Chapter 4

Syllable Structure

4.0. Introduction

The concept of the syllable has been with phonologists for a long time. However, it seems that there has been no agreement whether to take "syllable" as a legitimate unit of phonological description. An interesting observation concerning this is that Ladefoged (1975: 281) defines syllable as "a unit of speech for which there is no satisfactory definition". This seems to reflect the problem that phoneticians and phonologists face in dealing with the syllable. However, more recent work in phonological theory has demonstrated that the syllable should be incorporated as a relevant domain in rule description and rule application. For example, Kahn (1976) succinctly showed that syllables play a very important role in describing the generalizations of some phonological phenomena found in English.

With renewed interest in the syllable in phonology, researchers have proposed various syllable structures and syllabification processes. The aim of this chapter is to make a brief survey on different proposals of syllable structure and syllabification processes. Also in this chapter, I will adopt McCarthy and Prince's (1986) moraic syllable structure. One of the difficult problems of adopting McCarthy and Prince's (1986) syllable structure for Korean is that many past and present scholars in Korean phonology have defended Body-and-Coda structure such as the one proposed by Wheeler (1981) and Vennemann (1984). I will review some of the argument for Body and Coda structure in Korean and show that the arguments are not convincing. Further, I will show that there are some phonological phenomena that
crucially refer to moraic syllable structure, which include "li" irregular verb phonology. With brief discussion on such phonological phenomena found in Korean, I will argue that McCarthy and Prince's syllable structure best serves for a consistent analysis of Korean vowel phonology.

4.1. Background

In SPE, we do not find any specific explanation about the role of syllable in phonological description. As a matter of fact, the SPE style of phonological representation consists of the linear arrangement of segments which are separated by boundaries. Even before SPE, scholars such as Kohler (1966: 207) claimed that the syllable is "either an unnecessary concept... or an impossible one... or even a harmful one". Though SPE does not recognize the syllable, it needs some device to refer to syllabic segments among the string of segments. The feature [±syllabic] is introduced in SPE to overcome the inadequacy of eliminating the syllable from phonology.

One major phonological argument for doing without the syllable that emerges from SPE is that phonological descriptions seem to be satisfactorily done without the concept of syllable if segmental information is fully exploited. As shown in the comprehensive analysis of the English sound system in SPE, all the major phonological observations may be described without resorting to the syllable. It is quite understandable that SPE and Kohler (1966) do not recognize the syllable because, as Halle and Keyser (1971:141) point out, the notion of syllable is used as "the equivalent of sequence of speech sounds consisting of one syllabic sound preceded and followed by any number of consecutive non-syllabic sounds".
Another difficulty in introducing the syllable in the formal description of phonological phenomena is that while it is true that the syllable peak or the syllabic segment plays an important role in phonology, the major problem for those analyses is that it seems to be totally impossible to break down the sequence of segments into syllables. This is reflected in the early major papers that argue for the necessity of the syllable such as Haugen (1956), Hoard (1971), Vennemann (1972a), and Hooper (1972) who disagree with one another in how to set the syllable boundary.

The latter problem is dealt with in Kahn (1976). He presents a comprehensive framework for syllable division and syllabification and applies his theory to English phonology. Kahn argues against the strict linear arrangement of segments and boundaries: he suggests that phonemes and syllable nodes are on separate tiers and the two tiers are linked to each other by association lines. Kahn (1976: 22-24) posits the following syllabification rules:

(1) Syllabification Processes.
   a. Rule I
      With each [+syllabic] segment of the input string, associate one syllable.

   b. Rule II
      i) \[ C_1 \ldots C_i \ V \rightarrow C_1 \ldots C_i \ C_{i+1} \ldots C_n \ V \]
      \[ \begin{array}{c}
         \text{s} \\
         \text{s}
      \end{array} \]
      where \( C_{i+1} \ldots C_n \) is a permissible initial cluster but \( C_i \ldots C_n \) is not.
Where $C_1 \ldots C_j$ is a permissible final cluster
but $C_1 \ldots C_{j+1}$ is not.

Here the concept of the "permissible initial cluster" and the "permissible final cluster" provide a framework for positing syllable division. An illustration will clarify the point. Consider the syllabification process of the following permissible and impermissible words.

(2) English Syllabification Examples.

a. combat  

b. bcombat 

c. comdbat

Rule I:

\[
\begin{array}{ccc}
S & S & S \\
\text{combat} & \text{bcombat} & \text{comdbat}
\end{array}
\]

Rule II (i):

\[
\begin{array}{ccc}
S & S & S \\
\text{combat} & \text{bcombat} & \text{comdbat}
\end{array}
\]

Rule II(ii):

\[
\begin{array}{ccc}
S & S & S \\
\text{combat} & \text{bcombat} & \text{comdbat}
\end{array}
\]

The most important observation that we make here is that in the application of Rule II to the words in (2b) and (2c), we find that /bc/ and /db/ are not permissible initial clusters in a sense that no English words begin with /bc/ or /db/ and that /md/ is not a permissible final
cluster. The presence of unassociated segments in (2b) and (2c) renders these potential English words as ill-formed. Focusing on (2c), since /db/ is not a possible word initial cluster, it cannot be a permissible syllable initial cluster, and since /md/ is not a possible syllable final cluster, it cannot be a possible syllable final cluster. This type of attempt in accounting for clusters can be useful in providing wider support for the syllable as the major unit of phonological description.

Further Selkirk (1982: 337) strongly argues that syllable structure is necessary for "the most general and explanatory statement of phonotactic constraints", for "the proper characterization of the domain" of phonological rules, and for "an adequate treatment of suprasegmental phenomena such as stress and tone". Let's consider these arguments one by one. First of all, in English, we find that no words begin with a /tl/ sequence (thus "tlass" is not a permissible word), though the same sequence is allowed morpheme internally as in "atlas" or "cutlass" as observed by Kahn (1976). This may not be easily captured if we entirely rely on segmental strings. The correct generalization is that no syllable can begin with a /tl/ cluster in English. This strongly suggests that the syllable is essential in the formal description of phonotactic constraints.

Secondly, Selkirk talks about the "proper characterization of the domain" of phonological rule application. One good example as pointed out by Kahn (1976) is that there are many different phonological rules in SPE, that are applied either before a word boundary or before a consonant. Kahn's (1976: 10-11) example of the so-called r-less dialects of English show that /r/ is not pronounced in such words as "car", "cart", or "war", while /r/ appears in "rack" and "carry". We may say that /r/ deletes before a consonant or word boundary. Kahn points out that the environment the class of consonants and word boundary do not form a natural class". Kahn's solution to this problem is to introduce syllable in describing the rule environment. He argues that the environment {C, #}
can be often collapsed into a syllable boundary.

Another Example given by Vennemann (1972a) clearly supports the syllable analysis. In Icelandic, vowels are lengthened in certain environments. Consider the following examples:

(3) Icelandic Vowel Lengthening

a. hatur [haːtʰýr] hatred
titra [tʰɪːtʰra] shiver

b. ofsi [of:si] violence
hattur [hat:ýr] hat

The first example in (3a) shows that vowels are lengthened before CV, while the examples in (3b) show that they cannot be lengthened before CCV. However as the second example in (3a) shows, vowels can be long before CCV if the second consonant is /r/ (or /j/ or /v/). The vowel lengthening rule based on segmental phonology would look like (4):

(4) Vowel Lengthening in Icelandic – I

\[ V[+\text{Stress}] \rightarrow [+\text{long}] / \_ C1 (C2) V \]

Conditions:
- \( C_2 = r, j, v \); if present
- \( C_1 = p, t, k, s, \)

The rule given in (4) does not tell us anything about the motivation for vowel lengthening. However, knowing that an obstruent plus /r, j, v/ constitute a permissible onset cluster, we may easily understand that what happens in (3) is an instance of vowel lengthening in an open...
syllable. Further the segmental approach may need another rule to account for the consonant lengthening witnessed in the examples in (3b). The segmental approach loses the significant generalization that the final segment of the stressed syllable is lengthened regardless of whether it is a consonant or vowel. This can be easily captured in the syllable based approach as shown in (5):

(5) Lengthening in Icelandic – II

\[ \sigma \]

\[[+\text{seg}] \rightarrow [+\text{long}] / \]

Finally we see that the syllable also plays a very important role in stress assignment. This is clearly reflected in the work in metrical phonology. Even SPE tacitly recognized the role of syllable in stress placement. It introduces the notion of "strong" and "weak" clusters for stress phenomena. The SPE (1968: 83) formulation of a weak cluster is as follows:

(6) SPE Weak Cluster

\[
\begin{bmatrix}
V \\
-\text{tense}
\end{bmatrix}
\begin{bmatrix}
\alpha\text{voc} \\
\alpha\text{cons} \\
-\text{ant}
\end{bmatrix} 0
\]

A weak cluster is a sequence of a lax vowel followed either by a single consonant or by two consonants if the second consonant is either a glide or a liquid and the first one is an obstruent. Thus given the syllable the consonant sequence in a weak cluster can be viewed as the sequence which can come in the onset position, strong clusters can be viewed as heterosyllabic consonant
sequences. SPE argued that the division into strong and weak clusters is very important in explaining several phonological phenomena found in English.¹

SPE (241) observed that "an important generalization ... that consonant liquid and consonant-glide strings function as single consonants" is left unexplained and admitted that the repetition of weak clusters in the environment of several rules indicates that SPE "failed to capture important properties of strong and weak clusters and thus points to a defect in our theory that merits further attention". The "defect" in SPE is proven to be the absence of syllable. Scholars such as Vennemann (1972a) and Hoard (1972) turned to the syllable to find more realistic generalizations in phonological description.

The different theories on stress assignment such as Hayes (1981), Selkirk (1984), Prince (1983), Halle and Vergnaud (1987) and Hayes (1991) agree with one another in that the stress placement is dependent on syllables and syllable internal structure. The strong and weak clusters can be defined on the basis of syllable internal structure. All these combined provide unyielding support for the importance of the syllable in phonological description.

Once the syllable is accepted as a formal unit of phonological description, different proposals on the syllable internal structures have been suggested. Davis (1985) gives three of these proposals as shown in (7):

(7) Different Syllable Internal Groupings².

¹The concept of weak cluster is also employed in SPE to explain Tensing Rules (Auxilliary reduction rules, r-tensing and tensing before CiV) and Laxing Rules (precluster laxing).

²Some researchers such as Liberman and Prince (1977) or Kiparsky (1977) use s/w (strong, weak) instead of the name of the internal constituents. I will just take the s/w theory as an equivalent to the proposed syllable structure in (7a). The syllable structure proposed in the frameworks of Dependency Phonology will not be dealt with.
a. Rhyme-Structure Analysis

![Rhyme Structure Diagram]

b. Body-Structure Analysis

![Body Structure Diagram]

c. Level Syllable Structure

![Syllable Structure Diagram]

The structure in (7a) is strongly supported in Selkirk (1982) and in Halle & Vergnaud (1980). They claimed that the constituent Rhyme is universal. The structure in (7b) shows the grouping of onset and nucleus. McCarthy (1979) says that the syllable structures in (7b) as well as (7a) are needed for his explanation of Estonian. Wheeler (1981) proposed the structure in (7b) to explain the phonotactic constraints in Korean3. The syllable structure in (7c) is supported by Davis (1985). He reviews all the claims made by the supporters of the structure in (7a) and (7b) against various language data such as stress, phonotactic constraints and language games and concluded that "Rhyme" does not have to be universal and argues for the

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3Fudge (1987: 360) wrongly claimed that the syllable structure in (7b) had never been previously proposed.
Another approach adopted by Clements and Keyser (1983) is to posit a CV tier between the phoneme (or segmental) tier and the syllable tier, wiping out internal hierarchical syllable structure. The English word "plant" may have the following structure according to Clements and Keyser (1983):

(8) CV Representation of "plant"

The representation in (8) is just like Kahn's (1976) flat structure except that it has an intermediate CV tier between segments and syllable nodes. In a sense Clements and Keyser's proposal is closer to the syllable structure given in (7c) than to that in (7a) or in (7b) in that the syllable structure in (8) as well as that in (7c) does not allow the binary branching hierarchical structure. The major departure from (7) is that the CV approach does not take "onset" or "coda" as legitimate syllable internal constituents. Clements and Keyser (1983), however, notice the necessity of the nucleus as part of the internal structure of the syllable which should be represented on a different tier. In the CV framework, either a VV or a VC sequence within

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4Clements and Keyser (1983) also strongly oppose the branching structures such as those in (7a) or in (7b) by saying that unconstrained binary branching theory is in need of substantive constraints.

5The original CV tier approach was first adopted by McCarthy (1979). But for McCarthy (1979) the CV tier was not a part of the syllable structure. The CV tier was proposed as a separate morphemic plane.
a syllable constitutes a heavy syllable for the purpose of stress assignments. According to Clements and Keyser (1983), such sequences would be projected as part of the nucleus projection for stress assignment.

Further work in syllable structure requires us to accept the necessity of treating CVC and CVV sequences in a language particular way. As noted by Hyman (1984, 1985), McCarthy and Prince (1986), and Hayes (1989), onset segments do not contribute to the weight of a syllable and the syllable weight may differ from language to language. For example, some languages, such as Latin and English, take CVV and CVC as heavy syllables and CV syllables as light, while in other languages, such as the Australian language Lardil only the CVV syllable is heavy and CVC and CV syllables are both light. In light of these observations, the CV theory of syllable structure should have an additional condition apart from the syllable structure that will define what heavy and light syllables for each language are.

In order to capture the language specific difference in defining heavy syllable, a moraic theory of syllable structure was proposed. The basic assumption in moraic phonology is that languages differ in assigning moraic structures. For example a language such as English assigns two moras both to CVV and CVC syllables and only one mora to CV syllables, while Lardil assigns two moras to a CVV syllable and just one mora to a CVC or CV syllable. In

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Another variant of the CV tier is the X-tier proposed by Levin (1984, 1985). Levin proposed to use an X tier instead of a CV tier. She further proposes to use elaborate syllable structure employing N-bar theory. For Levin, a syllable is the maximal projection of the nucleus. The English word "plan" would have the following structure according to Levin:

```
N
  N
    N
  X X X X
p l a n
```

I would take Levin's structure as a hybrid of the CV structure and the structure given in (7a).
this framework, we do not need any conditions in interpreting a heavy syllable. A syllable will be universally considered heavy if it has two moras.

4.2. Moraic Syllable Structure

In this section, I will present the case for moraic syllable structure by summarizing the main points put forward by the advocates of that theory. I will also talk about three different proposals on syllable structure within a moraic framework and try to compare these proposals. I will defend the syllable structure proposed by McCarthy and Prince (1986). Afterwards, I will briefly discuss the syllabification process.

4.2.1. Motivations for Moraic Syllable Structure

We have already discussed a problem of CV theory of syllable structure in defining a heavy syllable in languages that have a quantity-sensitive stress system (Hyman (1984)) that does not arise in the moraic theory. In addition to that, the moraic theory of the syllable has been proven to be quite effective in explaining compensatory lengthening (Hayes (1989)) and reduplication phenomena (McCarthy and Prince (1986)).

Hayes (1989) presents very convincing evidence for the moraic theory from the asymmetry in compensatory lengthening. What he observes is that the deletion of a segment does not always result in compensatory lengthening. According to Hayes, the onset consonants do not have moras. Simplifying somewhat, Hayes claims that the deletion of a moraic segment results in a floating mora and that compensatory lengthening is the result of a
vowel segment spreading to the mora. Thus a vowel is linked up to two moras. However onset consonant deletion does not leave any empty mora, hence onset deletion does not trigger compensatory lengthening. In CV or X theory, the deletion of an onset segment would leave an empty slot, so compensatory lengthening may be predicted to occur as a result of such deletion. Thus Hayes (1989) convincingly shows that the moraic syllable structure theory is more effective than CV structure or X theory in handling compensatory lengthening and points out that both CV and X theory are inadequate in that they don't really differentiate between onset consonants and weighted coda consonants.

Hayes (1989) further argues that the compensatory lengthening by glide formation can be neatly explained by adopting the moraic theory of syllable structure. Glide formation is a process of delinking a moraic segment, and as a result the mora which dominated the glide is left unfilled and the following vowel segment spreads to the empty mora to make a well-formed syllable\(^7\) as schematically shown in (9):

\[
\begin{align*}
\text{(9) Glide Formation} \\
\begin{array}{c}
\sigma & \sigma \\
\mu & \mu \\
\end{array}
\rightarrow
\begin{array}{c}
\sigma & \sigma \\
\mu & \mu \\
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
\mu & \mu \\
\end{array}
\end{align*}
\]


\[^7\text{This can be easily explained by positing the following Satisfaction Condition as in McCarthy and Prince (1986: 6):}\
\text{Satisfaction Condition.}\
\text{All elements in a template are obligatorily satisfied.}\]
reference to the CV-tier. They point out that Marantz's analysis is problematic and that reduplication does not support the CV-tier but a moraic theory of syllable structure. For example, Marantz's theory fails to capture the invariance in reduplicated forms. Consider the Ilokano partial reduplication data in (10):

(10) Ilokano Partial Reduplication

<table>
<thead>
<tr>
<th>Word</th>
<th>Reduplication</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>/basa/</td>
<td>ag - BAS - basa</td>
<td>(be reading)</td>
</tr>
<tr>
<td>/adal/</td>
<td>ag - AD - adal</td>
<td>(be studying)</td>
</tr>
<tr>
<td>/trabaho/</td>
<td>ag - TRAB - trabaho</td>
<td>(be working)</td>
</tr>
</tbody>
</table>

The CV approach has to set up a CCVC template to account for the three words in the data. Note that in terms of a CV-tier the reduplicated forms vary from word to word: CVC, VC, and CCVC. There is no explanation why such variation exists. Such a CV segmental approach cannot capture the generalization that what reduplicates in Ilokano is a *bimoraic* syllable.

Further, McCarthy and Prince argue that the CV approach does not properly constrain templates in prosodic morphology in general since the CV approach may suggest impossible templates. For example there is no CVCCCV template in Arabic, but the CV theory cannot explain the absence of such a template in Arabic. For a prosodic approach, such a template is naturally excluded since Arabic syllabification disallows a CCC sequence.

In sum, Hayes (1989) and McCarthy and Prince (1986) have presented strong evidence to motivate a moraic-type syllable structure as opposed to one consisting of CV or X-slots.
4.2.2. Different Proposals

Recent studies in syllable internal structure in the framework of moraic phonology give rise to the following three possibilities as exemplified with English word "plant".

(11) Different Moraic Syllable Structures

a. Mora-only (=MO) Structure

b. Weighted-segment (=WS) Structure

c. Onset and Mora (=OM) Structure

All three structures are severely impoverished in that they do not have any elaborate internal structures. Moras are recognized as the legitimate and only internal constituents within a syllable. The structure in (11a) is proposed by Hyman (1985) and further elaborated in Zec (1988). This structure does not allow any segment to be directly linked to the syllable node. All the segments should be linked to the mora first and only moras are linked to the
syllable nodes. We will call this MO structure here. The syllable structure in (11b), which we will call WS structure, was adopted by McCarthy and Prince (1986) in explaining templatic morphology including reduplication in various languages. Hayes (1989) introduced the structure in (11c) for his explanation of compensatory vowel lengthening in many languages. We will call this OM structure.

The MO structure differs from this OM structure in that syllable initial consonants are directly linked to the syllable node in the latter, while in the former they are linked up to the mora. The MO structure shows that non-moraic syllable initial segments or more traditionally onset consonants are dominated by the mora while syllables dominate nothing but moras.

The MO and OM structures are different from the WS structure in the way they treat syllable final consonant clusters. In the former these are viewed as being attached to the second mora, not directly to the syllable. The WS structure, on the other hand, makes a very strong claim that only true moraic segments (like vowels) are associated to moras and all others are linked to the syllable directly, regardless whether the non-moraic segments are in syllable initial position or syllable final position.

McCarthy and Prince's (1986) WS syllable structure will be adopted in this paper. Basically it seems up to personal preference in choosing one out of the three proposed structures. But there is a certain amount of phonological evidence that seems to argue for WS structure. I will briefly present some phonological data which can be better explained by using WS structure.

4.2.3. The Weighted Segment Structure

To my knowledge, Steriade (1988:97) makes the first brief observation of the difference of the predictions that the MO and OM structures make in her discussion of Sanskrit
phonology. To recapitulate it in short, Sanskrit has an /a/-deletion rule that deletes /a/ in an unaccented syllable. If this rule is applied to /siand/, the resultant structure after the application of vocalization is not */sind/ but /syad/.

Now if we take the MO structure, /a/-deletion may result in the wrong surface form as in (12):

(12) A-deletion in MO Structure

\[
\begin{array}{c}
\sigma \\
\mu \\
\mu \\
\mu \\
s \\
i \\
an \\
d \\
\xrightarrow{\text{a-deletion}}
\end{array}
\quad \rightarrow 
\begin{array}{c}
\sigma \\
\mu \\
\mu \\
\mu \\
s \\
i \\
n \\
d
\end{array}
\]

\(=\)sind

According to Steriade, the OM or WS syllable representations along with the rule of vocalization can derive the correct phonetic form as in (13):

(13) A-deletion in WS and OM Structure

\[
\begin{array}{c}
\sigma \\
\mu \\
\mu \\
\mu \\
s \\
i \\
an \\
d \\
\xrightarrow{\text{a-deletion}}
\end{array}
\quad \rightarrow 
\begin{array}{c}
\sigma \\
\mu \\
\mu \\
\mu \\
s \\
i \\
n \\
d
\end{array}
\]

synd→syad

Though, there are things left unexplained here, this opens the possibility of comparing the different predictions that each of the different syllable structures make.

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8The vocalization rule ensures that there is a nucleus segment in a syllable throughout the phonological derivation. Steriade mentions that there are three mechanisms behind the vocalization rule as summarized below:

a. At every stage in the derivation, the nucleus is the leftmost rhyme segment.
b. Only a sonorant can be nuclear.
c. Restructuring:

A syllable lacking a well-formed nucleus is restructured by reassigning an onset segment to the rhyme.

9For example, it is curious why a mora is deleted in (13), while it remains in (12) and how to explain the change from syllabic /n/ to /a/.
In what follows, I will make a few more comparisons among these structures. First we will talk about the phonological nature of the onset consonants in Western Aranda stress rules and in language games. These data seem to indicate that linking non-moraic syllable initial segments directly to the syllable node (the OM and WS structures) provides a much better and more concise explanation than the MO structures. Afterwards, I will consider coda consonants and how they are linked to syllable nodes. Especially, I will argue that there are some phonological rules that have as their environment two weighted segments. This can be most simply expressed with the WS structure. Such an observation renders support to the WS structure.

Davis (1985, 1988) noted that there are cases where onset consonants play an important role in stress assignment. Western Aranda, an Arandic language of Australia, is one such language. In this language stress is assigned to the first syllable in disyllabic words and in the case of words with three or more syllables, stress falls on the first syllable if the word in question begins with a consonant; otherwise the stress is assigned to the second syllable as shown in (14):

(14) Western Aranda Stress (data from Strehlow: 1942)

a. bi-syllabic words

lái  go (imperative)
gúra  bandicoot
ílba  ear
wúma  to hear

b. vowel initial words with three or more syllable

inánga  arm
ibáːtja  milk
The generalization seems to be straightforward. In two syllable words primary stress falls on the initial syllable. In words of greater length, primary stress falls on the first syllable containing an onset consonant; secondary stress goes to every other syllable that follows the syllable with primary stress, but the last syllable is never stressed. Following Hayes (1991), we may formulate the following stress rules:

(15) Western Aranda Stress Assignment

a. Mark a vowel initial syllable extrametrical on the left edge.

b. Build trochees from left to right, with degenerate feet forbidden absolutely.

c. Word layer: End rule left.

(15a) and (15b) together guarantee that the first consonant-initial syllable carries a stress as well as every other syllable thereafter. The ban on degenerate feet (Hayes (1991: 82)) forces the final syllable to be stressless, even if it is potentially in a metrically strong position. (15c) places the primary stress on the head of the left-most trochee. Below are some sample derivations.

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10For different analyses, please refer to Archangeli (1986), Halle and Vergnaud (1987), and Davis (1988).
(16) Sample Derivation of Western Aranda Stress

a. ergúma  b. túkuma  c. ilba

Underlying Representation

erguma     tukuma     ilba

Extrametricality

<er>guma     _____     _____

Trochee Building

(x .)   (x .)   (x .)  
<er>g um a  t u k u m a  i l b a

End Rule Left

( x )   ( x )   ( x )   
<er>g um a  t u k u m a  i l b a

In (16a), the first syllable is marked extrametrical, and the syllable trochee is built from the second syllable, resulting in placing the primary stress on the second syllable. In (16b), the first syllable is not extrametrical since it is not vowel initial, and the stress is placed on the first syllable. Notice that the second trochee cannot be built on the final syllable since there is a ban on degenerate, or monosyllabic, feet. (16c) is an interesting example. The extrametricality cannot be applied to this string, since without the first syllable, there is only one syllable and there is a ban on degenerate feet. Such a case causes the revocation of extrametricality to keep the foot binary; hence in (16c) stress is on the first syllable though it is vowel initial.

Now the major concern for us is how to represent the extrametricality of the vowel initial syllables. For OM and WS, the description is simple and direct. It is the mora initial syllable at the left margin of a word which is extrametrical. Therefore we may formulate the
following rule to indicate the extrametricality:

\[(17) \quad \text{Western Aranda Extrametricality (OM & WS version)} \]

\[
\sigma \quad \xrightarrow{\text{word}} \quad \langle \sigma \rangle \\
\mu \quad \mu
\]

(A mora initial syllable at the left edge of a word is extrametrical.)

This formulation is not available to the MO structure, because all syllables, whether they are V-initial or C-initial, are mora initial. Actually with the MO, the syllable dominates only moras. In other words, the syllable begins and ends with a mora without exception. It seems to be extremely difficult to formalize the extrametricality of a vowel initial syllable at the beginning of a word in terms of the MO style of syllable structure.

I will briefly explore the difficulty in defining the extrametrical syllable with the MO structure. The only conceivable way to define the vowel initial syllable extrametricality is to claim that vowel initial syllables have non-branching moraic structure with the assumption that the coda consonants are moraic segments. This will give rise to the following structures:

\[(18) \quad \text{Word Structures in the MO Framework} \]

\[
a. \text{erguma} \quad b. \text{utnatawara} \\
\begin{array}{cccccccc}
\sigma & \sigma & \sigma & \sigma & \sigma & \sigma & \sigma & \sigma \\
\mu & \mu & \mu & \mu & \mu & \mu & \mu & \mu \\
\text{e} & \text{r} & \text{g} & \text{u} & \text{m} & \text{a} & \text{u} & \text{t} & \text{n} & \text{a} & \text{t} & \text{a} & \text{w} & \text{a} & \text{r} & \text{a}
\end{array}
\]
But such a move causes some unwanted problems: First of all we have to note that assigning moraic status to the syllable final consonant, Margin Creation Rule (Hyman, 1985: 18) or Weight by Position (Hayes, 1989: 258) is normally limited to those languages that treat CVC syllables as heavy for such phonological phenomena as stress assignment or compensatory lengthening. Here we can find a theory internal contradiction: no moraic status should be assigned to syllable final consonants in Western Aranda because this language does not have a quantity sensitive stress system where CVC is treated heavy for the purpose of stress assignment, however the final consonant should not be incorporated to the first mora for the description of extrametricality.  

Thus, we can see that the OM or WS structures provide a much more straightforward account of the extrametricality in the stress system of Western Aranda than the MO structure.

Another difficulty for the MO structure concerns the language games that McCarthy and Prince (1986) report. Consider the English and Kamrupi cases below.

(19) Echo words (data from McCarthy and Prince (1986: 85)

a. English

   table-shmable
   book-shmook
   apple-shmapple
   strike-shmike

---

11Another possibility is to treat the consonant after a vowel as an onset consonant of the following syllable. This, however, leads to the violation of sonority contour principle that onset consonants should have rising sonority (Zec, 1989: 110). In "erguma" /r/ is more sonorous than /g/, so that the syllable boundary should come between /r/ and /g/. This rules out the possibility of syllabifying "erguma" as in (e)- (rgu)- (ma)- · · ·
b. Kamrupi

<table>
<thead>
<tr>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ghar-sar</td>
<td>house</td>
</tr>
<tr>
<td>gharaa-saraa</td>
<td>horse</td>
</tr>
<tr>
<td>khori-sori</td>
<td>fuel</td>
</tr>
</tbody>
</table>

The analysis given by McCarthy and Prince for the data in (19) involves reduplication followed by melody detaching of the initial consonants and replacing or overwriting them by *shm* (as in English) or by *s* (as in Kamrupi). The question in point is how to formalize the detaching process here. To put it in terms of a Selkirk (1982) type of syllable structure, it is the onset cluster of the word initial syllable in both languages that detaches. With the OM or WS structures, we can easily identify what are the onset elements. Therefore the onset delinking process can be described as getting rid of any pre-moraic consonants. Here again, the MO structure may find difficulty in formally capturing the generalization of the onset deletion process.

Another important observation to make concerning the difference in the geometrical representation of a syllable comes from the fact that there are rules that involve two weighted segments. Korean umlaut, which will be discussed in Chapter 7 in detail, is a case in point. A back unround vowel is fronted if the following vowel is /i/. But the process is blocked if a geminate consonant intervenes between the two vowels. In order to explain the blocking effect of the intervening geminate consonant, we have to say that the rule operates on moraic tier adjacency. Nongeminate consonants are not moraic and the moraic tier adjacency can skip such intervening consonants. It is graphically shown in (20):
(20)  Geminate and Nongeminate Consonant Representation

a.  
\begin{array}{c}
| \sigma & \sigma \\
| \mu & \mu & \mu \\
\end{array}

b.  
\begin{array}{c}
| \sigma & \sigma \\
| \mu & \mu \\
\end{array}

(to be sucked)     (kettle)

In (20a), the two vowels, /a/ and /i/ are not adjacent with each other on the moraic tier, since another moraic segment intervenes between them. Compare (20a) with (20b). We notice that the two moraic segments are adjacent with each other without any intervening moraic segment. Interestingly, it is only the word in (20b) that undergoes vowel fronting to become [n`mbi]. What is crucially important here is to locate the weighted segments in the geometrical representations. But the OM or MO structures do not show it directly on the representation itself. Consider the following representations expressed in the MO and OM structures:

(21)  The Representation of "kettle" in the MO and OM Structures

a. The MO Structure     b. The OM Structure

\begin{array}{c}
| \sigma & \sigma \\
| \mu & \mu \\
\end{array}

\begin{array}{c}
| \sigma & \sigma \\
| \mu & \mu \\
\end{array}

n a m p i n a m p i

One cannot readily point out which are weighted segments in the representations given in (21). Though it is not impossible to define weighted segments with the MO or OM structures such as a condition that the target should be a head of a mora, there would be need to resort to ad hoc conditions on the umlaut rules for Korean.
With the preceding observations, we come to the conclusion that the weighted segments should be graphically represented and one way to do so is to link all and only the weighted segments to moras and other consonants to the syllable node directly. While none of the observations are crucial in choosing one structure over the other, I think there is a reasonable preference for McCarthy and Prince's weighted segment structure.

4.2.4. The Nature of the Mora

In this subsection, I will briefly consider the nature of the mora in syllable structure. I show that the mora is autosegmental in nature, it is a subconstituent of the syllable and it is a prosodic unit. In our discussion of compensatory lengthening, it is tacitly assumed that the moraic segment deletion leaves the mora intact. A mora may not be deleted even when the segments to which it is associated is deleted by the application of a phonological rule. In other words, moras are autonomous from segmental features. Compensatory lengthening is due to this autosegmental nature of the mora. Syllable weight and vowel length can be expressed because of the autosegmental nature of a mora.

At the same time, a mora is a structural constituent of a syllable. Within moraic phonology it can be viewed as the only legitimate constituent that a syllable has. I further suggest that the mora is an obligatory constituent of the syllable. A syllable without a mora is illformed. I will suggest the following syllable condition:

(22) Syllable Wellformedness Condition

\[
\begin{array}{c}
\ast \sigma \\
\downarrow \\
x & x
\end{array}
\]

(A syllable without a mora is illformed.)
Itô (1986) calls a syllable without an obligatory constituent a degenerate syllable. Degenerate syllables are not allowed at the surface level. Epenthesis is a process to make a degenerate syllable wellformed as argued in Itô (1986, 1989). In the present theory, epenthesis is the result of the Syllable Wellformedness Condition along with underspecification. Suppose that a consonant is left unsyllabified. This unsyllabified consonant is subject to one of two processes: Stray Erasure or Mora Projection. Stray Erasure (Steriade (1982), Itô (1986)) is a process that eliminates unsyllabified segments to make sure that all the segments are properly incorporated into syllables. The second process, Mora Projection, is another way to make the stray segment syllabified or the degenerate syllable wellformed. It is schematically shown in (23):

(23) Mora Projection

First consider that there is another possible structure that can come out of Mora Projection as shown in the parenthesis of (23). I will note that the CV structure is more natural than the VC structure and therefore it is the less marked form which will be universally adopted over the marked forms. We can see that the stray segment is incorporated into a wellformed syllable. But notice that the mora is left unfilled. I suggest that the unfilled mora is interpreted as the least specified vowel segment in the language.

Finally, we find that a mora is a prosodic unit as argued in McCarthy and Prince (1986), Zec (1988) and Bullock (1991). McCarthy and Prince convincingly show that a mora can constitute a prosodic template in the reduplication process as in the case of core syllable
reduplication. Zec (1988) and Bullock (1991) argue that a mora is a prosodic unit that can prosodically license moraic segments.

Thus we see that the mora is simultaneously an autosegmental unit, a subsyllabic unit and a prosodic unit. The mora therefore has multiple functions in the phonology.

4.2.5. Syllabification Process

There are two major assumptions about the syllabification process: one is that all the segments should be incorporated into syllables (Steriade (1982) Cairns and Feinstein (1982), Selkirk (1982), Itô (1986) among others) and that syllabification is predictable. The first assumption is well expressed in Itô’s (1986: 2) Prosodic Licensing condition given in (24):

(24) Prosodic Licensing

All phonological units must be prosodically licensed, i.e. belong to higher prosodic structure (modulo extraprosodicity).

The "higher prosodic structure" here surely includes syllables and thus all the segments should be syllabified with the exception of extraprosodic elements at the edge of a sequence.

The second assumption leads to the proposals on the syllabification procedure. There are mainly two different approaches to syllabification: the templatic approach (Selkirk (1982), Itô (1986)) and the rule based approach (Steriade (1982), Hyman (1985), McCarthy and Prince (1986)). In the templatic approach, the syllable structure is represented on a separate tier and segments are mapped onto the terminal constituents by association lines, while the rule based approach builds syllables on top of the melodic tier. Given that the syllable structure is very

---

12 Hyman (1990) makes a different proposal that syllabification may not be exhaustive.
simple and mechanically predictable, I will adopt the rule based approach in this dissertation.

It is generally agreed that the syllable building process can be divided into two independent processes: moraification and syllabification. Moraification is a process that identifies the moraic segment in the given string and the syllabification process takes the moraic and non-moraic segments and incorporates them into syllables. Bullock (1991) argues that there is an ordering between these two processes. She identifies three different ordering relations: Moraification before Syllabification, Syllabification before Moraification, and Moraification and Syllabification at the same time. Bullock's argument is based on the concept that Moraification is part of the derivational process. However, if we take Hayes' (1989) assumption that all the moras are projected in underlying representation, then syllabification cannot precede moraification.

4.2.5.1. Moraification

Different proposals have been made concerning moraification. Hyman (1985) and Bagemihl (1991) argue that underlyingly all segments are linked to single moras but a later rule "demoraifies" the "non-moraic" segment. Here is an example of demoraification from Bagemihl's (1990) work on Bella Coola:

(25) Moraification in Bella Coola

a. Underlying Structure

```
µ  µ  µ  µ  µ  µ
s q c i l
```
b. Demoraification and Syllabification

One brief observation we can make here is that the demoraification rule is strange given the autosegmental nature of a mora. The demoraification process has redundancies in that the moras are always deleted from a consonant which is before a vowel. Given the predictable nature of demoraification, I will argue that you do not have to link the non-moraic segments to moras in the underlying representation.

Zec (1988) takes a different approach. Zec (1988) shows the typological distribution of moraic and syllabic segments and argues that each language defines the moraic segments on the basis of universal principles related to sonority constraints. According to her, there are four typologically different languages as shown in (26):

(26) Typology of the Sonority of the Mora\textsuperscript{13}

a. Type One (syl < mora = segment)

All the segments can be moraic but not all moras can be syllabic.

(Cairene Arabic, Aklan, English ...)

b. Type Two (syl = mora < segment)

Only the vowels are moraic. (Khalkha Mongolian, Ilokano ...)

c. Type Three (syl < mora < segment)

All the vowels and a certain set of consonants can be moraic.

(Danish, Lithuanian, Kwakwala ...)

\textsuperscript{13}A\textless{}B means that the set A is properly included in the set B.
d Type Four (syl = mora = segment)

Even obstruents can be syllabic. (Imdlawn Tashlihiyt Berber ...)

With the parameterization of moraic segments and syllabic segments, Zec (1988) argues that only the moraic segments can project a mora. This does not mean that all the consonants are moraic in languages like in (26a). Zec (1988) provides a constraint on mora projection as given in (27):

(27) Zec's Moraification

Given a sequence $S$ of unlinked segments $S_1, S_2, \ldots S_i \ldots S_n$, Link $S$ to mora iff

a. $s_i$ is more sonorous than $s_{i-1}$

b. $s_n$ is a member of the set of moraic segments

c. $s_n$ is not immediately followed by a more sonorous segment.

McCarthy and Prince (1986) maintain that moras are projected from vocalic segments and that long vowels and geminate consonants carry one mora underlyingly. Thus hypothetical words, "paama" and "pamma" will be represented differently underlyingly as shown in (28):

(28) Examples of Mora Projection

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>a</td>
</tr>
<tr>
<td>a</td>
<td>m</td>
</tr>
<tr>
<td>a</td>
<td>m</td>
</tr>
</tbody>
</table>

It should be noted that Zec (1988) adopts the MO syllable structure proposed by Hyman (1985) which is illustrated in (11a).
Long vowels and geminate consonants have one mora underlyingly and the later moraification will project moras from moraic segments. Thus there are two different processes in moraification. Some moras are already projected in the underlying representation and other moras will be projected by later rule.

Hayes (1989) does not recognize the later rule of moraification. He would take the forms with all the moras projected as the underlying forms. Hayes (1989: 259) claims that putting all the moras underlyingly provides "the simplest description of possible contrasts in mora counts". He cites two examples of three way contrasts in mora counts. Kimatuumbi (Odden (1981)) and Gokana (Hyman (1985)) permit long syllabic nasals. Therefore a nasal, a geminate nasal, and a long syllabic nasal makes a three way contrast. Another example comes from languages where glides are underlyingly contrastive with high vowels. In such a language, /y/, /i/, and /i:/ make a three way contrast. This may be problematic for McCarthy and Prince's (1986) mora projection approach. Assuming that glides are underlying vowels, the mora projection as in McCarthy and Prince (1986) cannot satisfactorily explain such three way contrasts as shown in (29), since (29a) and (29b) would both be moraless in underlying representation in McCarthy and Prince's theory:

(29) Three Way Contrasts in Vowels

\[
\begin{align*}
\mu & \mu & \mu & \mu & \mu & \mu \\
/ & / & / & / & / & / \\
p & a & m & a & p & a & m & a
\end{align*}
\]
Korean is one of the languages that show surface glide and high vowel contrast.

Consider the following data:

(30) Glide High Vowel Contrast in Korean

a. suiombre, su (intermittently)

b. kiun, kyun (germ)

a. iuñ, iu (will)

In order to explain the surface contrast, we will have to assume either that the segments are syllabified fully in the underlying representation or that moras are present underlyingly. Given the general assumption that syllabification is predictable, putting the mora in the underlying representation is a simpler and better analysis. The exemplary derivation of the first word in (30) is given in (31):

(31) Exemplary Syllabification

For the moment, I will not be concerned with how to geometrically represent the glides. I will return to this in Chapter 5.
b. “beard”

As shown in (31), the underlying structures differ in the two words with respect to moraic status. The following syllabification is automatic and gives the correct surface forms. With these observations, I will adopt Hayes' (1989) proposal on underlying morafication\textsuperscript{16}. Therefore the theoretical assumption adopted in this study is a hybrid of Hayes (1989) and McCarthy and Prince (1986). Notice that the McCarthy and Prince's (1986) proposal of the syllable structure along with Hayes' (1989) morafication assumption is adopted here.

4.2.5.2. Syllabification

Syllabification operates on the projected moras. I assume the following processes in syllabification\textsuperscript{17}.

(32) Syllabification Rules

\begin{itemize}
\item a. Syllable Projection (=SP)
\item b. Weight by Position (=WP)
\item c. Syllable Incorporation (=SI)
\item d. Stray Syllabification (=SS)
\end{itemize}

\textsuperscript{16}It should be noted here that positing the mora in the underlying representation does not mean that all necessary moras are present underlyingly. There are other rules that assign a mora in the course of syllabification as will be discussed later in this subsection. Weight by Position rules and Stray Syllabification are processes of projecting moras in syllabification which is not present in the underlying representations.

\textsuperscript{17}Part of the syllabification algorithm that I do not talk about here is the direction of syllabification, like the directionality parameter discussed by Itô (1986), or the leftward and rightward strategies by Kaye & Lowenstamm (1981).
The syllable projection rule is equivalent to the CV rule in Steriade (1982) and the Universal Core Syllable Condition in Itô (1986: 5). This process groups a moraic segment and the preceding nonmoraic segment to form a syllable. Syllable projection is schematically shown in (33):

(33) Syllable Projection

\[
\begin{array}{c}
\mu \\
\text{R} \\
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
\mu \\
\text{R} \\
\end{array}
\]

(R stands for "Root Node").

The Weight by Position rule (Hayes (1989), or the Margin Creation rule (Hyman (1985)), is a language-particular rule that makes closed syllables heavy in languages where CVC syllables are considered heavy for the purpose of stress assignment. Hayes (1989: 258) assigns a mora to a coda consonant by means of the Weight by Position rule given in (34):

(34) Weight by Position

\[
\begin{array}{c}
\sigma \\
\mu \\
\alpha \\
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
\mu \\
\alpha \\
\end{array}
\]

where \( \alpha \) dominates only \( \mu \).

The rule of Weight by Position assigns a mora to a nonsyllabified segment in a monomoraic syllable and it is incorporated to the syllable making that syllable bimoraic. I assume that this

\[1\]

I assume that if the moraic segment does not have a preceding segment, the moraic segment alone makes an onsetless syllable.
Syllable Incorporation in (32c) is the process that links non-moraic consonants to the syllable. In this sense, we may say that the process includes both the onset rules and coda rules of Steriade (1982: 78-79). Following, Kahn (1976), Selkirk (1982), Vogel (1977) and many others, I will assume that there is an Onset Maximalization Principle, which prohibits a possible onset sequence from being a coda of the preceding syllable.

Another relevant aspect of syllabification comes from Prosodic Licensing. Suppose that there is a left-over segment after syllabification, which cannot be incorporated to the coda of the preceding syllable nor to the onset of the following syllable. Languages have options in this case: Stray Erasure or Stray Syllabification. Stray Erasure is a way to get rid of the unsyllabified segment in order to make all the segments prosodically licensed as discussed in detail in Steriade (1982) and Itô (1986). Another option is to put the unsyllabified segment into a syllable along with the necessary projection of a mora and the subsequent insertion of a vowel. Consider a schematized sequence of segments after syllabification given in (35):

(35) Unsyllabified Segments

Suppose that the unsyllabified consonant in (35) cannot be a coda nor can it constitute a part of complex onset of the following syllable, and Stray Erasure is not applicable in this language. The only way to make the string well-formed is to incorporate the stray segment
into another syllable. Then Stray Syllabification takes the unaffiliated segment and incorporates it into a syllable as in (36a). There are cases just like in (35b) where two segments are unaffiliated to syllable nodes for language specific reasons. If Stray Erasure is not operative at this level, and the second unassociated segment can be a rhyme member, then it can also be incorporated to a syllable as shown in (36b).

(36) Stray Syllabification (=SS)

a. \[
\begin{array}{c}
\sigma & \sigma & \sigma \\
\mu & & \\
C & V & C & C & V \\
\end{array}
\begin{array}{c}
\sigma & \sigma & \sigma \\
\mu & & \\
C & V & C & C & V \\
\end{array}
\]

b. \[
\begin{array}{c}
\sigma & \sigma & \sigma \\
\mu & & \\
C & V & X & X & C & V \\
\end{array}
\begin{array}{c}
\sigma & \sigma & \sigma \\
\mu & & \\
C & V & X & X & C & V \\
\end{array}
\]

The stray segments are linked up to a syllable node. This degenerate syllable is not well-formed. (cf. (22)) A mora is then projected from the syllable to make the syllable well-formed. Finally the mora will be filled with the least specified vowel in this language or by spreading of features from the surrounding segments. In the case of (36b) the output should conform to the well-formed syllable template. Otherwise Stray Syllabification will be applied twice in (36b). The mechanism may sometimes produce more than one possible output. Consider the different syllabifications illustrated in (37):
(37) Hypothetical CVCCV Syllabification.

a. Syllable Projection and Syllable Incorporation

```
µ µ μ µ
C V C C V  SP  µ µ
C V C C V  SI  µ µ
```

b. Syllable Projection and Stray Syllabification

```
µ µ μ µ
C V C C V  SP  µ µ
C V C C V  SS  µ µ µ
```

In (37a), the unsyllabified segment is syllabified as a coda of a preceding syllable, while it triggers Stray Syllabification in (37b). If the language does not allow coda consonants, then (37b) is the only well-formed syllabification. But if this language allows coda consonants, then which is the correct syllabification? There may be two ways to constrain the syllabification process. First we may say that there is an intrinsic ordering relationship between Syllable Incorporation and Stray Syllabification, since Stray Syllabification applies only when there is a segment which is not incorporated into the syllable. Or we may refer to general principle of syllabification as proposed in Kiparsky (1979: 432-433)19:

19Lowenstamm (1979: 97) also makes an identical proposal in one of his two basic principles of syllabification, as given below:

Basic Principles of Syllabification
Principle I - Minimize the number of syllables.
Principle II - Minimize the degree of markedness of each syllable.
Given alternative syllabifications for a string, choose the one that minimizes the total number of syllables.

Either of the approaches can correctly predict that the syllabification in (37a) is always preferable to that in (37b) in languages that allow a coda segment on the level of syllabification.

### 4.3. Syllable Structure in Korean

In this section, I will discuss the syllable structure in Korean. So far we have discussed that the moraic theory of syllable structure is well motivated for the explanation of compensatory lengthening, partial reduplication and stress placement. The Korean language, however, does not have a rich templatic morphology to motivate the use of mora, nor does the Korean language have a quantity sensitive stress system. However, I argue that these observations do not necessarily mean that moraic syllable structure is not motivated in Korean.

I will first briefly discuss the proposals made for Korean. Body (or Core) structure which is most extensively argued for Korean will be reviewed with the discussion on the major arguments for the structure. Then I will talk about the motivation for moraic structure in Korean. We have already seen that the surface contrast of a glide with a high vowel provides a good motivation for moraic structure in Korean. Further we have discussed that there is a vowel fronting rule in Korean that crucially refers to the weighted segments in Korean. I will further argue that the phonology of "lì" irregular verbs in Korean and the obligatory nature of
glide formation for some verbs strongly argue that there should be a moraic representation in the underlying representation.

4.3.1. Branching Structures

Two main hierarchical syllable structures proposed for Korean are the Left branching (Body/Coda) structure and the Right branching (Onset/Rhyme) structure. These two proposals are geometrically represented in (39):

(39) Two Hierarchical Syllable Structures Proposed for Korean

a. Left Branching

```
Syll
  Body (=Core)
     Coda
      Onset
         Nucleus

N''
  N'
   N
    X
     X
      X
```

b. Right Branching

```
Syll
  Onset
     Rhyme
       Nucleus
          Coda

N''
  N'
   N
    X
     X
      X
```

The structures on the left side show the traditional syllable structure with the specified constituent names, and the structures on the right are the translations of the structures in the

The language acquisition data are presented by Gim (1987) and S-C. Ahn (1988b) to argue for the Body-Coda structure for Korean. They observe that native children acquire CV forms before CVC and argue that the Body-Coda division is motivated in the language learning process. Gim (1987:23) and S-C. Ahn (1988b: 345-346) further argue that the syllable structure is reflected in explaining segment combinations. For example, when an adult teaches the pronunciation of /son/ (hand), there may be three different ways of explaining the pronunciation as illustrated in (40):

(40) Explaining the Pronunciation of /son/
   a. [so] plus [n] makes [son].
   b. [s] plus [o] plus [n] makes [son].
   c. [s] plus [on] makes [son].

The basic assumption that Gim takes is that if (40a) is the most frequent way of explaining the pronunciation, it means that the Korean syllable has the left branching structure. (40b) will support a flat structure such as Kahn's (1976) or Clements and Keyser's (1983). (40c), on the other hand, will support the right branching structure. Pointing out that (40c) is not possible in explaining the pronunciation of /son/, Gim and S-C. Ahn concluded that the right-branching structure cannot be motivated in children's recognition of a CVC syllable.

However, it should be noted that the CV syllable is universally unmarked regardless of
the difference in syllable structures of languages, as Lowenstamn (1979: 62), Steriade (1982: 78), Noske (1982: 271) and many others argue. Even in languages in which the right branching syllable structure is quite well motivated, such as English and French, children acquire CV syllables before VC syllables. The point is that it is not the syllable structure but the degree of markedness that explains the order of acquisition of different syllable types. Further, if we define the order of acquisition on the basis of syllable structure, which is untenable, we come to the conclusion that Korean children learn CGV syllables before CVC syllables. A brief survey of the Korean child's language shows that there are CVC monosyllabic words such as /kom/ (a bear), or /nun/ (eye) but no CGV monosyllable words. Again, assuming that the CV syllable is the most natural utterance unit, (40a) seems to be the natural way of explaining the sound combination. However, syllable structures may not be directly related to the method of explaining the acquisition of sound combinations.

The second argument for left branching syllable structure comes from language game data. Gim (1987) introduces two different language games: Popuri language game (CV insertion) and "nosa" insertion games. What is interesting in these language games is that the insertion site for CV or "nosa" is always after a nucleus. In other words, the inserted forms can separate the nucleus and the coda but they never break up the onset and rhyme. Some of the examples are given in (41):

(41) Korean Insertion Language Games

a. Popuri language

salam (man) → sapalapam

20Noske (1982: 271) sets up a markedness scale, where a CCV syllable is more marked than a CVC syllable. Thus the markedness theory can explain why children learn CVC syllables before CCV syllables.

21"Popuri" means a stutterer in Korean.
I will not attempt to present the comprehensive analysis here of the CV insertion language game, since it will be discussed in Chapter 5. I will simply show that the insertion site is not directly related to syllable structure. As Davis (1985: 167) and Y-S. Kang (1991: 47-48) point out, the insertion site is decided by the structure of the sequence to be inserted. Y-S. Kang (1991: 48) shows that since the inserted form is CV or CVCV, it cannot be inserted between C and V since such an insertion would result in an unsyllabifiable string of segments. Consider the two different insertion sites in a CVC word as shown in (42):

(42) Schematized Insertion Sites.
   a. Between Onset and Rhyme

   **CCVVC**

   b. Between Rhyme and Coda

   **CVCVC**

   (The bold faced parts are inserted)

Since the Korean language does not allow a CC cluster in syllable initial position, unless the second one is a glide, the segmental string in (42a) cannot be syllabified. As a result, such an insertion makes the whole string unpronounceable.

Further, Davis (1985) clearly shows that the insertion sites are decided by the nature of the inserted segments regardless of the language particular syllable structures. Consider the
summary of insertion language games from Davis (1985: 164-166):

(43) Examples of Insertion Language Games

a. Tagalog -pi- insertion after a vowel (Laycock (1972: 70))
   tubig → tupibipig

b. English -gV- insertion after a vowel (Laycock (1972: 74))
   away → agawagay

c. Spanish -fV- insertion after a vowel (Sherzer (1982: 187))
   grande → grafandefe

d. Chinese -ayk- insertion after an onset consonant (Yip (1982: 640))
   pey → paykey

e. English -ap- insertion after an onset consonant (Burling (1970))
   hiy wi (=he will) → hapiy wapi

The generalization we can draw from (43) is that if the inserted sequence begins with a consonant, it is inserted after a vowel and if the inserted sequence is vowel initial, the insertion site is after a consonant. Seen from this, it is only natural that the insertion site for CV insertion and "nosa" insertion language games is after a rhyme segment (a vowel) just as in Tagalog "pi" insertion language game and Spanish "fV" insertion language game. Thus I argue that the language game data fail to support the left-branching syllable structure in Korean.

Another type of evidence for the left-branching structure comes from CV deletion in fast speech. S-B. Cheon (1980: 20) observes that there is CV deletion in the fast speech of Korean and suggests that such deletion phenomena might reflect on the Korean syllable structure. His examples are given in (44):
(44) CV Deletion in Fast Speech.

a. ca-si-p-σ → cap-σ (a self-teaching book)
b. tʰæ-ki-ki → tʰæk-ki (the national flag of Korea)
c. tæ-hæn-σ-cin → tæn-σ-cin (a parade)
d. yal-mi-p-σan → yap-σan (provoking)

These data, if they are proven to be CV deletion, may support the left-branching syllable structure in Korean. However, I carefully call for reanalysis of the data given in (44). All the examples in (44) demonstrate that the second syllable is deleted in the fast speech and that the input is usually a tri-moraic word. I argue that the phenomena involve the deletion of a syllable in the weak position of a foot. The deletion can be represented schematically as in (45):

(45) Deletion in Fast Speech.

\[
\begin{align*}
\text{F} & \rightarrow \text{F} \\
\mu_1 & \rightarrow \mu_1 \\
\mu_2 & \rightarrow \mu_3 \\
\mu_3 & \\
\end{align*}
\]

The deletion results in the loss of a mora along with the dependent moraic segment, and the independently motivated cluster simplification rule will clean up the consonant clusters. An exemplary derivation is given in (46):

\[22\] I thank Stuart Davis for suggesting the alternative analysis given here.
The mora in the weak position of the foot is deleted and the consonants /s, p/ are left unsyllabified. Since the cluster is not allowed in the coda in Korean, the cluster simplification process gets rid of the coronal consonant, /s/ in the exemplary derivation and the remaining /p/ is incorporated to the coda of the first syllable.\(^{23}\)

Now consider the additional fast speech forms given in (47):

(47) Additional Data from Fast Speech

\[
\begin{align*}
\text{ak\textcircled{c}i} & \rightarrow \text{ak\textcircled{c}i} (\text{*\textcircled{c}i}) \quad \text{(forceful)} \\
\text{om\textcircled{n}i} & \rightarrow \text{om\textcircled{n}i} (\text{*\textcircled{n}i}) \quad \text{(mother)}
\end{align*}
\]

The CV deletion may predict the ill-formed outputs shown within parentheses in (47). However the foot-based deletion approach correctly predicts that the onset of the second syllable will surface as a coda segment of the first syllable.\(^{24}\)

---

\(^{23}\)See Y.Y. Cho (1988) for a detailed analysis of the cluster simplification.

\(^{24}\)It should be noted that there are other rules that interact with the fast speech deletion rule. For example, another fast speech phenomenon of /h/ deletion may be applied to such word as sohoks\textcircled{n} (small planet) before weak mora deletion. (See also the example given in (44c).) Here the apparent CV deletion can be reanalysed as the interaction of two independent rules, /h/ deletion and weak vowel deletion. Further it seems that the second mora resists deletion if it dominates a segment more sonorous than the moraic segment in the first mora.
Though a detailed analysis on setting up the correct environment for these deletion phenomena has not yet been done, we can at least say that there are alternative explanations other than resorting to syllable structure.

Pointing out some of the possible problems and presenting alternative explanations, however, does not lead us to accept the right-branching syllable structure for Korean. I am not familiar with any strong argument for the right-branching structure other than pointing out the demerits of the left-branching structure.

One traditional argument for Rhyme structure in phonology comes from metrical phonology in differentiating heavy and light syllables. If there is just one element in the Rhyme (=N'), the syllable is light. If there are two or more segments in the rhyme, the syllable is considered heavy. However, as discussed earlier, we have to note that one of the strong motivations for moraic structure of the syllable is the correct generalization concerning heavy versus light syllables which varies from language to language.

So far, we have seen various arguments for the hierarchical syllable structures in Korean. It has been observed that the motivation for either of the two hierarchical structures is not that strong. In the following subsection, I will try to show that the moraic structure is crucially important in explaining "li" irregular verb phonology.

4.3.2. "li" Irregular Verbs : A Case of /i/ Insertion

In this section, I will show that "mora" can effectively explain the alternations found in Korean "-li" final verb stems. There seem to be two different kinds of "-li" final stems as the following examples show:
(48) "li" Final Verb Stems

a. Verb Infinitive (-ə) Effective (-ini)
   chili (to pay) [chirə] [chirini]
   t'ali (to follow) [t'ara] [t'arini]
   kap₂ali (to be steep) [kap₂ara] [kap₂arini]

b. nuli (to press) [nullə] [nurini], [nullini]
   puli (to call) [pullə] [purini], [pullini]
   kali (to divide) [kalla] [karini], [kallini]

The words in (48a) show /i/ deletion in the course of morphological derivation. But the words in (48b), so called "li" irregular verbs, show optional /l/-gemination in effective forms. I will limit the discussion to the words in (48b), since (48a) can be explained straightforwardly by coalescence, which will be discussed in Chapter 8.

Kim-Renaud (1974, 1982), noting that the /l/-gemination in (48b) is much more frequent and productive, proposed that the underlying forms of the words in (48b) has a geminate /l/. She then proposed an optional rule of degemination to explain the existence of

25There is another kind of "li" final verb, the "lə" irregular verbs, which show yet another difference from (48a) or (48b). Some examples are given below:

ili (to reach) [irirə] [iririni]
phuḷi (to be blue) [phuirə] [phuirini]

The unique irregularity in these words is that another /l/ is added before /ə/ or /ini/.

For the purpose of expositional simplicity, I will not show the consonantal changes in the representation. The relevant consonantal change in the data is /l/ to [r] in syllable initial position.

26To be more specific, I would say that the relevant process is not /i/ deletion but syllabification and stray erasure which will be dealt with in Chapter 8 in detail.
two different forms in the effective formation. Y.-S. Kim (1984: 69), however, opposes Kim-Renaud's analysis by saying that if the geminate /l/ is posited underlyingly with optional degemination rules, then "geminate /l/ is equally acceptable as one with a single l which seems not to be the case". He presents the following nominalized forms and argues that the forms with geminate /l/ are much less acceptable than those with a single /l/. Some of his examples are given in (49):

(49) Derivations of "li" irregular Verbs

kei-li (to be lazy) + m (noun ending)  kei-lim, ^kei-lim
puli (to call) + m (Noun ending)     pulim, *pullim

Now, we have to explain three different things here: why nominalized forms and dictionary forms do not have geminated /l/, why the effective forms have two different surface forms, and finally why the infinitives do not have variants with non-geminate /l/. Neither underlying /l/ nor underlying /ll/ can satisfactorily answer all these three different problems.

However, I contend that the moraic syllable structure can account for these three phenomena without resorting to any ad hoc conditions. But before I present the analysis, I will briefly talk about geminate structure in moraic phonology. There are at least two different ways to produce a moraic consonant: in the underlying representation and by Weight by Position (Hayes (1989: 258)). The examples of these two moraic segments are shown in (50):

27The dictionary forms are made by suffixing "-ta" to the stem. I call this dictionary forms because that's how the verbs are listed in the dictionary.

28For example, if we suppose that the underlying forms have a geminate, we have to introduce the degemination rule. The problem is that the degemination rule should not be applied to infinitive forms, it should be optional for effective forms and further it should be obligatory for nominalized forms.
Two Different Moraic Consonants

a. Double Association

\[
\begin{align*}
\sigma & \quad \mu \quad \mu \\
V & \quad C & \quad C & \quad V
\end{align*}
\]

b. Single Association

\[
\begin{align*}
\sigma & \quad \mu \\
V & \quad C & \quad C & \quad V
\end{align*}
\]

The moraic consonants are shown in bold face. The moraic consonant in (50a) is doubly linked both to the mora of a syllable and to the next syllable. This is the typical representation of an underlying geminate. The structure in (50b), on the other hand, is derived by applying the Weight by Position rule which assigns a mora to a non-syllabified consonant that follows a monomoraic syllable. Notice that the Weight by Position rule is ideally only applied to quantity sensitive stress languages that treat a CVC syllable as heavy for the purpose of stress assignment. Since Korean lacks quantity sensitive stress, we would not expect to find a consonant with a single association to a mora, as shown in (50b) in Korean. Therefore I propose a moraic consonant wellformedness condition as given in (51):

\[(51) \text{ Moraic Consonant Wellformedness Condition} \]

\[
\begin{align*}
\sigma \\
\mu \\
R \text{ [cons]}
\end{align*}
\]

(A moraic consonant linked to one syllable node is ill formed.)

In order to interpret the condition given in (51), we need Hayes' (1986b) Linking Constraint given in (52):
(52) Linking Constraint

Association lines in structural descriptions are interpreted as exhaustive.

Note that there is only one line that links the consonantal root to syllables. Going back to the examples in (50), we can see that the condition in (51) allows the structure in (50a), while it rejects the representation in (50b).

With such an assumption on moraic consonants, I propose that the words in (48b) have an underlying moraic /l/ in the stem final position. Thus the words in (48b) have the following underlying representations:

(53) Underlying Representations of /l/ Irregular Verbs

a. b. c.

\[
\begin{array}{c}
\mu & \mu & \mu & \mu & \mu & \mu & \mu & \mu & \mu \\
\n\end{array}
\]

\[
\begin{array}{c}
n u l \\
\text{(to press)}
\end{array}
\]

\[
\begin{array}{c}
p u l k a l \\
\text{(to call)}
\end{array}
\]

\[
\begin{array}{c}
st u l t a \\
\text{(to divide)}
\end{array}
\]

Now, we will see how the representations in (53) explain the alternations of verbs in (48b). First, consider the dictionary forms and nominalized forms. The dictionary forms and nominalized forms have nongeminate /l/. I propose that this follows naturally from the representation and the surface form of the geminate consonant. Consider the dictionary forms with "ta" added to the stem as illustrated in (54) with the word in (53b):

(54) "ta" Affixation

\[
\begin{array}{c}
\mu & \mu & \mu \\
\text{syllabification}
\end{array}
\]

\[
\begin{array}{c}
\mu & \mu & \mu \\
\mu & \mu & \mu \\
\end{array}
\]

\[
\begin{array}{c}
p u l t a \\
\end{array}
\]

\[
\begin{array}{c}
p u l t a \\
\end{array}
\]
The next stage is to incorporate the moraic segment /l/ to the syllable. Here, we may not link the moraic segment to the first syllable, since the outcome, given in (55a), violates the syllable condition given in (51):

(55) Ill-formed Syllable Structures

\[
\begin{align*}
\text{a.} & \quad *\sigma & \quad \sigma \\
& \quad \mu & \quad \mu & \quad \mu \\
& \quad p & \quad u & \quad t & \quad a \\
\text{b.} & \quad *\sigma & \quad \sigma \\
& \quad \mu & \quad \mu & \quad \mu \\
& \quad p & \quad u & \quad t & \quad a
\end{align*}
\]

As can be seen in (55b), the double linking will not solve the problem, because the sequence /lt/ is not a possible onset cluster in Korean and for that matter in many other languages. Thus a stalemate is created by positing moraic consonant in the underlying structure. The only way out is to delink /l/ from the mora and syllabify /l/ as given in (56):

(56) Mora Delinking and Syllabification

\[
\begin{align*}
& \quad *\sigma & \quad \sigma & \quad \sigma \\
& \quad \mu & \quad \mu & \quad \mu \\
& \quad p & \quad u & \quad l & \quad t & \quad a \\
\end{align*}
\]

The empty mora will be realized as the least specified vowel, which is /i/, in Korean to given the form /puli̇ta/. The same explanation can be offered for the nominalized forms. The exemplary derivation of the nominalized form of the word "to call" is given in (57):

---

Notice that the sequence violates the sonority hierarchy.
Thus we can neatly explain that the "li" irregular verbs disallow the geminate /l/ in the nominalized forms and lexicon forms. Now let's consider the infinitive forms. The infinitive forms are made by adding /\ to stems. Since /\ does not have an onset it will take the preceding /l/ as the onset and thus the mora that dominates /l/ can be associated with the first syllable. The process is given in (58):

For effective forms, and conditional forms, there are alternations in the surface forms: forms can either have geminate /l/ or nongeminate /l/. The alternations can be neatly derived from the fact that the suffix initial vowel /i/ is weightless. Thus there are two options in the process of derivation as given in (59):

---

30See 8.3 for more discussion on the nonmoraic vowels.
In (59a), the mora which dominates /l/ does not syllabify and causes /l/ delinking. Then the syllable incorporation process takes the unsyllabified /l/ as an onset and the mora is left unlinked to the melodic tier. The unsyllabified /i/ is hooked up to the empty mora to give the output [pulini]. What if syllable incorporation process takes place before /l/ delinking? The answer is given in (59b). That the sequence of word internal /li/ is left unsyllabified triggers syllable incorporation. The /li/ forms a syllable with subsequent mora projection from the syllable node. Now the /l/ is doubly linked and the mora that dominates /l/ can be associated to the first mora resulting in the surface form [pullini].

With the moraic syllable structure, we are able to explain the difference between regular verbs and "li" irregular verbs both of which have stem final /li/. The apparently unpredictable variations of "li" irregular verbs are neatly explained without irregularity. Seen from this point what is irregular in the so called "li" irregular verbs is not the derivational
processes but the representation itself. As McCarthy (1988: 84) claims if the representations are right, then simple and general rules can explain the complexity of derivations in a consistent way. Such an analysis is possible only when moraic syllable structure is adopted, and I believe that the "li" irregular verbs provide fairly convincing evidence for the moraic theory of the syllable in Korean phonology.

Notice that all the syllabification processes are in conformity to the universal principles discussed in 4.2.3. The analysis given in this subsection crucially refers to the moraic syllable structure, which is absent in both the right and left branching structure. Another important observation is that we do not formulate /i/ insertion rules at all in explaining "li" irregular verbs. The apparent /i/ insertion phenomenon is actually the natural result of syllabification.

4.4. Summary

In this chapter, we have talked about different proposals regarding syllable structure. Unlike the claims made in SPE, syllables are important in the theory of phonology. Scholars have been interested in finding a suitable syllable structure. Kahn (1976) says that segments are directly linked up to syllable nodes while others suggest hierarchical syllable structure. Representative of such hierarchical structures are Selkirk (1982) and Wheeler (1981).

Clements and Keyser (1983) posit the CV tier in between segments and syllable nodes, which greatly simplifies the syllable structure by eliminating such constituents as onset or coda and replaces them by C or V. Levin (1984, 1985) further developed the idea of CV theory and presents the X’ theory of syllable structure.

However it has been found that such CV or X tier structure fails to account for the observations made in stress assignment and reduplicative processes. Hyman (1985) and Hayes
(1989) note that languages may differ from one another in defining a heavy syllable for the purpose of stress assignment. Further Hayes (1989) convincingly argues that the deletion of a segment does not always trigger compensatory lengthening and claims that the CV tier syllable structure cannot account for this. McCarthy and Prince (1986) show that Marantz's (1982) analysis of reduplication with reference to the CV tier is not constrained enough.

All these observations converge towards the proposal of moraic syllable structure. Moraic syllable structure argues that moras are the only legitimate syllable internal constituent thus eliminating the CV tier, the X tier and other types of syllable-internal constituents such as onset, rhyme or coda. While moraic syllable structure is well motivated in explaining stress assignment, compensatory lengthening, and templatic morphology, scholars do not agree on the precise nature of the internal structure of a syllable. There are three basic proposals on moraic syllable structure. Hyman (1985) and Zec (1988) propose that the syllable dominates only moras, and onset and coda consonants are associated with moras. McCarthy and Prince (1986) argue that only the weighted segments are affiliated with moras and other nonmoraic segments are directly linked up to the syllable nodes. Hayes (1989) makes reference to the syllable structure where onset consonants are directly linked to syllable node, while coda consonants are linked to moras.

I have considered data from stress rules and language games along with Korean vowel fronting to argue that McCarthy and Prince's (1986) proposal of moraic syllable structure can best handle the data. Though the analyses given here are not decisive, the McCarthy and Prince (1986) type syllable structure is adopted here.

Two processes of syllable building, moraification and syllabification were also discussed. Hayes' (1989) claim that all the moras are projected in the underlying representation is adopted here, though there are other proposals made by Hyman (1985), Zec (1988) and Bullock (1991). Hayes' proposal, however, seems to handle the underlying contrast of high
vowels and glides as well as geminate consonants and syllabic consonants.

I have also considered the proposals on Korean syllable structure. I argue that the data which were thought to be the evidence for the body-coda structure of the Korean syllable are not strong enough or they can be reinterpreted with respect to moraic structure in the present framework. The "li" irregular verb phonology supports the moraic syllable structure and the underlying moraic representation.

In Part I, we have discussed feature specification, Feature Geometry and syllable structure. In Part II, I will present a comprehensive analysis of the vowel phonology in Korean on the basis of the theoretical assumptions laid out in Part I.