THE SYLLABLE STRUCTURE OF JAPANESE

By

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ABSTRACT

The question of how to represent prosodic structure is of current theoretical interest in three dimensional phonology. Two current theories/models of representation are the onset/rime model (Kaye and Lowenstamm 1982, Kaye Lowenstamm and Vergnaud 1987 and Levin 1985) and the mora model (Hyman 1985, McCarthy and Prince 1986 and Hayes 1988). This thesis consists of a detailed investigation of the descriptive adequacy of these two theories for the Japanese language. Japanese can be considered an archetypal mora language since in the indigenous linguistic tradition it is analysed into moras.

The version of each model which I am adopting is explicitly stated in a set of universal syllabification rules. This syllabification algorithm is compatible with the following assumptions:

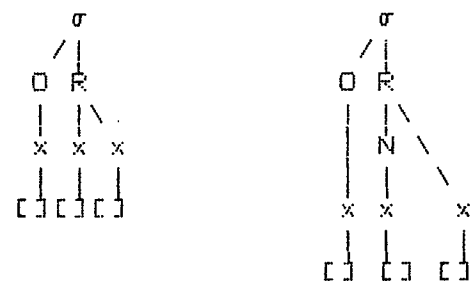
(1) a. No predictable prosodic structure is present in the underlying representation. The distribution of glides in most cases is predictable.

b. Prosodic structure is built by rule and is erected around a syllabic peak which is determined by the relative sonority of segments and not by a feature [syllabic].

Furthermore, the version of the onset/rime model I propose is a paramaterized model where the unmarked setting does not include a nucleus constituent. This onset/rime model is designed to account for weight distinctions as well as the mora theory. Sample structures from both theories are given below.

(2) a. onset/rime

(i) Type I (ii) Type II



b. mora

```
      σ
     /|\
    / μ μ
   /  | |
  [] [][]
```

A syllabification algorithm for Japanese is adapted from the general algorithm and fitted into a model of the lexical phonology of Japanese. It is shown that Japanese prosodic structure can be generated by rule, in either model, with no underlying distinctions between glides and high vowels, and with no feature [syllabic].

Therefore, it is concluded that both the onset/rime model and the mora model are adequate for describing the Japanese language. This conclusion crucially depends on the parameterization within the onset/rime model. Because Japanese is not the only language which employs the weight distinctions a Type I model represents, the parameterization is necessary for the onset/rime model to remain equal in descriptive power with the mora model.

TABLE OF CONTENTS

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INTRODUCTION

The question of how to represent prosodic structure and syllabicity is of current theoretical interest in three dimensional phonology. Three major theories or models of representation have emerged, (1) the CV model (Clements and Keyser 1983), (2) the onset/rime model (Kaye and Lowenstamm 1982 and Kaye, Lowenstamm and Vergnaud 1987, and Levin 1985) and (3) the mora model (Hyman 1985, McCarthy and Prince 1986 and Hayes 1988). Furthermore, it is not just the form of prosodic representation itself which commands current interest. There is also the deeper theoretical concern of ensuring that the prosodic representation can fit into a universal model of the phonology, that meets conditions on learnability, such as those discussed in Chomsky (1981).

The following is a detailed investigation of the descriptive adequacy of the onset/rime model and the mora model for the Japanese language. I will not be including the CV model in this investigation. We have seen in the literature to date several comparisons of the mora and onset/rime theories with the CV theory (see the authors above, for example), but few comparisons of the mora theory with the onset/rime theory.

Japanese can be regarded as an archetypal mora language

since in the indigenous linguistic tradition it is analysed into moras ('mora' is a Japanese word). Could Japanese be equally well described with an onset/rime analysis? If this is the case, then perhaps the two theories are, more or less, notational variants. Furthermore, in Hayes's (1988) comparasion of the mora and CV theories, he equates the CV theory with the onset/rime theory and calls them 'segmental models' (Hayes 1988.3). Therefore, in arguing for the superiority of the mora model over the CV model, Hayes implies that the mora model is also superior to the onset/rime model. The evidence from Japanese shows that this is not the case. Therefore, the onset/rime model cannot be equivalent to the CV model.

This thesis is divided into three chapters. In Chapter One, general aspects of syllable theory are discussed and the mora and the onset/rime model are examined in detail. Chapter Two is concerned with the lexical phonology of Japanese, and provides a background for the discussion in Chapter Three. In Chapter Three, the syllable structure of Japanese is analysed using both models of prosodic structure.

1 SYLLABLE THEORY

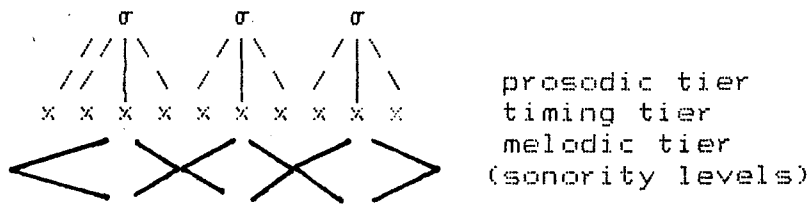
1.0 First, in 1.1, we discuss syllable structure in general and give some background on the two models. In 1.2 we outline certain assumptions about a universal theory of syllabicity and syllabification, which are maintained for both the models in question. In 1.3 and 1.4 we compare current proposals in the literature for the mora and onset/rime models respectively. Syllabification algorithms for the versions of both theories we are assuming are presented in 1.5.

1.1 Background

1.1.1 Both of the models I am considering are part of a multi-leveled phonological representation including the melody (features), timing units, and prosody. Prosody includes syllables and higher order categories like feet. The syllable is a constituent on the prosodic level which is usually comprised of more than one segment or feature matrix. The segments which form a syllable are grouped together not by a criterion of number, but by a criterion of relative sonority. Sonority is a property which is n-ary, not binary. Sounds in a language can be scaled according to their proportion of sonority. Vowels are usually the most sonorant and obstruents the least. A syllable is normally comprised of a group of sounds which form a left-to-right crescendo and decrescendo of sonority around a peak, which is the most sonorant segment in

the group. This description is illustrated below.

(1)



This description of sonority relations within a syllable corresponds to Selkirk's Sonority Sequencing Generalization: "In any syllable there is a segment constituting a sonority peak, that is preceded and/or followed by a sequence of segments with progressively decreasing sonority values" (1984.116). For a further discussion of sonority, see section 1.2.1.

The syllable is subdivided into smaller constituents and it is these smaller constituents which differ in the onset/rime and the mora theories. Constituent divisions are not trivial. A constituent is a group of elements which act together in a phonological process. For example, a constituent can be marked extrametrical, can be copied in reduplication, can be deleted or moved. Ideally, processes should only act on constituents. Thus, constituent structure in a model should reflect the empirical evidence for segment groupings. We will discuss evidence for constituent structure in 1.3 and 1.4. Representative structures for each model are given in (2).

(2)

a. mora

```
        σ                          σ = syllable
      / | \                        μ = mora
     /  μ  μ      prosodic tier
    /   |  |
  [ ] [ ][ ]      melodic tier
```

b. onset/rime

```
          σ                        σ = syllable
         /|                        R = rime
        / R                        O = onset
       /  |\                       N = nucleus
      O   N C     prosodic tier    C = coda
      |   | |
      x   x x     skeletal tier
      |   | |
     [ ] [ ][ ]    melodic tier
```

In (2a), the only constituent other than the syllable is the mora. The mora is an element which indicates weight. Weight is a property which distinguishes syllable structures; for example, certain syllable structures are considered heavy and others light . This distinction is called upon in phonological processes, in particular, stress systems. According to McCawley, "A mora can be described imprecisely as 'something of which a long syllable consists of two and a short syllable consists of one'"(1968.58). Although the number of segments comprising each mora may vary, each mora is equivalent in weight.

All syllables have at least one mora. For heuristic

reasons, let us call this the primary mora. The primary mora of a syllable is represented in two ways. In Hyman (1985) and McCarthy and Prince (1986), the primary mora consists of the first consonant or consonant cluster together with a short vowel or the first member of a long vowel. In Hayes (1988), the primary mora consists of a short vowel or the first member of a long vowel. The latter representation is given above in (2a) because it is the one we are adopting. Hayes's rationale for such a representation is that the domain of 'segment dominated by μ' is equivalent to the domain of 'rhyme-internal segment' (1988.10). Thus Hayes's innovation brings the mora theory closer to the onset/rime theory.

If a syllable has a long vowel or a heavy diphthong, or is a closed syllable (in a language where closed syllables count as heavy), then those segments outside the primary mora constitute a second mora. Thus, to recapitulate McCawley's definition, heavy syllables have two moras and light syllables have one. In a language where closed syllables are considered light, the margin consonant is linked to the primary mora by a language specific rule.

In (2b), the syllable is divided into constituents based on their relationship to the sonority peak, and not on their relationship to weight. The onset consists of those segments which precede the peak. The rime consists of the peak and everything that follows it. The nucleus marks the peak and

the coda consists of the segments following the nucleus. The second half of a long vowel is not dominated by a coda but by a branching nucleus, because it is a peak element. The segments which follow the nucleus can also be referred to as the margin, as can any consonants following the primary mora. I use the term margin to describe both post-nuclear and post-primary mora consonants without claiming that the margin is a constituent. Although the constituent divisions in this model are not designed directly to indicate weight, the heavy /light syllable distinction can be derived from a branching/non branching rime distinction, as shown in Hayes (1981).

1.1.2 In this section I would like to examine why there are two different representations of syllable structure within the three dimensional model. Tracing the development of the representation of prosodic structure in general would be beyond the scope of this section, so I will refer the reader to Hayes (1981), Clements and Keyser (1983), and Levin (1985) for a history of such developments.

Let us focus on the development of the different syllable-internal constituent structures found in the two theories in question. Most of the models mentioned in this discussion will be presented more explicitly in 1.3 and 1.4.

In Hayes' (1981) model, the syllable has two constituents, the onset and the rime. Two reasons which Hayes gives for

this split are: "(1) Generally, cooccurrence restrictions on the segments of a syllable are more stringent between vowels and following consonants than between vowels and preceding consonants, which suggests that such restrictions apply primarily within the rime; (2) Accent rules are almost always sensitive only to the number of segments in the rime, not in the onset" (1981.12). Hayes does state that, compared to the evidence for a rime constituent, there is less evidence for the onset constituent. He cites spoonerisms and the language game pig latin as possible evidence for the onset.

Thus, in Hayes' model, the distinction between light and heavy syllables is represented by the distinction between non-branching and branching rimes respectively.

Subsequent developments, such as Kaye and Lowenstamm (1982) and Levin (1985), produced models with more constituents within the syllable, the nucleus and coda, for example. These models also replaced the CV tier with a prosody-independent timing tier. Note that with a nucleus and coda distinction within the rime, the generalization captured by branching/non-branching rime can be captured only by a disjunction: heavy syllable = branching rime or branching nucleus.

This disjunction is one motivation for the proposal of a different syllable-internal structure, for example, Hyman's (1985) weight unit model, which is essentially a mora model.

As mentioned in 1.1.1, the mora model offers a straightforward representation of syllable weight.

Another motivation for the alternative mora model is the elimination of the independent timing tier. McCarthy and Prince (1986) reason that this tier is superfluous. In their estimation, when rules need to "count" items, they only seem to count moras, syllables or feet, not individual segments. Therefore, independent representation of individual segments is unnecessary and thus redundant. However, although the superfluousness of an independent timing tier is cited as a reason for the representation McCarthy and Prince use, the lack of an independent timing tier is not intrinsically part of a mora representation. No proponents of the mora theory that I know of include a timing tier in their models, but it is conceptually possible.

In addition, McCarthy and Prince point out, as did Hayes (1981), that there is slim evidence for an onset constituent and they argue that its loss in the mora model is of no consequence.

Hayes (1988) advocates the mora model instead of the onset/rime model. In arguing for this representation, he again raises the issue of cooccurrence restrictions and concludes that these restrictions are usually related to syllable weight, and therefore can be stated in the mora framework (1988.11). In 1.4, I propose a model of the

onset/rime theory, akin to Hayes'(1981) proposal, which accounts for weight distinctions as well as the mora theory.

Concerning the other differences between the two models, i.e. the timing tier and onset constituent, if evidence can be found to support the necessity of their existence that would argue in favour of the onset/rime model as the more superior. However, the Japanese language, in my analysis, only offers evidence that the onset/rime theory describes weight distinctions equally well as the mora theory.

1.2 Toward a Universal Theory of Syllabicity and Syllabification

1.2.1 The following is a sketch of a body of assumptions about the representation of syllabicity. I maintain that syllable structure is a universal level in the phonological representation and thus syllabicity is a universal property. The aim here is to propose a maximally non-redundant representation of this property.

In the linear model of SPE, syllabicity is indicated by the feature [syllabic]. Vowels are [+syllabic], nasals and liquids may be [+syllabic] and all the other major classes are [-syllabic]. Therefore, high vowels and glides are distinguished by this feature alone. In a model which

includes a hierarchical syllable structure in the phonological representation, like both the models we are considering, syllabicity is more properly a function of a segment's position in the syllable tree, and not an inherent feature on the melodic tier. So, syllabicity would be derived from syllable structure; therefore, the feature [syllabic] becomes redundant and can be eliminated. A by-product of the elimination of this feature is that glides and vowels are melodically indistinct, and appear in either form on the surface as a result of their position in the syllable tree.

There is also another potential redundancy in the phonological representation related to the question of syllabicity. Since syllable structure is in many cases predictable based on the combinations of features, it is redundant to have fully specified syllable structure in the underlying representation (UR), since this component is usually reserved for idiosyncratic information alone. We assume that syllable structure is erected by rule; therefore, our maximally non-redundant representation has syllabicity being derived from syllable structure, and has no syllable structure in the UR.

But, knowing the syllabicity of the segments is required for erecting syllable structure. It is necessary for determining the nucleus or peak of sonority of the syllable. Thus we have an apparent paradox: If syllabicity is derived from syllable

structure, how can it be determined beforehand in order to erect that structure? If we consider the syllabic or peak element of each syllable to be the most sonorant segment in the group, and we have a systematic method for determining a peak from the relative sonority of the feature matrices without syllable structure being present, then we have a solution to our problem.

A universal sonority hierarchy has been proposed by various authors, notably, Hankamer and Aissen (1974), Kiparsky (1979), Steriade (1982), and Selkirk (1984). Steriade's hierarchy lists features and groups of features in terms of their relative sonority. For instance, [-high] is more sonorant than [+high], and [-cons] is more sonorant than [+cons]. Therefore, [-cons] segments (vowels and glides) are more sonorant than [+cons] segments (consonants), and [-high,-cons] segments are more sonorant than [+high, -cons] segments, and so on. Using this hierarchy, peaks of sonority can be identified by their feature composition and thus syllable structure can be built around this.

The assumptions stated above can be summarized as follows: (1) There is no predictable syllable structure in the UR[1]. (2) There is no distinction between high vowels and glides in the UR. (3) The property syllabicity is derivable from the relative sonority of neighbouring feature matrices, or from the position of segments in the syllable tree.

These assumptions about syllabicity and syllable structure are considered universals which hold for both the onset/rime and mora models of prosodic representation.

1.2.2 Both the models I am considering are proposals for a universal representation of syllable structure. In other words, certain aspects of both constitute universal principles of syllabification, for example, onsets must be incorporated into the syllable structure before margins, or consonant clusters must be of decreasing sonority from the nucleus, and so on. Both also allow for parametric variation, such as, whether a language permits margins, or clusters before or after the peak of sonority. The syllabification rules will vary according to the parameter selected. Even what qualifies as a sonority peak is subject to parametric variation. In some languages, liquids and nasals as well as vowels can act as peaks. Furthermore, the relationships between the levels of the sonority hierarchy are implicational. For example, a language cannot select liquids to be peaks and not select vowels as well. The universals and parameters comprise the core of the theory, in the sense of Chomsky (1981).

But even with a parametric model, there are still going to be some idiosyncratic, language specific rules in the phonology. The theory is not sufficiently advanced to

eliminate these yet. Following Piggott (1988), I assume that language specific rules obey one constraint: they cannot contravene a principle in the core of the grammar (e.g. no language specific rule could stipulate that nasals but not vowels could act as syllabic peaks).

What would constitute a parameter selection as opposed to a language specific rule? Let us look at some examples from Japanese. I mentioned above that whether or not a language allows margins in a syllable is a parameter. Of all the single consonants, Japanese only allows nasals to appear as margins. Would this be a possible parameter, or an idiosyncratic fact about Japanese? Allowing only nasals in the margin is a common selection cross-linguistically, and could be related to sonority factors, i.e. nasals and liquids are the next sonorant segments to vowels and glides. So we could view the margin parameter as being not only a binary selection of [+margin] or [-margin] (the selection made by moving from the unmarked setting, [-margin], to [+margin], on the basis of margins existing in the input), but also including a scale of possible margins, first [nasals], then [nasals and liquids], then [nasals, liquids and obstruents], for example. Ideally, the relationships would be implicational, as with the scale for possible peaks, so a language should not be able to select stops as margins, excluding nasals and liquids.

Another fact about Japanese syllable structure is that the glides [w] and [y] can only appear with a restricted set of vowels. [w] only appears before [a], and [y] only appears before the back vowels, [u,o,a]. I have already mentioned in 1.1.1 that I am assuming a model where there are no underlying glides, so the syllabification rules will have to assign non-peak status to high vowels in certain positions so that they surface as glides. Would it be feasible to propose a parameter where glides can appear with first a restricted, then a more broad class of vowels in an implicational hierarchy like the one described above for margins? Is this a common cross-linguistic phenomenon, and moreover, would the restricted class consist of the vowels listed above for Japanese? It might be possible to appeal to the sonority hierarchy to formulate such a parameter. For example, the restricted class of glide/vowel combinations would be those exhibiting the greatest sonority difference. However, at this point, I consider these restrictions in the vowel/glide combinations to be a language specific property of Japanese.

How would the parameters be set for these models of syllabification? The evidence for setting parameters would ideally be positive evidence and not direct or indirect negative evidence. Direct negative evidence means correction. Indirect negative evidence means that the learner would assume a structure was not possible because he or she had never heard

it. Positive evidence means that the learner would assume that a structure did exist because he or she did hear it. According to Chomsky (1981), positive evidence is the most probable criterion for parameter selection; however, he does acknowledge that indirect negative evidence could play a role. At this point, I would like to consider only positive evidence as a criterion for parameter selection. Therefore, we could assume that the first hypothesis the learner makes about the syllable structure of the language is the canonical or least marked structure, which would be an open syllable with no onset clusters or long vowels: CV.CV. The parameters allowing more complex structures would be selected on the basis of positive evidence from the environmental input (see the above discussion on the margin parameter for an example). If we assumed that the learner started out with the most marked or complex structure first and retreated from that, we would have to permit indirect negative evidence to play a role. For example, if the learner started out with a complex structure and shifted to a simplier structure on the grounds that the language being learned does not require all the distinctions the complex structure represents, what would constitute the grounds for such a shift would be the lack of any evidence for the more complex structure and lack of evidence constitutes indirect negative evidence.

1.3 The Mora Theory

1.3 In the following discussion of the mora model of syllable structure, I will be refering to the work of Hyman (1985), McCarthy and Prince (1986) and Hayes (1988). I intend to adopt Hayes (1988) as the representative mora theory in my analysis of Japanese.

Recall that in the mora model there is no separation of skeleton and syllable constituents. Moras function as timing and minimal prosodic units. A sample inventory of structures, adapted from Hayes' model, is given below in (3). The data are ficticious.

```
(3)  a.  σ          b.      σ           c.     σ
         |                 /|                //|
         μ               / μ              // μ
         |              /  |             ||   |
         a  = [a]      t   a  = [ta]     tr   a  = [tra]

     d.      σ                  e.     σ
            /|\                      /|
           / μ μ                    / μ
          /  | |                   /  |\
         t   a p  = [tap]         t   a p  = [tap]
         closed σ is heavy        closed σ is light

     f.     σ                  g.     σ      σ
           /|\                      /|\    /|
          / μ μ                    / μ μ  / μ
         /  |/                    /  | |/  |
        t   a    = [taa]         t   a t   a  = [tatta]
```

```
h.      σ                    i.     *σ
       /|\                          /|\\
      / μ μ                        / μ μ μ
     /  | |\                      /  |/  |
    t   a n d  = [tand]          t   a   p   = [taap]
```

McCarthy and Prince (1986) rule out the possibility of a "super heavy" syllable, one with three moras, e.g. a long vowel and a weighted margin, and I accept this restriction. Syllables have a maximum of two moras. Any extra segments are linked to the second mora. This is why (3i) is illformed.

Hyman (1985) uses [x] instead of [μ] and calls this a weight unit (WU) instead of a mora. He attaches the pre-vocalic consonant to the primary mora. McCarthy and Prince (1986) also attach the pre-vocalic consonant to the primary mora. By attaching this consonant to the syllable node, Hayes (1988) creates a de facto rime constituent, i.e. everything dominated by a mora. However, there is still no onset constituent, since multiple pre-vocalic consonants attach to the syllable node, not to a common node. This innovation in Hayes' model brings the mora and onset/rime theories closer together.

Hyman (1985) allows for the possibility of some languages not having syllables. If a language has no phonological process which requires access to this category, it will have only moras in the prosodic representation. He uses Gokana as a example of this. Kaye, Lowenstamm and Vergnaud (1987) have eliminated the category syllable altogether in their version

of the onset/rime model.

But, with the mora model, there is ambiguity in the representation without syllable groupings which is not the case for the onset/rime model. Examine the structures below (the data are from Japanese).

```
(4)  a.     σ  σ   σ                    b.  σ      σ
            |  |   |                        |\     |
            x  x   x                        x  x   x
           /|  |  /|                      /|  |  /|
         k  a  e  d  e  "maple"          t  o  n  d  a  "flew"

     c.     σ  σ   σ                    d.     σ      σ
           /|  |  /|                        /|     /|
         O  R  R  O  R                     O  R   O  R
         |  |  |  |  |                     |  |\  |  |
         |  N  N  |  N                     |  N  C |  N
         |  |  |  |  |                     |  |  | |  |
         x  x  x  x  x                     x  x  x x  x
         |  |  |  |  |                     |  |  | |  |
         k  a  e  d  e                     t  o  n d  a
```

Both (4a) and (4b) have three moras, but (4a) has three syllables and (4b) only two. At the mora level these two words are indistinct prosodically. In (4c) and (4d) the distinction is represented at both levels, (4c) has three rimes and three syllables and (4d) has two of each. There is clearly a timing difference between these two words when spoken. However, if this distinction is necessary only to the surface phonetics, it may not be necessary to represent it in the phonology, at least at the lexical level.

According to Hyman, if the category syllable is needed for a

phonological process, then syllables would be present in the phonology of that language. In other words, the parameter with syllables would be selected by the learner for that language. So, it is not that syllables do not exist, they just do not exist in languages where there is no input to trigger that parameter setting. Examples of processes which need access to the category syllable are quantity insensitive stress systems in Hayes' (1981) analysis of Maranungku, Warao, Weri, Southern Paiute and Garawa, and reduplication in Levin's (1985) analysis of Mokilese and McCarthy and Prince's (1986) analysis of Ilokano, Orokaiva, Oykangand and Kaingang.

Therefore, as long as syllables are not needed in every language for the phonology, and as long as a representation with syllables is selectable on the basis of positive evidence, then Hyman's proposal is not incompatible with any of the assumptions expressed in 1.2. However, in the absence of a convincing analysis showing the syllable to be a redundant category in a significant number of languages, I will concede that this parameter is theoretically possible, but I will still adhere to a more standard assumption and consider the syllable a universal category in the mora model. Moreover, since I am adopting Hayes' (1988) model, which attaches the pre-vocalic consonant to the syllable node, the syllable constituent cannot be absent.

Now let us look at how syllables are formed in both Hyman's

(1985) and Hayes' (1988) model (McCarthy and Prince 1986 do not deal with initial syllabification rules).

In Hyman's (1985) model, all segments have a WU underlyingly. In the course of the syllabification, some WUs are discarded and segments dock onto other WUs to create a prosodic structure. The first rule of syllabification is the universal onset creation rule (OCR) illustrated in (5).

(5)

```
x        x
[+cons]  [-cons]
```

(Hyman 1985.15)

In the case of geminate consonants, which have two WUs, the OCR eliminates one WU, and incorporates the melody into a primary mora with a vowel. The second WU remains as a secondary mora in the preceeding syllable. This is illustrated for the Japanese word *onna* "woman".

(6)

```
x x x x          x x x x        x x  x
| |/  |          | |~~~|        | |  /|
/o n   a/   OCR: o n   a        [o n  a]
```

For languages where closed syllables are light, Hyman invokes a margin creation rule (MCR) which eliminates the WU from a margin consonant, and that consonant docks onto the preceeding WU. This syllabification process is demonstrated in (7).

(7)

```
                    UR      x  x  x
                            |  |  |
                            t  a  p

                    OCR     x  x  x
                            +-/|  |
                            t  a  p
                            |  |
MCR    x  x      <-----|  |------>    x  x      no MCR
      /|\ +                          /|  |
     t a p                          t a  p

       x                            same as above
      /|\
     t a p
```

(adapted from Hyman 1985)

Note that in Hyman's system it appears that a weighted margin is the unmarked case, since no rule is needed to derive this structure. The learner would then select the MCR if given evidence that margins are weightless in a process involving a heavy/light distinction. The converse is the case for Hayes' model.

After the OCR and MCR, the WU can be organized into higher order units like syllables.

Hayes' (1988) syllabification model differs from Hyman's because not all segments have moras underlyingly. If a language has (a) no long vowels or long syllabic consonants, (b) no geminates or (c) no syllabic nasals, and (d) the distribution of high vowels and glides is predictable, then no segments will have moras underlyingly. They are all assigned by rule. If (d) does not hold, and some underlying glides

exist, then those glides are mora-less underlyingly and high vowels are dominated by one mora underlyingly. If there are long vowels or long syllabic consonants, these are dominated by two moras underlyingly and if there are geminates or syllabic consonants these are dominated by one mora underlyingly. This system is designed so that any predictable information is assigned by rule.

This system also allows for language specific variation in the underlying representation, which can be incorporated into a parameter setting model. For instance, let us consider that the unmarked setting is the one where the answer to (a) through (d) is affirmative. Thus the unmarked setting has no moras underlyingly. Evidence in the input that glides and high vowels contrast, or that length differences are contrastive, etc., will trigger the appropriate placement of underlying moras. The representation for the most marked setting of an underlying inventory is presented in (8).

```
(8)  a.                b.  μ          c.
                           |
          t  = [t]         i  = [i]       i  = [y]

     d.  μ μ           e.  μ          f.  μ
         |/                |              |
         i  = [ii]         t  =[tt]       n  =[n̩]

     g.  μ μ
         |/
         n  =[nn]
              ̩ ̩
```

(adapted from Hayes 1988)

Hayes' syllabification rules are stated informally. They begin by assigning moras to the appropriate sonorant segments, which would usually mean non-high vowels in a language with an underlying inventory like that in (8), or to all vowels in a language where high vowels and glides do not contrast. Next, a syllable node is assigned to segments dominated by moras. Hayes does not elaborate on this, but I assume that syllable assignment must include a mechanism which prevents the assignment of a syllable node to both moras of a long vowel or to the mora dominating a geminate consonant. The next two processes involve adjunction of pre-vocalic consonants to the syllable node, and post-vocalic consonants to the final mora of the syllable. These last two processes are analogous to the OCR and MCR, and I have chosen to label them as such.

```
(9) OCR  a.   σ            σ     b.   σ              σ
              |           /|          |\            /|\
              μ  --->   / μ          μ μ  --->    / μ μ
              |        /  |          |/           /  |/
            t a       t   a        t a          t   a

    MCR  c.   σ          σ       d.   σ          σ
              |          |            |          |
              μ   --->   μ            μ   --->   μ
              |          |\           |          |\\
              a t        a t          a nt       a nt
```

(Hayes 1988.7)

As for geminate consonants, the OCR applies, but the segment already has a mora associated with it underlyingly, so it becomes doubly linked, and hence receives a geminate interpretation. Hayes assumes that the mora dominating the geminate gets attached to the preceding syllable, but does not formally nor informally state how this occurs. I call this process syllable incorporation, which is a rule in the general syllabification algorithms presented in section 1.5. Syllable incorporation applies several rules after the after the OCR in the algorithm.

```
(10)    σ   σ                          σ     σ
        |   |                          |     |
        μ   μ   μ                      μ     μ
        |   |   |                      |     |
      m a t a  ---->  OCR:  m   a t   a

                                       σ     σ
                                      /|\   /|
                                     / μ μ / μ
                                    /  | |/  |
                                       | |   |
                                syll incorp: m   a t   a
```

Notice that short syllabic consonants are represented like geminates, they are dominated by a single mora. As Hayes (1988.7) notes, because these consonants normally do not appear with an adjacent vowel, there is no danger of them being turned into onsets. In fact, in the syllabification algorithm in 1.5, these consonants are assigned their own

syllable before the OCR applies.

Between the application of the OCR and MCR, Hayes introduces a weight-by-position (WP) rule which operates in languages where closed syllables are heavy. This rule is presented below. Note that its effects do not absolutely bleed the MCR because second or third margin consonants will attach to the newly introduced mora. Note also that because this rule applies after the OCR, weighted margins will not become onsets like geminate consonants. The WP rule is given below.

(11)

```
σ              σ
|              |\
μ     --->     μ μ     where σ dominates only μ
|              | |
α  β           α β
```

(Hayes 1988.8)

The stipulation "where syllable dominates only mora" should follow from the universal prohibition on super-heavy syllables.

Note that in Hyman's model, margins are weighted underlyingly and are only rendered weightless by application of the MCR. For a learner to acquire the MCR, (s)he must employ indirect negative evidence, i.e. a lack of evidence for the necessity to weight the margin. On the other hand, in Hayes's model, the rule to be acquired is the WP. The evidence needed to acquire it would be positive evidence;

evidence that the margin does have weight. Considering our learnability assumptions, Hayes's model is preferrable.

Before closing this section, let us examine how glides are represented in the mora model.

Recall that, as stated in 1.2.1, with the view of syllabicity I am adopting, there is no melodic distinction between glides and high vowels. They are distinguished by their place in the syllable tree, vowels appearing in the peak position and glides appearing elsewhere.

In Hyman's (1985) model, glides and high vowels are distinguished on the melody tier. Hyman marks glides as [+cons]. In order to preserve the generalization stated in 1.2.1, I will not consider Hyman's representation as a possibility for the unmarked representation of glides.

Hayes (1988) does not deal with this issue.

In our model, the assigning of vowel moras proceeds in a two-step process. Moras and syllable nodes are assigned to all [-hi] vowels first, then the OCR applies, followed by the assignment of mora to any unassigned [+hi] vowels. Then the WP and MCR apply. This ensures that a high vowel/non-high vowel sequence will emerge as a glide/non-high vowel sequence, because the high vowel is syllabified as an onset, linked to the syllable node.

What this system does not account for is the appearance of a glide in a sequence of two high vowels, since both will have

moras. For example, if gliding takes place, would a sequence /iu/ or /ui/ appear as [yu] or [iw], [wi] or [uy] respectively? I intend to propose an answer to this question in my analysis of Japanese in Chapter Three. I do not deal with the representation of diphthongs at all in the syllabification rules for either theory, since there are no adequate proposals for doing so in the literature I have cited above, and Japanese itself has no diphthongs.

An explicit list of syllabification rules for the mora theory is provided in 1.5.

1.4 The Onset/Rime Theory

1.4 The onset/rime model shown in (2b) is a fully articulated one. We are adopting a simpler version for our analysis of Japanese. In this section I refer to the work of Levin (1985), Grignon (1985), Guerssel (1986) and Kaye, Lowenstamm and Vergnaud (1987). Let us look first at Levin (1985).

Levin employs a version of X-bar theory in her model of syllable structure. The nucleus is the head of the syllable, and the constituents rime and syllable are projected from that head. In this model, as with all onset/rime models, timing is represented by a separate tier, so each single segment is dominated by one x-slot and each geminate, long vowel, or long syllabic consonant is dominated by two segments. An illustration of syllable structure in Levin's (1985) model is given below.

(12)

```
              N"
             //|
           / / N'
          / /  |\\
         / /   N \ \
        / /    |  \ \
       x x     x   x x
```

(Levin 1985)

Notice that in this model, only the nucleus (N), the rime (N'), and the syllable (N") are constituents. There is no

onset or coda constituent; multiple pre-nuclear and post-nuclear consonants do not comprise a constituent of their own, but instead they link directly to the N" and the N', respectively. This may not be a trivial consideration. If there is substantial empirical evidence that the pre-nuclear and/or post-nuclear consonants do act together in processes, then the constituents onset and/or coda ought to be part of a model of syllable structure.

These sorts of questions prompted Kaye, Lowenstamm and Vergnaud 1987 (KLV, hereafter) to posit a model of syllable structure with certain constituents absent. In their model, there is no syllable or coda constituent. They argue that no process accesses these constituents and they are thus unjustified. Examples of structures in their model are given in (13). The sample data are fictitious.

```
(13)  a.  R        b.  O R        c.  O   R
          |            | |            |\  |
          N            | N            | | N
          |            | |            | | |
          x            x x            x x x
          |            | |            | | |
          a = [a]      t a  = [ta]    t r a  = [tra]

      d.  O R                      e.  O R
          | |\                         | |
          | N \                        | N
          | |  \                       | |\
          x x   x                      x x x
          | |   |                      | |/
          t a   p  = [tap]             t a    = [taa]
```

```
f.  O R     O R              g.  O R
    | |\    | |                  | |\
    | N \   | N                  | N \
    | |  \  | |                  | | |
    x x   x x x                  x x x x
    | |   |/  |                  | | | |
    t a   t   a  = [tatta]       t a n d  = [tand]

h.  *O R
     | |\
     | N \
     | |\ \
     x x x x
     | |/  |
     t a   p  = [taap]
```

So, in this model, the onset and the rime do not form a constituent together. Multiple consonants in the rime would not form a constituent together either. KLV disallow the possibility of a super heavy syllable, one with both a branching nucleus and a branching rime, therefore, (13h) is ill-formed. KLV do not explicitly state how a structure like (13g) is to be represented. I am assuming that linking both of the margins to the rime node would violate the stricture against super-heavy syllables, so I have conjectured that perhaps second or third margin consonants are extrametrical. Shaw points out that this representation would be impermissible if the syllable in question were word internal (personal communication).

A slightly different model of syllable structure is utilized by Guerssel (1986) for Berber, and Grignon (1985) for

Japanese. In this model, there is no nucleus constituent, so there is no distinction between a branching nucleus and a branching rime, which parallels Hayes'(1981) model (recall that Hayes' 1981 model is an onset/rime model, not a mora model). I have compiled an inventory of sample structures from this model in (14). As with KLV, neither Guerssel nor Grignon is explicit about the representation of structures like (14g). Most likely because these structures do not exist in the languages they are considering. Therefore, (14g) is represented according to the model we are adopting in 1.5. Note that by adjoining the extra margin segment to the syllable node we are eliminating the problem pointed out by Shaw with the representation in the KLV model[2].

```
(14)  a.  σ          b.     σ          c.       σ
          |                /|                  /|
          R               O R                 O R
          |               | |                /| |
          x               x x               x x x
          |               | |               | | |
          a  = [ta]       t a  = [ta]       t r a  = [tra]

      d.     σ                          e.     σ
            /|                                /|
           O R                               O R
           | |\                            | |\
           x x x                           x x x
           | | |                           | |/
           t a p  = [tap]                  t a    = [taa]
```

```
f.     σ       σ                    g.     σ
      /|      /|                           /|\
     O R     O R                          O R \
     | |\    | |                          | |\ \
     x x x   x x                          x x x x
     | | |/  |                            | | | |
     t a t   a   = [tatta]                t a n d   = [tand]
```

```
h.     σ
      /|
    *O R
     | |\ \
     x x x x
     | |/  |
     t a   p   = [taap]
```

Note that this lack of nucleus constituent creates an ambiguity on the prosodic tier. Both long vowel and vowel-margin sequences are dominated by a branching rime. This ambiguity is advantageous if these two sequences act together as a natural class. This would be the case for any language where a process needs to access a heavy syllable/light syllable distinction where a closed syllable is heavy. Recall from section 1.1.2 that the behavior of stress with respect to this ambiguity is the motivation behind Hayes' (1981) proposal.

Which of the three, the syllable, the coda, and the nucleus, are redundant constituents universally? I have already mentioned that the syllable is not a redundant constituent. There is evidence that the syllable is a necessary category because it is referred to in phonological processes like

stress assignment and reduplication (cf. 1.3). None of the models I am considering include a coda constituent, and I can find no evidence to support its existence, so let us eliminate that constituent universally. This leaves the nucleus constituent.

As mentioned in 1.1.2, the existence of the nucleus constituent creates a disjunction in the description of a heavy syllable: branching rime or branching nucleus. While Hayes (1981.45) acknowledges that the majority of heavy syllables fall under this description, he concedes that in some cases the long vowel does not count as heavy and a nucleus node, whose branching could be by-passed by the stress rule, may be a necessary addition to the syllable tree. Also, it is possible that a closed syllable does not count as heavy, but a long vowel does, for example, Tiberian Hebrew, as analysed by McCarthy (1979), or Lardil, according to Hayes (1988). Therefore, long vowels and vowel-margin sequences can act both as a natural class and in opposition. To account for this, I suggest that the nucleus constituent does exist, but not in all languages. It is a parameter, chosen by the language learner if the language exihibits the aforementioned opposition within the rime in a process. Thus, the initial structure assumed by the learner is the one without the nucleus.

In short, our onset/rime model includes two parameters for

the internal structure of the rime. One parameter has a nucleus and the other does not. The unmarked parameter is the latter, and I call it Type I. The former is Type II. Examples are given below.

(15) a. Type I b. Type II

```
O R      O R          O R        O R
| |\     | |\         | |\       | |
x x x    x x x        | N \      | N
| | |    | |/         | |  \     | |\
t a p    t a          x x   x    x x x
                      | |   |    | |/
                      t a   p    t a
```

Hayes (1988.4) argues that the mora theory is superior because it allows for the representation of language-specific differences in syllable weight. He uses Latin and Lardil as examples. In Latin, both CVV and CVC are heavy and in Lardil, CVV is heavy and CVC is light. This can be represented by assigning a bimoraic structure to CVV and CVC in Latin, but only to CVV in Lardil. CVC in Lardil would receive a monomoraic structure. Hayes claims that the onset/rime theory cannot account for this difference. However, this difference can be accounted for in an onset/rime theory with a TypeI/TypeII distinction. Latin is a Type I language where a syllable with a branching rime is heavy (so CVV and CVC are heavy). Lardil is a Type II language where a branching nucleus is heavy (so CVV is heavy). Thus, neither theory

accounts for this difference in a superior manner.

Furthermore, in Zubizaretta's (1982) discussion of pitch accent in Japanese, she also proposes two different rime-internal structures within syllable theory, one with and one without a nucleus. She argues with evidence from the pitch accent system that Japanese requires a branching rime structure without a nucleus, which would make Japanese a Type I language in our model. In 3.2 I also argue for this classification of Japanese, using evidence from other processes.

Notice that I have not yet considered the possibility for a parameter for the constituent syllable. I will hold the same position here as with the mora theory, I concede that the existence of such a parameter is theoretically possible, but at this point I will retain the category universally.

Notice that the Type I/Type II parameter claims that vowel-margin and long vowel sequences act either in opposition or as a natural class, but not both in the same language. If evidence is discovered of a language where they act both in opposition and as a natural class, then we must weaken our claim. We could propose that they must not act both in opposition and as a natural class in certain domains, but it is irrelevant if they do in others. For example, we could claim that the dichotomy must be preserved in stress systems, but need not be elsewhere. Thus, evidence of opposition in

the stress system would trigger the learner to select a Type II parameter. Japanese itself shows consistent evidence of long vowels and vowel-margins behaving as a natural class.

Note that in the mora model, a language with a WP rule would be equivalent to a Type I language. In languages without a WP rule, all margin consonants are subject to the MCR, so only syllables with long vowels are bimoraic. Therefore, a language without a WP rule would be equivalent to a Type II language.

How are onset/rime syllables erected? Out of the models we have considered, Levin (1985) offers the most explicit set of general syllabification rules.

The first rule of syllabification is the N-placement rule, which designates certain segments as nuclei. Typically, nuclei are assigned to positions which can serve as syllabic peaks in the unmarked case for that language. The N-placement rule is given below.

(16) N-placement

```
[αf]    [αf]
 |       |
 x ---> x
         |
         N
```

(Levin 1985.79)

The variable melody specification, [αf], indicates that what

can act as a syllabic peak varies from language to language.

After the application of N-placement, the other rules of syllabification apply. These are N" projection and N' projection. N" projection is a universal rule which erects the maximal node, the syllable, and picks up the adjacent segment to the left of the nucleus into the syllable. N' projection is a parameter. Languages which do not select for it are those without margins. This rule, in essence, creates a rime node between N and N" and picks up the adjacent segment to the right of the nucleus as part of the rime. Because these rules are iterative, and they do not form an onset or coda category over the segments they incorporate into the syllable and rime, there are no onset or coda constituents in this model, as I have stated earlier. The N" and N' projection rules are given in (17).

(17) a. N" projection

```
                                N"
                               /|
            N                 / N
            |                /  |
(x(')) x ---> (x)  x
```

x' = unsyllabified

b. N' projection

```
N"          N"
|           |
|           N'
|           |\
N           N \
|           |  \
x  x' ---> x    x
```

(Levin 1985.133,141)

Turning back to the N-placement rule, I must mention that Levin allows for three kinds of N-placement rules: redundancy rules, phonological rules, and lexical N-placement. This classification is relevant to the formation of glides from underlying high vowels. The redundancy rule corresponds to the rule given in (16). Phonological N-placement rules apply after the redundancy rules and after the other syllabification rules. Note that this system allows the syllabic nuclei of a language to be divided into two groups such as high and non-high vowels. The redundancy rules will assign nuclei to the non-high vowels, then the syllabification rules will incorporate into the syllable any high vowel in the relevant position. Thus these high vowels will surface as glides. Then, the phonological rules apply and assign nuclei to all high vowels which are not already syllabified. An example of this use of the redundancy and phonological rules is Levin's analysis of glides in Berber (based on Guerssel 1986; orig.

ms. 1984). Finally, lexical N-placement refers to idiosyncratic cases where the presence of a high vowel, as opposed to a glide, is not predictable by syllabification rules and therefore must be marked in the UR. An example of this is certain cases in Berber, as analysed by Guerssel (1986).

Thus, in Levin's model, underlyingly present prosodic structure consists of nuclei marking high vowels which contrast with glides, and syllabic consonants.

The set of general syllabification rules for the onset/rime model we are assuming, is presented in 1.5. In our model, we adopt two aspects of Levin's approach. First, we syllabify the pre-vocalic consonants before the post-vocalic consonants. Second, we assign peak status to non-high vowels before high vowels with an application of the onset creation rule in between. These two conventions serve to maximalize onsets and generate glides.

Another approach to glide generation is used by Grignon (1985). In her model, peak status is assigned to all vowels and is later removed from high vowels in environments where they surface as glides. I am not adopting this approach because it seems redundant to erect structure which is later deleted, especially when it is possible to obtain the same results with out doing so.

Our model differs from Levin (1985) in two aspects: the

nucleus parameter and the onset constituent. In Levin's model, all languages have a nucleus constituent which is the primary element of the syllable because it is the first element assigned in the syllabification process. In our model, in an unmarked language, the rime is the primary element. In a marked language the nucleus is the primary element. Different syllabification algorithms apply to languages which have different primary elements. Note that languages with nuclei also have rimes, so regardless of the existence of nuclei, all languages have rimes, onsets, and syllables. But in a Type II language, the rime is not the primary element.

Levin does not have an onset constituent. Therefore, pre-vocalic consonants are linked directly to the syllable node. Because pre-vocalic consonants are syllabified before post-vocalic consonants, the syllable node (N") is erected before the rime node (N'). Therefore, N' is inserted into an already existing structure between N and N". In our model, because there is an onset constituent, pre-vocalic consonants do not have to be linked directly to the syllable node. Therefore the syllable node is not erected before the rime node. So no N' or rime insertion is necessary. (Note that the question of rime insertion is only relevant to Type II languages).

1.5 Summary

1.5 Presented below is a brief summary of the representative models of the mora and onset/rime theories which I will be using in my analysis of Japanese.

The syllabification algorithms for both are intended to be universal rule schemas, or a universal syllabification strategy, so only in some cases are certain melody tier details given. For example, the specification of [high] in the syllabic peak assignment rules is to ensure glide formation, which is universal. However, any other feature specifications for the peak assignment rules is left blank because this can vary from language to language. Note that the rules pertaining to margins comprise a parameter, since not all languages permit margins.

Recall from 1.2 that I have not included a prosodic representation for diphthongs, since Japanese has none and the authors of the mora theory do not consider one either. Note that these rule systems do not include a mechanism for creating a glide-vowel sequence from two high vowels, for example, [yu] from /iu/. My analysis of Japanese will include a proposal for dealing with this case.

A summary of the mora theory is presented in (18) and one of the onset/rime theory is presented in (19). In (18a) I have represented the underlying inventory of Japanese, because in

the mora theory we are assuming, the underlying representation is subject to language specific variation, the details of which are given in 1.3. However, in (19a), I have included the underlying representations of all types of segments, since, in the onset/rime model, these do not vary between languages. Note that (') signifies the segment is unsyllabified.

(18) Mora theory

a. underlying representation

```
(i)                 (ii)

    t   = [t]           i   = [i]

(iii) μ μ           (iv) μ
      |/                 |
      i    = [ii]        t   = [tt]
```

b. structural inventory

```
(i)  σ          (ii)    σ          (iii)     σ
     |                 /|                  //|
     μ               / μ                 // μ
     |              /  |               //  |
     a   = [a]     t   a   = [ta]     tr   a = [tra]

(iv)     σ                    (v)     σ
        /|\                          /|
       / μ μ                        / μ
      /  | |                      /  |\
    t    a p   = [tap]          t    a p   = [tap]
    closed σ is heavy            closed σ is light
```

```
(vi)  σ                    (vii)  σ      σ
     /|\                          /|\    /|
    / μ μ                        / μ μ  / μ
   /  |/                        /  | |/  |
  t   a     = [taa]            t   a t   a   = [tatta]

(viii)  σ                  (ix)  *σ
       /|\                        /|\\
      / μ μ                      /μ μ μ
     /  | |\                    / |/  |
    t   a n d   = [tand]       t  a   p    = [taap]
```

c. general syllabification algorithm

(i) assign μ - 1 (μ - 1)

```
                μ
                |
[-hi] ---> [-hi]
```

In languages where segments other than vowels can act as sonority peaks, the melody specification would include other features, such as, [nasal].

(ii) erect syllable (σ)

```
(a)            σ
               |
    μ  --->    μ
    |          |
[-cons]    [-cons]
```

In languages with syllabic consonants, the melody specification would include other features, such as, [nasal].

(iii) onset creation rule (OCR)

```
        σ            σ
        |           /|
        μ          / μ
        |         /  |
[β]' [α]  ---> [β][α]
```

The specifications of α, β, and δ, in this and the following rules, would vary according to individual languages.

(iv) assign μ - 2 (μ - 2)

```
                          μ
                          |
[-cons]  ---> [-cons]
```

Repeat (ii) and (iii).

(v) weight by position (WP)

```
σ                σ
|                |
|                |
μ       --->     μ   μ
|                |   |
[α] [δ]'         [α][δ]
```

(vii) margin creation rule (MCR)

```
σ                  σ
|                  |
μ                  μ
|                  |\
[α][δ]'  --->  [α][δ]
```

(viii) syllable incorporation (σ - i)

```
σ                  σ
|                  |\
μ    μ'            μ   μ
|    |             |   |
[α] [δ]  --->  [α][δ]
```

(19) Onset/Rime theory

a. underlying representation

```
(i) x                  (ii) x
    |                       |
    t = [t]                 i = [i]
```

```
(iii) x x            (iv) x x
      |/                 |/
      i = [ii]           t = [tt]

(v) N or R           (vi) N       R
    |    |                |\      |\
    x    x                x x or  x x
    |    |                |/      |/
    n    n  = [n]          n       n  = [nn]

(vii) N    R         (viii) O
      |    |                |
      x or x                x
      |    |                |
      i    i  = /i/          i  = /y/
```

(vii) and (viii) are representations for idiosyncratic cases only, where the the distribution of the glide or vowel cannot be generated by rule.

b. structural inventory

Type I

```
(i)  σ        (ii)    σ       (iii)     σ
     |               /|               / |
     R              O R             O   R
     |              | |             |\  |
     x              x x             x x x
     |              | |             | | |
     a  = [ta]      t a  = [ta]     t r a  = [tra]

(iv)   σ                      (v)    σ
      /|                            /|
     O R                           O R
     | |\                          | |\
     x x x                         x x x
     | | |                         | |/
     t a p  = [tap]                t a   = [taa]
```

```
(vi)      σ       σ                (vii)     σ
         /|      /|                         /|\
        O R     O R                        O R \
        | |\    | |                        | |\ \
        x x x   x x                        x x x x
        | | |/  |                          | | | |
        t a t   a   = [tatta]              t a n d   = [tand]
```

```
(ix)      σ
         /|
       *O R
        | |\ \
        x x x x
        | |/  |
        t a   p   = [taap]
```

Type II

```
(i)     σ        (ii)     σ        (iii)     σ
        |                /|                 / |
        R               O R               O   R
        |               | |               |\  |
        N               | N               | | N
        |               | |               | | |
        x               x x               x x x
        |               | |               | | |
        a = [a]         t a   = [ta]      t r a   = [tra]
```

```
(iv)      σ                    (v)      σ
         /|                            /|
        O R                           O R
        | |\                          | |
        | N \                         | N
        | |  \                        | |\
        x x   x                       x x x
        | |   |                       | |/
        t a   p   = [tap]             t a     = [taa]
```

```
(vi)   σ          σ
      /|         /|
     O R        O R
     | |\       | |
     | N \      | N
     | |  \     | |
     x x   x    x x
     | |    |   |
     t a    t   a   = [tatta]
```

```
(vii)   σ
       /|\
      O R \
      | |\ \
      | N \ \
      | |  \ \
      x x   x x
      | |   | |
      t a   n d   = [tand]
```

```
(viii)    σ
         /|
       *O R
        | |\
        | N \
        | |\ \
        x x x x
        | |/  |
        t a   p   = [taap]
```

c. syllabification algorithm

Type I

(i) assign R - 1 (R - 1)

```
                R
                |
        x' ---> x
        |       |
      [-hi]   [-hi]
```

In languages where segments other than vowels can act as sonority peaks, the melody specifications would include other features, such as [nasal].

(ii) onset creation rule (OCR)

```
          R        O R
          |        | |
        x' x  ---> x x
```

(iii) assign R - 2 (R - 2)

```
                R
                |
      x' ---> x
      |         |
   [-cons] [-cons]
```

repeat (ii)

(iv) erect syllable (σ)

```
                σ
                |
   R  --->  R
```

(v) rime - incorporation (R - i)

```
   R          R
   |          |\
   x  x' ---> x  x
```

(vi) syllable incorporation (σ - i)

```
                  σ
                 /|
   O R  --->  O R
```

(vii) extra segment adjunction (esa)

```
      σ                σ
      |                |\
      R                R  \
      |\               |\  \
      x  x  x'  --->   x  x  x
```

Type II

(i) assign N - 1 (N - 1)

```
                N
                |
      x' ---> x
      |         |
   [-hi]    [-hi]
```

In languages where segments other than vowels can act as sonority peaks, the melody specifications would include other features, such as [nasal].

(ii) onset creation rule (OCR)

```
    N        O N
    |        | |
x'  x  --->  x x
```

(iii) assign N - 2 (N - 2)

```
              N
              |
  x'  --->    x
  |           |
[-cons]     [-cons]
```

repeat (ii)

(iv) erect rime (R)

```
            R
            |
N           N
|           |
x  --->     x
```

(v) erect syllable (σ)

```
            σ
            |
R  --->     R
```

(vi) rime incorporation (R - i)

```
R           R
|           |\
N           N  \
|           |   \
x  x'  --->  x    x
```

(vii) syllable incorporation (σ - i)

```
                    σ
                   /|
O R  --->  O R
```

(viii) extra segment adjunction (esa)

```
σ                  σ
|                  |\
R                  R  \
|\                 |\  \
  x  x'  --->        x  x
```

NOTES FOR CHAPTER ONE

[1] There are two kinds of unpredictable syllable structure which can be present in the UR. The first kind are prosodic representations which cannot be generated by the syllabification rules of the language, for example, certain glide positions in Berber (see Guerssel 1986). They must be prespecified as syllabic peaks in order to override the syllabification rules. The second kind are morphological prosodic templates, for example, a reduplication template (see Shaw 1985 and McCarthy and Prince 1986).

[2] However, one of the consequences of this approach is that the syllable can be ternary branching. Without this configuration the inventory of possible syllable trees is maximally binary. Therefore, this approach may not be compatible with a tightly constrained onset/rime theory which only allows a constituent to be binary branching.

I cannot offer a solution to this dilemma based on Japanese because Japanese has no syllables of this type. But, some representation of these syllables must be offered to complete the paradigm. Therefore, I adopt this approach over the extrametical approach, fully acknowledging that the choice is arbitrary.

2 JAPANESE LEXICON AND UNDERLYING REPRESENTATION

2.0 Introduction

2.0 The purpose of this chapter is to provide a framework for the discussion in Chapter Three. I present an overview of the lexical phonology of Japanese, the segmental inventory, and those allophonic and morphophonemic processes referred to in the following chapter which bear on the underspecified UR and redundancy rules. This chapter is not intended to be a definitive analysis of Japanese lexical phonology, but is instead intended to be a working system to provide a context for the analysis of syllable structure.

2.1 is a brief overview of the theory of lexical phonology and underspecification. 2.2 gives an account of the morphological component of the Japanese lexicon. 2.3 deals with the phonetic inventory and the allophonic rules which isolate the phonemic inventory. 2.4 deals with the phonemic inventory, the underspecified underlying representation and some morphophonemic processes. In 2.5, a summary diagram of the lexical phonology of Japanese is given.

2.1 Lexical Phonology

2.1 This model, first presented in Kiparsky (1982) and Mohanan (1982), organizes the morphological and phonological components of the grammar together. The phonological rules are divided up. Those which are highly exceptional and require reference to morphological categories or boundaries or any idiosyncratic information, are lexical rules. Those which are exceptionless, require less idiosyncratic information, which apply "across-the-board", are post-lexical rules. The component containing the former is called the lexical component, or lexicon, and the one containing the latter is called the post-lexical component.

The lexical component is stratified into levels. Conceptually speaking, the lexical items move directionally from the top to the lower levels. Each level comprises an interface between the phonological and morphological components, so select phonological rules can apply to select morphological structures at each level. Therefore, lexical items move from the morphological to the phonological component at each level before moving to the next level down.

The Bracket Erasure Convention (BEC) applies at each level. BEC means that all internal boundaries of a word are erased. How often it applies varies with different versions of this

theory. But, the BEC applies at least at the end of each level, so the phonological rules of the next level do not have access to the internal morphological structure of items. The intent of this convention is to block the application of rules that would otherwise apply if the internal structure could be accessed. The number of lexical levels and the directions of the morphological/phonological interfaces are two features which also vary with different versions of this theory. A diagram representing the version I am using is given below in (20).

(20)

```
------------------------------------------------
|                  LEXICON                      |
------------------------------------------------
|                                               |
|            |----------UR                      |
|            ↓                                  |
| morphological   --->   phonological  level 1  |
| rules          <---    rules                  |
|                     |                         |
|                 |-------                      |
|                 ↓                             |
| morphological   --->   phonological  level 2  |
| rules          <---    rules                  |
|                     |                         |
|                 |-------                      |
|                 ↓                             |
| morphological   --->   phonological  level 3  |
| rules          <---    rules                  |
|                                               |
------------------------------------------------
                          |
                          ↓
                  -------------------
                  |other components of|
                  |the grammar        |
                  -------------------
                          |
                          ↓
                  -------------------
                  |    POST-LEXICAL   |
                  |    COMPONENT      |
                  -------------------
```

(Based on Kaisse and Shaw 1985)

One other aspect of lexical phonology to mention is the Elsewhere Condition (EC).

(21) Elsewhere Condition

Rules A, B in the same component apply disjunctively to a form Ø iff:

> (i) The structural description of A (the special rule) properly includes the structural description of B (the general rule).
> (ii) The result of applying A to ξ is distinct from applying B to ξ.
>
> In that case A is applied first, and if it takes effect, B is not applied.
>
> (Kiparsky 1982a.136)

This condition prohibits the application of a general rule before a more particular one, if the domain of application is the same.

Kiparsky (1982b.46) argues that the Elsewhere Condition entails that lexical rules apply to derived forms only, forms which have previously undergone a morphological or phonological process. In other words, the EC entails the Strict Cycle Condition (Kiparsky 1982b.46). According to Kaisse and Shaw (1985), it is generally accepted that this entailment holds only for structure-changing rules. Structure-building rules can apply to non-derived forms. Syllabification rules can be classifired as structure-building rules.

In Kiparsky (1982b), a lexical phonology representation includes underspecification of underlying feature matrices as part of the model. The theory of underspecification I am assuming is based on Archangeli (1984,1988) and Archangeli and Pulleyblank (1986,1987). In an underspecified UR, all predictable values for features are eliminated and every specification for a feature will be one value, either [+] or

[-], but not both (cf. Archangeli and Pulleyblank 1986.8). Not all segments containing the non-redundant value of a feature have to be marked at the UR for that feature. In some cases doing so might allow predictable values to be present in the UR. For example, in Japanese, voicing is predictable for vowels, nasals and liquids. However, lack of voicing is predictable for obstruents. The only unpredictable voicing is that in voiced obstruents. So, even though [+voice] is the non-redundant underlying value, not all [+voice] segments will be specified in the UR for [voice], only voiced obstruents.

The redundant values of the features are supplied by redundancy rules. Archangeli and Pulleyblank (1986) categorize redundancy rules as either complement or default rules. Default rules assign a value which is considered to be the universal unmarked value and a complement rule assigns the opposite of the default value, the marked value. It is assumed that a default value for a feature would be the automatic selection of the learner unless evidence from phonological processes show the necessity of assigning the complement value. Archangeli (1988) has proposed a set of default rules for the vowel features, [high], [back] and [low], and I adopt these rules for Japanese.

Redundancy rules can apply at various stages of the lexical and post-lexical phonology. Archangeli and Pulleyblank (1986) propose a principle governing when redundancy rules

apply.

(22) Redundancy Rule Ordering Constraint (RROC)

> A default or complement rule assigning [αf] where "α" is "+" or "−", is automatically assigned to the first component in which reference is made to [αf].
>
> (Archangeli and Pulleyblank 1986.15)

Therefore, if a rule refers to a certain feature, the redundancy rule filling in the value of that feature must apply at the same level of the phonology. However, Ito and Mester (1986.70) point out that the RROC is not compatible with their analysis of the assignment of the feature [voice] in Japanese. (This relationship is discussed in 2.4 and footnote 5). Since I intend to adopt their analysis, I will not consider the RROC to be applicable in my system. To suggest an alternative universal principle to the RROC would be beyond the scope of this thesis, because presumably it would entail investigating more languages than Japanese. In my analysis the redundancy rules are ordered as the phonological processes of Japanese require them to be ordered.

Grignon (1985), Ross (1985) and Ito and Mester (1986) have shown the advantages of a lexical phonology analysis of Japanese. In the following sections of this Chapter, I present an analysis of the UR, lexical and post-lexical components of Japanese, drawing on these previous works.

2.2 Japanese Lexicon

2.2 According to Grignon (1985) and Ross (1985), the Japanese lexicon can be divided into three levels. In this section, we discuss the morphological component of these levels.

I am adopting Grignon's (1985) analysis of the organization of the verbal forms and Ross's (1985) analysis of the nominal forms. Below in (23) is an ordered list of the key morphological processes and affixes in Japanese.

(23)

Level I	verbal compounds:	V_1-V_2
	nominal compounds$_1$	
Level II	verbal compounds:	V_1-Vaspect
	verbal/adjectival inflections$_1$:	
	honorification	$[_{\upsilon}[_{\upsilon}...]$ninar$_{\upsilon}]$
	passive	$_{\upsilon}]$(r)are$_{\upsilon}]$
	causative	$_{\upsilon}]$(s)ase$_{\upsilon}]$
	desiderative	$_{\upsilon}]$ta$_{A}]$
	verbalizer$_1$	$_{A}]$gar$_{\upsilon}]$
	potential	$_{\upsilon}]$(r)are$_{\upsilon}]$ / $_{\upsilon}]$e$_{\upsilon}]$
	nominal compounds$_2$	
	'method' affix:	$_{\upsilon}]$kata$_{N}]$

Level III verbal/adjectival inflections$_2$:

negative	∪](a)na^]
non-past	∪](r)u∪]
	^]i^]
past	∪]ta∪]
gerund	∪]te∪]
conditional	∪]tara∪]
enumerative	∪]tari∪]
provisional	∪](r)eba∪]
cohortative/ tentative	∪](y)oo∪]
verbalizer$_2$	^]kar∪]
connective	^]ku∪]
	^]ke∪]

First, I would like to explain the function of the verbalizer$_1$, verbalizer$_2$ and connective affixes. Adjectives in Japanese can take verbal inflections, but must first attach one of these affixes. An adjective + 'gar' can take any level II or III verbal inflection. An adjective + 'kar' can only take other level III inflections, specifically 'ta', 'tara', and 'tari'. The connective form 'ku' is added to the adjective when it is at the end of a non-final sentence in a conjunction of two or more sentences. It is also added to an adjective before attaching 'te'. 'ke' is added to an adjective before attaching 'reba'.

Also, I would like to explain the existence of two potential forms at level II. Japanese verbs are divided into two groups: i-final, e-final roots or kamiichidan/kaminidan roots, and consonant final, u-final roots or yodan roots. There are no o-final or a-final verb roots in Japanese. I will refer to

the former as vowel final verbs and to the latter as yodan verbs[1]. The vowel final verbs take the 'rare' form of the potential and the yodan verbs take 'e'. Other inflections alternate their form depending on the verb group they are attached to. We discuss these alternations in 2.4.

Now, let us discuss the motivations for separating the verbal forms into three levels. Examples of Level I V_1-V_2 compounds and Level II V_1-Vaspect compounds are given below.

(24) a. V_1-V_2

nom-	aruk-	--->	nom -i-aruk-u	
drink	walk		drink-i-walk-np	
			"barhop"	
but-	koros-	--->	but-i-koros-u	
hit	kill		hit-i-kill -np	
			"punch to death"	

b. V_1-Vaspect

kak-	hadime-	--->	kak -i-hadime-ru	
write	begin		write-i-begin -np	
			"begin writing"	
kak-	owar-	--->	kak -i-owar -u	
write	finish		write-i-finish-np	
			"finish writing"	

'np' stands for non-past. The vowel [i] in the compounds has no meaning, it is added to all yodan (consonant-final) verbs before compounding.

Grignon (1985) points out that the difference between these two compounds lies in the ability to take level II

inflections, like passive or causative. In the V_1-Vaspect compounds, either member can take these inflections, which suggests that there is no ordering relationship between these compounds and the inflections, i.e. the compounding can take place before or after the affixes are attached. On the other hand, the V_1-V_2 compounds can only take the level II inflections after compounding, which suggests that there is an ordering relationship. These observations are illustrated in (25).

(25)	a.	nom-i -hadime-sase-ru drink-i-begin -caus-np	"make begin to drink"
		nom -ase -hadime-ru drink-caus-begin -np	"begin to make drink"
	b.	nom -i-aruk-ase -ru drink-i-walk-caus-np	"make barhop"
		*nom -ase -aruk-u drink-caus-walk-np	"make barhop"?

Grignon (1985.237)

Furthermore, V_1-V_2 compounds can take a Vaspect, but a V_1-Vaspect compound cannot compound with another verb.

(26)	a.	nom -i-aruk-i-hadime-ru drink-i-walk-i-begin -np	"begin to barhop"
	b.	*nom -i-hadime-aruk-u drink-i-begin -walk-np	"begin to barhop"?

Level II verbal inflections must be affixed before level III

ones. Showing the ordering relationships for all the inflections in both levels would yield a rather large data set. For the sake of brevity, I will only list a few examples.

(27)	a.	yom -are -ta read-pass-past	"has been read"
		*yom -ta -rare-ru read-past-pass-np	same as above
	b.	kak -ase -reba write-caus-prov	"provided that (someone) makes (someone) write"
		*kak -eba -sase-ru write-prov-caus-np	same as above
	c.	nom -i-aruk-i-hadime-tara drink-i-walk-i-begin -cond	"if (someone) has begun to barhop"
		*nom -i-aruk-i-tara-hadime-ru drink-i-walk-i-cond-begin -np	same as above

Now let us justify the division of the nominal compounds into level I and level II. First of all, the Japanese lexicon is divided into two types of words: native or Yamato words and non-native or Sino-Japanese words. The Sino-Japanese morphemes are Japanized forms of loan words from Chinese which were borrowed mainly between the 5th and 8th centuries A.D.. The Sino-Japanese words do have some unique properties. For instance, there are complex onsets, i.e. consonant-yod clusters, in the Sino-Japanese morphemes which do not appear in the Yamato morphemes. Also, there is a rule of high vowel

syncopation which applies only to Sino-Japanese compounds, and a voicing rule, called rendaku, which applies only to Yamato compounds.

Of the Sino-Japanese compounds, there is one group to which high vowel syncopation does apply, and one to which it does not. The former group of nominal compounds is the one listed at level I and the latter is at level II, in (23). High vowel syncopation consists of a high vowel deleting between two voiceless consonants at a morpheme boundary. Ross's (1985) formalization of the rule is given below.

(28) High vowel syncopation

```
 x  --->  Ø / C    ____ N]  C
 |            [+sino]        [+sino]
[+hi]         [-vcd]         [-vcd]
```

(Ross 1985.20)

If the two voiceless consonants are identical, they form a fake geminate after the deletion of the vowel. If they are not identical, the left-most consonant deletes, and the remaining consonant spreads to form a true geminate. Examples of level I nominal compounds are presented in (29).

(29)	teki + koku	--->	tek-koku	"enemy country"
	roku + ka	--->	rok-ka	"sixth lesson"
	iti + too	--->	it-too	"first class"
	butu + tai	--->	but-tai	"solid object"
	iti + sen	--->	is-sen	"one thousand"
	iti + ki	--->	ik-ki	"first period"
	butu + situ	--->	bus-situ	"substance"

(Ross 1985.22-23)

Examples of level II compounds are presented in (30). The environment to which high vowel syncopation would apply, and does not, is underlined.

(30)	bet<u>u</u> + hai-tatu	--->	betu-hai-tatu "special delivery"
	sya-zit<u>u</u> + ha	--->	sya-zitu-ha "realist movement"
	zi-ryok<u>u</u> + kei	--->	zi-ryoku-kei "magnetometer

(Ross 1985.24)

Thus, the rule of high vowel syncopation divides the nominal compounds into two groups, each at a different level of the lexicon.

2.3 Japanese Phonetic Inventory

2.3.1 In this section we discuss the phonetic inventory of Japanese, and in 2.3.2, we discuss the allophonic rules from which the phonemic inventory can be derived. The segmental

inventory of Japanese is given in (31).

(31) Phonetic inventory

	bilabial	alveolar	alveo-pal	palatal	velar	laryngeal
stops	p b	t d			k g	
affric.		ts	tɕ dʑ			
fric.	ɸ	s z	ɕ	ç		h
nasals	m	n			ŋ	
liquids		ɾ*				
glides	w			y		

vowels

i ɯ*
e o
a

* [ɾ] is a tap. [ɯ] is unrounded.

We are assuming a feature geometric representation of the melody tier. See Grignon (1985) for an analysis of both the phonetic and phonemic inventories of Japanese using a non-geometric representation. In a geometric representation the features are organized hierarchically so each segment does not consist of a bundle of unordered features. Various feature hierarchies are proposed in Clements (1985, 1987), Archangeli and Pulleyblank (1986,1987) and Sagey (1986). The

particular feature geometry model we are adopting is that of Piggott (1988b), which is presented below.

```
(32)        π                π = prosodic category, i.e. x or μ
           / \
      tone   root     =RN
           / / | \ \
          / /  |  \ \
      nas voc cons | \
                   |  \
              laryngeal\    =LN
                   |     \
              glottal  supralaryngeal    =SLN
              features      /  \
                           /    \
                   manner        \
                   features      place features   =PN
                                   / | \
                     Lab=   labial   |  \
                              |      |   dorsal =Dor
                              |      |     | \ \
                     Cor=    rnd  coronal  hi | lo
                                  /|        back
                              ant |
                                  distr
```

(Piggott 1988b.7)

Let us discuss some aspects of this model. First, Piggott (1988a) claims that only one of the major class features, [consonantal] and [vocalic], functions in a language. These features serve to indicate what segments can act as syllabic peaks. For languages which allow all [+vocalic] segments to be peaks, i.e. vowels, liquids and nasals, [vocalic] is the distinctive class feature and [consonantal] is not present. For languages which allow only [-consonantal] segments to be peaks, i.e. vowels, only [consonantal] is present. Japanese

falls into the latter category, therefore [consonantal] is the only major class feature present[2].

Notice that the place features are divided into three articulator tiers or nodes. This division is first introduced in Sagey (1986). According to Sagey (1986.66), only one articulator tier is present in the representation of a simplex sound. So, a simplex segment marked [+anterior] is <u>not</u> marked { [-labial], [-low], [-high], [-back] }, because the articulator tiers these features are attached to are not present in the representation. Complex segments can be defined as those segments which employ more than one articulator tier, such as, [kp] or [kw]. Note that this means that rounded vowels are complex segments, at least at the phonetic level.

Concerning roundedness, notice that the feature [round] and not [labial] appears under the labial articulator node. [round] is not a distinctive feature in Japanese, but [labial] is. For example, the high back vowel [ɯ] is not [+round] yet it is [+labial] and it triggers a process of labialization. [h] becomes [ɸ] before [ɯ]. Also, the consonants [m], [p] and [b] are not [+round], but they are [+labial]. Therefore, the labial node can exist independent of the presence of the feature [round] in the phonology. In my analysis of Japanese, there is no feature [round]. The labial articulator node functions as a privative feature: either present or absent.

Segments are either [+labial] or [0labial].

Moving on to the manner features, there is a problem in Japanese with isolating the segment [ɾ] with distinctive features. This segment is { [+voice], [-continuant], [+anterior] }. Therefore, it is indistinguishable from [d], given only these features. Considering [ɾ] to be [+continuant] would not only be phonetically inaccurate, but it would also render this segment indistinguishable from [z]. Considering [ɾ] to be [-anterior] would again be phonetically inaccurate and would impose an equipollent representation of this feature at the underspecified UR, which I have ruled out as a possibility in section 1. Following a suggestion of Shaw (personal communication), I will introduce an ad hoc feature [tap] solely in order to distinguish the segment [ɾ] from [d] and [z]. Together with [continuant], this feature hangs under the manner features node.

Among the glottal features, only [voice] is distinctive in Japanese, so only [voice] is present on the laryngeal tier.

Therefore, the features I will be using to describe Japanese are: [nasal], [consonantal], [voice], [continuant], [tap], [labial], [anterior], [high], [back], and [low]. A feature chart for the phonetic inventory of Japanese is shown in (33).

(33)

	p	t	ts	tʂ	k	b	d	dʐ	g	ʂ	s	ʂ	ç	h	z	m	n	ŋ	ɲ	w	y	i	e	a	o	ɯ
cons	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−
nas	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	−	−	−	−	−	−	−	−
voi	−	−	−	−	−	+	+	+	+	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	+
cont	−	−	−/+	−/+	−	−	−	−/+	−	+	+	+	+	+	+	−	−	−	−	+	+	+	+	+	+	+
tap	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−
lab	+					+				+						+				+					+	+
ant		+	+	−			+	−			+	−			+		+		+							
hi					+				+				+	−				+		+	+	+	−	−	−	+
bck					+				+				−	+				+		+	−	−	−	+	+	+
lo					−				−				−	+				−		−	−	−	−	+	−	−

2.3.2 Many of the segments listed above are predictable in distribution and therefore are not part of the underlying phonemic inventory. In this section I present the allophonic rules which account for these predictable distributions. Because allophonic rules are exceptionless and "across-the-board", they would be placed in the post-lexical component. Furthermore, because I consider all of the redundancy rules to have applied by this component, all the segments are fully specified.

Affrication/palatalization processes are given below in segmental notation.

(34) Affrication/palatalization

h ---> ç / __ i

z ---> dʑ / __ i

s ---> ɕ / __ i

{t,d} ---> {tɕ, dʑ} / __ i

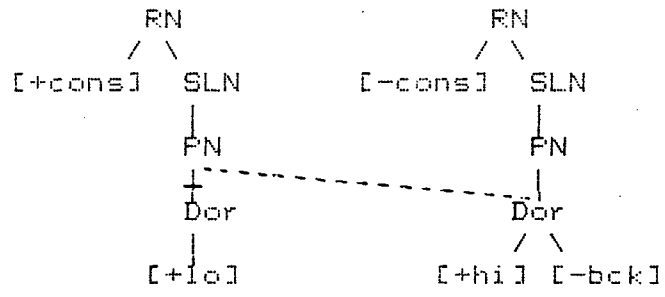
t ---> ts / __ ɯ

d ---> z / __ ɯ

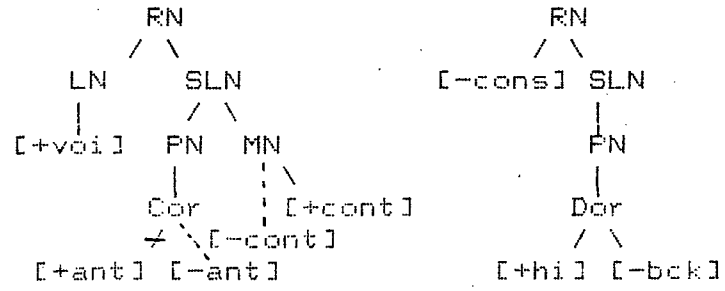
These processes are idiosyncratic. For instance, [z] affricates and palatalizes before [i], but [s] just palatalizes before [i]. Also, [t] affricates before [u], but [d] spirantizes before [u]. These inherent idiosyncracies make these processes difficult to formalize elegantly; however, they are also difficult to formalize because of the structure of the feature geometry. Palatalization is an assimilation process and assimilation processes ought to be represented by spreading in three dimensional phonology. However, recall that alveo-palatal sounds are [-ant], and are not marked for height because they have no dorsal tier. Likewise, vowels have no specifications for anteriority. If we altered the model somewhat and considered alveo-palatals to be both [+hi] and [-ant], we could distinguish them from palatals like [ç]. However, resolving this problem thoroughly would be tangential to the central concern of this thesis, so for now, palatalization must be expressed as a feature changing rule

where [-ant] is substituted for [+ant]. I consider this to be a shortcoming of this model. The rules in (34) are given in three dimensional notation in (35). The highest node given in the rule formulations is the root node, so these rules are compatible with either a mora or onset/rime model.

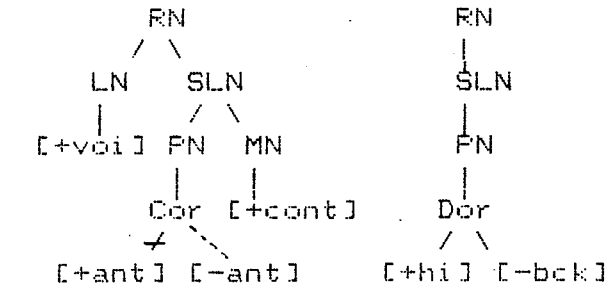
(35) a. h ---> ç / __ i



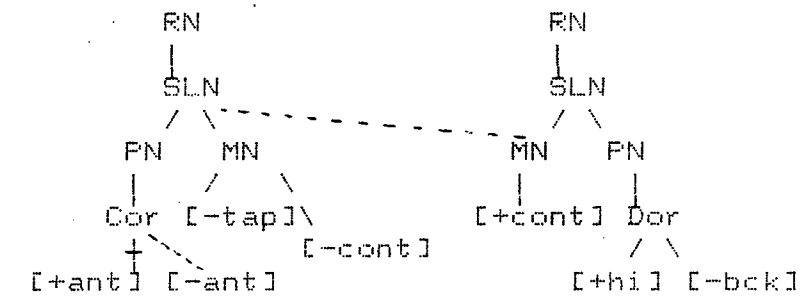
b. z ---> dʑ / __ i



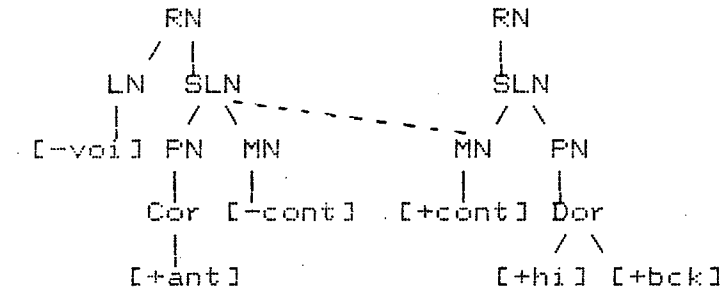
c. s ---> ɕ / __ i



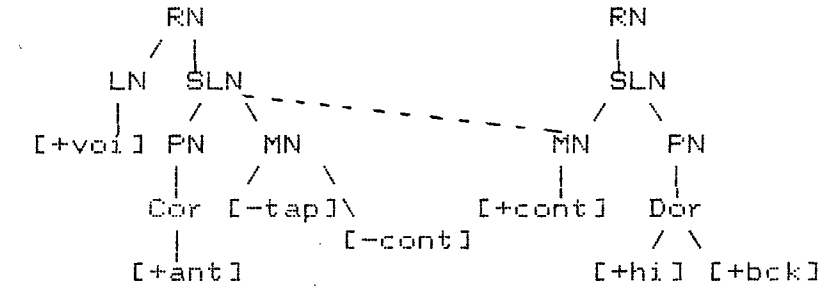
d. {t,d} ---> {tʃ, dʒ} / __ i



e. t ---> ts / __ ɯ



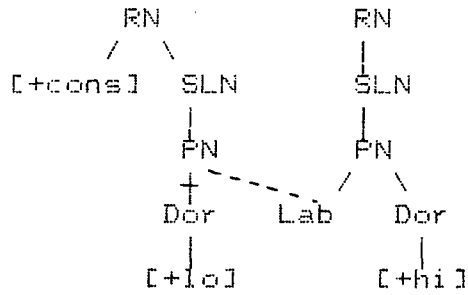
f. d ---> z / __ ɯ



The labialization process mentioned in 2.3.1 is formulated in (36).

(36) Labialization

h ---> ɸ / __ ɯ



The above rules have accounted for all the non-underlying forms except [n], [y] and [w]. [ŋ] surfaces when a margin nasal appears adjacent to velar sound, thus [ŋ] is a product of place assimilation[9]. I deal with this process of place assimilation as part of the discussion of the margin nasal in Chapter Three. Similarly, the surface positions of the glides are accounted for by rule in Chapter Three.

2.4 Japanese Phonemic Inventory

2.4.1 Eliminating the segments which are generated by the post-lexical rules in 2.3.2, we can consider the set in (37) to be the phonemic inventory of Japanese.

(37) Phonemic Inventory

	bilabial	alveolar	velar	laryngeal
stops	p b	t d	k g	
fricatives		s z		h
nasals	m	n		
liquids		r*		

vowels

i				u*
	e		o	
		a		

*I am using these symbols for [ɹ] and [ɰ] for typographical convenience.

As mentioned in 2.1, I am assuming that the underlying representations of these segments are underspecified. I am utilizing a system which Archangeli (1988) calls 'radical underspecification', as opposed to the 'contrastive underspecification' of Steriade (1987). Archangeli (1988) proposes a universal unmarked underspecification system for a five vowel inventory, which I adopt for Japanese. The underspecified values for the consonants have been chosen on the basis of sound patterning in processes in the language. A chart of the underspecified UR is given in (38).

(38) Underspecified UR

	p	t	k	b	d	g	m	n	s	z	h	r	i	e	a	o	u
cons													-	-	-	-	-
nas							+	+									
voi				+	+	+				+							
cont									+	+	+						
tap												+					
lab	+			+			+										
ant		+			+				+	+							
hi														-		-	
bck																+	+
lo											+				+		

Recall that the articulator tiers are labial, coronal and dorsal. With the exception of the surface representation of [u] and [o], segments in Japanese possess only one articulator tier. Therefore, in the interest of structure preservation, the redundancy rules only fill in values for features on the articulator tier which is present in that segment's hierarchy. So, a rule like [+cont] ---> [-hi] will not apply to the segment [s], because this segment has an articulator tier present, the coronal one, which does not contain this feature. If a segment has no articulator tier present, the first place feature rule which can apply to it will automatically create the relevant place tier for that feature in the segment's hierarchy. The segments without any articulator tier specified are [n], [r], [k] and [g].

The redundancy rules I propose for Japanese are given in (39), in order of application. In the limited number of

processes I am looking at in Japanese, I have found evidence for the application of many of the redundancy rules at various levels in the lexical component.

(39) Redundancy rules

level I

[ ] ---> [+cons]

[ ] ---> [-nas]

[ ] ---> [-tap]

$\begin{bmatrix} +cons \\ -nas \\ -tap \end{bmatrix}$ ---> [-voi]

$\begin{bmatrix} +lo \\ -cons \end{bmatrix}$ ---> $\begin{bmatrix} -hi \\ +bck \end{bmatrix}$

$\begin{bmatrix} -nas \\ -tap \end{bmatrix}$ ---> [+hi]

[-cons] ---> [-bck]

level III

[+nas] ---> [+voi]

post-lexical

$\begin{bmatrix} [+tap] \\ [-cons] \end{bmatrix}$ ---> [+voi]

[+bck] ---> [+lab]

$\begin{bmatrix} +nas \\ -lab \end{bmatrix}$ ---> [+ant]

[+tap] ---> [+ant]

[ ] ---> [-lo]

[+cons] ---> [+bck]

[+lo] ---> [-hi]

[-cons] ---> [+cont]

[ ] ---> [-cont]

2.4.2 First, let us discuss the reasons for the early (level I) application of some of the rules.

The specification of [-hi] is required by the syllabification rules, which are presented in the next Chapter.

The application of the rules inserting [+consonantal], [+high], and [-voice] is motivated by the process we have examined earlier called High Vowel Syncopation. The formalized rule is repeated below in (40) from (28), along with a reformalization using our feature system.

In this rule, and all the rules in this chapter, the character [π] stands for prosodic category. In the case of the onset/rime model this would indicate a skeletal slot. In the mora model this could be either a mora or a syllable node. In the case of deletion, the [π] only deletes in the mora model if it dominates a vowel. Otherwise, just the root node deletes. I am employing this convention in order to avoid writing separate versions of each rule for each model.

(40) High vowel syncopation

```
a.  x  ---> Ø  /  C    ___ N]  C
    |             [+sino]       [+sino]
  [+hi]           [-vcd]        [-vcd]
```

```
b.   π    ---->  Ø  /  [[ π   ___ N][π    N]α]
     |                   |          |
     RN                  RN         RN
     |                   |          |
     Dor                 LN         LN
     |                   |          |
   [+hi]             [-voi]     [-voi]
```

α = Sino-Japanese

The phonology must have access to the above feature values in order to apply this rule. Note that [+consonantal] is not mentioned in (40b). It is not necessary because of the voice specification; however, the feature [consonantal] must be fully specified in order for the redundancy rule marking [-voice] to apply. This is also the reason for the [-tap] and [-nasal] specifications. We will justify the peculiar split in the specification of the feature [voice] later on in this section.

Other rules which are relevant to the redundancy rule application are i-epenthesis, r-deletion and s-deletion. i-epenthesis applies at all levels, the other two apply at level II and III only. When yodan verbs are compounded (level I or II) or concatenated with the method affix 'kata', or the desiderative 'ta', the vowel [i] is inserted and in most cases, but not all, this vowel functions to break up impermissible consonant clusters. There is only one instance I am aware of where i-epenthesis applies at level III, and in that case it applies to s-final verbs only. Because we will

be dealing in chapter three with the level III verbal paradigm where i-epenthesis applies, I do not include data of the s-final verbs here. Data from level I and II illustrating i-epenthesis are given below in (41).

(41) a. Verbal compounds

nom-i-aruk-	"barhop"
tabe-aruk-	"eat while walking"
kak-i-das-	"begin writing"
tabe-das-	"begin eating"
kak-i-owar-	"finish writing"
tabe-owar-	"finish eating"

b. Method affix

kak-i-kata	"method of writing"
yom-i-kata	"method of reading"
tabe-kata	"method of eating"
osie-kata	"method of teaching"

c. Desiderative

kak-i-ta-	"desire to write"
yom-i-ta	"desire to read"
tabe-ta-	"desire to eat"
osie-ta-	"desire to teach"

A formal rule for i-epenthesis is given below. Note that the feature [-back] is also necessary to single out the focus for this rule.

(42) i-epenthesis (subsequent revision in 59)

$$\emptyset \;\text{--->}\; \begin{array}{c}\pi\\ |\\ RN\\ |\\ Dor\\ |\\ \begin{bmatrix}+hi\\ -bck\end{bmatrix}\end{array} \;/\; \ldots_{\alpha}] \;\_\_\; [_{\theta} \qquad \begin{array}{l}\theta = V\\ \quad\;\; kata\\ \quad\;\; ta\\ \\ V_{\alpha} = yodan\end{array}$$

Note that the passive and causative affixes, which apply at level II, are listed in (23) as '(r)are' and '(s)ase'. The segments which are indicated as optional are not actually randomly optional. These consonants appear when preceded by vowel final verbs and do not appear when preceded by yodan verbs, for example, 'tabe-rare' "be eaten"/ 'tabe-sase' "made to eat" and 'kak-are' "be written"/ 'kak-ase' "made to write". Therefore, I suggest that these forms possess the initial consonants underlyingly. The consonants are deleted after concatenation with yodan verbs. An r/s-deletion rule is formalized in (43).

(43) r/s-deletion

$$\begin{array}{c}\pi\\ |\\ RN\\ |\\ MN\\ |\\ \begin{bmatrix}[+tap]\\ [+cont]\end{bmatrix}\end{array} \;\text{--->}\; \emptyset \;/\; \ldots_{\alpha}] \;\_\_\; V_{\alpha} = yodan$$

Note that r-deletion applies also at level III, to the non-past suffix 'ru', and the provisional 'reba'. For example, 'tabe-ru' "eat"/ 'tabe-reba' "provided that s.o. eat" and 'kak-u' "write" and 'kak-eba' "provided that s.o. write".

A rule is also necessary to delete the [y] (an [i] underlyingly) in the level III cohortative suffix 'yoo'. This segment deletes when it is preceded by a yodan verb. For example, 'tabe-yoo' "let's eat" and 'kak-oo' "let's write"[4]. Also, the [a] in the negative suffix 'ana' deletes when preceded by a vowel final verb. For example, 'tabe-na-' "not eat" and 'kak-ana-' "not write". These two rules are given in (44):

(44) a. i-deletion

```
          π      --->  Ø  /     vα] __ π   π
          |                             \/
          RN                            RN
         / |                            |
[-cons] PN                              PN
          |                             |
          Dor                           Dor
          |                             |
        [+hi]                          |+bck|
                                       |-hi |
```

b. a-deletion

```
          π    --->  Ø  /     vβ] __
          |
          RN
          |
          PN
          |
          Dor
          |
        [+lo]
```

V_α = yodan
V_β = vowel final

Now let us discuss the voicing specifications. Voiced obstruents are the only segments marked for voicing underlyingly. A redundancy rule at level I supplies a [-voice] specification to voiceless obstruents, because these segments must be identified for the rule of high vowel syncopation. Another redundancy rule supplies a [+voice] specification to nasals at level III and vowels and liquids are specified for [+voice] at the post-lexical level. The separate specifications for nasals, vowels and liquids is motivated by a process of voice assimilation.

Ito and Mester (1986) analyse a voice assimilation process called rendaku. In two member nominal compounds, if the second member begins with a voiceless obstruent, that obstruent becomes voiced. This process of rendaku applies to Yamato morphemes only. Some examples of this process are given in (45). The data are compiled from Ito and Mester (1986). This compounding takes place at level I, in our model.

(45) a. Yamato

iro + kami	--->	iro-gami	"coloured paper"
yo + sakura	--->	yo-zakura	"blossoms at night"
e + tako	--->	e-daku	"picture kite"
ike + hana	--->	ike-bana*	"flower arranging"

b. Sino-Japanese

han + tai	--->	han-tai *han-dai	"opposition"
san + poo	--->	sam-poo *sam-boo	"stroll"

*Note that voiced [h] surfaces as [b]. When [h] is geminated, it surfaces as [pp]. See Grignon (1985.178-180) for an analysis of these phenomena.

Rendaku does not apply if there is already a voiced obstruent in the second morpheme. This is known as Lyman's law. For instance, [kami + kaze] "divine wind becomes 'kami-kaze' not *'kami-gaze'.

Ito and Mester (1986) account for these facts by the following analysis: Voicing is only specified underlyingly for voiced obstruents, and only voiced obstruents are specified at the level rendaku applies, in their model. Rendaku consists of the insertion of the feature [+voice] between the morphemes in a compound. A rule of rightward spreading spreads this feature onto the adjacent segment which is the first consonant of the second member of the compound. These two processes are presented below.

(46) a. Rendaku

Insert [+voi] /] __ [

x

b. Voicing spread

[+voi]

x x

(from Ito and Mester 1986.57,58)

Since only voiced obstruents are marked for [voice] at this level, only they spread voicing. Ito and Mester assume that Lyman's law acts as a prohibition against two or more specifications for voicing within one morpheme, so this prohibition serves to block the spread of the inserted [+voice] feature if there is already a voiced obstruent in the morpheme.

To incorporate this analysis into our lexical component, we must modify the voicing spread rule because at the level where rendaku applies, level I, the voiceless obstruents are marked for [voice]. A reformulization of this rule is given in (47).

(47) Voicing spread

[π] π $_{\alpha}$] α = Yamato

RN RN

LN LN

[+voi] [−voi]

I assume that Lyman's law prohibits two or more [+voice] specifications on the Laryngeal tier in one morpheme. Lyman's law applies as a configurational constraint, as in Archangeli and Pulleyblank (1986.25). This constraint is operative at all levels of the lexical phonology.

(48) Lyman's law

```
*[ π ... π α]      α = Yamato
   |      |
   RN     RN
   |      |
   LN     LN
   |      |
[+voi] [+voi]
```

There is another process of voice spreading in Japanese. Nasals voice a following [t] when concatenated with a level III suffix. (In monomorphemic words with a sequence of margin nasal-obstruent, the obstruent is always voiced, but we cannot generate this by rule because these are not derived forms).

Examples of nasal voicing are given in (49).

(49)

"die"		"wait"
sin-		mat-
sin-da	past	mat-ta
sin-de	gerund	mat-te
sin-dara	conditional	mat-tara

Therefore, I have placed the redundancy rule assigning [+voice] to nasals at level III. Notice in (45b) that the

nasal does not voice the following [p] in 'sampoo' "stroll". So nasal voicing is not an "across-the-board" rule, it applies to Yamato morphemes only. Therefore it cannot be a post-lexical rule. Since the rule of voicing spread applies to Yamato forms only as well, we can use it to account for nasal voicing as well as rendaku voicing. It is not triggered by nasals at level I because nasals are not marked for [voice] at level I. So, voicing spread applies throughout the lexical component.

Vowels and liquids never trigger voicing and so their voice specifications are added at the post-lexical component where voicing spread no longer applies[5].

2.5 Summary

2.5 Below is a diagram which summarizes what we have discussed in this chapter. It is a model of the lexical phonology of Japanese with all the morphological and phonological processes we have discussed listed in order of application.

UNDERLYING REPRESENTATION

	p	t	k	b	d	g	m	n	s	z	h	r	i	e	a	o	u
cons													−	−	−	−	−
nas							+	+									
voi				+	+	+				+							
cont									+	+	+						
tap												+					
lab	+			+			+										
ant		+			+				+	+							
hi														−		−	
bck																+	+
lo											+				+		

LEXICON

	MORPHOLOGY	PHONOLOGY
LEVEL I	V_1-V_2 nominal compounds $_1$	[ ] ---> [+cons] [ ] ---> [-nas] [ ] ---> [-tap] [+cons, -tap, -nas] ---> [-voi] [+lo, -cons] ---> [-hi, +bck] [-nas, -tap] ---> [+hi] [-cons] ---> [-bck] high vowel-syncopation (40b) rendaku (46a) voicing spread (47) i-epenthesis (42) constraints: Lyman's law (48)
LEVEL II	V_1-Vaspect [o[v...]ninar v] v]rare v] v]sase v] v]ta A] A]gar v] v]rare v]/v]e v] nominal compounds$_2$ v]kata N]	voicing spread (47) i-epenthesis (42) r/s-deletion (43) constraints: Lyman's law (48)
LEVEL III	v]ana A] v]ru v] A]i A] v]ta v] v]te v] v]tara v] v]tari v] v]reba v] v]ioo v] A]kar v] A]ku v] A]ke v]	[+nas] ---> [+voi] voicing spread (47) i-epenthesis (42) r/s-deletion (43) a-deletion (44.b) i-deletion (44.a) constraints: Lyman's law (48)

POST LEXICAL COMPONENT

$\begin{bmatrix} [+tap] \\ [-cons] \end{bmatrix}$ ---> [+voi]

[+bck] ---> [+lab]

$\begin{bmatrix} +nas \\ -lab \end{bmatrix}$ ---> [+ant]

[+tap] ---> [+ant]

[ ] ---> [-lo]

[+cons] ---> [+bck]

[+lo] ---> [-hi]

[-cons] ---> [+cont]

[ ] ---> [-cont]

allophonic rules (35), (36)

NOTES FOR CHAPTER TWO

[1] In other analyses, (for example, McCawley 1968, Fukui 1986 and Poser 1986), u-final verbs are considered w-final verbs. The only surface appearance of [u] in these verbs is [w]. [u] appears as [w] before [a] and in all other environments [u] deletes. (This deletion process is discussed in Chapter Three). Therefore, it is not only a defensible position to consider these forms w-final, but it is also a position which conforms to the notion of minimizing opacity. In other words, how can we posit [u] as the underlying form when [u] never surfaces?

Contrary to the models assumed by the authors above, it is a universal principle in our model that surface [w] derives from underlying [u], with the exception of a few idiosyncratic cases. Therefore, in our model it follows that these verbs are u-final, not w-final.

The consonants and the vowel [u] do not form a natural class, but neither do the consonants and the glide [w]. [w] is [-consonantal], as is [u]. So, in either analysis, it remains an idiosyncratic fact of Japanese that the yodan verbs do not consist of a natural class.

[2] The margin nasal in Japanese is often referred to as a syllabic nasal. This segment does bear weight but it does not in fact form the peak of a syllable. A detailed analysis of the margin nasal is presented in chapter 3.

[3] In the Tokyo area dialect there is a velar nasal which is not formed through assimilation to a following stop. It is found in the place of [g] in words like the nominative marker 'ga', 'eigo' "English", 'eiga' "movie". I do not provide an account of the distribution of this velar nasal in this thesis.

[4] Another possible analysis of this process is that [y] is inserted to break the hiatus between the three vowels and is not part of the underlying form of this morpheme.

[5] The RROC (Archangeli and Pulleyblank 1986.15) requires that a redundancy rule assigning a particular value of a feature, [αf], must apply at the first level where [αf] is referred to in a phonological rule. This is not compatible with our analysis of voicing spread in Japanese. This rule applies at level I and refers to the feature [+voice]. But, the redundancy rules which assign [+voice] to nasals and vowels and liquids do not apply until level II and the post-lexical level respectively.

3 JAPANESE SYLLABLE STRUCTURE

3.0 Introduction

3.0 Now that we have a background in syllable theory from Chapter One and a background in Japanese phonology from Chapter Two, we can go on to discuss the syllable structure of Japanese.

As mentioned earlier in chapter one, Japanese is often considered an archetypal mora language. This is chiefly because in the indigenous linguistic tradition the language is analysed with the unit 'mora'. These traditional moras correspond the moras, or weight units used in Hyman (1985) because the onset consonant of a syllable is included in the first mora of that syllable. For example, the writing system is broken down into moras, one grapheme = one mora, so all the consonant-vowel pairings which form light syllables are represented by a single grapheme each; whereas, the second member of a long vowel, a margin nasal and the first member of a geminate are represented by separate graphemes.

In Chapter One, we also mentioned that the mora model is designed to represent weight distinctions. These distinctions are relevant in Japanese; for example, the pitch accent system, as analysed by McCawley (1968) and Zubizaretta (1982),

refers to weight distinctions. I am claiming that the type I onset/rime model I propose accounts for weight distinctions as adequately as the mora model. In this chapter we show evidence that Japanese is indeed a type I language and is equally well described by a mora or an onset/rime model of syllable structure.

This chapter is organized as follows: 3.1 deals with the inventory of syllable structures in Japanese. 3.2 deals with the evidence supporting a type I representation for Japanese. In 3.3 the distribution of glides in Japanese is discussed. In 3.4 syllabification algorithms for Japanese, in both models, are presented along with derivations.

3.1 Syllable Inventory

3.1 Japanese has both open and closed syllables, but there are restrictions on what segments can hold a margin position. A margin can either be a nasal or the first member of a geminate consonant. Among open syllables, the syllabic peak can be either a long or short vowel. There are no true diphthongs in Japanese, so a sequence of two non-identical vowels forms two separate syllables. An open syllable with a long vowel or a closed syllable constitutes a heavy syllable.

In (50), some data are presented which illustrates the

syllable inventory of Japanese. The data are structured in both a mora and an onset/rime framework. I am using the onset/rime Type 1 model since I consider Japanese to be a Type 1 language. I provide support for this claim in section 3.2.

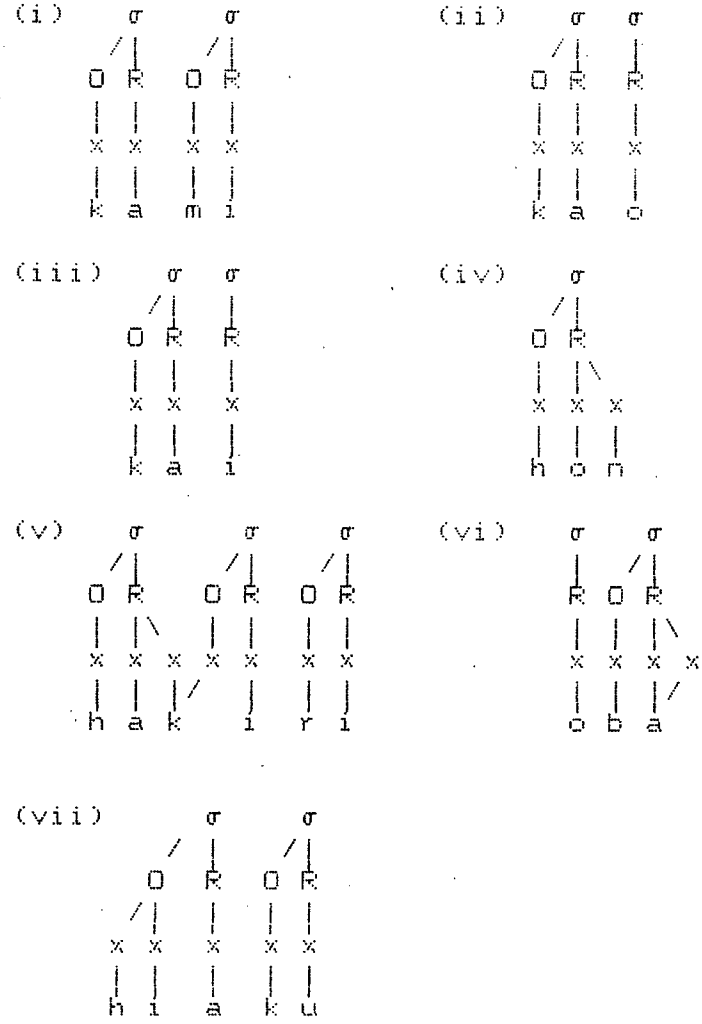
(50) a.

(i)	kami	"god"
(ii)	kao	"face"
(iii)	kai	"shell"
(iv)	hon	"book"
(v)	hakkiri	"certainly"
(vi)	obaa	"grandmother"
(vii)	hyaku	"one hundred"

b. mora model

```
(i)      σ       σ
        /|      /|
       / μ     / μ
      /  |    /  |
     k   a   m   i

(ii)     σ   σ
        /|   |
       / μ   μ
      /  |   |
     k   a   o

(iii)      σ   σ
          /|   |
         / μ   μ
        /  |   |
       k   a   i

(iv)     σ
        /|\
       / μ μ
      /  | |
     h   o n

(v)      σ       σ       σ
        /|\     /|      /|
       / μ μ   / μ     / μ
      /  | |/  |   /   |
     h   a k   i  r    i

(vi)     σ       σ
         |      /|\
         |     / μ μ
         μ    /  |/
         |   /   |
         o  b    a

(vii)        σ       σ
            //|      /|
           // μ     / μ
          //  |    /  |
         h i   a k    u
```

c. onset/rime model (type 1)



3.2 Evidence for Type I

3.2.0 In chapter one we presented an onset/rime model which included two parameters labelled Type I and Type II. Type I is the unmarked form and contains no nucleus constituent so a branching or non-branching rime corresponds to the distinction

between a heavy and a light syllable. Thus, in terms of expressing weight distinctions, a Type I model is equivalent to the mora model.

Zubizaretta (1982) and Grignon (1985) propose a syllable structure for Japanese without a nucleus constituent, offering evidence from the assignment of pitch accent and structural inventory, respectively. In this section I provide further evidence that Japanese is a Type I language. The evidence consists of a process of nasal assimilation and one of complementary gemination/compensatory lengthening.

In the following analyses, the data are represented in the onset/rime model only. This is for the sake of brevity only, and is not meant to imply that the mora model could not adequately represent the data.

3.2.1 The margin nasal, or mora nasal, undergoes a process which supports a Type I syllable analysis for Japanese.

A nasal in a margin position assimilates to the place and manner of articulation of a following consonant, if that consonant is [-cont]. If the nasal is followed by a [+cont] consonant, or by nothing, it assimilates to the place and manner of articulation of the preceding vowel. The data in (52) illustrate this process.

(52) a. sentoo "public baths"
kendoo "fencing"
sampoo "stroll"
samba "midwife"
seŋkoo "stick of incense"
maŋga "comic book"
semmee "clearness"
tenno "emperor"
senree "baptism"

b. seẽsei "teacher"
hoõ "book"

Grignon (1985.184)

Note that this process is independent of voicing spread, e.g. 'sentoo' and 'kendoo'. In fact, nasal assimilation is an exceptionless process that even occurs across word boundaries, for example,

(53) hoŋ ga aru "There are books."
books nom exist

nom = nominative

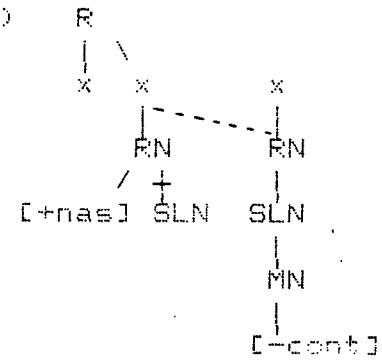
Therefore, I consider nasal assimilation to be a post-lexical process.

If we assume a Type I prosodic structure, then whether the spreading is rightward or leftward we can maintain a generalization about the target: branching rime. If we assume a Type II structure then the leftward spreading must be accompanied by a change in prosodic structure.

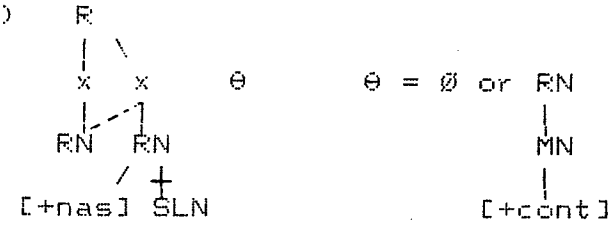
(54) Nasal assimilation[1]

a. Type I

(i)

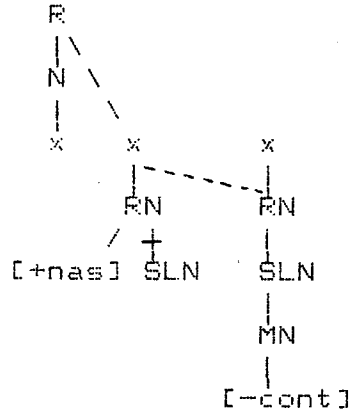


(ii)



b. Type II

(i)



```
(ii)    R                          R
        |\                         |
        N \                        N
        |  \                       |  \
        x   x     θ     --->       x   x
        |   |                      |  /|
       RN  RN                     RN  RN
          / +                        |
   [+nas] SLN                     [+nas]
```

Furthermore, because margin nasals undergo this process, in a type I framework we can make a generalization about branching rimes: the second member must have a many-to-one mapping between the melody and the skeleton.

```
(55)  a.      σ       σ       σ        b.   σ    σ
             /|      /|      /|             |   /|
            O R     O R     O R            R O R
            | |\    | |     | |            | | |\
            x x x   x x     x x            x x x x
            | | |/  |       | |            | | |/
            h a k   i       r i            o b a

      c.      σ       σ        d.     σ
             /|      /|              /|
            O R     O R            O R
            | |\    | |            | |\
            x x x   x x            x x x
            | | |\| |              | |/|
            s a m b a              h o n
```

This generalization is not available in a type II framework because a branching rime is distinct from a branching nucleus.

3.2.2 The second set of data which provides evidence that Japanese is a Type I language is a level III verbal paradigm. This paradigm consists of yodan verbs concatenated with t-initial suffixes: 'ta', 'te', 'tara', and 'tari'. This concatenation produces a series of alternations. We are going to focus only on those alternations which are relevant to prosodic structure. See Paradis (1986) for a complete set of rules accounting for the data.

Data exemplifying the alternations is given in (56). Note that in the case of the u-final roots, the alternations differ between the two major dialect groups: Kanto (north east) and Kansai (south west).

(56) a. Kanto

root-past			gloss
mat-ta	--->	matta	"wait"
nar-ta	--->	natta	"become"
kau-ta	--->	katta	"buy"
omou-ta	--->	omotta	"think"
kuu-ta	--->	kutta	"eat"
tob-ta	--->	tonda	"fly"
yom-ta	--->	yonda	"read"
sin-ta	--->	sinda	"die"
kak-ta	--->	kaita	"write"
kag-ta	--->	kaida	"bite"
kas-ta	--->	kasita	"lend"

b. Kansai (only the forms which differ from above)

kau-ta	--->	koota
omou-ta	--->	omoota
kuu-ta	--->	kuuta

There are processes in these data which we have discussed earlier. The form 'kasita' can be considered the output of i-epenthesis. In fact, as i-epenthesis is formalized in (42), it would apply to all the forms above. Thus it must be altered in formalization and ordered after the rules which account for all but the s-final forms. I present a reformalized version of i-epenthesis in (59). I do not consider 'kaita' and 'kaida' examples of epenthesis for reasons of the apparent consonant deletion and voice spreading across what would be the domain of insertion. I analyse this alternation as velar vocalization. See Paradis (1986) for details, as this is beyond the scope of the present work.

Voicing spread, as it is formalized in (47), applies to 'tonda', 'yonda', 'sinda', and 'kaida'. The nasals trigger this rule at level III because they are marked [+voice] at this level. [r] and the vowels are not marked for voice at level III and consequently do not meet the structural description of voicing spread.

Nasal place assimilation, which we discussed in 3.2.1, has applied to 'tonda', 'yonda', and 'sinda' at the post-lexical level.

During the discussion of high vowel syncopation in 2.2, we saw that after this rule applies, a consonant cluster results and if the consonants are non-identical it is an impermissible cluster. In this case the leftmost consonant deletes and the

rightmost one spreads onto the empty slot (cf. 29). This process is similar to the one illustrated in (56).

Concatenation of a nasal final or t-final root with a t-initial suffix does not create an impermissible cluster and deletion does not occur. Concatenation of r-final and b-final roots with a t-initial suffix does create impermissible clusters and deletion does occur. However, concatenation of u-final roots with a t-initial suffix also triggers deletion even though no impermissible cluster has been created. Therefore we cannot attribute this deletion process solely to phonotactics.

Furthermore, even if we eliminate the u-final cases from consideration, the particular repair strategy exhibited in the data is still not explained by the creation of impermissible clusters alone. Why do [r] and [b] not delete completely, producing an output with less marked syllable structure? What triggers gemination in some cases and compensatory lengthening in others?

Leaving aside the s-final and velar final forms, note that all the remaining forms above, in both dialects, have one thing in common: the suffixed root's final syllable is a heavy one. This is represented by a branching rime in a Type I model. Let us suppose that this branching rime generalization is not an accidental result of the deletion and spreading processes, but is instead the trigger for them.

Throughout this thesis our assumption has been that syllable structure is built up from the melody. In other words, the combinations of feature matrices determine the prosodic structure above. This assumption follows from another assumption that predictable information is assigned by rule. Syllable structure is predictable in most cases.

In Chapter One, footnote one, we discussed the types of cases where syllable structure can be prespecified because it is not predictable. One instance is where the correct surface prosodic structure differs from what the syllabification algorithm would generate. Another is where prosodic structure exists independently of the melody as part of a morpheme. This is called a template. In 3.3.2, I argue that a case of the former exists in Japanese, and I would like to argue here that the data in (56) are a case of the latter.

I propose that a branching rime template is assigned to the final syllable of all non-continuant, non-velar roots when a t-initial suffix is attached. The template and the suffix form a discontinuous morpheme. The presence of a branching rime over the [r], [b], [u] final roots violates well-formedness conditions and therefore their subsequent deletion can be considered a repair strategy. The presence of the branching rime also explains why complete deletion of the final segment does not occur, why the root final position is preserved. Furthermore, the Type I structure of the template

serves to unify the two dialects. If a Type II structure were employed, Kansai would need two templates, a branching rime template for the consonant final roots and a branching nucleus template for the [u]-final roots.

Lowenstamm and Kaye (1986) also use a branching rime template in their analysis of a complementary gemination/compensatory lengthening process in Tiberian Hebrew. As with Japanese, the branching rime template unifies these two processes because there is no nucleus constituent[2]. Furthermore, Lowenstamm and Kaye argue that once the template is in place, whether the process after deletion is gemination or compensatory lengthening is attributed to a principle of the grammar and need not be stipulated. According to Lowenstamm and Kaye (1986.125), a priority relationship exists between the two processes. The priority relationship is that compensatory lengthening occurs just in case gemination cannot. Well-formedness conditions of individual grammars determine whether gemination can occur.

Note that compensatory lengthening occurs with u-final forms only in Kansai. We must assume that the deletion process differs in Kanto and Kansai. In Kanto, everything below the root node is deleted. In Kansai, everything below the supralaryngeal node is deleted. Therefore, in Kansai, gemination can occur in the cases where [r] and [b] are deleted because the target node for the spreading is specified

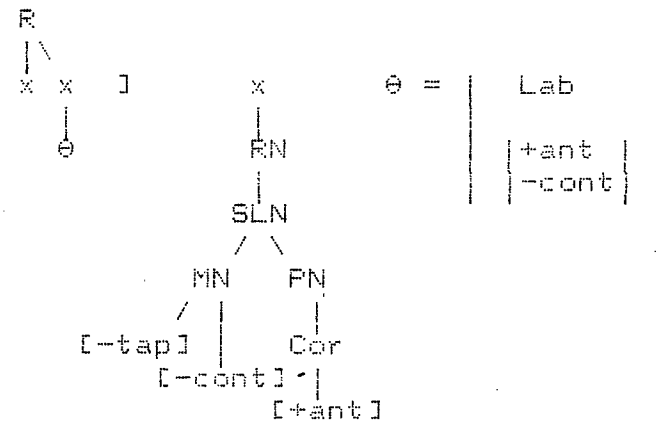
[+cons]. In the case of u-final forms, the target node is already specified as [-cons], so compensatory lengthening must occur because a consonant cannot spread onto it. In Kanto, either can occur because the consonantality specifications have been deleted. Since gemination has priority, gemination occurs.

The template is assigned after the concatenation of the t-initial suffix. In order to isolate the rule's environment, some redundancy rules which are placed in the post-lexical component in 2.5 must be repositioned at level III. Therefore, the template is not assigned at the same time as concatenation because the template's structural description cannot be met until after the redundancy rules have applied. Recall that in the lexical phonology model we are using, the lexical items move through the morphological component before the phonological component. The template assignment and the redundancy rules in question are presented in (57).

(57) a. Redundancy rules

```
[-cons]  --->  [+cont]
[ ]  --->  [-cont]
[+bck]  --->  [+lab]
|+nas|
|-lab|  --->  [+ant]
[+tap]  --->  [+ant]
```

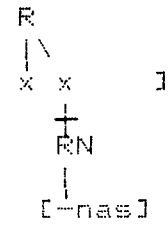
b. Heavy syllable template



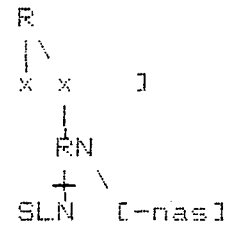
Deletion and compensatory spreading rules are given in (58). The compensatory spreading rule consists of three rules which illustrate the different environments. Under a strong interpretation of Lowenstamm and Kaye (1986) the spreading rules could be less explicit. Perhaps the rule could be stated: "spread RN", and the correct RN and target site would be determined by principles of the grammar.

(58) a. Yodan deletion

(i) Kanto

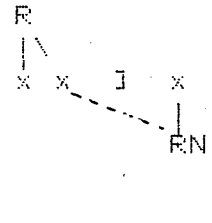


(ii) Kansai

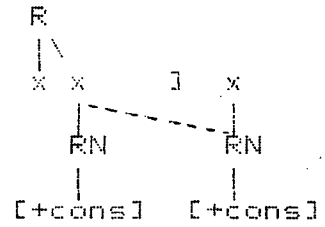


b. Compensatory spreading

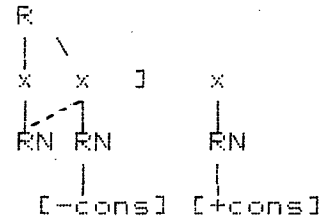
(i)



(ii)



(iii)



Also, note that, in the form 'tonda,' instead of a voiced geminate [dd], there is a [nd] sequence. Japanese does not permit voiced obstruent geminates. Ito and Mester (1986.59) point out that this result of a nasal-consonant sequence in place of a would-be voiced geminate happens in another case of morphological gemination called intense infixation. They argue that the [+nasal] specification of the first member of a derived voiced geminate is a repair strategy, and I would like to adopt this analysis.

Presented below is the version of i-epenthesis which applies at level III.

(59) Level III i-epenthesis

```
Ø  --->  π     /      π      ]  __  [ π
         |            |                |
         RN           RN               RN
         |           /  \              |
         Dor   [+cons] MN          [+cons]
         |             |
       |+hi |        [+cont]
       |-bck|
```

The rules we have discussed in this section are presented with the other rules from level III, in order of application.

(60) Level III phonological component

```
[+nas]  --->  [+voi]
[-cons]  --->  [+cont]
[ ]  --->  [-cont]
[+bck]  --->  [+lab]
|+nas|
|-lab|  ---> [+ant]
[+tap]  ---> [+ant]
voicing spread (47)
r/s-deletion  (43)
a-deletion  (44.b)
i-deletion  (44.a)
heavy syllable template (57.b)
yodan deletion (58.a)
comp-spreading (58.b)
i-epenthesis (59)

constraints:  Lyman's law (48)
```

3.3 Glides and Vowels

3.3.0 Before presenting the syllabification rules in 3.4, it is necessary to discuss some language particular aspects of the appearance of glides. In this section we examine the vowel-vowel, vowel-glide and consonant-glide sequences in Japanese.

3.3.1 According to Hinds (1986), any combination of vowels can occur in Japanese. He supports this claim with a list of data revealing all the possible non-identical short vowel pairings, which is given below in (61).

(61)	a.	akai	"red"
		kau	"buy"
		aenai	"cannot meet"
		kao	"face"
	b.	kiatu	"atmospheric pressure"
		yomiuri	name of a newspaper
		mienai	"cannot see"
		sio	"salt"
	c.	fuan	"ill at ease"
		fuirumu	"film"
		kutibue	"whistle"
		sizuoka	place name
	d.	pea	"pear"
		sii	"zealously"
		bideo	"video"
	e.	kooan	"riddle"
		koi	"love"
		omou	"think"
		koe	"voice"

from Hinds (1986.404)

Hinds (1986) is concerned only with the linear phonetic string. When we take into account syllable groupings and internal morphological structure, we see that not all vowel-vowel combinations are possible.

First, notice that in the cases where [u] and [i] appear before other vowels, the sequence is preceded by a consonant. If the sequence is preceded by another vowel, or nothing, the high vowel cannot always appear. A high vowel-vowel sequence which is preceded by another vowel, or nothing, will surface as a glide-vowel sequence, if the glide-vowel combination is well-formed.

The restrictions on the appearance of glides is as follows: [y] can only appear with [+back] vowels and [w] can only appear with [a]. A list of the permissible and impermissible glide-vowel combinations is given in (62).

(62)	*yi	*wi
	*ye	*we
	yu	*wu
	yo	*wo
	ya	wa

Thus the appearance of glides is predictable and ought to be generated by rule, although those rules will be more complex than the ones outlined in 1.3.3, due to these cooccurrence restrictions.

When a high vowel-vowel sequence would produce an ill-

formed glide-vowel sequence the high vowel remains as a syllabic peak. However, there are cases where the high vowel in this position deletes. Let us examine these cases.

Hinds (1986) does not consider the internal morphological structure of the data in (61). For instance, he lists the form 'kau' "buy", as an example of the sequence [au]. Actually, /kau-/ is the root of this verb, so the non-past form which Hinds (1986) cites is underlyingly /kau-ru/, and the [r] and one of the [u]s deletes. In fact, in any case where [u] appears between two other vowels at a morpheme boundary and the following vowel is not [a], the [u] deletes. In (63), a rule of u-deletion is formalized. Note that the rule is specified to apply to verbal suffixes only, this is to block its application to 'ana', which is an adjectival suffix. u-deletion occurs at both Level II and Level III. Examples of u-deletion are presented below in (64) using suffixes and other phonological processes we have previously discussed. A non-u-final yodan verb is also given in (64) for comparison. A derivation of 'au' "meet" is given in (65).

(63) u-deletion

```
π   ---> Ø  /  __ ]  π   ∪]
|                    |
RN                   RN
|                    |
PN                [-cons]
|
Dor
/ \
[+hi] [+bck]
```

(64) a. au- "meet"

au-i-ta-i ---> aitai
au-rare-ru ---> awareru
au-sase-ru ---> awaseru
au-e-ru ---> aeru
au-ru ---> au
au-reba ---> aeba
au-ana-i ---> awanai
au-ioo ---> aoo

b. kau- "buy"

kau-i-ta-i ---> kaitai
kau-rare-ru ---> kawareru
kau-sase-ru ---> kawaseru
kau-e-ru ---> kaeru
kau-ru ---> kau
kau-reba ---> kaeba
kau-ana-i ---> kawanai
kau-ioo ---> kaoo

c. yom- "read"

yom-i-ta-i ---> yomitai
yom-rare-ru ---> yomareru
yom-sase-ru ---> yomaseru
yom-e-ru ---> yomeru
yom-ru ---> yomu
yom-reba ---> yomeba
yom-ana-i ---> yomanai
yom-ioo ---> yomoo

(65) Derivation of 'au'

Level II

	/au-ta-/	/au-rare-/	/au-sase-/	/au-e-/
i-epen	au-i-ta-			
r/s del		au-Øare-	au-Øase-	
u-del	aØ-i-ta-i			aØ-e-
	[aita-]	[aware-]	[awase-]	[ae-]

Level III

	/au-ru/	/au-reba/	/au-ana-i/	/au-ioo/
r/s del	au-Øu	au-Øeba		
i-del				au-Øoo
u-del	aØ-u	aØ-eba		aØ-oo
	[au]	[aeba]	[awanai]	[aoo]

Consider the rule of u-deletion in light of the following data.

(66) iu- "say"

iu-ru ---> yuu
iu-reba ---> ieba
iu-ana-i ---> iwanai

The forms 'ieba' and 'iwanai' are expected outputs, given the derivation above. But 'yuu' is not the expected output of /iu-ru/. The [i] gliding to [y] before [u] is predictable, but the [uu] sequence is not. The expected output would be 'yu'. u-deletion has not applied to this form.

McCarthy and Prince (1986.2) claim that the Kansai dialect of Japanese has a prohibition against a content word having less than two moras. In other words, a content word must minimally consist of two light syllables or one heavy syllable. There are some counter examples to this claim in both the Kansai and Kanto dialects; such as, 'te' "hand", 'ha' "tooth", 'me' "eye" and 'e' "picture". However, if we qualify this minimum word template so that it applies to

heteromorphemic forms, then there are no counterexamples that I know of. Therefore, let us assume that there is a minimum word template in Japanese consisting of two light syllables or one heavy syllable.

We can consider the minimum word template to be a configurational constraint, like Lyman's law which is presented in (48). According to Archangeli and Pulleyblank (1986.25), a configurational constraint functions to block the application of rules whose outputs are contravene the well-formedness conditions expressed by the constraint.

A minimum word template is formalized in (67). It is a negative constraint indicating that a heteromorphemic word cannot consist only of one light syllable. This constraint will block the application of u-deletion to the structure /iu-u/ (the structure after r/s-deletion), and the correct output is generated.

(67) Minimum word template

a. $*[\ \mu\ _{\alpha}]$

b. $*[\ \begin{pmatrix} O \\ | \\ x \end{pmatrix}\ \begin{matrix} R \\ | \\ x \end{matrix}\ _{\alpha}]$

α = heteromorphemic word

Actually, the specification that this template applies to heteromorphemic forms is redundant if we assume that

configurational constraints are subject to the Strict Cycle Condition (cf 2.1).

Fukui (1986) analyses the form 'yuu' "say" using a rule w-deletion and one of leftward spread. His rule of w-deletion deletes the melody only, leaving an empty x-slot. The empty x-slot is filled by the spreading of the remaining vowel. This process is illustrated below.

```
(68)          x  x  +  x
              |  |     |
             /i  w     u/

    w-del     x  x  +  x
              |  +     |
              i  w     u

    left
    spread    x  x  +  x
              |     \  |
              i        u
```

Fukui does not account for the appearance of [y] instead of [i] in the surface form.

Fukui's analysis is not compatible with our assumptions about the distribution of glides. In our model, [w] never appears underlyingly or before [u]. Furthermore, Fukui's rule of w-deletion cannot apply to the other cases where [w] or [u] is deleted (cf.64) because in these cases no x-slot is left behind. Note that a rule such as w-deletion could not fit in a mora framework, because there is no prosody-independent timing tier and [w] is not dominated by a mora.

Poser (1986,1988) also provides an analysis of 'yuu'. In his analysis, 'yuu' is underlyingly /iw-ru/. Deletion of the [w] and the [r] produces the intermediate form /iu/. Poser argues that /iu/ undergoes a process of glide formation and compensatory lengthening which he attributes to a need to preserve the mora count of the word. Poser offers no illustration of this process. The process is described as follows: The melody of [i] moves leftward to an empty onset position, thus generating [y]. The position vacated by the [i] is then filled by the spreading of the [u]. It is difficult to see how this analysis is compatible with a mora model since onset positions empty of melodic content are non-existent.

Poser's motivation for the exceptionality of 'yuu' is the same as in our analysis. However, we do not produce the surface form by deletion and subsequent spreading. We achieve the same results by using the motivation, preserving the mora count, to block deletion of the second [u]. (The [r] is deleted by the rule of r-deletion). Furthermore, we need no extra rule to turn [i] into [y]. The [y] is generated by the syllabification algorithm.

3.3.2 Consonant-glide or consonant-yod clusters are found in Sino-Japanese morphemes only. They are the only onset clusters which appear in Japanese. All consonants except [d]

appear in these clusters; however, the consonant-yod clusters face the same cooccurrence restrictions as the independent [y]: they only appear before [+back] vowels. Data illustrating these facts are given in (69).

(69)	a.	happyaku	"eight hundred"
		pyuuto	"whizzing"
		pyonpyon	"hop"
	b.	byakuren	"white lotus"
		byuuken	"fallacy"
		byooki	"sickness"
	c.	myakudoo	"pulsation"
		myuudikaru	"musical"
		myooban	"tomorrow"
	d.	tyansu	"chance"
		tyuumon	"order"
		tyootyo	"butterfly"
	e.	syabondama	"bubble"
		syuukan	"custom"
		syoogun	"military leader"
	f.	zyarimiti	"gravel road"
		zyuutan	"rug"
		zyoodan	"joke"
	g.	ryakusetu	"brief explanation"
		ryuukoo	"fashion"
		ryokan	Japanese-style inn
	h.	nyannya	"kitty"
		nyuumon	"introduction"
		nyoobo	"wife"
	i.	kyanpasu	"campus"
		kyuusyuu	place name
		kyooiku	"education"
	j.	gyangu	"gang"
		gyuunyuu	"milk"
		gyogyoo	"fishing industry"

k.	hyaku	"one hundred"
	hyuuzu	"fuse"
	hyooban	"reputation"

from Hinds (1986.395)

The alveolar obstruents and [h] are palatalized by the [y], as they are by [i]. However, this palatalization is a kind of coalescence, as shown below.

(70) tyuumon ---> cuumon
syuukan ---> suukan
zyuutan ---> dzuutan
hyaku ---> caku

Given our assumption that glides are derived from underlying high vowels, the [y] in these clusters must be [i] underlyingly. This conclusion is further supported by the fact that the [y] appearing in a cluster is subject to the same cooccurrence restrictions as the independent [y] and it triggers the same palatalization processes that [i] does.

In the syllable inventory in (50), the consonant-yod sequences are represented as complex onsets in the onset/rime model and as mora-less members of the syllable in the mora model. Thus the non-peak status of the [y] is expressed by these representations. Let us now discuss whether this is the optimal way of representing these forms.

Recall the following forms from (61):

(71) yomiuri name of newspaper
kiatu "atmospheric pressure"
sio "salt"

If we represent the consonant-yod clusters underlyingly as consonant-[i], undifferentiated on the melody tier from the consonant-[i] sequences in (71), the syllabification algorithm will not know which consonant-[i] sequences to make into consonant-yod clusters and which to leave as consonant-[i]. The form 'kiatu' is morphologically divided between the [i] and [a], e.g. [ki-atu], but the form 'sio' is monomorphemic, so we can not appeal to the cyclic application of the syllabification rules to solve this problem. Therefore, we must differentiate those consonant-[i] clusters which are destined to be consonant-yod clusters from those which are not. We could do this in two ways: represent them as being structurally different on the melody or timing tier, or prespecify some prosodic structure. Let us weigh the advantages and disadvantages of these two approaches.

Perhaps the consonant-yod sequences could be represented as being dominated by the same x-slot, as illustrated in (72).

(72) a.
```
x x x x x
| | | | |
k i a t u
```

b.
```
x     x x x x x x
/ \   | | | | | |
k   i a n p a s u
```

The advantage of this approach is that the two forms are structurally distinct, and the syllabification rules can then assign peak status to the [i] in forms like 'kiatu'. The disadvantages of this approach are twofold. First, how would the data in (72) be represented in the mora theory, since there is no independent timing tier? I reject the possibility of conjoined root nodes because allowing the root nodes to serve that function would amount to creating a defacto independent timing tier. However, this is more a disadvantage of the mora model than it is of this analysis. But, there is another disadvantage to this analysis and that is the complications it would create for the segmental inventory. The underlying segmental inventory would have to be expanded to include complex structures; whereas, as it stands in (37), there are simplex forms only. Furthermore, the number of additional structures is eleven, which would constitute a significant expansion of the inventory. The structures could not be created by a restructuring rule in the lexical phonology because the environment for such a rule would be indistinguishable from the environment of the forms where [i] does not become part of an onset cluster. And again, the mora a model could not accommodate such a rule.

A prespecification analysis fares better than the one above. It entails specifying in the UR either a rime or a mora over an [i] which is positioned between a consonant and a back vowel

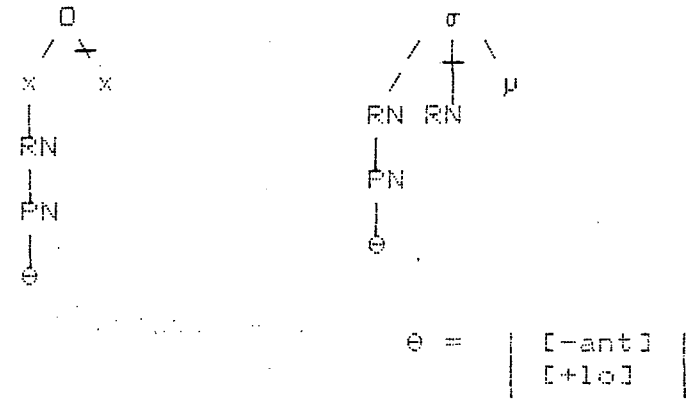
and does not become a [y]. For example:

```
(73)  a.     R                        μ
             |                        |
           x x x x x              / k i a t u /
           | | | | |
         / k i a t u /

      b.   x x x x x x x x     / k i a n p a s u /
           | | | | | | | |
         / k i a n p a s u /
```

In cases like (73b), the syllabification rules assign [i] non-peak status as part of an onset cluster. Both the mora and onset/rime theories are equipped to handle such an analysis. Also, such a prespecification analysis has a precedent in Guerssel's (1986) analysis of Berber. A disadvantage is that the syllable inventory is rendered more complex; however, I consider this disadvantage to be outweighed by the advantages of the prespecification approach.

One more thing remains to be done with respect to the consonant-yod clusters and that is to present a rule to account for the palatalization process in (70). The palatalization rules in (35) apply to these forms, so what is needed is a deletion rule following palatalization. In (74), a rule of yod-deletion is presented, and is ordered after the allophonic rules in the post-lexical component.

(74) Yod-deletion



3.4 Syllabification Algorithm

3.4.1 In 3.4.2 I present a syllabification algorithm for Japanese. Before examining the specific rules, let us discuss how a syllabification algorithm fits into our lexical phonology of Japanese.

The syllabification algorithm is a set of rules which always applies as a group, therefore no other phonological rules can apply between them. The algorithm is ordered directly after the redundancy rules in the phonological component of Level I. It applies again at the end of the phonological components of Level II and Level III and at the end of the post-lexical component. The early application in Level I is necessary because, in the mora model, the prosodic structure is the only structure above the melody tier and this structure is needed for input to rules, for example, high vowel syncopation.

Because syllabification rules are structure building, not structure changing, they can apply to underived forms. This means they can apply to all forms. However, I would like to stipulate that bound roots and affixes are not syllabified until concatenation. The reason for this stipulation is the heavy syllable template (57b). We do not want this rule to override already exising syllable structure. The heavy syllable template applies after concatenation with the t-initial suffixes and before the syllabification algorithm.

Presented below is a diagram of the lexical phonology, updated from the one given in 2.5.

(75)

LEXICON

	MORPHOLOGY	PHONOLOGY
LEVEL I	V_1-V_2 nominal compounds $_1$	[ ] ---> [+cons] [ ] ---> [-nas] [ ] ---> [-tap] |+cons| |-tap | |-nas | ---> [-voi] |+lo | ---> |-hi | |-cons| |+bck| |-nas| |-tap| ---> [+hi] [-cons] ---> [-bck] syll-algo (77),(78) high vowel- syncopation (40b) rendaku (46a) voicing spread (47) i-epenthesis (42) constraints: Lyman's law (48) min word temp (67)
LEVEL II	V_1-Vaspect [o[$_\vee$...]ninar$_\vee$] $_\vee$]rare$_\vee$] $_\vee$]sase$_\vee$] $_\vee$]ta$_\wedge$] $_\wedge$]gar$_\vee$] $_\vee$]rare$_\vee$]/$_\vee$]e$_\vee$] nominal compounds$_2$ $_\vee$]kata$_N$]	voicing spread (47) i-epenthesis (42) r/s-deletion (43) u-deletion (63) syll-algo (77),(78) constraints: Lyman's law (48) min word temp (67)

LEVEL III	⌄]ana⌃] ⌄]ru⌄] ⌃]i⌃] ⌄]ta⌄] ⌄]te⌄] ⌄]tari⌄] ⌄]reba⌄] ⌄]ioo⌄] ⌃]kar⌄] ⌃]ku⌄] ⌃]ke⌄] ⌄]tara⌄]	[+nas] ---> [+voi] [-cons] ---> [+cont] [ ] ---> [-cont] [+bck] ---> [+lab] |+nas| |-lab| ---> [+ant] [+tap] ---> [+ant] voicing spread (47) r/s-deletion (43) a-deletion (44b) i-deletion (44a) heavy syll temp (57b) yodan deletion (58a) comp-spread (58b) i-epenthesis (59) u-deletion (63) syll-algo (77),(78) constraints: Lyman's law (48) min word temp (67)

POST LEXICAL COMPONENT

|[+tap] |
|[-cons]| ---> [+voi]

[+lo] ---> [-hi]

[ ] ---> [-lo]

[+cons] ---> [+bck]

allophonic rules (35), (36)
yod deletion (74)
nasal assimilation (54)
syllabification algorithm (77),(78)

3.4.2 The syllabification algorithm presented below in (77) and (78) is a language specific version of the one in 1.3.3.

The syllabic peak assignment and OCR are more complex than that in 1.3.3 in order to account for the restrictions on glide-vowel cooccurrence, and the consonant-yod clusters. In fact, the syllabification rules are designed so that the well-formedness conditions on syllable structure and the structural inventory can be derived from them.

In the rules, the features on the melody tier are listed in matrices instead of being arranged in a feature hierarchy. This is for the sake of convenience of exposition. I am assuming that the features listed are organized hierarchically.

Let us discuss briefly the relationship between this set of rules and the question of learnability. I mentioned in Chapter One that a proposed universal model of prosodic structure must meet conditions of learnability.
We explained that this means that the parameters within such a prosodic model must be selectable on the basis of positive evidence. Parameters in the prosodic domain are such things as whether syllables have margins or whether only vowels or vowels, liquids and nasals can act as syllabic peaks.

The general syllabification algorithm in 1.3.3 is a proposal for a universal, unmarked, syllabification strategy. Each language has a specific syllabification algorithm, but certain principles remain constant, such as maximizing onsets, and generating glides from underlying high vowels.

These principles are reflected in the way the rules in 1.3.3 are formalized and organized. For instance, the OCR is ordered before the MCR, and the assign mora and assign rime rules deal first with [-high] vowels, then [+high] vowels, with the OCR ordered in between. The general algorithm also expresses parameters: for instance, the existence of the Margin Creation Rule is a parameter selection.

As I mentioned in 1.2.2, the glide-vowel cooccurrence restrictions in Japanese are most likely not parameters, but language specific attributes. Therefore, I do not make any claims about what evidence must be used to learn them. Furthermore, I do not make any claims about the learnability of a language specific syllabification algorithm in its entirety. Presumably a language's algorithm is composed according to a universal syllabification strategy, incorporating universal principles, parameters and language specific facts. I am only claiming that the parameter portion is learned through positive evidence.

In the course of the building of syllable structure I am assuming that the OCP operates to generate structures like those in (76b) from those in (76a).

```
(76)  a.  σ σ                    b.   σ
          | |                         |\
          μ μ                         μ μ
          |/                          |/
         [-cons]                    [-cons]

          R R                         R
          | |                         |\
          x x                         x x
          |/                          |/
         [-cons]                    [-cons]
```

Consider the verb [iu-u] "say". This form consists of one syllable. However, because the [uu] sequence is formed by morphological concatenation, it is not doubly linked and therefore does not invoke the OCP as the structures in (76) do. Therefore, the syllabification rules would render 'yuu' a disyllabic form. McCarthy (1986) argues that a process of tier conflation places separate morphemes on the same tier and fuses fake geminates, which are positioned across morpheme boundaries, into real geminates. I assume that after tier conflation applies to form a real geminate in 'yuu', the correct prosodic output is generated. McCarthy (1986) does not address the question of when tier conflation applies in the phonology and I will not address it either. As long as it applies before the final application of the syllabification algorithm in the post-lexical component, the correct output is generated.

In (77) and (78), a syllabification algorithm for Japanese is presented in the mora and onset/rime models respectively.

(77) Syllabification algorithm for Japanese (mora)

a. assign mora - 1 (μ-1)

```
                    μ
                    |
[-hi]'  --->  [-hi]          [ ]' = unsyllabified
```

b. erect syllable (σ)

```
                    σ
                    |
   μ                μ
   |                |
[-cons]  --->  [-cons]
```

c. onset creation rule (OCR)

(i)

```
                σ                      σ
                |                    / |
                |                   /  |
                μ                  /   μ
                |                 /    |
|-cons|' [+bck] ---> |-cons|[+bck]
|-bck |              |-bck |
```

(ii)

```
                          σ                      σ
                          |                    / |
                          |                   /  |
                          μ                  /   μ
                          |                 /    |
|[-cons]|  |-cons|' [+lo] ---> |-cons|[+lo]
|   #   |  |+bck |              |+bck |
```

(iii)

```
                σ                      σ
                |                    / |
                |                   /  |
                μ                  /   μ
                |                 /    |
[+cons]' [-cons] ---> [+cons][-cons]
```

d. assign mora - 2 (μ-2)

```
                          μ
                          |
|-cons|' ---> |-cons|
|+bck |        |+bck |
```

repeat (b)
repeat (c)

e. assign mora - 3 (μ-3)

```
                          μ
                          |
|-cons|' ---> |-cons|
|-bck |        |-bck |
```

repeat (b)
repeat (c)

f. weight by position (WP)

```
 σ   \              σ
 |                  |
 μ                  μ    μ        δ = |[+nas]|
 |                  |    |            |       |
[α] [δ]' ---> [α] [δ]                 | \ /   |
                                      |  δ    |
```

g. syllable incorporation - 1 (σ-i-1)

```
 σ                σ
 |                | \
 μ    μ'          μ   μ
 |    |           |   |
[α] [δ] ---> [α][δ]
```

h. syllable incorporation - 2 (σ-i-2)

```
          σ                  σ
        /|                //|
       / μ               // μ
      /  |              //  |
[ɟ̞]' [β][α] ---> [ɟ̞][β][α]          β = |-cons|
                                         |+hi  |
                                         |-bck |
```

(78) Syllabification algorithm for Japanese (onset/rime)

a. assign rime - 1 (R-1)

```
                R
                |
   x'           x
   |            |
[-hi]  ---> [-hi]
```

b. onset creation rule (OCR)

(i)

```
                R            O        R
                |            |        |
      x'        x            x        x
      |         |            |        |
|-cons|  [+bck] ---> |-cons|  [+bck]
|-bck |              |-bck |
```

(ii)

```
                                R            O        R
                                |            |        |
                      x'        x            x        x
                      |         |            |        |
|[-cons]|  |-cons|  [+lo] ---> |-cons|  [+lo]
|   #   |  |+bck |              |+bck |
```

(iii)

```
                R        O    R
                |        |    |
      x'        x  --->  x    x
      |                  |
[+cons]          [+cons]
```

c. assign rime - 2 (R-2)

```
                        R
                        |
   x'                   x
   |                    |
|-cons|  --->  |-cons|
|+bck |        |+bck |
```

repeat (b)

d. assign rime - 3 (R-3)

```
                        R
                        |
   x'                   x
   |                    |
|-cons|  --->  |-cons|
|-bck |        |-bck |
```

repeat (b)

e. erect syllable (σ)

```
            σ
            |
R  --->     R
```

f. rime incorporation (R-i)

```
R              R
|              |\
x  x'  --->    x  x          δ =  |[+nas]|
   |              |               |  \ /  |
   δ              δ               |   δ   |
```

g. onset incorporation (O-i)

```
      O            O
      |          / |
x'    x   --->   x  x
      |            |
   |-cons|      |-cons|
   |-bck |      |-bck |
   |+hi  |      |+hi  |
```

h. syllable incorporation (σ-i)

```
     σ            σ
     |          / |
O    R   --->   O  R
```

Now let us look at some derivations illustrating these rules. In the first set of derivations in (79), the data are from (50). These words show the range of bimoraic syllables/branching rimes.

(79) a.

kai	"shell"
hon	"book"
hakkiri	"certainly"
obaa	"grandmother"

b. mora model

```
                                    μ                 μ μ
                                    |                 |/
        /k a i/   /h o n/  /h a k i r i/  /o b a/

            μ         μ         μ μ           μ   μ μ
            |         |         | |           |   |/
μ-i       k a i     h o n     h a k i r i     o b a

            σ         σ         σ             σ   σ
            |         |         |             |   |\
            μ         μ         μ μ           μ   μ μ
            |         |         | |           |   |/
σ         k a i     h o n     h a k i r i     o b a
```

```
                 σ           σ           σ               σ     σ
                /|          /|          /|               |    /|\
               / μ         / μ         / μ μ             μ   / μ μ
              /  |        /  |        /  | |             |  /  |/
OCR           k  a i      h  o n      h  a k i r i       o b  a


μ-2           __          __          __                 __

                 σ                       σ
                /|                      /|
               / μ μ                   / μ μ μ   μ
              /  | |                 /  | | |   |
μ-3           k  a i      __          h  a k i r i      __

                 σ σ                     σ   σ   σ
                /| |                    /|   |   |
               / μ μ                   / μ μ μ   μ
              /  | |                 /  | | |   |
σ             k  a i      __          h  a k i r i      __

                                         σ     σ     σ
                                        /|    /|    /|
                                       / μ μ / μ   / μ
                                      /  | |/  |  /  |
OCR           __          __          h  a k   i r  i   __

                            σ
                           /|
                          / μ μ
                         /  | |
WP            __         h  o n      __                __

                            σ           σ     σ     σ
                           /|\         /|\   /|    /|
                          / μ μ       / μ μ / μ   / μ
                         /  | |     /  | |/  |  /  |
σ-i-1         __         h  o n      h  a k   i r  i   __

σ-i-2         __          __          __                __

        σ σ         σ           σ     σ     σ     σ     σ
       /| |        /|\         /|\   /|    /|    |    /|\
      / μ μ       / μ μ       / μ μ / μ   / μ    μ   / μ μ
     /  | |     /  | |     /  | |/  |  /  |    | /   |/
    [k  a i]   [h  o n]   [h  a k   i r  i]  [o b   a]
```

c. onset/rime model

```
          x x x     x x x     x x x x x x x     x x x x
          | | |     | | |     | | |/  | | |     | | |/
         /k a i/   /h o n/   /h a k   i r i/   /o b a/

            R         R         R                R   R
            |         |         |                |    |\
          x x x     x x x     x x x x x x x     x x x x
          | | |     | | |     | | |/  | | |     | | |/
R-1       k a i     h o n     h a k   i r i     o b a

          O R       O R       O R                R O R
          | |       | |       | |                | | |\
          x x x     x x x     x x x x x x x     x x x x
          | | |     | | |     | | |/  | | |     | | |/
OCR       k a i     h o n     h a k   i r i     o b a

R-2       --        --        --                --

          O R R                 O R       R    R
          | | |               | |       |    |
          x x x               x x x x   x x x
          | | |               | | |/  | | |
R-3       k a i     --        h a k   i r i     --

                                O R    O R O R
                                | |    | | | |
                                x x x  x x x x
                                | | |/  | | |
OCR       --        --        h a k   i r i     --

            σ σ       σ         σ       σ    σ    σ    σ
            | |       |         |       |    |    |    |
          O R R     O R       O R    O R O R    R O R
          | | |     | |       | |    | | | |    | | |\
          x x x     x x x     x x x  x x x x    x x x x
          | | |     | | |     | | |/  | | |    | | |/
σ         k a i     h o n     h a k   i r i     o b a
```

```
                      σ          σ       σ   σ
                      |          |       |   |
                      O R        O R     O R O R
                      | |\       | |\    | | | |
                      x x x      x x x   x x x x
                      | | |      | | |/  | | |
R-i          __       h o n      h a k     i r i      __

O-i          __       __         __                   __

                σ σ        σ          σ       σ   σ     σ   σ
               /| |       /|         /|      /|  /|     |  /|
              O R R      O R        O R     O R O R     R O R
              | | |      | |\       | |\    | | | |     | | |\
              x x x      x x x      x x x   x x x x     x x x x
              | | |      | | |      | | |/  | | | |     | | |/
σ-i           k a i      h o n      h a k     i r i     o b a

                σ σ        σ          σ       σ   σ     σ   σ
               /| |       /|         /|      /|  /|     |  /|
              O R R      O R        O R     O R O R     R O R
              | | |      | |\       | |\    | | | |     | | |\
              x x x      x x x      x x x   x x x x     x x x x
              | | |      | | |      | | |/  | | | |     | | |/
            [k a i]    [h o n]    [h a k     i r i]   [o b a]
```

This next set of partial derivations in (80) illustrates how the syllabic peak assignment rules and the onset creation rules interact to generate the correct distribution of glides and high vowels. The data display a range of positions for high vowels: initial, intervocalic, and between a consonant and another vowel. Note that the form 'sio' "salt" has an underlying prosodic specification for [i]: it is marked as a syllabic peak. Even though some of the bimorphemic words in the data are concatenated at different levels of the lexicon, the syllabification process is the same for each level. None

of them consist of morphemes which are already syllabified or have undergone any phonological changes after concatenation.

(80) a.

sio	"salt"
syoogun	military leader
oya	"parent"
yuki	"snow"
fuan	"ill at ease"
wadai	"topic"
iwanai	"say (neg)"

b. mora model

```
                 μ            μ μ
                 |            |/
            /s i o/   /s i o g u n/    /o i a/   /i u k i/

                 μ μ                      μ    μ
                 | |                      |    |
μ-1         s i o     __                 o i  a     __

                 σ σ          σ           σ    σ
                 | |          |\          |    |
                 μ μ          μ μ         μ    μ
                 | |          |/          |    |
σ           s i o     s i o g u n        o i  a     __

                              σ           σ     σ
                             /|           |    /|
                            / μ μ         μ   / μ
                           /  |/          | /   |
OCR (i)     __          s i  o g u n      o i   a    __

OCR (ii)    __          __                __        __

                   σ σ
                  /| |
                 / μ μ
                /  | |
OCR (iii)   s   i o     __                __        __
```

```
                                σ
                               /|
                              / μ  μ   μ                      μ
                             /   |/    |                      |
μ-2          __          s i   o   g u n      __        i u k i

                                σ     σ                      σ
                               /|     |                      |
                              / μ  μ   μ                      μ
                             /   |/    |                      |
σ            __          s i   o   g u n      __        i u k i

                                                            σ
                                                           /|
                                                          / μ
                                                         /   |
OCR (i)      __          __                   __        i   u k i

OCR (ii)     __          __                   __        __

                                σ        σ
                               /|       /|
                              / μ  μ   / μ
                             /   |/  /   |
OCR (iii)    __          s i   o   g    u n   __        __

                                                            σ
                                                           /|
                                                          / μ    μ
                                                         /   |    |
μ-3          __          __                   __        i   u k i

                                                            σ    σ
                                                           /|    |
                                                          / μ    μ
                                                         /   |    |
σ            __          __                   __        i   u k i

OCR (i)      __          __                   __        __

OCR (ii)     __          __                   __        __
```

```
                                                                  σ     σ
                                                                 /|    /|
                                                                / μ   / μ
                                                               /  |  /  |
OCR (iii)   __          __                  __                 i  u  k  i

            /f u a n/   /u a d a i/   /i u a n a i/

                μ          μ   μ           μ   μ
                |          |   |           |   |
μ-1         f u a n     u a d a i       i u a n a i

                σ          σ   σ           σ   σ
                |          |   |           |   |
                μ          μ   μ           μ   μ
                |          |   |           |   |
σ           f u a n     u a d a i       i u a n a i

OCR (i)     __          __              __

                                  σ   σ           σ   σ
                                 /|   |          /|   |
                                / μ   μ         / μ   μ
                               /  |   |        /  |   |
OCR (ii)    __                 u  a d a i      i u  a n a i

                                  σ     σ         σ     σ
                                 /|    /|        /|    /|
                                / μ   / μ       / μ   / μ
                               /  |  /  |      /  |  /  |
OCR (iii)   __                 u  a d  a i     i u  a n  a i

                σ
                |
              μ μ
              | |
μ-2         f u a n     __              __
```

```
                 σ σ
                 | |
                 μ μ
                 | |
σ              f u a n      __              __

OCR (i)        __           __              __

OCR (ii)       __           __              __

                 σ σ
               /| |
              / μ μ
             /  | |
OCR (iii)    f  u a n       __              __

                                 σ     σ           σ     σ
                               /|    /|          /|    /|
                              / μ   / μ μ       μ / μ   / μ μ
                             /  |  /  | |       | /  |  /  | |
μ-3            __            u  a d  a i       i u  a n  a i

                                 σ     σ σ       σ     σ     σ σ
                               /|    /| |       |    /|    /| |
                              / μ   / μ μ       μ / μ   / μ μ
                             /  |  /  | |       | /  |  /  | |
σ              __            u  a d  a i       i u  a n  a i

OCR (i)        __           __              __

OCR (ii)       __           __              __

OCR (iii)      __           __              __
```

c. onset/rime model

```
                R
                |
               x x x      x x x x x x x      x x x      x x x x
               | | |      | | |/  | | |      | | |      | | | |
              /s i o/    /s i o    g u n/    /o i a/   /i u k i/
```

```
                 R R          R                R   R
                 | |          |\               |   |
                x x x        x x x x x x x     x x x
                | | |        | | |/  | | |     | | |
R-1             s i o        s i o   g u n     o i a     __

                             O R                R O R
                             | |\               | | |
                            x x x x x x x       x x x
                            | | |/  | | |       | | |
OCR (i)         __          s i o   g u n       o i a     __

OCR (ii)        __          __                  __        __

                O R R
                | | |
                x x x
                | | |
OCR (iii)       s i o       __                  __        __

                             O R      R                     R
                             | |\     |                     |
                            x x x x x x x                 x x x x
                            | | |/  | | |                 | | | |
R - 2           __          s i o   g u n       __        i u k i

                                                          O R
                                                          | |
                                                         x x x x
                                                         | | | |
OCR (i)         __          __                  __        i u k i

OCR (ii)        __          __                  __        __

                             O R   O R
                             | |\  | |
                            x x x x x x x
                            | | |/  | | |
OCR (iii)       __          s i o   g u n       __        __
```

```
                                                          O R   R
                                                          | |   |
                                                          x x x x
                                                          | | | |
R-3          __          __                  __           l u k l

OCR (i)      __          __                  __           __

OCR (ii)     __          __                  __           __

                                                          O R O R
                                                          | | | |
                                                          x x x x
                                                          | | | |
OCR (iii)    __          __                  __           l u k l


             x x x x     x x x x x           x x x x x x
             | | | |     | | | | |           | | | | | |
            /f u a n/   /u a d a l/         /l u a n a l/

                 R           R   R                 R   R
                 |           |   |                 |   |
             x x x x     x x x x x           x x x x x x
             | | | |     | | | | |           | | | | | |
R-1          f u a n     u a d a l           l u a n a l

OCR (i)      __          __                  __

                         O R   R               O R   R
                         | |   |               | |   |
                         x x x x x           x x x x x x
                         | | | | |           | | | | | |
OCR (ii)     __          u a d a l           l u a n a l

                         O R O R               O R O R
                         | | | |               | | | |
                         x x x x x           x x x x x x
                         | | | | |           | | | | | |
OCR (iii)    __          u a d a l           l u a n a l
```

```
                 R R
                 | |
                 x x x x
                 | | | |
R-2              t u a n      --              --

OCR (i)          --           --              --

OCR (ii)         --           --              --

                 O R R
                 | | |
                 x x x x
                 | | | |
OCR (iii)        t u a n      --              --

                                O R O R R       R O R O R R
                                | | | | |       | | | | | |
                                x x x x x       x x x x x x
                                | | | | |       | | | | | |
R-3              --             u a d a i       i u a n a i

OCR (i)          --             --              --

OCR (ii)         --             --              --

OCR (iii)        --             --              --
```

NOTES FOR CHAPTER THREE

[1] Note that in the formalization of this process, the supralaryngeal node of the margin nasal is deleted so that the manner and place specifications are derived from the adjacent segment. The nasal also derives its consonantality specifications from the adjacent segment. But, the feature [consonantal] is not a daughter of the supralaryngeal node. Therefore, the rule should delete this feature as well. Because [consonantal] is grouping with the place and manner features, this process argues that perhaps they ought to form a constituent in the feature hierarchy.

[2] In Lowenstamm and Kaye (1986)'s prosodic model, a nucleus and a coda constituent do exist. In the template, the second member of a branching rime is unspecified, but it is later specified by the spreading processes. Gemination produces a coda and compensatory lengthening produces a nucleus. I reject this approach because a rime node dominating two nucleus nodes is ill-formed. A long vowel is dominated by a branching nucleus, not a branching rime. If the analysis were altered so that compensatory lengthening is accompanied by a change in the prosodic tree, this would undermine the claim that the branching rime template unfies the processes of gemination and compensatory lengthening.

CONCLUSION

There are three main areas of concern in this thesis. The first area of concern is the representation of prosodic structure and syllabicity. We have proposed a model for a universal, unmarked syllabification strategy which is compatible with the following assumptions:

(81)

a. No predictable prosodic structure is present in the underlying representation. The distribution of glides in most cases is predictable.

b. Prosodic structure is built by rule and is erected around a syllabic peak which is determined by the relative sonority of segments and not by a feature [syllabic].

The second area of concern is a comparison of two models of syllable structure, the mora model and the onset/rime model. The mora theory is chiefly designed to account for weight distinctions, which are widely employed in languages. We have proposed a parameter within the onset/rime representation which accounts for weight distinctions as well as the mora model: the type I onset/rime model. Therefore, either model is adequate to describe a language which distinguishes between light and heavy syllables. Other differences between the two

models such as the presence or absence of an onset constituent, is not addressed due to the lack of decisive evidence from Japanese.

The third area of concern is the syllable structure of Japanese. Because Japanese is considered to be an ideal language for a mora representation, it provides a good testing ground for the descriptive adequacy of the onset/rime model.

Using both models, we have analysed the phonological processes of Japanese and proposed a syllabification algorithm, based on the universal syllabification strategy in chapter one. Both models can represent the processes in the phonology and both syllabification algorithms can generate the language's prosodic structure.

Thus, we have shown that the onset/rime model is equally well capable of capturing the empirical generalizations of Japanese as is the mora model. This conclusion is crucially dependent on the adoption of the Type I/Type II parameterization of the onset/rime model. Since Japanese is by no means the only language which employs the light/heavy syllable distinction represented by a Type I model, this parameterization is necessary for the onset/rime model to remain a worthy competitor of the mora model in phonological theory.

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