Locating the Height Features: Evidence from Japanese

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B.A., The University of British Columbia, 1999

A thesis submitted for partial satisfaction of the requirements for the degree of Master of Arts in the Faculty of Graduate Studies (Department of Asian Studies)

We accept this thesis as conforming to the required standard

University of British Columbia
Vancouver, BC

July, 2002

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Date July 22/2002
Thesis Abstract

Both the alternations of the Japanese verb paradigm and the formation of the go’ on and kan’ on substrata of the Sino-Japanese contain rules that refer to high vowels and velar consonants. In the verb paradigm, there is a rule that deletes velar stops before the high front vowel in certain environments. Thus we have kaku ‘write’ (non-past), but kaita ‘wrote’. The Middle Chinese velar nasal coda was borrowed as a nasalized high vowel in the go’ on and kan’ on substrata of Sino-Japanese. The kan’ on reading of a Middle Chinese word such as tawrj ‘winter’ was tou at the time of borrowing. The objective of this thesis is to argue that this relationship between high vowels and velar consonants is a result of their featural makeup – namely that high vowels contain a dorsal node.

The argument for the hypothesis is presented in the form of two constraint-based analyses, of which the first is of the verb paradigm. Previous analyses of modern Japanese have all assumed that the i in forms such as kaita ‘wrote’ is not present in the underlying form. I argue that based on the historic and modern-day morphological data, there is insufficient evidence to support such an assumption about the underlying representation. As such, I develop two analyses, one with i in the underlying representation, and another where it is absent. It will be shown that in both cases the results are the same: a constraint-based account is able to derive the correct results only if we assume that the high front vowel contains a dorsal node.

The second half of the argument is a constraint-based analysis of the way Late Middle Chinese codas were borrowed during the formation of the kan’ on substratum of Sino-Japanese. Again it will be shown that a constraint-based analysis is able to derive the correct results if we assume that the high front vowel contains a dorsal node.
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Acknowledgements

First of all, I would like to thank Kenichi Takashima for three years of guidance and support, and for believing in me enough to let me pursue my whims and chase my dreams. His open and carefree nature with all of his students will always be a role model to me. Next I would like to thank the rest of my committee members, Doug Pulleyblank, Edwin Pulleyblank, and Patricia Shaw for their invaluable advice and their continuous display of patience as I struggled with some of the more intricate areas of linguistic theory. I would also like to thank for her continuing support my wife Yumiko, who as my only source of data has had to suffer my constant bombardment of questions about Japanese. Finally, I would like to thank Popo and Chacha for keeping me company through the many late nights it took to complete this project. I could have never done it without you guys.
1 Introduction

1.1 Alternations between i and k in Japanese

Rule-based accounts of the Japanese verb paradigm (c.f. McCawley 1968, Vance 1987, Tsujimura 1996) contain a rule that deletes velar consonants before the high front vowels. Tsujimura gives the following examples of gerund and past tense forms of velar final verbs (p.45):

<table>
<thead>
<tr>
<th>Verb</th>
<th>Gerund</th>
<th>Past Tense</th>
</tr>
</thead>
<tbody>
<tr>
<td>/kak+u/</td>
<td>[kaku]</td>
<td>[kaku]</td>
</tr>
<tr>
<td>/sak+u/</td>
<td>[saku]</td>
<td>[saku]</td>
</tr>
<tr>
<td>/tug+u/</td>
<td>[tsugu]</td>
<td>[tsugu]</td>
</tr>
<tr>
<td>/tog+u/</td>
<td>[toug]</td>
<td>[toug]</td>
</tr>
<tr>
<td>/kak+ta/</td>
<td>[kaita]</td>
<td>[kaita]</td>
</tr>
<tr>
<td>/sak+ta/</td>
<td>[saita]</td>
<td>[saita]</td>
</tr>
<tr>
<td>/tug+ta/</td>
<td>[tsuida]</td>
<td>[tsuida]</td>
</tr>
<tr>
<td>/tog+ta/</td>
<td>[toida]</td>
<td>[toida]</td>
</tr>
</tbody>
</table>

To account for the alternations in (1b), she posits the following rules (ibid. p.59):

(2) \( \varnothing \rightarrow i \) / velar stop ___ + ta

velar stop \( \rightarrow \varnothing / ___ i + ta \)

This apparent relationship between a velar consonant and a high vowel is not limited to the verb paradigm. During the formation of the go 'on and the kan 'on substrata of Sino-Japanese (SJ), the velar nasal coda was borrowed as a nasalized high vowel (3). Consider the following kan 'on examples:

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>kjaawŋ &gt; kau</td>
<td>'large river'</td>
</tr>
<tr>
<td>tawn &gt; tou</td>
<td>'winter'</td>
</tr>
<tr>
<td>toqŋ &gt; tau</td>
<td>'to hit (a target)'</td>
</tr>
<tr>
<td>piaŋ &gt; pei</td>
<td>'soldier'</td>
</tr>
<tr>
<td>kiaŋ &gt; kei</td>
<td>'capital'</td>
</tr>
</tbody>
</table>

---

1 See §2.2.1 for the phonemic inventory of modern Japanese.

2 See §3.10 for the phonemic inventories of Old Japanese and Late Middle Chinese.
The goal of this paper is to argue that such alternations as those shown in (1) and (3) are not coincidental, but are in fact motivated by the phonological makeup of the phonemes involved, namely that velar consonants and high front vowels share a common featural node, the dorsal node. Three models of feature geometry will be examined in light of an Optimality Theoretic (OT) account of the data from the Japanese verb paradigm and the kan‘on substratum in Sino-Japanese. It will be argued that only one model, namely the model where the feature [+high] is located under the dorsal node, allows for an explanation of the facts.

1.2 Three Candidates for the Location of the Height Features

1.2.1 Sagey (1986) and Pulleyblank (1989)

Work in autosegmental phonology led to the theory of feature geometry. In this model, phonological features are no longer arranged in matrices, but rather in hierarchies, with each feature occupying its own tier and connected to a node based on which articulator is involved in the production of that feature. The tree in (4) is a subsection of the hierarchy posited by Sagey, showing the place node (Sagey 1986, 1990). The feature [round] is connected to the labial node since it is executed by the lips. Likewise, the vowel quality features are connected to the dorsal node since they are executed by the tongue body. Sagey’s definition of the feature [+high] is carried over from The Sound Pattern of English (Chomsky and Halle 1968, hereafter SPE), which defines it as “raising [of] the body of the tongue above the level that that it occupies in neutral position” (p.304). 3

---

3 In the SPE system, the following segments are [+high]: dentals, palato-alveolars, palatals, velars, high vowels, and the glides /y/ and /w/ (p.307).
Sagey intends for the phonological representation of non-round vowels to contain only the dorsal node, and round vowels to contain the labial and the dorsal nodes. Consonants are not specified for height (in the Underlying Representation (UR)), but are specified for [back].

Starting with Clements (1976), several linguists (c.f. Clements and Hume 1995 for references), argues that the front vowel patterns with coronal consonants, and therefore contains the coronal node. Pulleyblank (1989) posits replacing the feature [back] with [front], which is placed under the coronal node. More importantly, he explicitly states that high front vowels and glides are doubly articulated. In the case of the high front vowel, it is both [+front] implying the presence of the coronal node, and concomitantly [+high], implying the presence of the dorsal node.

1.2.2 Lahiri and Evers (1991) and Clements and Hume (1995)

According to Lahiri and Evers (1991), feature geometries such as Pulleyblank’s are not without theoretical problems. In their words, “...if front and back vowels are grouped under separate nodes (along with the corresponding consonants), while tongue features like [high] and [low] remain dependant on the dorsal node, then it is impossible to refer to natural classes of vowels by their height features alone...” (idib.:86).⁴ This observation, along with the work of Clements (1989) motivated them to posit the following model:

---

⁴ Although it is unclear as to why the features alone cannot be used to represent the natural classes of vowels.
(5) the place node in Lahiri and Evers' feature hierarchy

Place

Articulators

Labial Coronal Dorsal Radical

Tongue Position

[high] [low]

They separate the height features under a node they call *tongue position*. They also point out that the *SPE* definition of [high] is inadequate given that in the formation of different vowels there is considerable difference in the area of the tongue that is raised, and instead choose to define the height features in terms of acoustic formant structure: [+high] is inversely correlated with F1 (p.89). Although they claim that their model allows for the representations of both vowels and consonants to contain the height features (p.89), their definition of the height feature is problematic in that obstruents such as /k/ have no noticeable impact on the first formant (Ladefoged 2001).

In the constriction-based model of Clements and Hume (1995), features\(^5\) are based on the observation that every segment is the product of the constriction of the oral tract. Constriction is in turn defined by the location of constriction and the degree of constriction. While both vowels and consonants use the same features for location of constriction ([labial], [coronal], [dorsal], and [pharyngeal]), they use different features for degree of constriction: [continuant] for consonants and multiple tiers of [open] for vowels, allowing for consonant constriction to be transparent to the spreading of vowel height. The feature [open] is associated with the aperture node, which unlike the tongue position node in Lahiri and Evers' model, is found in the hierarchy for vowels, glides, and consonants with secondary articulation, but not in other segments.

---

\(^5\) Clements and Hume use the terms *node* and *feature* interchangeably for [labial], [coronal] and [dorsal]. From this point on, I also do the same.
1.2.3 Padgett (1995)

The final possibility to be considered is Padgett’s feature class theory (1995). Padgett points out that there are many examples of vowel harmony where the features back and round spread together. In feature geometry, this is the exact motivation for positing a class of features linked under a single node. As such, the features [round] and [back] should be grouped under the same node. There is no way to do this in the models discussed above, since they are based on either the articulator involved, or the location of constriction. Padgett proposes feature classes, with the members of each class sharing some common property, such as the fact that they spread together. Thus for instance, the class PLACE is the set \{LABIAL, CORONAL, DORSAL, PHARYNGEAL, Hi, Lo, BACK, ROUND\}, while the class COLOR, consists of only \{BACK, ROUND\}. Phonological processes refer (for the most part) not to nodes, but to classes, and features naturally belong to more than one class. This, however, does not completely replace feature geometry, as Padgett posits retaining the absolutely minimally required geometry (p.400):

\[(6) \quad \text{Padgett's feature geometry} \]

\[
\begin{array}{c}
\text{root[son]} \\
\bigg/ \bigg/ \\
\text{[voice]} \quad \text{Lab Phar [hi]} \quad \text{Cor [back]} \quad \text{[lo]} \quad \text{[nasal]} \quad \text{Dor ...} \\
\bigg/ \\
\text{[ant]} \quad \text{[dist]} \\
\end{array}
\]

In Padgett’s hierarchy, there is no node that corresponds to the height node. In fact, the only internal structure carried over from previous models is the locating of the [anterior] and [distributed] features under the coronal node, with the nodes such as Articulators now replaced by their corresponding feature classes. I make use of Padgett’s concept of the feature class to help account for the restrictions on codas in Japanese (§3.4.1). I do not however, assume his restricted feature hierarchy.

In the discussion so far, there have been three proposals for the location of the height features:
located under the dorsal node (7a), located under a height node that is sister to the dorsal node (7b), and located directly under the root node (7c).

(7) three candidates for the location of the height features

a. place
   
   [dorsal]
   
   [±hi][±low]

b. place
   
   [dorsal]
   height
   
   [±hi][±low]

c. root
   
   [dorsal][±hi][±low]

The first model, with the height features under the dorsal node, predicts that any vowel specified for height must necessarily contain the dorsal node. In the following sections I will argue that this prediction is essential to correct derivation of both the verb paradigm and the formation of the *kan' on* substratum of Sino-Japanese.
2 Theoretical Assumptions

2.1 Two Types of Features

Consistent with all of the models discussed, I assume that there are both privative features and equipollent features; those preceded by a mathematical operator (+, -, or ±) are equipollent, whereas features lacking a sign are privative. The fundamental difference between the two types of features is that phonological rules do not operate on the negative values of the privative features. This intrinsic difference is reflected in several different key assumptions about their behaviour. In the case of the equipollent features, if the feature is present then the associated node must necessarily be present. On the other hand, the presence of a privative does not imply the presence of any of the features dominated by that node. Equipollent features are necessarily terminal, whereas privative features may be terminal, but are not necessarily so. As well, phonological processes that refer to equipollent features do so by changing the value of the feature, whereas phonological processes that refer to privatives do so in terms of absence and presence, or insertion and deletion.

I also assume that Optimality Theoretic constraints (Prince and Smolensky 1993) behave differently depending on the feature. In Optimality Theory, features in the input (underlying) form stand in correspondence with features in output (surface) form, where correspondence is defined in (8a). Equipollent features are governed by the constraint demanding identity between correspondents (8b), whereas privative features are governed by constraints that militate against insertion (8c) and deletion (8d).

(8) correspondence constraints governing features (based on McCarthy and Prince 1995)

a. Given some output string $S_2$ for some input string $S_1$, then correspondence is the relation $\mathcal{R}$ between the elements of $S_1$ and those of $S_2$. An element $\alpha \in S_1$ and an
element $\beta \in S_2$ are in correspondence when $\alpha \mathcal{R} \beta$.  

b. $\text{IDENT}(F)$ – for every equipollent feature $F$, if there are two elements $\alpha \in S_1$ and $\beta \in S_2$ such that $\alpha \mathcal{R} \beta$, then if $\alpha$ is $[\gamma F]$, $\beta$ is also $[\gamma F]$. (Equipollent features must not change their value.)

c. $\text{MAX}(F)$ – for every privative feature $F$ in $S_1$, there are two elements $\alpha \in S_1$ and $\beta \in S_2$ such that $\alpha \mathcal{R} \beta$. (Privative features in the input must not be deleted.)

d. $\text{DEP}(F)$ – for every privative feature $F$ in $S_2$, there are two elements $\alpha \in S_1$ and $\beta \in S_2$ such that $\alpha \mathcal{R} \beta$. (Privative features in the output must not be inserted; i.e. they must have correspondents in the input.)

Given these definitions, there is no constraint that governs the insertion or deletion of equipollent features. Although this assumption does not have any consequences for the discussion at hand, it is obviously a hypothesis that needs further investigation.

As well, as argued for in Padgett (1995), I assume the existence of feature classes that coexist along side the feature geometry. In particular, crucial to the investigation is the assumption that vowel place features and consonant place features belong to separate classes, VPlace, and CPlace respectively, besides belonging to a more general place class.

### 2.2 The Features of the Japanese Phonemes

#### 2.2.1 The Modern Japanese Phonemic Inventory

Modern Japanese has the following phonemes:

(9) the phonemic inventory of Modern Japanese

<table>
<thead>
<tr>
<th>Labial</th>
<th>Alveolar</th>
<th>Alveopalatal</th>
<th>Retroflex</th>
<th>Palatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>p, b, m</td>
<td>t, d, n, z, s</td>
<td>f, tʃ, dʒ</td>
<td>r[t]</td>
<td>y[j]</td>
</tr>
</tbody>
</table>

---

6 I assume that an element is any constituent formally recognized by current phonological theory.
velar: k, g
glottal: h
vowels: i, u, e, o, a

There is an important co-occurrence restriction on coronals in Modern Japanese: of the alveolars, only n occurs before the high front vowel and the palatal glide. Furthermore, the palatal glide does not occur before front vowels. The prohibited combinations are listed in (10).


Where we would expect to find these combinations, alveolopalatals are used instead. This co-occurrence restriction can be accounted for by the assumption of an Obligatory Contour Principle constraint (hereafter OCP, McCarthy 1986) *[cor][cor] that is only active if the second coronal segment is specified as [+hi]. This point is elaborated in §5.2. Relevant to this constraint is the fact that except for the foreign loan stratum, the mid front vowel does not occur after alveolopalatals: *Je, *tje, *d3e. The constraints governing this second set of restrictions will be elaborated on in Appendix B.

2.2.2 The Features of the Moraic Nasal

The moraic nasal plays a key role in the formation of the kan'on forms. Although it goes without saying that the phonetic nature of the moraic nasal at the time of the borrowing is speculative, I am assuming that it behaved then as it does in present-day Japanese. The exact phonetic nature of the moraic nasal varies a fair bit, depending on the environment. The following descriptions are based on Vance (1987) and Akamatsu (1997).

word-final position

There is a great amount of disagreement on the exact phonetic nature of the moraic nasal in word-final position in the literature. Not only is there disagreement on the place of articulation, which ranges from alveolar to uvular, but also on the manner of articulation, being either a nasal stop or a nasal approximant.
before stops, affricates, nasals, and the flap /r/

Before stops, affricates, and nasals, it is a nasal stop with the same place of articulation as the following segment.

before fricatives

Before fricatives, it is a nasal approximant anticipating the point of articulation of the following fricative. It does not have complete closure. The moraic nasal that appears before /h/ acts as if it was before a vowel.

before vowels and glides

The moraic nasal before a vowel or glide completely lacks oral closure. It is essentially a nasalized vowel whose quality depends on the preceding vowel: [i] after /i e j/, [uí] after /u a/ and [uí] after /o w/. The preceding vowel will also have some influence. For example, between two rounded, back mid vowels, as in hon o, the moraic nasal may drop down to [ö].

If we assume that only underspecified features are filled in from the surrounding environment, then based on the above descriptions the moraic nasal is specified in underlying representation (UR) as [+sonorant], [nasal], [-vocoid] and [continuant], and underspecified for all other features.

2.2.3 Features of the Japanese High Back Vowel

I assume that the high back vowel has a labial component. Modern Japanese u involves lip compression, not lip rounding (Tsujimura 1996, Vance 1987). According to Ladefoged and Maddieson (1996:p.295), “the acoustic characteristics of lip compression ... are presumably similar to those of lip rounding and protrusion insofar as any decrease in lip aperture tends to lower all formant frequencies,” hence motivating the [labial] feature. This assumption plays a key role in the explanation of the patterning of the second vowel in Sino-Japanese morphemes.

Akamatsu (1997) disagrees with Vance, instead stating that the lips remain in a neutral position.
The following table shows the relevant features for those phonemes that play a role in the following discussion.\(^8\)

|          | p | b | m | t | d | s | n | f | r | k | g | n | N | j | w | u | i | o | e | a |
| son      | - | - | + | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + | + |
| approx   | - | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + | + |
| cons     | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| nasal    |   |   |   |   |   |   |   |   |   | * |   |   |   |   |   |   |   |   |   |   |   |   |
| voice    | * | * | * | * | * | * | * | * |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| contin   | * | * | * | * | * | * | * | * |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| labial   | * | * | * | * | * | * | * | * |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| coron    | * | * | * | * | * | * | * | * |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| dorsal   | * | * | * | * | * | * | * | * |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| phar     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| anter    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| high     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

Finally, I assume a feature hierarchy that is fundamentally the same as Clements and Hume (1995) with the exception of the use of the feature [consonantal] instead of their [vocalic]. An abbreviated version showing the relevant section of their hierarchy follows. Note that at this point the height features have intentionally been left out.

(12) (a) consonants

\[\begin{array}{c}
\text{root} \\
\text{C-Place} \\
\text{labial} \\
\text{coronal} \\
\text{dorsal} \\
\text{pharyngeal} \\
\text{[anterior]} \\
\end{array}\]

(b) vowels

\[\begin{array}{c}
\text{root} \\
\text{C-Place} \\
\text{labial} \\
\text{coronal} \\
\text{dorsal} \\
\text{pharyngeal} \\
\text{[anterior]} \\
\end{array}\]

A vowel with a place feature associated to its C-Place node is theoretically ill formed, but a consonant may have V-Place nodes as secondary articulation. Thus for instance, a palatalized velar stop has the following hierarchy:

\[^8\text{A \* indicates the presence of a privative feature. For the sake of argument, I will start out by assuming that the high vowels do not contain a dorsal node.}\]
2.3 Assumptions on Language Contact and Loanword Phonology

Previously, it has been argued that the processes that govern the formation of loanwords act on a superficial acoustic signal that lacks phonological representation. Native phonemes of the borrowing language are then mapped onto this signal as the first stage of the borrowing (Silverman 1992, Yip 1993). Jacobs and Gussenhoven (2000) argue against Silverman and Yip, instead claiming that the “input to the phonological grammar of the borrowing language is not an unanalysed acoustic pattern, but a universally defined, fully specified phonological representation…” (p.190). This agrees with the facts of kan'on forms, which used three different strategies to borrow the bilabial, alveolar, and velar nasal codas (c.f. §5.3). Given Silverman’s assumptions we would expect to see only a two-way contrast given that Old Japanese didn’t have a velar nasal.

As well, following LaCharité and Paradis (1997), I assume that Old Japanese (OJ) speakers had access to Middle Chinese (MC) phonology. Access to the source language’s phonology allows for the introduction (promotion) of key faithfulness constraints into the Japanese grammar that only apply within the (sub)stratum concerned (c.f. Itô and Mester 1995, 2000 for discussion of the different rankings of OT faithfulness constraints for the different strata). This assumption helps account for the difference in the treatment of the velar nasal in modern Japanese loanwords:

---

9 Jacobs and Gussenhoven argue that the actual underlying representation adapted into the borrowing language is the result of Lexicon Optimization. After the borrowed form is adopted into the language, the underlying representation is modified to reflect this.
loanwords from English always borrow the velar nasal a homorganic nasal obstruent cluster followed by an epenthetic vowel if it is word final (14a), whereas modern loanwords from Chinese, on the other hand, always render the velar nasal as the moraic nasal (14b).\(^{10}\)

(14) the different treatment of the velar nasal in modern loanwords

a. song > sŏngu
   singer > shingaa

b. Shanghai > ShaNhai
   Song > SoN

The word "song" acutely illustrates the point. This difference in treatment can be accounted for by observing that in Chinese (almost) all morphemes are monosyllabic (Duanmu 2000), and that this constraint carries over into modern SJ. This point is further verified by the observation that during the initial stages of contact with Chinese, codas were always borrowed as onsets. Consider the four different pronunciations for the same two words, arranged in chronological order from left to right of time of borrowing:

(15) Manyōgana  go’on  kan’on  tō’on / sō’on
      kagu / kago  ko.u  kja.u  kjoN  ‘fragrant’
      nagi  na.u  da.u  doN  ‘bag, pocket’

Reconstructions of the Chinese forms on which the Japanese forms are based consistently end in a velar nasal, regardless of the time period of the reconstruction (c.f. Baxter 1992, Karlgren 1940, Pulleyblank 1984, etc.). This shows that the change in the way the velar nasal was adopted was due to a change in the Japanese phonology, not a change in the Chinese phonology. Gradually over a long period of time, the Japanese phonology changed so that if possible, codas preferred to be borrowed as codas. Although this change took place so that now current day Japanese language has the ability to borrow nasal codas as codas, it does so only in the case of modern

\(^{10}\) This point is made based on my observations of Japanese classmates while I was studying Chinese in a classroom environment in Jinan, China. It is also consistent with the ‘katakana pronunciation’ given as pronunciation guidelines in any introductory Chinese phrasebook, maps of China, travel guidebooks, etc. published in Japan. An interesting observation made Ken Takashima (p.c.) is that unless the Japanese person is familiar with the Chinese language, they will automatically resyllabify codas as onsets, pronouncing Chinese words such as Song as Sŏngu. This is most likely due to the influence of the foreign stratum, which is for the most part, based on English.
Chinese loans, but not in the case of modern English loans. This contrast can only be due to influence from the source language.
3 The Japanese Verb Paradigm

3.1 Introduction

In this chapter, I introduce the Japanese verb paradigm, focusing primarily on those verb forms that show alternations. Previous analyses of modern Japanese have all assumed that the /i/ in forms such as kaita ‘wrote’ is not present in the underlying form. I argue that based on the historic and modern-day morphological data, there is insufficient evidence to support such an assumption about the underlying representation. As such, I develop two analyses, one with /i/ in the underlying representation, and another where it is absent. It will be shown that in both cases the results are the same: a constraint-based account is not able to derive the correct results if we assume that the high front vowel does not contain a dorsal node.

3.2 The Verb Paradigm

Modern Japanese verbs are traditionally analyzed as four types – godan katsuyō, kami’ichidan katsuyō, shimoichidan katsuyō, and hentai katsuyō. With the exception of the last group, the behaviour of the verb morphology is quite straightforward:

(16) godan katsuyō verbs

<table>
<thead>
<tr>
<th>non-past</th>
<th>negative</th>
<th>potential</th>
<th>desiderative</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>katsu</td>
<td>katanai</td>
<td>kateru</td>
<td>kachitai</td>
<td>‘win’</td>
</tr>
<tr>
<td>kau</td>
<td>kawanai</td>
<td>kaeru</td>
<td>kaitai</td>
<td>‘buy’</td>
</tr>
<tr>
<td>karu</td>
<td>karanai</td>
<td>kareru</td>
<td>karitai</td>
<td>‘clip / mow’</td>
</tr>
<tr>
<td>tobu</td>
<td>tobanai</td>
<td>toberu</td>
<td>tobai</td>
<td>‘fly’</td>
</tr>
<tr>
<td>kamu</td>
<td>kamanai</td>
<td>kameru</td>
<td>kamitai</td>
<td>‘bite’</td>
</tr>
<tr>
<td>shinu</td>
<td>shinanai</td>
<td>shineru</td>
<td>shinitai</td>
<td>‘die’</td>
</tr>
<tr>
<td>kasu</td>
<td>kasanai</td>
<td>kaseru</td>
<td>kashitai</td>
<td>‘lend’</td>
</tr>
<tr>
<td>kaku</td>
<td>kananai</td>
<td>kakeru</td>
<td>kakitai</td>
<td>‘write’</td>
</tr>
<tr>
<td>kagu</td>
<td>kaganai</td>
<td>kageru</td>
<td>kagitai</td>
<td>‘sniff’</td>
</tr>
</tbody>
</table>
(17)  *kami‘ichidan katsuyō* verbs

<table>
<thead>
<tr>
<th>non-past</th>
<th>negative</th>
<th>potential</th>
<th>desiderative</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>miru</td>
<td>minai</td>
<td>mirareru</td>
<td>mitai</td>
<td>‘see’</td>
</tr>
<tr>
<td>ochiru</td>
<td>ochchinai</td>
<td>ochirareru</td>
<td>ochitai</td>
<td>‘fall, fail’</td>
</tr>
<tr>
<td>nobiru</td>
<td>nobinai</td>
<td>nobirareru</td>
<td>nobitai</td>
<td>‘extend, lengthen’</td>
</tr>
</tbody>
</table>

(18)  *shimoichidan katsuyō* verbs

<table>
<thead>
<tr>
<th>non-past</th>
<th>negative</th>
<th>potential</th>
<th>desiderative</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>eru</td>
<td>enai</td>
<td>erareru</td>
<td>etai</td>
<td>‘gain’</td>
</tr>
<tr>
<td>taberu</td>
<td>tabenai</td>
<td>taberareru</td>
<td>tabetai</td>
<td>‘eat’</td>
</tr>
<tr>
<td>neru</td>
<td>nenai</td>
<td>nerareru</td>
<td>netai</td>
<td>‘sleep’</td>
</tr>
</tbody>
</table>

(19)  *hentai katsuyō* verbs

<table>
<thead>
<tr>
<th>non-past</th>
<th>negative</th>
<th>potential</th>
<th>desiderative</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>suru</td>
<td>shinai</td>
<td>dekiri</td>
<td>shitai</td>
<td>‘do’</td>
</tr>
<tr>
<td>kuru</td>
<td>konai</td>
<td>korareru</td>
<td>kitai</td>
<td>‘come’</td>
</tr>
</tbody>
</table>

In Japanese, the verb root comes to the left, followed by the various suffixes. In the *godan katsuyō* verbs (16), all of the non-past forms end in the suffix -u, with the residue to the left of the suffix the verb root. In the case of the *kami‘ichidan katsuyō* (17) and *shimoichidan katsuyō* (18) verbs, the non-past suffix is -ru. There are only two *hentai katsuyō* verbs in Japanese, and their morphological behaviour is irregular, as shown in (19). They will not be considered in this thesis.

For expository purposes, I will reclassify the verbs into two groups based on the final segment of the root (the residue of the non-past verb form after the appropriate ending, either u or ru, is dropped). Verbs with a root ending in a consonant will be called C-final verbs, whereas verbs with a root ending in a vowel will be called V-final verbs.

(20)  Classification of Japanese verbs

- a. C-final verbs  
  - *godan katsuyō*  
  - e.g. roots: kat, shin, tob, etc.
- b. V-final verbs  
  - *shimoichidan katsuyō*  
  - e.g. roots: mi, ochi, nobi, etc.
  - *kami‘ichidan katsuyō*  
  - e.g. roots: e, tabe, ne, etc.

The analysis of this section will focus on the verbal paradigms that show phonological alternation:
the gerund and the non-past forms for C-final verbs. The paradigms, along with the verb roots are depicted in (21) for C-final verbs. V-final verbs are given in (22) for comparison.

(21)  C-final verb paradigms

<table>
<thead>
<tr>
<th>root</th>
<th>non-past</th>
<th>gerund</th>
<th>past</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>kat</td>
<td>katsu</td>
<td>katte</td>
<td>katta</td>
<td>‘win’</td>
</tr>
<tr>
<td>kaw</td>
<td>kau</td>
<td>katte</td>
<td>katta</td>
<td>‘buy’</td>
</tr>
<tr>
<td>kar</td>
<td>karu</td>
<td>katte</td>
<td>katta</td>
<td>‘clip / mow’</td>
</tr>
<tr>
<td>tob</td>
<td>tobu</td>
<td>tonde</td>
<td>tonda</td>
<td>‘fly’</td>
</tr>
<tr>
<td>kam</td>
<td>kamu</td>
<td>kande</td>
<td>kanda</td>
<td>‘bite’</td>
</tr>
<tr>
<td>shin</td>
<td>shinu</td>
<td>shinde</td>
<td>shinda</td>
<td>‘die’</td>
</tr>
<tr>
<td>kas</td>
<td>kasu</td>
<td>kashite</td>
<td>kashita</td>
<td>‘lend’</td>
</tr>
<tr>
<td>kak</td>
<td>kaku</td>
<td>kaite</td>
<td>kaita</td>
<td>‘write’</td>
</tr>
<tr>
<td>kag</td>
<td>kagu</td>
<td>kaide</td>
<td>kaida</td>
<td>‘sniff’</td>
</tr>
</tbody>
</table>

(22)  V-final verb paradigms

<table>
<thead>
<tr>
<th>root</th>
<th>non-past</th>
<th>gerund</th>
<th>past</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>mi</td>
<td>miru</td>
<td>mite</td>
<td>mita</td>
<td>‘see’</td>
</tr>
<tr>
<td>ochi</td>
<td>ochiru</td>
<td>ochite</td>
<td>ochita</td>
<td>‘fall, fail’</td>
</tr>
<tr>
<td>nobi</td>
<td>nobiru</td>
<td>nobite</td>
<td>nobita</td>
<td>‘extend, lengthen’</td>
</tr>
<tr>
<td>e</td>
<td>eru</td>
<td>ete</td>
<td>eta</td>
<td>‘gain’</td>
</tr>
<tr>
<td>tabe</td>
<td>taberu</td>
<td>tabete</td>
<td>tabeta</td>
<td>‘eat’</td>
</tr>
<tr>
<td>ne</td>
<td>neru</td>
<td>nete</td>
<td>neta</td>
<td>‘sleep’</td>
</tr>
</tbody>
</table>

Paradigms for the V-final verbs (22) are straightforward. The C-final verbs (21), on the other hand, are much more complex. Of particular interest are the gerund and past tense forms for the verb roots that end in velar stops, which show an alternation between a k and the high front vowel.

3.3  Is i in the Underlying Form?

The first problem I shall address is the nature of the i in kaite and kaide (the gerund forms of kak and kag). There are three approaches possible:

1. i is absent in the underlying form and is inserted after velars and sibilants

---

11 There are other suffixes that show identical allomorphy, such as -tari and -tara, but these can be taken as morphologically complex ta + ri and ta + ra.

12 Historically, w-final roots are reconstructed as having ended in a bilabial stop /p/. Diachronically /p/ dropped out before all vowels except /a/, in which case it became /w/. W-final roots pattern with other C-final roots, and therefore are classified as such.
2. / is in the underlying form as the velar stop, which surfaces as /, and inserted after sibilants.

3. / is present in the underlying form and is deleted after every verb root except those ending in velars and sibilants.

3.3.1 / as an Epenthetic Vowel

Every reference to the / that I am aware of, be it either a rule-based theory account (c.f. McCawley 1968, Tsujimura 1996, Vance 1987) or a constraint-based theory account (c.f. Itô and Mester 2000, Lombardi 1998, Matsui 1998) treats the / in forms such as kaite as epenthetic. Matsui even goes so far as to claim that / is the default epenthetic vowel in the Yamato strata. However the only supporting evidence given by Matsui is the verb paradigms under discussion here.

Generative analyses are typical of Tsujimura's (1996) presentation, which includes the following ordered pair of rules:

\[(23)\]
\[
\begin{align*}
\varnothing & \rightarrow /i/ k + \text{ta} \\
/\theta/ & \rightarrow /i/ g + \text{ta} \\
/\kappa/ & \rightarrow /i/ i + \text{ta} \\
/\gamma/ & \rightarrow /\varnothing/ i + \text{ta}
\end{align*}
\]

Tsujimura fails to provide a rule for roots ending in sibilants. Such a rule would look like this:

\[(24)\]
\[
\varnothing \rightarrow /i/ s + \text{ta}
\]

It is easy enough to see why treating / as an epenthetic vowel is the orthodox approach: of the nine roots listed in (16), / only appears in three. But while descriptively such rules generate the correct result, they do not give any insight into why the / is inserted only after the velar obstruents \(k\) and \(g\), and the alveolar sibilant \(s\).

As well, there is no reason given for why the vowel /, as opposed to some other vowel, is chosen here. Elsewhere, an epenthetic / only appears due to vowel assimilation with a preceding front vowel in the Sino-Japanese stratum (c.f. §5.2), or as assimilation to a preceding palatal consonant in the foreign stratum (25a). A \(u\) on the other hand, appears in a much wider range of
environments, including after velars (25b). If it truly is an epenthetic vowel that we are talking about, then why is \( i \) chosen here when \( a \) \( u \) is chosen in the same environment in other strata?

(25) English Japanese
a. college korejji
   match matchi
b. pack pakkku
dog doggu
song songgu

Although there are clearly arguments against the hypothesis that \( i \) is epenthetic, it is still widely accepted as the correct analysis among Japanese linguists. As such, for the sake of thoroughness, I will develop one analysis based on the assumption that \( i \) is epenthetic.

3.3.2 \( i \) as "Velar Gliding"

Lombardi (1998) refers to the alternation between \( k \) and \( i \) in the Japanese verb paradigm as "velar gliding" (p.11). Although the term seems to imply correspondence between the two segments, Lombardi does not necessarily adhere to such a view, but rather sidesteps the issue by stating that "[w]hat exactly happens to the velar consonant to change it to or replace it with a vowel is ... highly specific to the verbal paradigm" (ibid.). Either way, the possibility that surface form's \( i \) and the UR's \( k \) are in correspondence needs to be considered.

3.3.3 \( i \) as Present in the UR

When the verb paradigm is examined from a historic perspective, we see that at one point the \( i \) was clearly present in the suffix. The Classical Japanese period (eighth to the twelfth century), is often claimed to be the zenith of pre-modern literature, and includes such classics as *The Tale Of Genji* (early eleventh century), and *The Pillow Book* (ca. 1000). The morphology of the verb paradigm was more regular (in that it showed fewer alternations), as shown by (26).
In Classical Japanese, the / is treated as a morpheme that attaches to verb roots to form what is called the renyōkei, or the 'adverbial' form. Although it does not have semantic content, it clearly serves a grammatical function in the minds of the Japanese speakers.

Although the historical forms bear little weight in deciding the underlying form in a synchronic analysis, as a child growing up in modern day Japan and learning to speak Japanese does not have access to such forms, what they do allow us to do is to rephrase the question. Obviously the / was in the underlying form in the past. Over time, due to / syncope in certain environments, the / dropped out. The crucial question then becomes is there evidence to show that the underlying form has changed over time?

3.3.4 The Morpheme i Elsewhere in the Verb Paradigm

All of the verb forms seen above are morphologically complex in that they consist of a number of morphemes. In most cases, breaking a word up into morphemes is straightforward. Take for example the morpheme potential form of the C-final verbs as seen in (16)–(19), which can be analyzed as -e-/-rare-. Following are some examples of the break down:
(27) a. potential, non-past, informal

<table>
<thead>
<tr>
<th>C-final root</th>
<th>root + e + ru</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>kat</td>
<td>kateru</td>
<td>'win'</td>
</tr>
<tr>
<td>tob</td>
<td>toberu</td>
<td>'fly'</td>
</tr>
<tr>
<td>kak</td>
<td>kakeru</td>
<td>'write'</td>
</tr>
<tr>
<td>hanas</td>
<td>hanaseru</td>
<td>'sniff'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V final root</th>
<th>root + rare + ru</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>mi</td>
<td>mirareru</td>
<td>'see'</td>
</tr>
<tr>
<td>ochi</td>
<td>ochirareru</td>
<td>'fall'</td>
</tr>
<tr>
<td>tabe</td>
<td>taberareru</td>
<td>'eat'</td>
</tr>
<tr>
<td>ne</td>
<td>nerareru</td>
<td>'sleep'</td>
</tr>
</tbody>
</table>

b. potential, negative, non-past, informal

<table>
<thead>
<tr>
<th>C-final root</th>
<th>root + e + nai</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>kat</td>
<td>katenai</td>
<td>'win'</td>
</tr>
<tr>
<td>tob</td>
<td>tobenai</td>
<td>'fly'</td>
</tr>
<tr>
<td>kak</td>
<td>kakenai</td>
<td>'write'</td>
</tr>
<tr>
<td>hanas</td>
<td>hanasenai</td>
<td>'sniff'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V final root</th>
<th>root + rare + nai</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>mi</td>
<td>mirarenai</td>
<td>'see'</td>
</tr>
<tr>
<td>ochi</td>
<td>ochirarenai</td>
<td>'fall'</td>
</tr>
<tr>
<td>tabe</td>
<td>taberarenai</td>
<td>'eat'</td>
</tr>
<tr>
<td>ne</td>
<td>nerarenai</td>
<td>'sleep'</td>
</tr>
</tbody>
</table>

In (27) there are two allomorphs of the potential morpheme, -e- and -rare-. The first attaches to C-final verbs while the second attaches to V-final verbs. In both cases, the resulting stem behaves as V-final verb. In the case of i-initial suffixes, however, the break down is not as clear-cut. Take for example the desiderative.

(28) desiderative, non-past, informal

<table>
<thead>
<tr>
<th>C-final root</th>
<th>root + itai</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>kat</td>
<td>kachitai</td>
<td>'win'</td>
</tr>
<tr>
<td>tob</td>
<td>tobitai</td>
<td>'fly'</td>
</tr>
<tr>
<td>kak</td>
<td>kakitai</td>
<td>'write'</td>
</tr>
<tr>
<td>hanas</td>
<td>hanashitai</td>
<td>'sniff'</td>
</tr>
</tbody>
</table>

etc.
The problem is whether to take the desiderative after a C-final root as a single unit *itai*, or break it up into *i* + *tai*. Minimal pairs help that differ only in the vowel in the location of *i* help us make the decision:

(29)  
(a) kakitai 'to want to write (informal)'
    kaketai 'to want to be able to write (informal)'
(b) kakisō 'appears to (be about to) write'
    kakeso 'appears to be able to write'
    etc.

The two forms in each of (29a), (29b), and (29c) differ only in a single vowel. In one case that vowel is *i*, in the other it is *e*. Based on such forms as seen in (29), the Japanese speaker will presumably take the *i* in *kakitai* to be some sort of 'morpheme-like' unit complete onto itself. Thus forms such as *kakitai* are underlyingly *kak + i + tai*. Given that the morpheme *i* is present and isolatable elsewhere in the Japanese language, how then does a learner choose that the *i* in forms such as *kaita* is epenthetic and not the same morpheme as in *kakitai*? Although in the end there isn't any convincing evidence against the *i* as an epenthetic vowel, given the complete lack of evidence supporting the claim that *i* is epenthetic, to call it as such is nothing more than a convenient way to sweep the idiosyncratic residue leftover from the historical sound changes under the carpet.

This discussion so far shows that historically, the *i* was present in the underlying form of the *renyōkei* of C-final roots as a morpheme. Over time it dropped out before the gerund and the past tense morphemes after most of the C-final roots, resulting in the modern day forms. Other analyses of the Japanese verb paradigms treat *i* as epenthetic, but not only is there no decisive
evidence in support of such an approach, there seems to be evidence against it. At the same time, although the i was present in the UR historically, this does not mean that it is necessarily present in the UR in modern Japanese. As well, there must be some key difference between the underlying representations kaita and kakitai that accounts for the k-o alternations in one case but not the other. At this point, the evidence seems to be inconclusive. As such, I will pursue the problem from both angles, presenting an OT analysis with i absent from the UR in the following section, and another OT analysis with i present in the UR in §3.5.

3.4 OT Analysis with i Absent from the UR

This section is an attempt to derive the phonological alternations seen in the gerund forms of C-final verbs.

3.4.1 The Constraints on Codas

In Japanese, a coda can only occur when (Itô 1986, Vance 1987, Tsujimura 1996):

(30) a. the coda consists of the moraic nasal; or  
b. the coda consists of a nasal homorganic with the onset the following syllable; or  
c. the coda is the first half of a geminate

The first task is to determine the constraints that govern the behaviour of codas. Itô and Mester (1994) take the ambiguous “Coda Condition” constraint and replace it with the following alignment constraint (p.34, definition my own):

(31) ALIGNL(CPlace,σ)\(^{13}\) – for every feature belonging to the feature class CPlace \{[labial], [coronal], [dorsal], [pharyngeal]\}, there must be some syllable such that the left edge

---

\(^{13}\) See McCarthy and Prince (1993) for formalization of alignment constraints. Itô and Mester do not use features classes, instead referring to the node C-Place with the intention that vowels would not violate the constraint. However they fail to give a formal definition of the constraint. Nor is it clear how an alignment constraint that refers to the node C-Place could be defined as to rule out vowels (which contain a C-Place node) and at the same time not have negative consequences for other uses of alignment constraints, such as root node alignment. Using the feature class CPlace allows reference of the identical set of features (those that are associated to the C-Place node) without having the added consequence of referring to the C-Place node itself. Note that only features, not nodes, belong to feature classes. Therefore, the V-Place node, although it also associates to the C-Place node, is not a member of the feature class CPlace.
of the feature is aligned with the left edge of the syllable

This constraint will penalize any segment linked to either [labial], [coronal], or [dorsal] if the feature is not at the left edge of a syllable. The following diagram from Itô and Mester (1994:34) illustrates this point. The dashed line marks the syllable boundary:

(32) a. kama 'kettle'     b. kampai 'cheers!'
    \[ \begin{array}{c}
    \sigma \\
    k \quad a
    \end{array} \]  \[ \begin{array}{c}
    \sigma \\
    k \quad a \quad m \quad a
    \end{array} \]
    [labial]

    c. kappa 'water imp'
    \[ \begin{array}{c}
    \sigma \\
    k \quad a \quad p
    \end{array} \]
    [labial]

    d. *kapta
    \[ \begin{array}{c}
    \sigma \\
    k \quad a \quad p \quad t \quad a
    \end{array} \]
    [labial] [coronal]

In (32a) through (32c) the constraint is not violated since the left edge of the feature [labial] is aligned with the left edge a syllable. Note that in (32b), the m and p share a single [labial] feature. In (32d), the feature [coronal] does not violate the constraint, but [labial] does, as it does not lie at the left edge of a syllable. Note the moraic nasal will not violate this constraint since underlyingly it is not linked to one of the place features [labial], [coronal], [dorsal].

The ALIGNL(CPlace,σ) constraint alone is almost sufficient to govern the behaviour of codas in Japanese, with one exception: it permits voiced geminates. To block voiced geminates, we need a separate markedness constraint:

(33) *DD – no voiced obstruent geminates

That there are two constraints governing the behaviour of codas and not just a single “Coda Condition” constraint is motivated by the observation that in the foreign strata, while voiced geminates are permitted, all of the other restrictions on the coda still hold (Itô and Mester 2000).
3.4.2 Retaining the Suffix Onset

The alignment constraint in (31) is not capable of determining if for example \( p + t \) yields a bilabial geminate \( pp \) or an alveolar geminate \( tt \), as neither violate \( \text{ALIGNL(CPlace,\sigma)} \). This is not however, the simple retention of some features at the expense of others. If, for instance, looking at the gerund forms we note that the [coronal] place feature of the \(-te\) is always retained, we might opt for a constraint ranking such as \( \text{MAXIO(coronal)} \gg \text{MAXIO(dorsal), MAXIO(labial)} \).

However such a ranking cannot resolve the choice when the place of articulation is the same but the manner differs, as in \( n + t \).

\[
\begin{array}{|c|c|c|}
\hline
\text{ii. } /\text{sin+te/} & \text{MAXIO (nasal)} & \text{MAXIO (coronal)} & \text{ALIGNL (CPlace,\sigma)} \\
\hline
a. shitte & *! & & \\
b. shinne & & & \\
c. shinde & & & \\
\hline
\end{array}
\]

This problem can be solved by observing that in all of the gerund forms, as well as everywhere else in the Japanese language such as in the Sino-Japanese compounds (c.f. §3.5.3), if assimilation occurs then the coda always assimilates to the place and manner of articulation of the following onset. This agrees with the cross-linguistic observation that the onset is a privileged position (Beckman 1998). This effect can be captured by positional faithfulness constraints such as \( \text{IDENT-ONSET(manner)} \) (ibid.). There is however a theoretical shortcoming of Beckman’s constraint, viz. as Beckman points out, positional faithfulness constraints are only capable of capturing the desired effects if formulated in terms of segmental correspondence (as opposed to featural correspondence). However, an OT derivation of the Japanese verb paradigm crucially relies on featural correspondence (Lombardi 1998). Although given that languages such as Japanese show that the development of a positional faithfulness theory that is compatible with
featural correspondence is urgently needed, to do so here is beyond the scope of this thesis.\textsuperscript{14} Realizing that at this point it is inadequate, I posit the following constraint without giving a formal definition.

(35) \textsc{PreserveOnset} – preserve the place and manner features of an onset\textsuperscript{15}

The following tableau shows the derivation for an r-final root.

(36)

<table>
<thead>
<tr>
<th>/kar+te/</th>
<th>\textsc{Preserve Onset}</th>
<th>\textsc{Alignl (CPlace,o)}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. karte</td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>COR COR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. karre</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>COR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. $ katte</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.4.3 Nasals and Voicing

The following constraint will penalize candidates that do not retain an underlying [nasal]:

(37) \textsc{MaxIO(nasal)} – the feature [nasal] in the input must have a correspondent in the output

This constraint is also undominated, forcing a segment in the input linked to the feature [nasal] to surface as a nasal. If this results in a NC cluster, the alignment constraints will force the nasal to assimilate to the place of articulation of the following consonant.

Next is a markedness constraint that penalizes voiceless stops after nasals.

(38) \textsc{PNV} (post-nasal voicing) – obstruents following a nasal segment are voiced\textsuperscript{16}

Adding these two constraints to the top of the ranking hierarchy, we are now able to derive the

\textsuperscript{14} There have been a number of phonetic-based works that address this problem by showing that the onset is a privileged position because of the robustness of the perceptual clues found there (Jun 1995, Steriade 1995, 1997).

\textsuperscript{15} In the following tableaux this constraint is violated once for each change in place, voicing, nasality and continuity of the onset. This is a convenient abbreviation of what should be a number of different positional faithfulness constraints that refer to the features themselves.

\textsuperscript{16} This constraint is formulated in a positive manner (as opposed to, for example, *[nas][-voi]) to avoid reference to an equipollent voicing feature, or in the case of a privative feature for voicing, reference to the lack of a feature. Another option would be to use the privative [-voice], but the Japanese \textit{rendaku} voicing phenomenon provides evidence that if privative, then the voicing feature is [+voice] (c.f. Itô and Mester 1986).
gerund form for roots that end in a nasal (39).\footnote{Another candidate that is not considered would be kaNde, with a placeless nasal. Such a candidate is ruled out by the constraint *NoPLACE. See (84a) for definition.}

<table>
<thead>
<tr>
<th>i. /kam+te/</th>
<th>MAXIO (nasal)</th>
<th>PNV</th>
<th>ALIGNL (CPlace,σ)</th>
<th>PRESERVE ONSET</th>
<th>MAXIO (labial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. katte</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. kamte</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. kante</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. kande</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ii. /sin+te/</th>
<th>MAXIO (nasal)</th>
<th>PNV</th>
<th>ALIGNL (CPlace,σ)</th>
<th>PRESERVE ONSET</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. shitte</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. shinte</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. shinde</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. shinne</td>
<td></td>
<td></td>
<td>*!</td>
<td>*</td>
</tr>
</tbody>
</table>

Alternations involving a nasal violate the PRESERVEONSET constraint by changing the voicing of an onset in order to satisfy the Post Nasal Voicing constraint.

To derive the correct result for b-final roots, we need an undominated constraint that forces the retention of the [voice] feature.

(40) MAXIO(voice) – the feature [voice] in the input must have a correspondent in the output

The following tableau shows the derivation of a b-final root:

<table>
<thead>
<tr>
<th>/tob+te/</th>
<th>MAXIO (voice)</th>
<th>*DD</th>
<th>PNV</th>
<th>ALIGNL (CPlace,σ)</th>
<th>PRESERVE ONSET</th>
<th>MAXIO (labial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. totte</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. tobbe</td>
<td></td>
<td>*!</td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. todde</td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. tomte</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d. tonte</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e. tonde</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Once the feature [voice] is retained, the constraints on the coda will rule out candidates with voiced geminates, leaving the homorganic nasal stop cluster as optimal.
3.4.4 Inserting the i

The next hurdle to overcome is motivating the insertion of the i. This involves two separate tasks: blocking gemination, and choosing i over other vowels.

Following Alderete et al. (1999), I will use the universal markedness hierarchy posited by Prince and Smolensky (1993) to choose the quality of the epenthetic vowel:

(42) *LAB, *DORS, *PHAR, *-HIGH >> *COR, *+HIGH

Furthermore, insertion of a segment violates the following constraint:

(43) DEPIO(root) – any segment (here represented by the root node) in the output must have a correspondent in the input

The following tableau shows that the i is the least costly vowel to insert:¹⁸,¹⁹

<table>
<thead>
<tr>
<th></th>
<th>*LAB</th>
<th>*DOR</th>
<th>*PHAR</th>
<th>*-HIGH</th>
<th>*COR</th>
<th>*+HIGH</th>
<th>DEPIO (root)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>a</td>
<td></td>
<td>*!</td>
<td>*!</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>b.</td>
<td>i</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>c.</td>
<td>u</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>d.</td>
<td>e</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>e.</td>
<td>o</td>
<td>*!</td>
<td>*!</td>
<td>*!</td>
<td></td>
<td></td>
<td>+</td>
</tr>
</tbody>
</table>

From this point on, for the sake of brevity it will be assumed that this markedness hierarchy holds throughout, and only candidates that use i as an epenthetic vowel will be considered.

In the case of s-final roots, candidates with geminates can be ruled out by demanding that the feature [continuant] is retained.

(45) MAXIO(cont) – the feature [continuant] in the input must have a correspondent in the

---

¹⁸ As mentioned earlier, for the sake of argument, I assume that the front vowels do not contain the feature [dorsal]. However, note that even if it were assumed that the front vowels do contain a [dorsal] feature, the tableau still derives the same result.

¹⁹ This tableau shows the necessary ranking of constraints to select i as the default epenthetic vowel. As I pointed out earlier, in the foreign stratum, u is the default vowel. This means the ranking of these markedness constraints differs from stratum to stratum. However, Ito and Mester (2000) argue that different strata within a single language only differ in their ranking of faithfulness constraints; the ranking of markedness constraints is consistent across all strata. Ito and Mester’s conclusions are one more argument against positing i as the epenthetic vowel.
Following is the tableau for an s-final root.

<table>
<thead>
<tr>
<th>/kas+te/</th>
<th>MAXIO (cont)</th>
<th>ALIGNL (CPlace,a)</th>
<th>PRESERVE ONSET</th>
<th>DEPIO (root)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td>!</td>
<td>!</td>
<td>*</td>
</tr>
<tr>
<td>d.</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

3.4.5 Velar-final Roots

The only alternations not yet accounted for are those of the velar-final roots. As mentioned in §3.3, when considering the velar-final roots, there are two possibilities that need to be considered: the $i$ is epenthetic, and the $i$ is present in the UR as the velar consonant. In the former case, DEPIO(root) will be violated. In the latter case, we need a new constraint, one that penalizes changing a consonant into a vowel:

(47) IDENTIO(cons) – segments in correspondence must have the same value for the feature [consonantal]

We are now ready to look at velar-final roots.²⁰

<table>
<thead>
<tr>
<th>/kaki+te/</th>
<th>ALIGNL (CPlace,a)</th>
<th>IDENTIO (cons)</th>
<th>PRESERVE ONSET</th>
<th>DEPIO (root)</th>
<th>MAXIO (dorsal)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td>!</td>
<td>!</td>
<td>!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>!</td>
<td>*</td>
<td></td>
<td>!</td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>!</td>
<td>!</td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

As tableau (48) shows, the correct candidate (one of (48e) or (48f)) is not chosen. But this is not due to a problem of our constraint ranking. The candidate that is chosen will always violate fewer constraints than the correct candidate, as it only violates the constraint MAXIO(dorsal), whereas

²⁰ At this point I am still assuming that the high front vowel does not contain the dorsal node.
both (48e) and (48f) violate MAXIO(dorsal) and one other constraint. As long as a candidate that uses an alveolar geminate violates a subset of constraints that the candidate that is the attested output violates, the incorrect candidate will be chosen as optimal. This is a consequence of the assumption that front vowels do not contain the [dorsal] feature. If we instead assume that \(i\) contains a dorsal node, then by ranking MAXIO(dorsal) over IDENTIO(cons), we obtain the correct result (49).

(49)

<table>
<thead>
<tr>
<th>/kak+te/</th>
<th>ALIGNL (CPlace,σ)</th>
<th>MAXIO (dorsal)</th>
<th>PRESERVE ONSET</th>
<th>DeepO (root)</th>
<th>IDENTIO (cons)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kakite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. kakte</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. kakke</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. katte</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e. kaije</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>f. kaije</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note that this tableau rules out the possibility of \(i\) being an epenthetic vowel. An epenthetic \(i\) does not preserve the dorsal feature of the \(k\) regardless of what our assumptions are, and therefore will always violate MAXIO(dorsal).

3.5 OT Analysis with \(i\) Present in the UR

3.5.1 Deleting the \(i\)

If we assume that the \(i\) is present in the UR, then we need to motivate its deletion in forms such as \(katta\). But why this \(i\) dropped out of some forms is not clear.\(^{21}\) Perhaps it lack of semantic content

\(^{21}\) A close examination of the diachronic changes shows that while the \(i\) deleted from the classical forms of the gerund and past tense (26), it did not delete from the desiderative forms (16) even though the phonological environment was the same in both cases. Thus for example, the Classical Japanese past tense of the verb \(kaku\) ‘write’ is \(kakita\), while the modern Japanese desiderative for the same verb is \(kakitai\). Although the \(i\) is in the same environment in both cases, only in the former case did it delete. That the change took place in one form but not the other even though the
made it more marked. Either way we are left speculating about a change that took place long ago, and as such are forced to use a descriptive markedness constraint until further the production of further insight as to why the / dropped out.

(50) \(+i+ - do not retain the / morpheme (the + signs note morphological boundaries)

Any candidate that does not include the / will naturally violate the following faithfulness constraint:

(51) \(\text{MAXIO}(\text{root})\) – each and every segment (here represented by the root node) in the input must have a correspondent in the output.

Following are the tableaux for t-final, r-final roots and w-final roots.

<table>
<thead>
<tr>
<th>(52) i. /kat+i+te/</th>
<th>ALIGNL (CPlace,σ)</th>
<th>PRESERVE ONSET</th>
<th>*+i+</th>
<th>MAXIO (root)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kachite</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ® katte</td>
<td></td>
<td></td>
<td>*</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>c. kaite</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(53) ii. /kar+i+te/</th>
<th>ALIGNL (CPlace,σ)</th>
<th>PRESERVE ONSET</th>
<th>*+i+</th>
<th>MAXIO (root)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. karite</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. karte</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. karre</td>
<td></td>
<td></td>
<td><em>:</em></td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>d. ® katte</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>e. kaite</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

environment was identical shows that the change was a morphological one. Martin (1987) hypothesizes that syncope in one case but not the other is due to a dropping of the morphological boundary between the / and the following gerund or past tense morpheme. In other words, what was originally \(\text{root+i+te}\) lost the second morphological boundary to become \(\text{root+ite}\). One possible approach to this problem would be to use constraint-ranking domains. Such a solution would involve setting up a number of different constraint rankings that would co-exist in the same phonology. Each of the suffixes would then be assigned to one of these domains. This however, is beyond the scope of the thesis.
In all three cases, the candidate with the alveolar geminate is the optimal one. The two alignment constraints work in tandem to force the more optimal geminate to be doubly linked to the place of articulation of the right consonant, at the expense of the left consonant’s place feature. This of course violates the constraints MAXIO(feature), but the violated constraints are crucially ranked lower than the constraints that motivate gemination.

As in the previous analysis, to derive the correct result for s-final roots, we need to block the deletion of the i with a higher-ranking MAXIO(cont) constraint, which demands the retention of the feature [continuant].

3.5.2 Nasals and Voicing

With the addition of the MAXIO(nasal), MAXIO(voice) and PNV constraints, m-final, n-final and b-final roots are taken care of.
### 3.5.3 Velar-Final Roots

The next task to is to determine why the $i$ was not deleted in the gerund and past tense of the velar-final roots. To do this, I will turn to gemination in the Sino-Japanese stratum for insight.

Following is a list Sino-Japanese compounds illustrating the gemination process.

(54) | /kam+i+te/ | MAXIO (nasal) | PNV | $i$+ | ALIGNL (CPlace,ω) | PRESERVE | MAXIO (root) | MAXIO (labial) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kamite</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>b. katte</td>
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<td>*</td>
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</tr>
<tr>
<td>c. kamde</td>
<td></td>
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<tr>
<td>d. kante</td>
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<tr>
<td>e. kande</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>/sin+i+te/</th>
<th>MAXIO (nasal)</th>
<th>PNV</th>
<th>$i$+</th>
<th>ALIGNL (CPlace,ω)</th>
<th>PRESERVE</th>
<th>MAXIO (root)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. shinite</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>b. shitte</td>
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<td>c. shinte</td>
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<tr>
<td>d. shinde</td>
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<tr>
<td>e. shinne</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>/tob+i+te/</th>
<th>MAXIO (voice)</th>
<th>PNV</th>
<th>$i$+</th>
<th>ALIGNL (CPlace,ω)</th>
<th>PRESERVE</th>
<th>MAXIO (root)</th>
<th>MAXIO (labial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. tobite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. totte</td>
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<td>*</td>
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<td></td>
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<tr>
<td>c. tobbe</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>d. tomde</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>e. tonde</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

(55) a. jupun | jupu + pun | ‘ten minutes’
| jitte | jipu +te | ‘truncheon used by police in feudal Japan’
| jukko | jupu + ko | ‘ten items’
| jusshin / jisshin | jupu / jipu + shin | ‘decimal’

b. jubun | jupu + bun | ‘enough’
| juiji | jupu + ji | ‘a cross’

(56) a. rikken | ritu + ken | ‘to establish a constitution’
| ritto: | ritu + to: | ‘to establish a political party’
| rippo: | ritu + po: | ‘to form a law’
| rissho: | ritu + sho: | ‘to establish proof’
| risshhi | ritu + shi | ‘to be successful’
Gemination is automatic before voiceless consonants when the left consonant is underlying /p/ (55a) or /t/ (56a), but not so in the case of /k/, only occurring before another /k/ (57a). In (55b), (56b), and (57c) gemination is blocked by the voicing of the following consonant. In rule-based derivational analyses, this pattern of gemination is limited to the Sino-Japanese stratum by the inclusion of some feature such as [+Sino] in the rule description. However, note that the pattern of gemination that occurs in the gerund form of C-final verbs matches the pattern of Sino-Japanese gemination.

\[
\begin{array}{|c|c|c|c|c|}
\hline
(58) & \text{gerund form} & \text{Sino-Japanese} \\
& \text{underlying} & \text{surface} & \text{underlying} & \text{surface} \\
\hline
\text{a.} & \text{p + t} & \text{kap + ite} & \text{katte} & \text{jip + te} & \text{jitte} \\
\text{t + t} & \text{kat + ite} & \text{katte} & \text{ritu + to:} & \text{ritto:} \\
\text{b.} & \text{k + t} & \text{kak + ite} & \text{kaite} & \text{gaku + to} & \text{gakuto} \\
\hline
\end{array}
\]

In (58a) gemination occurs, regardless of which stratum, whereas in (58b) gemination is blocked, again regardless of which stratum. Kurisu (2000) uses a high-ranking faithfulness constraint to demand retention of the dorsal feature in SJ. I will posit that this is the same reason the \(i\) does not delete in the Yamato stratum; deleting the \(i\) would entail gemination, which would result in the deletion of the \(k\) and loss of the dorsal feature.

3.5.4 Velar Elision

On the other hand, Japanese also had a rule that deleted velars. Historically, the deletion of \(k\)
before a high vowel was a common phenomenon, and is one of a collection of rules called onbin in Japanese. Following are some examples of Classical Japanese (CJ) vocabulary items with their modern-day counterparts (+ marks a morphological boundary) (Miller 1967, Martin 1987):

(59)   CJ       modern
      ohayoku     ohayō      ‘good morning’ (lit. early, honorific, adverbial)
      arigataku  arigatō     ‘thank you’ (lit. difficult to exist, adverbial)
      itaku       itō        ‘extremely’ (archaic)
      karaku+shite karōjite  ‘barely, with much difficulty’
      Saki+tama   Saitama    (place name)
      tsuki+tachi tsuitachi  ‘the first day of the month’
      taki+matsu  taimatsu   ‘(pine) torch’

Velar elision only took place before a high vowel at the right edge of morpheme or word. Thus for instance, the CJ attributive form of ‘big’ ookiki is ookii in Modern Japanese, not *ooii. For this, I will use a purely descriptive markedness constraint, called VELAR ELISION (but see Appendix A).

(60)   VELAR ELISION - *C V ] where the square bracket marks a morphological boundary
       [dorsal] [+high]

We now have all of the tools needed to explain the gerund form kaite; it is derived from underlying kak + ite, with gemination blocked because the root ends in a velar. The root-final k deletes in the surface form due to the process of velar elision.

(61)   /kak+i+te/   VELAR ELISION  *+i+  ALIGNL (CPlace,o)  PRESERVE ONSET  MAXIO (dorsal)  MAXIO (coronal)  MAXIO (root)
       a. kakite    *!  *!             *             *             *
       b. kakte     *!  *!             *             *             *
       c. kakke     *!  *!             *!  **             *             *
       d. □ katte   *!  *!             *!  *!             *             *
       e. □* kaite  *!  *!             *!  *!             *             *
optimal. It appears that the constraint *+i+ inadvertently rules out the attested candidate. Furthermore, this time the derivation fails regardless of our assumptions about the dorsal node. The following two tableaux, in which the dorsal node present in the feature geometry of the high vowel, illustrate this point.

\[
\begin{array}{|c|c|c|c|c|c|c|c|c|}
\hline
\text{/kak+i+te/} & \text{VELAR ELISION} & \text{ALIGNL (CPlace,σ)} & \text{*+i+} & \text{PRESERVE ONSET} & \text{MAXIO (dorsal)} & \text{MAXIO (coronal)} & \text{MAXIO (root)} \\
\hline
\text{a. kakite} & *! & *! & & & & & \\
\text{b. kakte} & *! & & & & & & \\
\text{c. kakke} & & *! & & & ** & * & \\
\text{d. katte} & & & * & & ** & & \\
\text{e. kaite} & & & & * & & * & \\
\hline
\end{array}
\]

MAXIO(dorsal) needs to be ranked higher than *+i+ to derive the correct result for velar-final roots in (62). This ranking however causes the other tableaux, such as (63) to choose the wrong candidate. It seems that there is no simple solution with the i present in the UR.

\[
\begin{array}{|c|c|c|c|c|c|c|c|}
\hline
\text{/kat+i+te/} & \text{VELAR ELISION} & \text{ALIGNL (CPlace,σ)} & \text{MAXIO (dorsal)} & \text{*+i+} & \text{PRESERVE ONSET} & \text{MAXIO (coronal)} & \text{MAXIO (root)} \\
\hline
\text{a. kachite} & & & & * & & & \\
\text{b. katte} & & *! & & & ** & & \\
\text{c. kaite} & & & & * & & *! & \\
\hline
\end{array}
\]

### 3.6 Is a Solution using Sympathy Constraints Possible?

Before we can conclude that OT is not able to derive the correct results unless we assume that the high front vowel contains the dorsal node, a solution using sympathy constraints (McCarthy 1999) need to be explored. Such a solution is particularly plausible given that an ordered set of rules such as those in (2) can account for the alternations.

#### 3.6.1 Sympathy for a UR with i Absent

A sympathy solution will first be attempted for a UR not containing i. This will be followed by a sympathy solution for an UR with i present in the following section. Previously, I argued that a
high-ranking faithfulness constraint demanding the retention of the dorsal feature blocked
gemination. Following this argument, it is only logical that MAXIO(dorsal) is the selector
constraint. Furthermore, if we wish to avoid choosing *katte* as the sympathy candidate, then we
necessarily need to use MAXIO(dorsal) as the selector constraint. The goal is to choose *kakite* as
the sympathy candidate. Then by using a sympathy-output faithfulness constraint to retain *i*, we
hope to obtain the correct result.

(64) \[ \text{MAX}^{\circ}(O(i)) \text{ – any high front vowel in the sympathy candidate must have a correspondent}
\text{in the output} \]

Following is tableau (48) with sympathy constraints added (while the order of constraints has
remained, some previously unranked constraints are now crucially ranked):

(65)

<table>
<thead>
<tr>
<th>/kak+i+te/</th>
<th>MAX^{\circ} O (i)</th>
<th>PRESERVE ONSET</th>
<th>ALIGNL (CPlace;e)</th>
<th>IDENTIO (cons)</th>
<th>DEPIO (root)</th>
<th>♦MAXIO (dorsal)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ⊕ ⊕ kak+i+te</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. kakte</td>
<td>*!</td>
<td>*</td>
<td></td>
<td>✓</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. kakke</td>
<td>*!</td>
<td></td>
<td>°</td>
<td>°</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. katte</td>
<td>°</td>
<td></td>
<td>°</td>
<td>°</td>
<td>°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. ⊕° kai+i+te</td>
<td>*!</td>
<td>°</td>
<td>°</td>
<td>°</td>
<td>°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. ⊕° kai+j+te</td>
<td>°</td>
<td>°</td>
<td>°</td>
<td>°</td>
<td>°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unfortunately the historic form *kakite* is chosen as optimal.

3.6.2 Sympathy for an UR with i Present

If the *i* is in the UR, it would appear that our choices for the selector constraint are greater; we
can focus now on the retention of the *i* or the *k*. But if we use a faithfulness constraint that
motivates the retention of the *i* as the selector constraint, then we lose the contrast between velar-
final roots and alveolar-final roots. We need to choose MAXIO(dorsal) as the selector constraint.

Following is tableau (61) repeated with sympathy constraints added:
(66)  

<table>
<thead>
<tr>
<th>/kak+i+te/</th>
<th>MAX⊙O (i)</th>
<th>ALIGNL (CPlace, o)</th>
<th>PRESERVE ONSET</th>
<th>*+i+</th>
<th>VELAR ELISION</th>
<th>♦ MAXIO (dorsal)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ⊗ ⊗ kakite</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. kakte</td>
<td>✓</td>
<td>*%</td>
<td>*%</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. kakke</td>
<td>*%</td>
<td>i*</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. katte</td>
<td>*%</td>
<td>i*</td>
<td>*%</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. © kaite</td>
<td>*%</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Again we incorrectly choose *kakite* as the optimal candidate, showing that a sympathy solution is not feasible.

### 3.7 The Height Features and the Verb Paradigm

Of all the different approaches taken, only when we adopted the assumptions that the front high vowel is not present in the UR, but is either epenthetic (as in *kashite*), or is in correspondence with an underlying *k*, and that it contains the dorsal node were we able to derive the correct results. Once we have made the assumption that the high front vowel contains the dorsal node, then the candidate where the *k* and *i* are in correspondence turns out to be optimal, as that way the dorsal feature is preserved.

As I have discussed in §3.3.3, historical forms show that the *i* was present in the UR. For the tableaux to derive the correct result, the *i* must no longer be in the UR. This shows that at some point, historical reanalysis took place, causing the underlying form to be rewritten in the lexicon.

It is interesting to note that this took place even though some evidence supporting the original UR still existed in the gerund and past tense forms of the s-final and velar-final verb roots. This has interesting implications of an OT-based theory of language change, but this issue will not be pursued here.
4 Middle Chinese, Old Japanese, and the Formation of Sino-Japanese

4.1 The Make-up of the Japanese Language

Modern Japanese is composed of four different strata, each with its own phonology (Itō and Mester 1995, 2000).

(67) the four strata of modern Japanese
  • Yamato (native)
  • Foreign (mostly from English)
  • Sino-Japanese
  • Onomatopoeic / Mimetic

What is rarely discussed in the linguistic literature on Japanese is the fact that the Sino-Japanese stratum is made up from several different substrata, again each with their own phonology (Miller 1967).22

(68) the substrata of Sino-Japanese
  • pre-Nara period loans (nativized)
  • Manyōgana (no longer used except in some place names)
    • go 'on
    • kan 'on
    • tō 'on
    • sō 'on

Although all of the substrata are relevant to the discussion, the focus of this paper is on the kan 'on forms.

4.2 A Brief History of the Formation of the Substrata

Japan’s contact with the continental mainland had deep repercussions on Japanese society from long before the first recordings of Japanese history. The importation of rice cultivation allowed

---

22 Besides the different ways of borrowing the velar nasal (compare the previously mentioned modern loans from Chinese with the kan 'on forms in §3.5), another major difference was the presence / absence of vowel assimilation (c.f. §§3.6 and 4.2)
for the transition from a hunter-gather society to an agrarian one, whereas the introduction of metallurgy changed the face of warfare. This continental influence in prehistoric times set a precedent of extensive borrowing and adaptation from foreign culture that can still be seen today.

Due to the continuous contact with China and Chinese culture, either directly or indirectly via Korean culture, there has always been an influx of new technology, and along with it new vocabulary. However it was not until the beginning of the fifth century that the Chinese language began to play a significant role in Japan. According to the *Nihon Shoki*, a historical chronicle, the Chinese writing system was officially introduced to the Yamato court by an emissary from the Korean state of Paekche. Not long afterward, a group of Chinese immigrants arrived at the court and established themselves as scribes (Hall et al. 1993: vol.2 343). Their skills began to be utilized more and more, doing such tasks as recording taxes levied and writing official decrees. As this group of immigrants was slowly assimilated into the population literacy began to spread among the upper class, and over time the Chinese language and culture formed the basis for all things political. The *Manyōshū*, a collection of over 7000 poems, although compiled much later in 760, records many of these lexical items with both their original Chinese graphs and the Japanese pronunciations that were current at the time.

Initially the use of Chinese was limited to the upper echelons of society. However this soon changed with the official adoption of the Buddhism as the state religion in 594. As Chinese was used to write and recite the scriptures, there was a sudden zeal to learn the language. The fact that all religious canons, including the sutras were written in Chinese helped spread the language through the religious community (Loveday 1996: 31). The resulting pronunciation of the Chinese graphs based on borrowings at this time is called the *go 'on* reading.

Beginning in 607, a series of Japanese missions were sent to the Chinese capital to learn directly from the Chinese. Those who managed to successfully return to Japan brought with them many books and much contemporary knowledge. As well, Chinese scholars who accompanied the
missions returning to Japan augmented the already established tradition of Chinese scribes and language experts. By the time of the Nara period (710-94), the Chinese language and culture had substantial influence on almost every aspect of aristocratic life, ranging from politics and religion to the fine arts such as painting, poetry composition, and painting, and fashion, to the point that a small portion of the society was bilingual (Loveday 1996: 32).

The beginning of the Tang dynasty (618 - 907) the capital moved to the city of Chang-an, and over time, the dialect spoken in and around this city gained prestige. Eventually the go’on pronunciation that the Japanese Buddhist monks had exerted so much effort to learn, which was based on the dialect of the Mandarin before the relocation of the capital to Chang’an, was considered out of date. It then became the job of the Chinese pronunciation experts residing in Japan, and those returning from having studied abroad in China to establish new standards of pronunciation based on the Chinese dialect current, the capital of Tang China. This new pronunciation was called kan' on.

The last official mission to go to Tang China left in 838 and returned in 847. After this, although political, economic and cultural trade continued, it was no longer deemed necessary to borrow exhaustively from China. After 847, maintaining “correct” pronunciation of the Chinese loan words gradually became less important. The hyaku-yomi, or ‘peasant reading-style’ gained popularity among the general populace, and eventually established itself as the norm (Lovedale 1996:29-37). Although there was later contact and another influx of vocabulary items, due to its wide-spread usage, the kan’ on substrata was never replaced, and now forms the basis for the majority of the modern Sino-Japanese vocabulary, while the later reading styles, the sōin reading borrowed during the Kamakura period (1185-1333) and the tōin reading borrowed during the Edo period (1600-1867), were for the most part limited to Zen Buddhism terminology and Neo-Confucianism.
4.3 The Consonant Inventories of Late Middle Chinese and Old Japanese

In order to limit the scope of the investigation to something manageable, I will only deal with in detail the formation of the kan 'on substratum. The kan 'on substratum is based on the language of Late Middle Chinese (LMC), the dialect spoken at the end of the seventh century in and around the capital city of Chang'an.

LMC had the following phonemes (Pulleyblank 1984:63ff, 1991):

(69) the phonemic inventory of Late Middle Chinese

labial: \( p, p^h, p^v, m \)
labiodental: \( f, f^h, v \)
alveolar: \( t, t^h, ts, ts^h, s, s^\), \( n, n^\), \( d, n, l \)
retroflex: \( tr, tr^h, ts, ts^h, s^\), \( n^\), \( nr, r \)
palatal: \( j \)
velar: \( k, k^h, g, g^\), \( 1, x, x^h \)
laryngeal: \( ? \)

The phonemes that occurred in the coda position were limited to \( [p, t, k, m, n, \eta, j, w] \). Note that LMC had a three-way contrast in place of articulation of the coda stops and nasals. As previously mentioned, the fact that this three-way contrast was preserved in the loan forms of morphemes that ended in nasal stops is of particular significance to the discussion.

Next let's take a look at the OJ onset inventory. Based on the usage of Chinese ideographs in the Manyōshū, the following inventory has been reconstructed for the Japanese language spoken during the period of 650 AD to 750 AD (Kishida 1998, Lange 1973, Syromiatnikov 1981, Yoshitake 1934):

While there is a high degree of confidence in the reconstructions of the consonants for both MC and OJ, the vowels are another story altogether. Due to the general lack of agreement on the reconstruction of the vowels among the authors, I do not include the vowels in the inventories.\(^{23}\)

\(^{23}\) \([tr, tr^h, dr, "dr"]\) are non-strident retroflex affricates, somewhat like the \( tr \) in English. \( [r] \) is a retroflex continuant.\(^{24}\)

\(^{24}\)
(70) the phonemic inventory of Old Japanese
labial: p, b, m
alveolar: t, d, n, z, s
retroflex: r
palatal: y
velar: k, g
labio-velar: w

Other than loanwords borrowed from Chinese, OJ did not have codas. By the time of the formation of the kan’on substratum, this inventory had been expanded somewhat with the addition of the allophones [f, tʃ, dʒ], and the moraic nasal N, all of which were used in the earlier go’on forms. There was also allophonic variation of some of the phonemes of which one alternation needs mentioning, namely that at some point between the period of Old Japanese and the 16th century, /u/ began to surface phonetically as [ts] before /u/. I will draw on this point in the tableaux that determine the quality of the second vowel in the kan'on substratum (§5.2).

4.3.1 Kan’on Onsets

The following table shows how the LMC onsets were borrowed into OJ (Pulleyblank 1984, Numoto 1986):

---

25 Kishida and Yoshitaki reconstruct this phoneme as a bilabial fricative [ɸ].
While the place of articulation was always faithfully preserved, the glottal features of aspiration and murmur were lost. Nasalization was also faithfully preserved with the exception of the velar nasal, which was borrowed as a velar obstruent. Prenasalization was also lost. Affricates were allophones that occurred before the palatal glide and the high front vowel.

4.3.2 Kan’on Codas

The nasal and stop codas were borrowed in the following way:

(72) rendering of Middle Chinese codas in kan’on

<table>
<thead>
<tr>
<th>LMC</th>
<th>kan’on examples: (Pulleyblank 1984, Numoto 1986)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>p pu njiap &gt; gepu ‘industry’ lip &gt; ripu ‘to stand’</td>
</tr>
<tr>
<td>t</td>
<td>t tu gyat &gt; gyetsu ‘moon’ kjit &gt; kitsu ‘fortunate’</td>
</tr>
<tr>
<td>k</td>
<td>k ki / ku kak &gt; kaku ‘each’ sfiajk &gt; seki ‘stone’</td>
</tr>
<tr>
<td>b.</td>
<td>m mu ?im &gt; imu ‘sound’ sam &gt; samu ‘three’</td>
</tr>
<tr>
<td>c.</td>
<td>n N san &gt; saN ‘mountain’ trin &gt; tjiN ‘rare’</td>
</tr>
<tr>
<td>d.</td>
<td>nj u / i tawn &gt; tou ‘winter’ kiajn &gt; kei ‘capital’</td>
</tr>
</tbody>
</table>

Voiceless coda stops were resyllabified as onsets followed by an epenthetic vowel (72a). Nasal codas were treated differently depending on the place of articulation. The labial /m/ was
resyllabified as an onset (72b), the moraic nasal was used in the case alveolar /n/ (72c), and the velar /ŋ/ was replaced by a nasalized vowel (72d).

4.4 The Second Vowel

As originally presented in Martin (1952), the quality of the second vowel in kan'on Sino-Japanese morphemes is predictable from the first vowel and the second consonant. The following table gives examples of the possible combinations:

<table>
<thead>
<tr>
<th></th>
<th>$V_1 = \text{a}$</th>
<th>$V_1 = \text{o}$</th>
<th>$V_1 = \text{u}$</th>
<th>$V_1 = \text{e}$</th>
<th>$V_1 = \text{i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_2 = /t/ $</td>
<td>kwatsu ‘life’</td>
<td>kotsu ‘bone’</td>
<td>utsu ‘melancholy’</td>
<td>tetsu ‘metal’</td>
<td>hitsu ‘brush’</td>
</tr>
<tr>
<td>$C_2 = /p/ $</td>
<td>papu ‘law’</td>
<td>--</td>
<td>--</td>
<td>kepu ‘to cooperate’</td>
<td>kipu ‘to cry’</td>
</tr>
<tr>
<td>$C_2 = /m/ $</td>
<td>samu ‘three’</td>
<td>--</td>
<td>--</td>
<td>kemu ‘sword’</td>
<td>kimu ‘gold’</td>
</tr>
<tr>
<td>$C_2 = /k/ $</td>
<td>kaku ‘feeling’</td>
<td>gyoku ‘jade’</td>
<td>puku ‘clothing’</td>
<td>eki ‘station’</td>
<td>--</td>
</tr>
<tr>
<td>$C_2 = /ŋ/ $</td>
<td>wau ‘king’</td>
<td>toū ‘east’</td>
<td>puū ‘wind’</td>
<td>mei ‘name’</td>
<td>--</td>
</tr>
</tbody>
</table>

The gaps in the table are due to missing vowel-coda combinations in Chinese at the time of borrowing (although some do occur in other Sino-Japanese substrata). Although the velar nasal does not surface, it is included to show the complete pattern. The second vowel is u after $t$, $p$, and $m$, and after $k$ if the previous vowel is back. The front vowel $i$ occurs after $k$ when the previous vowel is front. The second vowel of the surface forms for URs that end in the velar nasal pattern the same as the second vowel in forms where the second consonant is the velar stop. In general, after the velar stop or nothing, the frontness of the second vowel assimilates to that of the previous vowel, otherwise it is a back vowel.\footnote{Kurisu (2000) lists several exceptions to the predictability of the second vowel. However, a closer examination of his exceptions (74) shows that in every case the exception is a reading from the 26 Although I ignore phonemes such as iku (LMC iwk) ‘to raise a child’ where the second vowel is back due to a labio-velar glide between the vowel and the coda in the UR here, the OT derivation presented in §4.2 will naturally choose the correct candidate in these cases as well.
earlier *go on* substratum that has fossilized.

(74) examples of exceptions to the predictability of the epenthetic vowel

<table>
<thead>
<tr>
<th><em>go on</em></th>
<th><em>kan on</em></th>
<th><em>go on</em></th>
<th><em>kan on</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>ichi</td>
<td>itsu</td>
<td>kichi</td>
<td>kitsu</td>
</tr>
<tr>
<td>shichi</td>
<td>shitsu</td>
<td>hachi</td>
<td>hatsu</td>
</tr>
<tr>
<td>nichi</td>
<td>jitsu</td>
<td>rachi</td>
<td>ratsu</td>
</tr>
</tbody>
</table>

‘one’  ‘lucky’  ‘seven’  ‘eight’  ‘sun, day’  ‘bound’

For the most part, Sino-Japanese words use the *kan on* reading. However, there are a notable number of words that are exceptional in that they use forms from another substratum (compare *Nichi-yō-bi* ‘Sunday’ with *kyū-jitsu* ‘holiday’). As far as the phonological rules go, these are exceptions if all of the substrata are lumped together, as Kurisu has done in his analysis of modern Sino-Japanese, but the rules are consistent within each individual substratum.
5 OT Analysis of the Kan’on Substratum

Within the framework of OT, the exact intricacies involved in the way segments are borrowed falls out of the tension from the conflicting demands of a set of universal constraints. Before looking at the OT derivation for the codas and the evidence it provides for the placement of the height features in §5.5, the onsets will first be examined in §5.1, followed by vowel assimilation in §5.2. The possibility of a sympathy solution or a solution using constraint conjunction will be examined in §5.4. Finally, concluding remarks concerning the location of the height features will be presented in §5.5.

5.1 The Onsets

If there was a one-to-one match with the place of articulation, then the place features were always preserved at the expense of the manner features (although I doubt that this is a cross-linguistic generalization).

(75) examples of preservation of place of articulation

\[
\begin{align*}
\text{a. } f &\rightarrow p \quad \text{example: } fuq > pu \quad \text{‘husband’} \\
&\quad u \rightarrow b \quad vi > bi \quad \text{‘micro’} \\
\text{b. } x &\rightarrow k \quad xjyt > ketsu \quad \text{‘blood’} \\
\text{c. } ^{\text{g}}g &\rightarrow g \quad ^{\text{g}}gi > gi \quad \text{‘doubt’}
\end{align*}
\]

In (75a) the feature [labial] is preserved at the expense of [continuant]. In (75b) the feature [dorsal] is preserved also at the expense of [continuant]. In (75c) the feature [dorsal] is preserved at the expense of [nasal]. This shows that in general, constraints governing the identity of the place features outrank those governing the identity of the manner features. An example tableau follows:

(76)

<table>
<thead>
<tr>
<th>/xa/</th>
<th>*x</th>
<th>MaxIO (dorsal)</th>
<th>MaxIO (cont)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. xa</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. sa</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. * ka</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.2 The Quality of the Second Vowel

There are two aspects of the quality of the second vowel that need to be accounted for: height and frontness. The first is easily accounted for by a constraint ranking of *[-high] ≫ * [+high]. As such, candidates with non-high vowels will not be considered.

Following (Smolensky 1993), I assume that the assimilation of the frontness of the second vowel to that of the first vowel is motivated by alignment of the relevant features (in this case the features that distinguish front vowels from back ones) to the appropriate edge of the morpheme. Clements and Hume (1995) argue that the feature [-back] is redundant, as the frontness of a vowel can be determined by the presence of absence of the feature [coronal]. As such, it is the features [coronal] and [labial] that spread.

(77) ALIGNR(labial, morpheme) – every feature [labial] must be aligned with right edge of a morpheme

ALIGNR(coronal, morpheme) – every feature [coronal] must be aligned with right edge of a morpheme

As the features spreads rightward, it will naturally encounter the following consonant, the coda in the UR, which is resyllabified as an onset. The constraint NOGAP (78) (Padgett 1995) prevents the spreading from simply skipping over the intervening consonant.

(78) NOGAP

\[ * \alpha \beta \gamma \]

where \( \alpha, \beta \) and \( \gamma \) are anchors for \( F \)

In order to satisfy (78), the vowel features must spread through intervening consonants. If this is the case, then we will expect to see, for instance, a (doubly articulated) palatalized segment

\[ \text{\footnote{In both references to the phonology of the Chinese language (Middle Chinese as well as modern Chinese) and the phonology of the Sino-Japanese stratum of the Japanese language, the term \textit{morpheme} corresponds to the Chinese term \textit{zi} \textquoteleft character\textquoteright – a monosyllabic written ideograph that in most cases is also a morpheme in the sense that it has associated to it specific semantic content (c.f. DeFrancis 1984 for further discussion of ideographs and the Chinese language). The difference between Chinese and Sino-Japanese, as discussed in this thesis, is that while Chinese morphemes are monosyllabic, Sino-Japanese morphemes are either monosyllabic or disyllabic.}} \]

48
between the two front vowels. This is exactly what is found in the modern Sino-Japanese morphemes such as *eki ‘train station’ (Akamatsu 1997). At the same time, these doubly articulated segments are more marked than singly articulated segments, motivating the following constraint (Padgett 1995).

(79)  *COMP SEG – consonantal segments must not have more than one place feature

Following is the tableau showing front vowel assimilation across a velar stop.

<table>
<thead>
<tr>
<th>/ʃaijk/</th>
<th>NoGAP</th>
<th>ALIGNR (coronal)</th>
<th>*COMP SEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. seku</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>COR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. seki</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. ~ seki</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>COR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the case of an alveolar consonant, as explained in §4.3, at some point, $t$ stopped occurring before $i$. This is one of a group of coronal co-occurrence restrictions (c.f. §2.2.1), all of which can be accounted for by OCP constraint *[cor][cor] that is only active if one of the coronal segments is also specified as [+hi]. This constraint prevents $t$ from occurring before $i$. The OCP constraint blocks multiple [coronal] features, while the ALIGNR constraint causes [coronal] to spread. The feature geometry of a candidate that satisfied both of these constraints would need to look like this:

---

28 Although it is clear that this constraint was present by the 16th century (Martin 1987), it is not clear as to how early it appeared. Although it may seem that it is highly speculative to claim that the constraint was active at the time of the formation of the kan ‘on substratum, however doing so does account for one important difference with the earlier go ‘on forms: in the go ‘on forms an UR such as /kiti/ surfaces as [kiti].
Note that the [coronal] feature of the \( t \) does not spread because a vowel with a place feature linked to its C-Place node is ill formed. Since in Clements and Hume's theory of feature geometry the V-Place of a consonant is reserved for marking secondary articulation, in (81) the \( t \) is a palatalized alveolar stop. However such a candidate is ill formed in that it is simultaneously [+anterior] and [-anterior]. This problem could be solved by positing the exact same candidate with two [-anterior] features, essentially a stop articulated behind the alveolar ridge.\(^{29}\) This would then be phonetically interpreted as alveolopalatal affricate (Akamatsu 1997).\(^{30}\) This would give us a well-formed candidate, but at the expense of faithfulness to the [anterior] feature. It is the demand for the preservation of this feature that blocks vowel harmony, as illustrated by the following tableau.

\(^{29}\) This can be generalized to include all of the combinations of phonemes listed in (10). In every case, the coronal feature of the vowel links to the preceding consonant, and in doing so spreads the [-anterior] feature along with it. This cases the preceding alveolar stop to become a alveolopalatal affricate.

\(^{30}\) The tension between the choice of retaining the separate coronal features for a series such as \( ti \) and violating the OCP constraint, or spreading the coronal feature of the vowel onto the consonant and satisfying the OCP constraint but altering the place of articulation can be seen in the cross-linguistic tendency for alveolars to become to palato-alveolars before front vowels.
Although candidate (82c) is far from ideal, as it violates the OCP constraint, its violations are fewer than candidate (82a). Furthermore, it is well formed, and preserves the [+anterior] feature of the t. Note also that the OCP constraint also plays a key role determining the quality of the back vowel by blocking candidate (82a).

The labial stop /p/ also blocks vowel harmony. This is easily accounted for if we assume that ALIGNR(labial) outranks ALIGNR(coronal). Such a ranking cases the labial component of the /p/ to spread to the following vowel regardless of the quality of the preceding vowel.

For the sake of brevity, in the next section candidates that violate vowel harmony are not considered unless relevant to the discussion.

5.3 The Codas

Next let’s consider the constraints that govern the behaviour of the codas. I assume that segments such as the placeless nasal glide of Japanese that always assimilate their place of articulation to that of their surroundings are naturally more marked (in the sense that they seem to be cross-
linguistically rare)\textsuperscript{31} than segments with place features, so we need a constraint that penalizes placelessness (84a). Next a constraint is needed to penalize codas while still allowing for geminates, homorganic nasal obstruent clusters, and the moraic nasal. Following Itô and Mester (1994), I assume that this is a consequence of the non-crisp edge alignment constraint (84b). This constraint penalizes place features that are not aligned with the left edge of a syllable. Geminates and homorganic nasal stop clusters do not violate this constraint as long they share a single place feature, and that feature’s left edge is flush with the left edge of the syllable boundary that the geminate or cluster straddles. As well, resyllabification of the LMC coda as an onset in Sino-Japanese needs to be penalized. This is done by demanding that segments at the right edge in the underlying representation remain at the right edge in the surface form (84c). Finally, the absence of the velar nasal in the Japanese inventory is due to a high-ranking constraint banning segments with both the place feature [dorsal] and the manner feature [nasal] (84d).

\begin{enumerate}
\item \textbf{a.} *NOPLACE} – segments must be linked to place feature
\item \textbf{b.} ALIGNL(CPlace,σ) – for every feature belonging to the feature class CPlace
\begin{itemize}
\item [{labial}, {coronal}, {dorsal}, {pharyngeal}],
\end{itemize}
there must be some syllable such that the left edge of the feature matches the left edge of the syllable
\item \textbf{c.} ANCHORR – a segment at the right edge of the input word must have a correspondent at the right edge of the output word
\item \textbf{d.} *ŋ – segments containing the feature [nasal] and the place feature [dorsal] are prohibited
\end{enumerate}

The least complicated cases are those involving a voiceless obstruent coda. Following is the tableau for a morpheme with an underlying */k/ in coda position.

\textsuperscript{31} Other than Japanese, I only know of one other language that includes a placeless nasal glide in its phonemics inventory, that is Malay (Trigo 1991).
The most faithful candidate (85a) violates the restriction on codas. Simply deleting the coda (85b) violates faithfulness and ANCHORR. The optimal candidate (85c) maintains the coda, but as onset followed by an epenthetic vowel. This violates the lower ranking constraint, DEPIO(root). The derivations for a bilabial and alveolar codas will be identical to (85) with the exception that the relevant place feature will be [labial] and [coronal] respectively. Regardless of the place feature, MaxIO(place) will outrank DEPIO(root), resulting in the resyllabification of the coda as an onset followed by an epenthetic vowel.

The derivations for the nasal codas are not so trivial, and form the crux of the argument. In each case there are five scenarios that need to be considered:

1. the nasal coda is resyllabified as a nasal onset followed by an epenthetic vowel
2. the nasal coda is resyllabified as a stop onset followed by an epenthetic vowel
3. the nasal coda surfaces as the placeless nasal N
4. the nasal coda surfaces as a nasalized vowel, and the segments are in correspondence
5. the nasal coda surfaces as a nasalized vowel, and the segments are not in correspondence

The first scenario is what happens to the bilabial nasal, and also to the alveolar nasal in the Manyoshū forms. The second scenario needs to be considered since the velar nasal /ŋ/ was borrowed as /g/ in coda position in the Manyoshū forms. The third scenario is what happens to the alveolar nasal and in the more modern sóin and tōin forms. One of the fourth and fifth scenarios is what happens to the velar nasal /ŋ/ in the kan’on reading.

Let’s start with the bilabial nasal. It was borrowed as an onset followed by an epenthetic vowel.
As such, the optimal candidate violates the constraint against epenthesis, DEPIO(root). The tableau follows. (Constraint rankings anticipate future tableaux as well.)

<table>
<thead>
<tr>
<th>/sam/</th>
<th>ALIGNL (CPlace,σ)</th>
<th>MAXIO (labial)</th>
<th>MAXIO (nasal)</th>
<th>ANCHORR</th>
<th>IDENTIO (cons)</th>
<th>*No PLACE</th>
<th>MAXIO (root)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. sam</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. saN</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. sa.u̯</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>d. sa.u̯</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>e. sa.mu</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As candidate (86c) shows, the candidate with the nasalized vowel that is not in correspondence with the UR’s coda will always violate ANCHORR. The epenthetic vowel after an /m/ is always /u/ for the same reason as it is /u/ after /u/: the feature [labial] spreads to the right.

Next is the alveolar nasal. It was replaced by the moraic nasal N. Given the assumption that N is placeless, MAXIO(coronal) and *NoPLACE must be ranked lower. As well, given that N is placeless, any candidate with N in coda position will not violate ALIGNL(PLACE,σ).

<table>
<thead>
<tr>
<th>/gan/</th>
<th>ALIGNL (CPlace,σ)</th>
<th>MAXIO (nasal)</th>
<th>ANCHORR</th>
<th>IDENTIO (cons)</th>
<th>*No PLACE</th>
<th>DEPIO (root)</th>
<th>MAXIO (coronal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. san</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. saN</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. sa.u̯</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d. sa.mu</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the first vowel is a front vowel, as in sen ‘one thousand’, then the candidate with the moraic nasal will still be chosen over the candidate with the nasalized front vowel even though MAXIO(coronal) would be satisfied, since IDENTIO(cons) outranks the constraints *NoPLACE and MAXIO(coronal).

Last is the velar nasal. It was replaced by a nasalized high vowel. As stated, I will assume a feature geometry model where the height features are not under the dorsal node, models (7b) and (7c). This means that the high front vowel does not contain the feature [dorsal]. Our constraints have no problem choosing the correct candidate as optimal when the nasalized vowel is a back
vowel, since this preserves the dorsal feature (88i). However, when the nasalized vowel is a front vowel, the correct candidate is not optimal (88ii).

\[(88)\]

| i. /taw\n\n| | ALIGNL (CPlace,σ) | MAXIO (dorsal) | MAXIO (nasal) | ANCHORR | IDENTIO (cons) | *No PLACE |
|---|------------------|-----------------|---------------|----------|----------------|------------|
| a. to\n\n | ⋄ | *! | *! | | | |
| b. to\n\nu | *! | | | | |
| c. toN | *! | | | | * |
| d. # to\ui | | * | * | | |
| e. to\gu | | * | * | | |

| ii. /kia\n\n| | ALIGNL (CPlace,σ) | ALIGNR (coronal) | MAXIO (dorsal) | MAXIO (nasal) | ANCHORR | IDENTIO (cons) | *No PLACE |
|---|------------------|-----------------|---------------|---------------|----------|----------------|------------|
| a. kel | *! | *! | *! | | | |
| b. ke\n | | *! | *! | | | * |
| c. ke\ui | | *! | | * | | |
| d. # ke\i | | *! | * | | | * |
| e. @ ke\gi | | | * | * | | |

In candidates (a), (d), and (e), the coronal feature has spread to satisfy the ALIGNR(coronal) constraint, resulting in two candidates (a), and (e) that have codas with consonants with secondary articulation. Unfortunately, candidate (d), the attested candidate, is ruled out by a violation of MAXIO(dorsal). To choose the correct candidate as optimal would require a reversal in ranking of MAXIO(dorsal) and ANCHORR, but this would in turn cause candidate (e) toN to be incorrectly chosen in the previous tableau (88).

### 5.4 Is a Solution using Sympathy Constraints Possible?

Again, for the sake of thoroughness, a solution using sympathy constraints needs to be pursued. A sympathy solution is not possible, as shown by tableau (89). The closest we can get is to choose the candidate with the nasalized back vowel (89c) as the sympathy candidate by lowering the vowel harmony constraint ALIGNR(coronal), and using ANCHORR as the selector. But even still,
there is no way to formulate a sympathy constraint (hence the absence of the constraint) that chooses the candidate with vowel harmony over the one without, as this will entail violating MAXIO(dorsal).

\[ \begin{array}{|c|cccccccc|} \hline /\text{kia}\text{j\text{\text{}}}/ & \text{ALIGNL} & \text{MAXIO} & \star \text{ANCHORR} & \text{IDENTIO} & \text{ALIGNR} & \star \text{NO} & \text{MAXIO} \\ & (\text{CPlace},\sigma) & (\text{dorsal}) & (\text{cons}) & (\text{coronal}) & (\text{root}) & \text{PLACE} & (\text{root}) \\ \hline a. & \text{ke}\text{j} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} \\ b. & \text{keN} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} \\ c. & \text{ke.u} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} \\ d. & \text{ke.}\text{i} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} \\ e. & \text{ke.}\text{g} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} \\ \hline \end{array} \]

5.5 The Height Features

The problem with tableau (88) is the failure of the attested candidate to preserve the feature [dorsal]. But this is a consequence of our theoretical assumptions made about feature geometry. By assuming a geometry whereby the feature [high] implies the feature [dorsal], such as (7a), then the attested form becomes the optimal candidate:

\[ \begin{array}{|c|cccccccc|} \hline ii./\text{kia}\text{j\text{\text{}}}/ & \star & \text{ALIGNL} & \text{ALIGNR} & \text{MAXIO} & \text{ANCHORR} & \text{IDENTIO} & \star \text{NO} & \text{MAXIO} \\ & (\text{CPlace},\sigma) & (\text{coronal}) & (\text{dorsal}) & (\text{cons}) & (\text{cons}) & (\text{root}) & \text{PLACE} & (\text{root}) \\ \hline a. & \text{ke}\text{j} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} & \text{!} \\ b. & \text{keN} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} & \text{!} \\ c. & \text{ke.u} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} & \text{!} \\ d. & \text{ke.}\text{i} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} & \text{!} \\ e. & \text{ke.}\text{g} & \star & \star & \text{!} & \text{!} & \text{!} & \text{!} & \text{!} \\ \hline \end{array} \]
6 Conclusion

There have been three main proposals in the literature for the location of the height features in feature geometry. These are under the dorsal node, under an aperture (tongue height) node that is sister to the place features, and directly under the root node. An Optimality Theoretic analysis of the alternations shown by velar-final roots in the verb paradigm and of the way the velar nasal was borrowed in the kan'on forms of Sino-Japanese gives strong evidence for locating the height features under the dorsal node.

Clements and Hume point out that there is evidence that height features spread as a single unit, supporting the aperture node (p.281). While such evidence supports an aperture node, it does not give any evidence for the location of that node, and as such does not provide a counterargument to the argument presented here. On the other hand, the argument presented here does provide a counterargument to their hypothesis that the aperture node is sister to the place feature nodes. In this thesis, I have managed to get away with only one height feature, [±high], by using the pharyngeal node to distinguish low vowels, and therefore have had no use for an aperture node. In languages with a four-way height distinction, this would not be possible, and therefore there is a very real need for such a node. What has become clear is that it should be located under the dorsal node, and not sister to it.

The alternations shown by the verb paradigm are the product of a number of diachronic processes applying independent of each other, but interacting in such a way that in some cases the earlier processes bleed the later processes. As in any case were diachronic processes have applied to the extent that they obscure the relationship between morphemes, it could always be argued that forms such as kaita are learned the same way other irregularities in a grammar such as the English words feet and mice are learned, through memorization. However, the formation of the Sino-Japanese substrata took place over relatively short periods of time, and therefore gives us a
clearer snapshot of the phonology at that time that is not blurred by diachronic processes. As such, the Sino-Japanese data cannot be ignored.

Although placing the height feature under the dorsal node allows for a straightforward OT account of why the velar nasal was replaced by a high vowel in the *kan'on* forms, the case is far from closed. The conclusions drawn here force us to expand the natural class defined by the dorsal node to include not only dorsal consonants and back vowels, but also high vowels. This raises the question, what about the mid vowels? If the feature distinguishing high vowels from mid vowels is the privative [hi], then this is not a problem, but if it is equipollent, then [-hi] must also imply the presence of dorsal node. It is easy enough to see how physiologically [+hi] would imply the dorsal node; the raising of the dorsum in the formation of a high vowel is a similar motion to that in the formation of a velar stop. But this is not true for [-hi]. This question is left open for further exploration.
Appendix A - Motivating the VELAR ELISION Constraint

One of the fundamental hypotheses of OT is that constraints are universal; every constraint posited for grammar A is also present in every other grammar, and every other grammar's constraints are also present in grammar A (although not necessarily active). This hypothesis would be seriously weakened if it was discovered that it was absolutely necessary to use arbitrary constraints in some grammars. As things stand, there are three approaches that can be taken to motivate a markedness constraint. While the concept itself is not at all new, recently there has been a lot of literature written in the vain of a "phonetically-driven" gradient theory of phonology (c.f. Flemming 1995, Hsu 1996, Jun 1995, Steriade 1997, Kirchner 1998, Zhang 2000, etc.). In such a theory, there are two driving forces behind the constraints that shape the phonology of a language: the minimization of effort and the maximization of perceptual (auditory) contrast. These are the first two approaches. The actual physiological makeup of the vocal tract has also been an important determining factor (for example Sagey’s feature hierarchy discussed in §1.2.1). This is the third approach. In this section I will take up the seemingly arbitrary VELAR ELISION markedness constraint of §3 and try to motivate it on the grounds of expense of effort, auditory contrast, or physiological factors.

A.1 Markedness Motivated by Expense of Effort

Kirchner observes that in general, if lenition occurs, then “lenition is more likely to occur the more open the segments which flank the target” (2001:137). Based on this observation, Kirchner makes the following generalization (ibid.:144):

---

32 An arbitrary constraint is any constraint that makes reference to context, but fails to relate the markedness to that context. Thus for example, PNV (obstruents following a nasal segment are voiced) is not arbitrary because it is possible to relate the marked segment (voiceless obstruents) to the context (after nasals).
a. The Aperture Conditioning Generalization

If a consonant C lenites when preceding (or following) X, and X' has aperture greater than or equal to X, then C lenites, to the same extent or greater extent, when preceding (or following) X' as well.

b. The aperture scale:

Low vowels > mid vowels > high vowels > {glides, liquids} > stops

Segments are ranked on the aperture scale (91b) according to the size of the gap between the articulators, with stops having the smallest degree of aperture, and low vowels have the greatest.

In the case of the Japanese velar elision, the target segment is the lenited velar. The environment following the target is always a high vowel. The environment preceding the target is inconsistent; regardless of which vowel precedes the target, as long as a high vowel follows, then the target lenites. As such, the preceding environment will be ignored, and we will only focus on the environment after the target. If we look at the Aperture Conditioning Generalization in light of the Japanese data, then a prediction is made: given that a velar consonant lenites when preceding a high vowel, it is predicted that a velar consonant should also lenite when preceding any vowel with an aperture greater than a high vowel, i.e. all other vowels according to the aperture scale. But this clearly isn’t what happens, as seen by the verb forms in (92).

(92) kakeru ‘write (potential)’
kakanai ‘not write’
kakoo ‘write (volitional)’

If the elision of the velars was motivated by effort, then we would expect to see elision in the forms in (92) as well since in each form the velar is followed by a vowel with greater aperture than the high vowels. Since elision is not seen, the motivation behind the Velar Elision constraint is most probably not conservation of effort.

A.2 Markedness Motivated by Auditory Contrasts

According to Flemming’s dispersion theory of contrast (1995), the distinctions between different lexical items are formed in such a way as to maximize the distinctiveness of contrasts, maximize
the number of contrasts, and minimize the effort required to produce those contrasts. A contrast is any auditory property such as formant frequency, loudness, voice onset time, etc. that is relevant to the phonology (2002:17). In such a theory, any environment that takes away from the distinctiveness of a contrast can be considered as marked.

Returning back to Japanese velar elision, if a velar consonant should somehow alter the phonetic quality of the following vowel in such a way as to make it sound more like another vowel, then we have motivation for the deletion of the velar. Thus for instance, in many languages, coronals condition the fronting of vowels (making them sound more like front vowels) and labials condition the rounding of vowels (making them sound more like back vowels). The problem that we are dealing with is velars and vowel height, which is directly correlated to the first formant (F1). But as I stated in §1.2.2, velars do not have any impact on the first formant. If velars do not alter the first formant of the following vowel, there isn’t any reduction in height contrast.

The other possibility is that the vowels have altered the phonetic quality of the consonant. While there is a cross-linguistic tendency for velar stops to be fronted, the problem is that the environment also includes the back high vowel as well, which obviously does not cause the velar stop to front. Given this it is extremely difficult to motivate the markedness of a velar stop before a high vowel from a perceptual angle.

A.3 Markedness Motivated by Physiological Factors

Having failed to motivate the Velar Elision constraint on the grounds of articulatory effort and auditory contrast, that leaves physiological factors as the final option. This option, however, turns out to be much more fruitful. A velar stop is articulated by forming a closure by raising the body of the tongue until it makes contact with the velum or the soft palate (Ladefoged and Maddieson 1996). High vowels also involve a raising of the tongue body towards the velum of the soft palate (depending on whether it is a front or a back high vowel), although not to the extent that a closure is formed. Thus velar stops and high vowels involve not only the same articulators, but also
involve the same motion of those articulators.

It is clear that if the existence of such a constraint as VELAR ELISION, and in more general, the relationship between high vowels and velar consonants that I have argued for, is to be motivated (and indeed it must be) then it is to be done so by considering physiological factors of the articulation of the velar consonants and the high vowels.
Appendix B - The Coronal Node

B.1 Motivating the Coronal Feature

Throughout the thesis I have assumed that the front vowels contain the coronal node. This assumption has had no direct impact on the argument, and in fact the entire argument of the thesis could conceivably be reworked with [-back] as the feature distinguishing front vowels from back vowels. While it is orthogonal to the main argument, in order to explicitly specify the featural hierarchy of the high vowels (in particular the high front vowel), the coronal component of the high front vowel needs to be motivated in Japanese.33

The relationship between the front vowels and the palatal glide can be seen in the diachronic coalescence that occurred in the Sino-Japanese stratum. Following are listed several reconstructions of kan'on forms at the time of borrowing and their corresponding modern forms.

(93) diachronic vowel coalescence in the Sino-Japanese stratum

<table>
<thead>
<tr>
<th>historic</th>
<th>modern</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. eu</td>
<td>yo:</td>
<td>'waist'</td>
</tr>
<tr>
<td></td>
<td>teu</td>
<td>'morning'</td>
</tr>
<tr>
<td></td>
<td>keu</td>
<td>'to pinch'</td>
</tr>
<tr>
<td>b. ou</td>
<td>o:</td>
<td>'yellow, golden'</td>
</tr>
<tr>
<td></td>
<td>tou</td>
<td>'east'</td>
</tr>
<tr>
<td></td>
<td>kou</td>
<td>'throat'</td>
</tr>
<tr>
<td>c. iu</td>
<td>yu:</td>
<td>'friend'</td>
</tr>
<tr>
<td></td>
<td>tiu</td>
<td>'morning'</td>
</tr>
<tr>
<td></td>
<td>kiu</td>
<td>'nine'</td>
</tr>
<tr>
<td>d. tu:</td>
<td>tsu:</td>
<td>'to hurt, pain'</td>
</tr>
<tr>
<td></td>
<td>ku:</td>
<td>'sky'</td>
</tr>
</tbody>
</table>

As (93a) shows, front mid vowel followed by a back high vowel coalesced to become a palatal glide followed by long back mid vowel. Comparing minimal pairs in (93a) and (93b) show that the historical forms differ in only the frontness of the first vowel, whereas the modern versions of the same minimal pairs differ only in the presence of a palatal glide. The forms in (93c) and (93d)

33 I say this because although there are a significant number of arguments for front vowels containing a coronal node (c.f. §1.2.2) a priori it is theoretically possible that the phonemes that act as the Japanese front vowels do not contain a coronal node.
show the same, but this time with a high vowel. From this we can conclude that the distinctive feature that accounts for the difference between front and back vowels is also the feature that accounts for the palatal glide in the modern day forms.

At this point, our interim conclusion is that there is some feature that is inherent to both front vowels and the palatal glide, but we have yet to make any claim as to what that feature is. Itô and Mester (1989) argue that palatalization is in fact coronalization. If this is the case, then the emergence of the palatal in (93b,d) is due to the retention of the coronal feature when the vowels coalesce. The gist of Itô and Mester’s argument follows.

The addition of the palatalization morpheme to a word in the mimetics stratum adds a feeling of ‘uncontrolledness’, or more specifically, conveys a sense of ‘childhood, immaturity, instability, unreliability, uncoordinated movement, diversity, excessive energy, noisiness, lack of elegance, and cheapness’ (Hamano 1986:239 as cited in Itô and Mester 1989:268). Minimal pairs are given in (94), with the palatalization morpheme represented by the capital letter Y (all examples are from Itô and Mester 1989).

(94) kasa-kasa ‘rustling sound’
    kasYa-kasYa ‘noisy rustling sound’
    kata-kata ‘homogeneous hitting sound’
    katYa-katYa ‘nonhomogenous hitting sound’
    noro-noro ‘slow movement’
    nYoro-nYoro ‘slow wiggly movement’

Itô and Mester list four generalizations about the distribution of the palatalization morpheme, summarized in (95).

(95) i. *monopalatality* – on the surface, palatalization only occurs on one consonant per root.
    - pYoko-pYoko ‘jumping up and down’
    - pYokYo-pYokYo
    - potYa-potYa ‘splashing’
    - pYotYa-pYotYa

ii. *initiality* – palatalization of non-coronals occurs on the root-initial consonant, and never on a medial consonant.

---

34 There are no Sino-Japanese morphemes pronounced [u:] with which to form a minimal pair with [iu].
pYoko-pYoko ‘jumping up and down’ * pokYo-pokYo
pYoko-pYoko ‘lightly, nimbly’ * hokYo-hokYo

iii. **coronal dextrality and dominance** – palatalization occurs on the right-most coronal within a root. This takes precedence over the palatalization of non-coronals.

metYa-metYa ‘destroyed, extremely’
kasYa-kasYa ‘noisy rustling sound’
dosYa-dosYa ‘in large amount’
nYoki-nYoki ‘sticking out, one after another’

iv. **rhotic exclusion** – the retroflex flap r, although coronal, is never palatalized in the mimetic stratum.

nYoro-nYoro ‘slow wriggly movement’ *norYo-norYo
gYoro-gYoro ‘goggle-eyed’ *gorYo-gorYo

To account for the generalizations, Ito and Mester assume that palatalization is an independent morpheme that lies on its own autosegmental tier. To associate itself correctly to the root, it scans the root from right to left looking for consonantal segment containing a coronal feature. If it finds one, the palatalization morpheme then docks onto that coronal consonant. If after scanning the root it comes to the left edge without finding a coronal consonant, then the palatalization morpheme automatically docks to the consonant at the left edge. The morpheme does not dock onto the segment r because it is underspecified for the feature coronal (see Ito and Mester 1989:273-6 for relevant argumentation). The key point to be observed is that palatalization interacts with coronals.

But the fact that the palatalization morpheme interacts with coronals alone is not sufficient, as the question still remains, what is the featural makeup of the palatalization morpheme. Ito and Mester initially follow the SPE tradition that palatalization is due to the feature [-back], but point out the inadequacies of such a proposal, and instead opt for [-anterior]. To be consistent with my assumptions on features, we need to assume that the presence of a coronal node automatically entails the presence of the anterior feature. The target morpheme is then scanned right to left for the feature anterior. If it is found, then it is changed to [-anterior]. If an anterior feature is not
found, a coronal node with a [-anterior] feature is associated to the V-Place of the leftmost segment, resulting in secondary articulation.

The essential point here is that the coronal node is necessarily present in any segment that is palatalized. Given this we can now go back to the diachronic changes in (93), and safely conclude that it is the preservation of the coronal node of the front vowels that accounts for the palatalization. In conclusion, having motivated both the coronal node and the dorsal node, the featural hierarchy of the high front vowel looks like this:

(96)

\[
\begin{array}{c}
\text{root} \\
\text{C-place} \\
\text{V-place} \\
\text{coronal} \\
\text{dorsal}
\end{array}
\]

\[\begin{array}{c}
\text{[+sonorant]}
\text{[+approximant]}
\text{[+vocoid]}
\text{[+high]}
\end{array}\]

B.2 The Coronal Co-occurrence Restrictions

As mentioned in §2.2.1, there are certain combinations of coronals that do not occur, or only occur in certain strata. This section is a further elaboration of the constraints and constraint ranking that govern the distribution of coronals in the four different strata.

The following combinations do not occur in any strata:


The occurrence of alveo-palatals is also restricted. The following combinations are restricted to the foreign strata:

(98) s\text{e}, t\text{e}, d\text{e}

The Sino-Japanese and mimetics strata allow alveo-palatals except before e. The native stratum does not allow alveo-palatals at all except as allophones of t, d, s, and z before the high front vowel and the palatal glide.
The first set of restrictions can be accounted for with an OCP constraint *[cor][cor] that is only active if the one of the coronal segments are specified as [+hi]. To briefly recap the discussion of this constraint in §5.2, violations of the OCP constraint are avoided in candidates that contain only a single coronal node that is linked to both segments. However, since vowels and approximants are necessarily [-anterior], and the anterior feature is associated to the coronal node, any candidate with only a single coronal node must use coronal consonants articulated in the posterior region. This forces \( t, d, s, \) and \( z \) to become alveolopalatals before the high front vowel and the palatal glide.

But how can we account for the limited distribution of (98)? Clearly, there is at least one other constraint active beside the OCP constraint. One approach would be to use purely descriptive markedness constraints such as *fe.\(^{35}\) While this would allow for the development of an Optimality Theoretic solution, as mentioned in Appendix A, any usage of descriptive markedness constraint seriously weakens the theory.

Insight can be found by looking at the historical reconstructions of the Japanese inventory. According to reconstructions of OJ (c.f. Kishida 1998, Lange 1973, Syromiatnikov 1981, Yoshitake 1934, etc.), alveolopalatals were not a part of the phonemic inventory. This absence of alveolopalatals can be accounted for by the following markedness constraint:

\[
\text{(99) *ALVEOLOPALATAL} - \text{alveolopalatals ([-approximant], [continuant], [-anterior]) are not allowed}
\]

The phonemic inventory of the native stratum can then be accounted for by the following ranking:

\[
\text{(100) OCP} \gg \text{*ALVEOLOPALATAL} \gg \text{faithfulness}
\]

Here faithfulness denotes the various faithfulness constraints that would require an alveolopalatal in the UR to be retained as such in the surface representation. This constraint ranking bans

\(^{35}\) See Itō and Mester (1995, 2000) for an analysis that resorts to descriptive markedness constraints to account for these coronal co-occurrence restrictions.
alveolopalatals unless they are required to avoid a violation of the OCP constraint. The following two tableaux illustrate this:

(101) |  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i. /si/, /fi/</td>
<td>OCP</td>
<td>*ALVEOLOPALATAL</td>
<td></td>
</tr>
<tr>
<td>a. si</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ^Ji</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>ii. /se/, /fe/</td>
<td>OCP</td>
<td>*ALVEOLOPALATAL</td>
<td></td>
</tr>
<tr>
<td>a. ®&quot; se</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Je</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

In the first tableau, the alveolopalatal is always chosen, regardless of the UR. In the second tableau, the alveolopalatal is never chosen, regardless of the UR. This accounts for the distribution of the alveolopalatals in the native stratum, namely that they only occur only as allophones before the high front vowel.

The distribution of alveolopalatals in the foreign stratum is straightforward: the alveolopalatals occur before all of the vowels. This means that faithfulness outranks the restriction on alveolopalatals. Following is the constraint ranking for the foreign stratum:

(102) OCP \gg \textit{faithfulness} \gg \textit{*ALVEOLOPALATAL}

Because the OCP constraint still dominates faithfulness, \( ty, dy, sy \), etc. will be ruled out.

The Sino-Japanese stratum is interesting in that alveolopalatals occur, but not before \( e \). This is neither like the native stratum, nor like the foreign stratum. At first glance, it appears as if we need more constraints. However, it turns out that the Sino-Japanese alveolopalatals correspond to Middle Chinese retroflexes (c.f. §4.3.1). Middle Chinese had its own co-occurrence restriction prohibiting retroflex consonants before front vowels (Pulleyblank 1984:p.25). This accounts for the appearance of alveolopalatals before the back vowels in Sino-Japanese. But then why do still we see \( fi, tfi, \) and \( dz\bar{i} \)? These appear as the borrowings of Middle Chinese \( si, zi, ti \) and \( di \), which
were prohibited in OJ but not in MC. Thus the Sino-Japanese stratum has the same constraint ranking as the foreign stratum.

This leaves the mimetics stratum. Again given *ALVEOLOPALATAL we expect to not see alveolopalatalals. They however occur to satisfy the palatalization process. But why don’t we see $fe$, $tfe$, and $dje$? These should occur as the palatalized versions of $se$, $ze$, and $te$. If we use the same ranking as the foreign and SJ strata, then alveolopalatalals will be allowed to occur as long as they do not violate the OCP constraint. Assuming that the palatalization process inserts a fully specified palatal glide (i.e. specified for [coronal] and [+hi]), then this constraint ranking can account for why forms that use $fe$, $tfe$, and $dje$ are ruled out.\(^\text{36}\) In the following tableaux, *faithfulness* has been replaced by the constraints MAXIO(coronal) and MAXIO(+hi), and the palatalization morpheme is indicated by Y (tY is a palatalized alveolar which is then phonetically interpreted as alveolopalatal).

\(^\text{36}\) At this point I am not clear about the occurrence of alveolopalatalals in the mimetic stratum outside the palatalization process. Itô and Mester point out that there are a few cases of mimetics with palatalization that do not have nonpalatalized counterparts, and give the examples munya-munya and uja-uja (p.269). However, uza-usaha is listed in the *Koujien* as having the same meaning as uja-uja. Consultations with native speakers were not able to produce a single example of a mimetics stratum word with palatalization that did not have a nonpalatalized counterpart, other than the example munya-munya. This shows that they are sparse at best. The cases such as munya-munya that do exist are most likely due to their nonpalatalized counterparts gradually falling out of use. If this is true, then we need to ban any occurrences of alveolopalatalals outside of the palatalization process. This however falls out of the constraint ranking naturally, as if we assume that alveolopalatalals only occur in the mimetics stratum to either avoid OCP violations or to satisfy faithfulness to the palatalization morpheme. The following tableau illustrates this:

\[
\begin{array}{|c|c|c|c|}
\hline
\text{\textit{fe, su, jo, ja}} & \text{OCP} & \text{MAXIO (coronal)} & \text{MAXIO (+hi)} & \text{*ALVEOLO PALATAL} \\
\hline
\text{a. fe, su, jo, ja} & & & & *! \\
\text{b. se, su, so, sa} & & & & \\
\hline
\end{array}
\]
In the first tableau, candidate (c) violates the OCP constraint since the palatalization morpheme, which is [coronal] and [+hi], is both preceded and followed by a coronal. Candidate (b) avoids the OCP violation by using a single coronal node shared between the phonemes. This however violates the faithfulness constraint MAXIO(coronal) twice. The candidate without palatalization turns out to be optimal. The second tableau shows an example where palatalization is allowed to occur. Again an OCP violation is avoided in candidate (c) by sharing a single coronal node. This results in a single violation of the faithfulness constraint MAXIO(coronal), the same as candidate (a) without palatalization. However candidate (a) does not retain the [+hi] feature, resulting in it being ruled out. Thus the same constraint ranking as the foreign and OJ strata also allows us to account for the distribution of the alveolopalatals in the mimetics stratum.

What has been presented here is far from a complete account of the phonology of the mimetics, as none of Itô and Mester’s generalizations have been accounted for. However a more thorough analysis is beyond the scope of this thesis. But what has been done is a derivation of the distribution of the alveolopalatals in the various strata without resorting to the usage of arbitrary markedness constraints.
References


Jacobs, Haise and Carlos Gussenhoven. (2000) ‘Loan Phonology: Salience, the Lexicon and


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