate the ill-formed syllable sequences which violate this principle.

Note that the derived words such as bathe, lose have ill-formed underlying structures, since the suffixation of -e creates the word-final sequence of two Rimes as illustrated in 11.

(11) O X X X X
    R R

We will assume that the ill-formed Rime-sequence is eliminated by means of the following Rime Deletion rule, which applies at Stratum I in the framework of Lexical Phonology.

(12) Rime Deletion

R → φ / R

After the application of this rule, the structure 11 will change into 13. Notice that the vowel E is now associated to the X-slot which is no longer a member of Rime.

(13) O X X X X
    R R

It is assumed that there is a condition which we state as follows.

(14) Constraint

A vowel cannot be linked to an X-slot which is not a member
of Rime.
Because of this condition, the vowel E in 13 is dissociated from the X-slot as shown in 15. This results in a final vowel E left unassociated on the segmental tier. We will call this as a floating vowel, and indicate them by circling them hereafter.

(15) O R
    X X X X
    b æ θ (E)

This change subsequently motivates the lengthening of the preceding vowel. To illustrate this point, let us see the derivation of long vowel in bathe. First, the final consonant /θ/ in 15 is reassociated to the word-final vacant X-slot as in 16a. This change creates a new vacant X-slot on the timing tier, which eventually motivates a spreading of the preceding vowel /æ/ onto the X-slot as in 16b.

(16) a. O R
    X X X
    b æ θ (E) → b. O R
    X X X X

The floating vowel (E) in 16b is finally deleted by Vowel Deletion (9) after the application of Consonant Voicing (5). This results in a structure 16c. Finally, the final X-slot which is linked to /ð/ is re-syllabified as a member of Rime in the preceding syllable, as indicated in 16d.

(16) c. O R
    X X X
    b æ θ → d. O R
    X X X X

We need certain other rules in order to get the correct output [beið] from 16d. For example, it is well-known that long vowels in English are redundantly tense and diphthongized. However, this is surface detail and has no bearing on the main issue of this article. It must also be kept in mind that the branching rime in 16d is subject to Vowel Shift. This, too, is unrelated to the main issue and will not be discussed here. We will simply note that Diphthongization, Tensing, and Vowel Shifting

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3 The structure 16b then satisfies the condition of Consonant Voicing (5), which operates to change /bæθ/)E/ into bæð)E. This means that Consonant Voicing should be intrinsically ordered after Vowel Lengthening.
should be specified for vowels which are associated to two X-slots in English.

Note that the process from 16a to 16b involves re-timing of relations within a word. We will view this process as a type of compensatory lengthening because it involves the spreading of a vowel to an unassociated X-slot that was earlier occupied by a consonant.

The spreading of the segment to the unassociated X-slot in 16a and 16b is achieved by the universal convention of the Autosegmental Theory, which ensures that if there is any X-slot left unassociated in the timing tire, it will automatically be associated with an available segment in the segmental tier.

It should be noticed that the consonant which spreads in 16a is not allowed to link to two X-slots, and thus dissociated from the X-slot that was earlier linked with the consonant. On the other hand, the vowel which spreads in 16b is associated with two X-slots, and thus phonetically realized as a long vowel. To account for this difference, we need a constraint in English that blocks the derivation of geminate clusters.

(17) Constraint

In the course of English phonological derivation, a consonant cannot be linked to more than one X-slot.

This constraint predicts correctly that there is no geminate in the phonetic representation of English.

The ordering of rules developed so far is summarized as follows.

(18) a. Rime Deletion (12) and subsequent Vowel Lengthening
    b. Consonant Voicing (5)
    c. Velar Softening (8)
    d. Vowel Deletion (9)

As is shown in §2.1., with regards to the examples in 6, Consonant Voicing is extrinsically ordered before Velar Softening. Rime Deletion and subsequent Vowel Lengthening are ordered before Consonant Voicing, since the former rules feed the latter one in the derivation of breathe, lose, etc. Finally, Vowel Deletion should be extrinsically ordered after Consonant Voicing and Velar Softening, so that the final vowel E is present in bathe, lose, produce, etc. when these rules apply.

3. CiV LENGTHENING

3.1. CiV LENGTHENING AS A COMPENSATORY VOWEL LENGTHENING. We can now turn our eyes to the vowel alternations observed in 2. This
phenomenon is traditionally called “CiV Lengthening”, which is formally expressed by Halle and Mohanan (1985) as follows.4

(19) CiV Lenthening (Halle and Mohanan (1985))

\[
\begin{array}{c}
\text{Rime} \\
\times \\
[-\text{cons}]
\end{array} \quad \begin{array}{c}
\text{Rime} \\
\times \\
[-\text{cons}]
\end{array} \quad \begin{array}{c}
+\text{high} \\
-\text{cons} \\
-\text{stress} \\
-\text{back}
\end{array}
\]

The rule states that non-branching Rime becomes branching when followed by unstressed /i/.

Notice that Rule (19) merely “describes” the vowel alternations observed in 2. But we should also try to “explain” why such a phenomenon as CiV Lengthening exists in English.

Ono (1984) has challenged this question by introducing a new type of analysis for the vowel alternations in English. He postulates that English vowels are tensed by a rule to change light syllables (C0V) to super-heavy ones (C0V C0) when accented and followed by other super-heavy syllables. This is formally expressed by Ono as in 20.

(20) L H H (Ono (1984))

(' stands for accent, H for super-heavy syllable and L for light syllable)

According to Ono, CiV Lengthening is motivated by way of the following process. In the words such as Iranian, melodious, and collegiate, the penultimate high vowel /i/ is first changed into the tense long vowel [ı] by Prevocalic Tensing Rule formulated in 21, which is independently necessary to change the lax vowels to tense ones in algebraic, variety, heroic, etc.

(21) Prevocalic Tensing (Ono (1984))

\[
\begin{array}{c}
V \\
+\text{tense} \quad / \quad V
\end{array}
\]

After application of 21, the syllable sequences LL become LH in the words Iranian, melodious, collegiate, etc. These are then subject to rule (20). According to this solution, the word Iranian, for example, will undergo the following change.

(22) a. / ir\text{\'}an\text{\'}an / \quad b. ir\text{\'}an\text{\'}an \quad c. ir\text{\'}an\text{\'}an

\[
\begin{array}{c}
L \quad L \\
(21) \quad L \quad H \\
(20) \quad H \quad H
\end{array}
\]

4 There are, however, a clear class of exceptions to this rule. Notice that in Darwin ~ Darwinian, logic ~ logician, malice ~ malicious, office ~ official, etc., the rule does not operate to change the antepenultimate high vowel /i/ into [ai]. Thus rule 18 states that it only applies to [−high] vowels.
This solution, however, is counter-intuitive. As pointed out by Ono himself, one may wonder why the penultimate super-heavy syllable in 22c is not subject to Diphthongization (*/i/ → aj), while the antepenultimate one is diphthongized (/æ/ → ej). Notice that the penultimate vowel /i/ in *Iranian, melodiuous, collegiate*, etc. phonetically never realizes itself as a tense vowel. Instead, the penultimate vowel is often reduced and changed to a glide /y/, or even deleted after causing coronal obstruents to palatalize. Consider the following examples.

(23) a. Lilliputian [lilipyyosjen] i → y
   Panamanian [pænæmeinian ~ nyon]

   b. fallacious [faeleisəs] i → φ
   Scotia [skoûsə]

Ono’s solution requires the underlying lax high vowel /ī/ to become tense once, and then return to lax vowel again. This means that our lax vowel /ī/ should undergo the following change: /ī/ → ĭ → ĭ → y → φ. But it is not natural that a vowel which was once tense in its derivation appears as a glide or is deleted. In order to explain the internalized knowledge of the native speaker of English, we should attempt a simpler and more natural solution for the vowel lengthening observed in 2.

In this paper, we will consider CiV Lengthening as a type of Compensatory Vowel Lengthening, which should be described with the same rule as we formalized for the vowel lengthening in *bathe, lose*, etc. in the previous section.

We assume that the syllable structure of the suffixes -ian, -ial, -ious, -iate, etc. are as illustrated below.

(24) R R
     X X X
     i æ n

When these suffixes are attached to the noun stems, we get a sequence of Rimes as in 25, which is an obvious violation of our Rime-Onset Alternation Principle (10).

(25) R O R R R
     X X X X X X
     [æ r æ b] i æ n

As we have seen for the suffixation of the verb-forming suffix -e in the previous section, the deletion of a Rime is motivated to eliminate the ill-formed Rime sequence in 25. Rule 12 applies to delete the penulti-
mate Rime as in 26a.\(^5\) In accordance with the condition 14, the vowel /i/ is subsequently dissociated from the X-slot and becomes a floating vowel as illustrated in 26b.

\[(26)\] a. \[\begin{array}{cccccccc} R & O & R \hline X & X & X & X & X & X \hline æ & r & æ & b & i & æ & n \end{array} \quad \rightarrow \quad \begin{array}{cccccccc} R & O & R \hline X & X & X & X & X & X \hline æ & r & æ & b & i & æ & n \end{array}\]

This change then motivates the lengthening of the preceding vowel as is illustrated below.

\[(26)\] c. \[\begin{array}{cccccccc} R & O & R \hline X & X & X & X & X \hline æ & r & æ & b & i & æ & n \end{array} \quad \rightarrow \quad \begin{array}{cccccccc} R & O & R \hline X & X & X & X & X \hline æ & r & æ & b & i & æ & n \end{array}\]

Finally, the X-slot which is associated with /b/ in 26d becomes an Onset of the following syllable as shown in 26e.

\[(26)\] e. \[\begin{array}{cccccccc} R & O & R \hline X & X & X & X \hline æ & r & æ & b & i & æ & n \end{array} \quad \rightarrow \quad \begin{array}{cccccccc} R & O & R \hline X & X & X & X \hline æ & r & æ & b & i & æ & n \end{array}\]

### 3.2. FLOATING VOWELS IN -ial, -ious, -iate, ETC.

Here, one may wonder what will occur to the floating vowel /i/ in 26e. Recall that in the examples in 23, the vowel /i/ often realizes with a glide [y] or is deleted after making palato-alveolar consonants to palatalize. We will explain this phenomenon by assuming that the floating vowels in these examples are re-associated with the Onset as shown in 27, which then makes this vowel appear as the glide [y].

\[(27)\] \[\begin{array}{cccccccc} O & R \hline X & X & X \hline n & i & æ & n \end{array} \quad \rightarrow \quad \text{ny\textalpha n}\]

\(^5\) One might think that the deletion of Rime is equally possible for either of the last two Rimes in this example. However, as explained above, since Rule 12 is a lexical rule which applies at Stratum I, it does not apply to delete the final Rime. The Strict Cyclicity Principle predicts that a lexical (cyclic) rule cannot be applied to change the structure which is not derived within the designated cycle, i.e. cyclic rules apply only to derived representations. See Mascaro (1976) and Kiparsky (1982) for more information on Strict Cyclicity.
The change from /i/ to [y] is achieved by a general convention of the segments which ensures that high vowels are changed to glides when linked to Onset.  

A modicum of support for this solution is provided by the data of palatalization. As shown in Halle and Mohanan (1985), palatalization is motivated when a coronal obstruent is followed by the glide [y], but not by the full-vowel [i]. Observe that the final consonants in 28a are palatalized while the ones in 28b are not.

(28) a. miss you s → ʃ  
got you  t → č  
did you  d → j

Thus we can formalize the rule of palatalization as follows.

(29) Palatalization

\[
\begin{array}{c}
[\text{-son}] \\
[+\text{cor}] \\
\end{array}
\rightarrow
\begin{array}{c}
[\text{-ant}] \\
[+\text{strid}] \\
\end{array}
/ _y
\]

Notice that in the following examples, the coronal obstruents are palatalized when followed by the suffixes -ial, -ion.

(30) race ~ racial,  office ~ official  s → ʃ  
digest ~ digestion  t → č  
confuse ~ confusion  z → ʒ

It is important, therefore, that the initial vowel /i/ in these suffixes be

---

6 Rather than formalizing the change i → y by an independent rule, we can handle it by a general convention which ensures that vowels are changed into glides with the same features except [±syllabic]. (Thus i → y, and u → w).

Alternatively, we can express this by the framework of sonority indices suggested by Selkirk (1984). She proposes that there be language-particular conditions of segments about their positions in a syllable. For example, when a segment x is associated with Onset, it has to appear with certain sonority which is less than those of any vowels. Thus the vowels which are associated with an Onset is automatically excluded and thus change to the corresponding glides.

7 Based on this fact, Rubach (1984) claimed that the environment of Palatalization must have /i/ underlyingly. Thus, according to him, the underlying representations for -ian, -ial should be /iæn/ /iæl/ respectively. The present analysis, on the other hand, adopts nonlinear framework, and assumes that the suffixes -ial, -ian, etc. have underlying /i/ in the segmental tier. This /i/ can be changed to [y] only if it is linked with Onset of a syllable.
changed to [y] prior to Palatalization.\(^8\)

As is clear from the pronunciation of *racial* [reːʃal], *courageous* [kɔrəʃəs], *digestion* [daɪʒəʃən], etc., the glide [y] is usually deleted after palato-alveolar obstruents (š, ž, č, ř).\(^9\) We will ensure this by the following Glide Deletion Rule.

\[(31) \text{ Glide Deletion} \]

\[
y \rightarrow \phi \quad \left( \begin{array}{c}
-\text{ant} \\
+\text{cor} \\
-\text{son}
\end{array} \right)
\]

\(^8\) Note that Palatalization may also apply to derived coronal obstruents as shown in (i) below.

(i) a. logic ~ logician, academic ~ academician /k/ → s → š
   b. protect ~ protection, opt ~ option /t/ → s → š
   invade ~ invasion, allude ~ allusion /d/ → z → ż

The alveolar fricatives (s, z) in (ia) and (ib) are derived from underlying /k/, and /t/ or /d/ respectively, by means of Velar Softening (k → s), and Spirantization (t → s, d → z). These fricatives are then subject to Palatalization.

It is not the case, however, that all underlying /k/, /t/, /d/ undergo this change. Consider the following examples, in which the derived [s] is *not* subject to Palatalization.

(ii) a. critic ~ criticism /k/ → s → *ś
     opaque ~ opacity
     classic ~ classicist
   b. vacant ~ vacancy /t/ → s → *ś
     adjacent ~ adjacency
     secret ~ secrecy

The difference between (i) and (ii) lies in the syllable structures of these words. The derived [s] or [z] in (i) undergo Palatalization because they are followed by /i/ which is associated with Onset, as shown in (iii a). On the other hand [s] in (ii) is followed by /i/ which is associated with Rime, as shown in (iii b).

\[(iii) \]

\[
\begin{array}{c}
\text{a.} \\
O \quad R \\
X \quad X \\
| \quad | \quad | \\
\sigma & \text{X} & \text{X} \\
\text{b.} \\
O \quad R \\
X \quad X \\
| \quad | \quad | \\
\sigma & \text{X} & \text{X} \\
\end{array}
\]

\(^9\) The glide [y] must be deleted in -ion as in *option* [ɔpʃən], *invasion* [inveʃən], etc. But it may appear in other suffixes such as -ian in *Lilliputian*, *Caucasian*, etc. We must take into consideration that there is a great dialectal and idiolectal variation with regard to Palatalization and subsequent Glide Deletion. This fact suggests that these are low-level phonetic rules.
This deletion rule is only allowed to apply to the glide /y/ which is associated to the same Onset with a palato-alveolar obstruent.

3.3. Regular exceptions to CiV Lengthening. It should be noted here that there is a regular class of exceptions to our Compensatory Vowel Lengthening triggered by the affixation of -ial, -ian, -ious, etc. Notice that the antepenultimate vowels are not lengthened in the examples in 32.

(32) Kant ~ Kantian, president ~ presidential
     commerce ~ commercial, finance ~ financial
To handle this fact, we will simply assume that the vowel lengthening operates vacuously when the structures already have branching Rimes. This is illustrated by the derivation of Kantian as shown below.

(33) a. O R R
     X X X X X X X
     k a n t (i) æ n
b. O R R
     X X X X X X X
     k a n t (i) æ n
After Rime Deletion (12) applies, subsequent delinking of the vowel /i/ as in 33a and consonant spreading as in 33b creates an unassociated X-slot on the timing tier; but this does not affect the preceding Rime, since the Rime is already mapped onto more than two timing slots. We therefore need to delete an unassociated X-slot, which will be achieved by the following X-slot deletion rule.

(34) X-slot Deletion
     X → φ
     R
     X X
     φ

Finally note that the vowel lengthening does not operate in the following examples, to which the suffixes -ual, -uous, -uate are adjoined.10

(35) habitual, perpetual
     ambiguous, virtuous
     attenuate, superannuate
We capture this fact by assuming that -ual, -uous, and -uate are different

10 It follows from this that the long vowels in mutual, usual, etc. are underlingly marked as [+tense].
from -ial, -ious, and -iate at the level of their underlying syllable structures. As shown in 36a, the structure of -ual has an Onset already occupied by the vowel /u/, and thus does not motivate the vowel lengthening of the preceding Rime. This can be compared with the structure of -ial in 36b, to which Rime Deletion (12) applies to delete the penultimate Rime.

\[
(36) \quad \begin{array}{c}
\text{a.} & \begin{array}{c}
\text{O} \\
\text{X} \\
\text{u} \\
\text{æ} \\
\text{l}
\end{array} & \begin{array}{c}
\text{R} \\
\text{X} \\
\text{æ} \\
\text{l}
\end{array} & \begin{array}{c}
\text{R} \\
\text{X}
\end{array} \\
\text{b.} & \begin{array}{c}
\text{R} \\
\text{X} \\
\text{i} \\
\text{æ} \\
\text{l}
\end{array} & \begin{array}{c}
\text{R} \\
\text{X}
\end{array} & \begin{array}{c}
\text{R} \\
\text{X}
\end{array}
\end{array}
\]

(12) 

Note that the words in 35 phonetically have [y] between the stem-final consonant and the suffix-initial vowel /u/, as in ambiguous [æmbɪɡjuəs], attenuate [ətəˈnuɪt], etc. In light of this, we assume that the Onset X-slot in 36a is later delinked from the vowel /u/, and subsequently [y] is inserted and associated to the Onset X-slot by the following rule.11

\[
(37) \quad \text{Glide Insertion}
\]

\[
\phi \longrightarrow y
\]

Again, we find support for assuming this rule in the data relating to Palatalization. It was previously noted, with respect to the examples in 28, that the environment of Palatalization requires [y] after coronal obstruents. Note that in the following examples /t/ is palatalized to [ç].

11 Then the structure 36a will be changed as indicated below.

\[
\begin{array}{c}
\text{(i)} & \begin{array}{c}
\text{O} \\
\text{X} \\
\text{u} \\
\text{æ} \\
\text{l}
\end{array} & \begin{array}{c}
\text{R} \\
\text{X}
\end{array} \\
\text{(ii)} & \begin{array}{c}
\text{O} \\
\text{X} \\
\text{y} \\
\text{u} \\
\text{æ} \\
\text{l}
\end{array} & \begin{array}{c}
\text{R} \\
\text{X}
\end{array}
\end{array}
\]

A conceivable alternative to this solution is to treat (ii) as the underlying structure for the suffix -ual, i.e. the suffix underlyingly possesses /yl/. However, we must reject this solution, since the occurrence of [y] in this position is totally predictable. As noted in Halle and Mohanan (1985), the glide [y] is regularly followed by the [u] or [uw] in English. Because of this, while we have words with [Cw + different vowels] as in [kwəɪn], [kwæk], [kwəm], [kwʌt], we do not have [Cy + different vowels] _ *[kyɪn], *[kyæk], *[kyəm], *[kyʊt]. That is, [Cy] only occurs before [u]. In light of this fact, we follow the practice of SPE, and disallow underlying /Cy/, instead establishing Glide Insertion (37) and inserts [y] before certain vowels.
(38) habitual [hæbiːtjuːl]  
virtuous [vəːçuəs]
We take this to be an argument for assuming [y] between the stem-final consonants and the suffix-initial vowels in the examples in 35. After causing the coronal consonant /t/ to palatalize into [c], the glide [y] in 38 is deleted by Glide Deletion (31). Therefore, we must order Glide Insertion (37) prior to Palatalization (29) and Glide Deletion (31).

To sum up, the rules in this section are ordered as indicated below.

(39)  
   a. Rime Deletion (12)  
   b. X-slot Deletion (34)  
   c. Glide Insertion (37)  
   d. Palatalization (29)  
   e. Glide Deletion (31)  

As is seen above, Glide Insertion must apply before Palatalization since the former rule feeds the latter one. Glide Deletion is extrinsically ordered after Palatalization. Rime Deletion and X-slot Deletion is intrinsically ordered as such, since an unassociated X-slot which is subject to the latter rule is created as a result of the former one.

4. Conclusion. So far we have seen that the two types of vowel lengthening illustrated in 1 and 2 are, in fact, the manifestations of a single phenomenon, although they appear to be separate, distinct processes. This paper attempts to collapse these two vowel lengthenings into a single operation by means of the more general rule and convention—namely Rime Deletion (12) and subsequent spreading of segments to unassociated X-slots in the timing tier. The operation is then shown to interact with various other segmental rules in English—Velar Softening (8), Consonant Voicing (5), as well as Palatalization (29).

Furthermore, the present paper proposes that the operation relating to the vowel lengthening is motivated as a retiming of segments within a word. The two distinct alternations illustrated in 1 and 2 can then be expressed quite simply; the vowels in these examples are lengthened as a result of delinking of the following consonants from the timing slots to which they associate. Note that this result can only be achieved in the framework of the multi-tiered phonology. By assuming the autonomy of the timing tier (the X-slot tier), we were able to show that the vowels are lengthened to compensate the timing unit left unassociated in the X-slot tier.

Another important proposal of this paper is that these vowel length-
enings are ascribed to the well-formedness condition of the phonological strings. By proposing **Rime-Onset Alternation Principle** (10), the paper showed that there is a class of phonological rules which are motivated to achieve the well-formedness of the sequence of syllables.

The solution proposed in this paper allows us to capture the generalization in determining the grammar of a native speaker of English. The study also confirms the central role that syllables play in the phonology of a language.

REFERENCES


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