Coda Constraints and Conditions on Moraic Projection

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In this paper compensatory lengthening is accounted for by invoking the mechanism of mora projection. In the containment model of Optimality Theory, in which this paper is couched, any input segment is contained in the output; if this segment is phonetically unrealized, it may nonetheless exert influence on the shape of the output, as an unparsed segment. Here we explore cases in which a moraic position is projected by an unparsed segment, and filled by a parsed segment which is not responsible for mora projection, thus leading to compensatory lengthening. The unparsed segment is "deleted" in order to avoid constraint violation; here we focus on coda constraints and their interaction with compensatory lengthening. We present three cases of compensatory lengthening, Pali, Japanese and Piro, addressing also the issue of mora projection as related to possible mora fillers in a language, based on the Italian facts. While the conclusions of this paper are not tenable within the correspondence model of Optimality Theory (McCarthy and Prince 1995), we include it in this volume because certain aspects of our findings do not crucially depend on the framework in which this study has been framed.

1 Introduction

The focus of this paper is a specific type of compensatory lengthening, manifested as a pattern of segment loss accompanied by gemination. This phenomenon is elucidated in the studies of three unrelated languages—Pali, Japanese and Piro, and its theoretically relevant facets are captured within Optimality Theory (Prince and Smolensky 1991, 1992, 1993, McCarthy and Prince 1993 and the references therein); the characterizations of compensatory lengthening in the languages studied here are remarkably similar when viewed from this perspective. The analysis crucially relies on minimal constraint violation, one of the central aspects of Optimality Theory, a constraint-based framework in which output forms are evaluated with respect to a set of ranked constraints. Two functions play a crucial role in this framework: Gen, which associates each input with a candidate set of possible analyses, and H-eval, which determines which of the outputs best satisfies the constraint set (Prince and Smolensky 1993:4). The basic principles of the framework are listed below (following McCarthy and Prince 1993:1-2):

(i) **Violability**: Constraints are *violable* (but violation is minimal).
(ii) **Ranking**: Constraints are *ranked* on a language-particular basis, forming a constraint hierarchy.
(iii) **Parallelism**: Best-satisfaction of the constraint hierarchy is computed over the

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whole hierarchy and the whole candidate set.

Within the autosegmental framework, compensatory lengthening is represented in a straightforward fashion, as originally noted in Ingria (1980): segment loss and the concomitant lengthening (or gemination) are not directly related, but are instead mediated through the "timing" tier. In the hypothetical examples in (1.1), the segment \( p \) is lost, yet its prosodic projection on the "timing" (here, moraic) tier remains, and is filled by an adjacent segment, the preceding one in (1.1a), and the following one in (1.1b).

(1.1) a. \[ \begin{array}{c}
\sigma \\
\mu \\
\downarrow \\
\emptyset \\
\end{array} \]

\[ \begin{array}{c}
\sigma \\
\mu \\
\downarrow \\
\emptyset \\
\end{array} \]

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

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

In a constraint-based framework, this simple and highly intuitive scenario gives rise to a paradox. Two constraints are needed, one that dictates the inclusion of \( p \) into syllable structure, and is thus responsible for the projection of a prosodic position; and another, which prohibits the occurrence of this segment within the syllable, and is responsible for its disappearance from the structure. In order to have an empty prosodic position, both constraints need to take effect, yet they are in direct conflict with each other.

The crucial question to ask is whether the segment responsible for a prosodic position is necessarily included in the syllable structure. My answer will be negative, and in order to show this, we turn to the alignment of segments with weight units, the only "timing" slots that are recognized within the moraic framework (Hyman 1985, Hayes 1989, Zec 1988, Ito 1989).

The alignment of segments and moras is governed by sonority: any segment whose sonority is at least equal to, if not greater than, that of the following segment projects a mora. This is formally captured by MORAIC PROMINENCE, a general constraint on moraic structure (see also Zec 1988:100-105):

(1.2) MORAIC PROMINENCE (preliminary version):
Segment \( r_i \) projects (and links to) a mora iff it is not followed by a more sonorous segment \( r_j \).

\[ \begin{array}{c}
\mu \\
\downarrow \\
r_i \\
r_j \\
\end{array} \]

Condition: \( \text{Son} (r_i) \geq \text{Son} (r_j) \)
Here, \( r_i \) and \( r_j \) stand for adjacent root nodes; \( r_i \) is aligned with a mora only if it forms a sonority peak, that is, if its sonority is not lower than that of the following segment (with vowels being the most sonorous, and obstruents the least sonorous ones). The background assumption is that moras are freely inserted by Gen, and then their affiliations are evaluated by **Moraic Prominence**.

In English, for instance, the parse of the string *simply* in (1.3a) adheres to the constraint in (1.2), while those in (1.3b) and (1.3c) do not. In (1.3b) this is due to the failure of \( m \) to project a mora, although it is followed by a less sonorous segment; and in (1.3c) this is because the segment \( p \) projects a mora, yet it is followed by a more sonorous segment.\(^1\)

\[
\text{(1.3) a. } \mu \mu \mu \\
\text{ s i m p l y }
\]

\[
\text{b. } * \mu \mu \\
\text{ s i m p l y }
\]

\[
\text{c. } * \mu \mu \mu \mu \\
\text{ s i m p l y }
\]

**Moraic Prominence** will act in tandem with a constraint setting the sonority threshold on moras (Prince 1983, Zec 1988, 1995). Languages may admit all segments as mora projectors, as is the case in English, or may restrict this set to a sonority class, say, the class of vowels, or sonorants (for examples, see Zec 1995).

As stated in (1.2), **Moraic Prominence** expresses the fact that, in English, the segment that projects a mora necessarily links to the projected mora. In certain other languages, however, this is not necessarily the case, and this is accounted for by factoring out mora projection and segment linking. The revised statement of **Moraic-Prominence** in (1.4) captures only the general aspect of this constraint, that is, the principles of mora projection, represented here by coindexing:

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\(^1\)English is used here simply to illustrate the relevant point. For a detailed analysis of English within the moraic framework, see Lamontagne (1993).
(1.4) **MoraicProminence** (final version):
Segment \( r_i \) projects a mora iff it is not followed by a more sonorous segment \( r_j \).

\[ \mu_i \]

\[ r_i \quad r_j \]

Condition: \( \text{Son} (r_i) \geq \text{Son} (r_j) \)

In (1.5) is given an explicit representation licensed by (1.4), with both segments and moras fully linearized: segments form a total ordering, and each mora is aligned, and coindexed, with the segment which projects it.\(^2\)

(1.5) \[ \mu_j \mu_k \mu_m \]

\[ s_i \quad i_j \quad m_k \quad p_l \quad 1 \quad y_m \]

Segment linking is subsumed under the general constraint **Parse** (Prince and Smolensky 1993, McCarthy and Prince 1993), which governs the inclusion of segments into prosodic structure. **Parse** ranks high in English and other languages in which the segment projecting a mora necessarily links to the projected mora; in languages in which this is not necessarily the case, it ranks low (i.e., may be violated).

(1.6) **Parse**: A segment has to be incorporated in syllabic or moraic structure.

Relevant in this context is also the constraint **Fill**, which ensures that a mora be filled by some segment (not necessarily the one responsible for its projection).

(1.7) **Fill**: A mora must be filled with (i.e., must dominate) a segment.

(Prince and Smolensky 1993, McCarthy and Prince 1993)

These three constraints, **MoraicProminence**, **Parse**, and **Fill** play central roles in the three case studies to be presented here—those of Pali, Japanese and Piro. Crucially, in all these languages, the segment responsible for projecting a mora may remain unparsed, yet the projected mora has to be filled, a scenario accounted for in terms of constraint ranking.

A comment is in order on the principles that govern filling moraic positions with segments. Ideally, a moraic position is filled by the segment that projects it, that is, segments \( r_j, r_k \), and \( r_n \) in (1.8).

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\(^2\)**MoraicProminence** ought to be accompanied with the following proviso, in order to insure that segments and projected moras are properly linearized: If segments \( r_i \) and \( r_j \) project moras \( \mu_i \) and \( \mu_j \) respectively, and if \( r_i \) precedes \( r_j \), then \( \mu_i \) precedes \( \mu_j \).
Failing this, due to an interference with Parse, a mora ought to be filled by a segment adjacent to the projector. Assuming that, in (1.9), \( r_k \) may not be parsed, the only potential fillers are \( r_i \) and \( r_j \), as in (1.9a) and (1.9b) respectively. Filling an empty moraic position with a segment that is not adjacent to the projector, say, \( r_m \) in (1.9c), gives rise to an illicit representation.

In other words, a moraic position ought to be filled locally, by linking to a parsed segment that best satisfies this requirement. This condition is reminiscent of the prohibition against crossing association lines (Goldsmith 1976, Sagey 1986, Bird and Klein 1990), and is stated as a constraint on **Structural Coherence**:

\[
\text{(1.10) \textit{Structural Coherence}: Moraic positions have to be filled locally.}
\]

A more explicit statement of what constitutes a locally filled mora is given in (1.11):

\[
\text{(1.11) A moraic position } \mu_i \text{ projected by segment } r_i \text{ is filled locally iff}
\]

(a) \( \mu_i \) is filled by \( r_i \), or

(b) \( \mu_i \) is filled by \( r_n \), such that \( r_n \) is adjacent to \( r_i \)
This general condition, which is stated here disjunctively, should in fact be broken down into at least two constraints, ranked with respect to each other, and interacting with the requirement to parse segments. Here, it will be tacitly assumed that constraint (1.10) is satisfied by a representation consistent with (1.11b) only if (1.11a) is not available due to the interference of PARSE. The effect of constraint (1.10) will become obvious in the discussion of Piro (section 4), in which a moraic position is not filled in some cases, in order to avoid the violation of STRUCTURALCOHERENCE.

The paper proceeds as follows: the three case studies are presented in sections 2 - 4, Pali in section 2, Japanese in section 3, and Piro in section 4; certain residual issues are addressed in section 5, and the concluding remarks are given in section 6.

2 Pali

The complex system of Pali syllable structure is partly manifested as an elaborate pattern of cluster simplification (Geiger 1968, Hankamer and Aissen 1974, Junghare 1979, Murry 1982, Wetzels and Hermans 1985, Cho 1990, Vaux 1992), which provides ample evidence for the capacity of an unparsed segment to project a moraic position.

A syllable in Pali may include at most one consonant in the onset, and one in the coda. In addition, Pali exhibits the bimoraic constraint: CV syllables are light, CVV and CVC syllables are heavy, and there are no super heavy (either CVVC or CVCC) syllables in the inventory. These facts are summarized in (2.1).

(2.1)  
   a. light CV vs. heavy CVV, CVC
   b. no super heavy syllables: *CVVC, *CVCC
   c. at most one onset consonant: *CCV, *CCVV, etc.

Moreover, special restrictions hold of the coda consonant, which may be either a nasal (placeless, or homorganic with the following stop) or the first half of a geminate, as stated in (2.2):

(2.2) Consonants permitted in the coda:
   a. nasal (placeless, or homorganic with the following stop)
   b. first half of a geminate consonant

These properties are brought into relief by comparing Pali forms with those in Sanskrit, a "parent" language of Pali. While Sanskrit permits a fairly free occurrence of word-final consonants, Pali prohibits consonants in word-final position, as shown in the following examples taken from Geiger (1968:108).
(2.3) Loss of word-final consonants in Pali

<table>
<thead>
<tr>
<th>Skt.</th>
<th>Pali</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>tatas</td>
<td>tato</td>
</tr>
<tr>
<td>b.</td>
<td>punar</td>
<td>puno, puna</td>
</tr>
<tr>
<td>c.</td>
<td>pra:patat</td>
<td>papata:</td>
</tr>
</tbody>
</table>

The range of consonant clusters is highly limited in Pali. Further comparison with Sanskrit shows that the only type of Sanskrit cluster retained in Pali is a nasal followed by homorganic stop, as in (2.4a). Otherwise, Sanskrit biconsonantal clusters were simplified in two fashions: in word internal contexts, the two consonants were reduced to one which geminates, as in (2.4b-e), while in word-initial position we encounter only cluster reduction, with no concomitant gemination, as shown in (2.5).

(2.4) Simplification of intervocalic clusters:

<table>
<thead>
<tr>
<th>Skt.</th>
<th>Pali</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. nasal + stop</td>
<td>danta</td>
<td>danta</td>
</tr>
<tr>
<td></td>
<td>sambuddha</td>
<td>sambuddha</td>
</tr>
<tr>
<td>b. stop + stop</td>
<td>mudga</td>
<td>mugga</td>
</tr>
<tr>
<td></td>
<td>sakthi</td>
<td>satthi</td>
</tr>
<tr>
<td></td>
<td>bhakta</td>
<td>bhatta</td>
</tr>
<tr>
<td></td>
<td>śabda</td>
<td>sadda</td>
</tr>
<tr>
<td></td>
<td>sapta</td>
<td>satta</td>
</tr>
<tr>
<td>c. liquid + stop</td>
<td>karka</td>
<td>kakka</td>
</tr>
<tr>
<td></td>
<td>sarpa</td>
<td>sappa</td>
</tr>
<tr>
<td></td>
<td>vacca</td>
<td>vakka</td>
</tr>
<tr>
<td></td>
<td>kilbiṣa</td>
<td>kibbisa</td>
</tr>
<tr>
<td>d. liquid + fric</td>
<td>karṣaka</td>
<td>kassaka</td>
</tr>
<tr>
<td></td>
<td>sparsa</td>
<td>phassa</td>
</tr>
<tr>
<td>e. liquid + nasal</td>
<td>dharma</td>
<td>dhamma</td>
</tr>
<tr>
<td></td>
<td>karna</td>
<td>kaṇṇa</td>
</tr>
<tr>
<td></td>
<td>kalmaṣa</td>
<td>kammasa</td>
</tr>
</tbody>
</table>

(2.5) Simplification of word-initial clusters:

<table>
<thead>
<tr>
<th>Skt.</th>
<th>Pali</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>traana</td>
<td>taana</td>
<td>'protection'</td>
</tr>
<tr>
<td>kramat</td>
<td>kamati</td>
<td>'walks'</td>
</tr>
<tr>
<td>prati</td>
<td>paṭi</td>
<td>'against'</td>
</tr>
<tr>
<td>śvaśru</td>
<td>sassu</td>
<td>'mother-in-law'</td>
</tr>
</tbody>
</table>

---

3 The data in this paper are taken from Fahs (1985), Geiger (1968), and Junghare (1979).
4 Root-initial clusters in (2.5) which are simplified in word-initial position, result in gemination if a prefix precedes the root, as in pakkamati 'goes away'. 
The asymmetry between the intervocalic clusters, whose simplification results in a geminate, and word-initial clusters, which are reduced to a simplex segment, strongly suggests that syllable weight is playing a crucial role in this case of cluster simplification.

Synchronic cluster simplifications, which take place across morpheme boundaries, parallel the simplifications attested historically. As evidenced by the forms in (2.6), a consonant cluster arising by virtue of morpheme concatenation is simplified in exactly the same fashion as in the historical data. Again, only clusters consisting of a nasal followed by a homorganic stop, as in (2.6 d, k, l), and geminate consonants, as in all the other cases listed in (2.6), are permitted in intervocalic position.

(2.6) Synchronic cluster simplification (across morpheme boundaries):

-tun (infinitival marker)

| a. vas + tun | vatthuN | cf. vasati | ‘to dwell’ |
| b. kar + tun | kattuN | cf. karoti | ‘to make’ |
| c. labh + tun | laddhuN | cf. labhati | ‘to take’ |
| d. khan + tun | khantuN | cf. khanati | ‘to dig’ |

-la (past. part)

| e. sup + ta | sutta | cf. supati | ‘to sleep’ |
| f. tap + ta | tatta | cf. tapati | ‘to shine’ |
| g. caj + ta | catta | cf. cajati | ‘give out’ |
| h. kas + ta | kattha | cf. kasati | ‘to farm’ |
| i. aarabh + ta | aaraddha | cf. aarabhati | ‘to begin’ |
| k. dam + ta | danta | cf. dameti | ‘to tame’ |
| l. vam + ta | vanta | cf. vamati | ‘to investigate’ |

-na (past. part)

| m. nud + na | nunna | cf. nudati | ‘to remove’ |
| n. lag + na | lagna | cf. lagati | ‘to attach’ |
| o. han + na | hanna | cf. hanati | ‘to empty’ |
| p. kir + na | kinya | cf. kirasi | ‘to strew’ |

-yu (passive)

| r. kar + ya | kayya | cf. karoti | ‘to make’ |
| s. mas + ya | massa | cf. masati | ‘to touch’ |
| t. kas + ya | kassa | cf. kasati | ‘to farm’ |
| u. pac + ya | pacca | cf. pacati | ‘to cook’ |
| w. khan + ya | khanja | cf. khanati | ‘to cook’ |
| y. dam + ya | damma | cf. dameti | ‘to tame’ |

The gist of the analysis to be presented is that consonant gemination forms a pattern of its own, independent of the patterns associated with consonant loss. Constraints on syllable margins, specifically on codas, are posited to capture the pattern of consonant loss, while consonant gemination is attributed to MORAICPROMINENCE, introduced in the previous
section, which governs the alignment of moras and segments. What contributes to the complexity of this system, I believe, is that different aspects of the phonological structure impose conflicting requirements, which is made fully explicit under the approach developed in Optimality Theory.

2.1 Constraints on codas

As already noted, a Pali syllable may be closed either by the first half of a geminate or by a nasal, placeless or homorganic with the following stop. This pattern strongly suggests that consonantal place features are prohibited in the coda (cf. Itô 1986, Goldsmith 1990). This is expressed by positing a constraint which disallows the consonantal place node in syllable-final position (Itô 1986, 1989), as stated in (2.7):

(2.7) NOPLACEINCODA: Consonantal place is prohibited syllable-finally

* [+cons] _σ
  |
Place

A consonant in syllable-final position may satisfy this constraint by being linked to both the onset and the coda, since consonantal place occurs freely in the onset. The linking may be either partial, as in the forms listed in (2.6 d, k, l), or total, giving rise to geminate consonants, as in all the other forms listed in (2.6).

However, nasal consonants may satisfy this constraint in yet another fashion. In addition to being homorganic with the following stop, a nasal may also be placeless, assuming the form of anusvara (cf. Trigo 1988). A nasal is realized as an anusvara (marked as N) if it is word-final or followed by a [+ continuant] consonant. Examples of anusvaras in word-final position and before s are given in (2.8):

(2.8) a. janāṇ ‘knowing (nom.sg.ppr.)’
b. vicarāṇ ‘wondering (nom.sg.ppr.)’
c. hāṇsati ‘bristles’
d. kāṇsa ‘vessel made of metal’
e. pāṇsu ‘dust’

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5 Cho (1989) recognizes the need for a coda constraint in Pali. The constraint she proposes (p. 226), however, prohibits all features in the coda; the facts discussed in this section make it clear that the prohibition should be restricted to the place features.

6 An alternative formulation of this constraint would be to allow the place features only in the onset, following the proposal of Lombardi (1991). The two formulations yield identical results in the case under discussion, although they may be empirically different in more complex cases.
Forms derived with the prefix \textit{saN-}, listed in (2.9), provide further examples of anusvaras. The coda nasal adopts the place features of the following [-continuant] consonant, as in (2.9a-e), and remains placeless if the following consonant is [+continuant], as in (2.9f-i) (Junghare 1979:52, 99).

\begin{enumerate}
\item sampamodi\textit{ta} cf. pamodi\textit{ta} ‘delighted’
\item sambuddha cf. buddha ‘enlightened’
\item sandhamati cf. dhamati ‘blows’
\item sandhuupeti cf. dhupeti ‘fumigates’
\item sannidha\textit{ana} cf. nidha\textit{ana} ‘putting down’
\item saNyamati cf. yamati ‘draws together’
\item saN\textit{rakkhati} cf. rakkhati ‘guards’
\item saN\textit{vasati} cf. vasati ‘cohabitates’
\item saNyufjati cf. yufjati ‘joins with’
\end{enumerate}

In sum, the nasal may possess place features only if it shares them with a following [-continuant] consonant, which appears in the onset, where place features are fully licensed. Word-finally, as in (2.8 a, b), no place features can be provided by an onset-linked consonant, and in this position the nasal is placeless. This analysis is supported by the fact that the preceding vowel is nasalized, which according to Trigo (1988) typically occurs in the environment of a placeless nasal.\footnote{Trigo (1988) refers to placeless, or debuccalized, nasals as nasal glides, and notes the process of nasal “absorption” whereby a nasal glide causes the nasalization of the preceding vowel.}

That a placeless nasal, or anusvara, also appears before a [+continuant] consonant, as in (2.8 c, d, e) and (2.9 f-i), is accounted for by invoking the constraint on segment structure in (2.10), which prohibits nasals marked as [+continuant] (following Padgett 1991).

\textbf{(2.10)} \textit{No[+cont]NAsal: A nasal may not be [+cont]}

\begin{verbatim}
 * [Nasal]
 | [cont]
\end{verbatim}

If we further assume that the feature [continuant] is a dependent of Place (Padgett 1991), then it follows that segments sharing their place features also share the specification for continuancy. Thus, a nasal sharing its place features with a [+continuant] consonant would have to be marked as [+continuant], in violation of the constraint in (2.10), which prohibits [+continuant] nasals. Instead, the nasal remains placeless in this context, as evidenced by the nasalization of the preceding vowel.
The nasalized vowel which precedes the anusvara is regularly short, as in (2.8), or shortened if the anusvara belongs to a suffix added to a stem that ends in a long vowel, as in (2.11) (see Junghare 1979:85). Here, the accusative ending is a nasal, which is realized as an anusvara; the preceding vowel is shortened and nasalized.

(2.11) The vowel preceding the anusvara is short and nasalized:

a. sasu: (nom.sg.) sasūN (acc.sg.) ‘mother-in-law’
b. nadi: (nom.sg.) nādiN (acc.sg.) ‘river’
c. kaṇṇa: (nom.sg.) kaṇṇāN (acc.sg.) ‘girl’

This I take as further evidence that the anusvara is indeed present in the structure. Although it is claimed in Junghare (1979:52) that the nasal is dropped in this context, I argue that vowel shortening can be accounted for only under the assumption that the nasal segment remains in syllable-final position. The presence of an additional segment in syllable-final position contributes a third mora, which leads to vowel shortening, since a syllable in Pali is maximally bimoraic.⁸

However, given that the anusvara does appear word-finally and before a [+continuant] consonant, the question arises why a coda nasal is not always realized as an anusvara. This is explained by invoking another constraint on segment structure, which states that a consonant has to possess a place node.

(2.12) NOPLACELESSCONS: A consonant has to be linked to [Place].

```
[+cons]
\[ Place \]
```

Note that, regarding nasals, this constraint is satisfied only if there is a source of place features in the immediate environment, as in danta (2.4 a), but is violated if the nasal is word final, as in the accusative forms in (2.11), or adjacent to a [+continuant] consonant, as in (2.8 c, d, e) and (2.9 f - i):

(2.13) NOPLACELESSCONS is

a. observed in danta (2.6k)
b. violated in nādiN (2.11b) and hānsati (2.8c)

⁸According to Geiger (1968:63) the fact that a nasalized vowel is regularly short suggests that "every syllable with a nasal vowel is considered as closed," which is consistent with the claim advanced here that a nasalized vowel corresponds to a vowel+nasal sequence.
The paradoxical behavior stated in (2.13) is accounted for by constraint ranking: the constraint prohibiting place in the coda (\textsc{noPlaceInCoda}) and the constraint against [+continuant] nasal consonants (\textsc{no[+cont]Nasal}) rank higher than the constraint against placeless consonants (\textsc{noPlacelessCons}); while the latter may be violated, the former two never are. The ranking \textsc{noPlaceInCoda} \gg \textsc{noPlacelessCons} is shown in the tableau in (2.14), where the relevant output forms for \textit{nadi\\ü} are evaluated.

\begin{tabular}{|c|c|c|}
\hline
 & \textsc{noPlaceInCoda} & \textsc{noPlacelessCons} \\
\hline
\textit{nadi\\ü} & & \\
\textit{nadim} & *! & \\
\hline
\end{tabular}

By contrast, the best formed candidate in (2.15), \textit{danta}, violates neither of these constraints, because the nasal shares its place features with the following onset consonant.

\begin{tabular}{|c|c|c|}
\hline
 & \textsc{noPlaceInCoda} & \textsc{noPlacelessCons} \\
\hline
\textit{danta} & & \\
\textit{dan\textit{t}a} & *! & \\
\textit{dan\textit{ta}} & *! & \\
\hline
\end{tabular}

Finally, the tableau (2.16) shows that \textsc{no[+cont]Nasal} ranks higher than \textsc{noPlacelessCons}. No ranking can be established between \textsc{no[+cont]Nasal} and \textsc{noPlaceInCoda}.

\begin{tabular}{|c|c|c|}
\hline
 & \textsc{noPlaceInCoda} & \textsc{no[+cont]Nasal} & \textsc{noPlacelessCons} \\
\hline
\textit{h\textit{a}nsati} & & & \\
\textit{hansati} & *! & & \\
\textit{hamsati} & *! & & \\
\hline
\end{tabular}

In sum, \textsc{noPlacelessCons} is satisfied whenever the context provides a source of place features, and is violated if no such source is available.\footnote{Placeless nasals are never found in the onset. This is because \textsc{noPlacelessCons} can only be violated in the coda, due to the pressure of \textsc{noPlaceInCoda}. No such pressure is exerted in the onset position, therefore the best formed candidates in the onset have to possess place features.}

A further question may be asked at this point: Why is it that the placeless nasal is retained in the structure, in violation of \textsc{noPlacelessCons}? One way of satisfying all the
constraints posited thus far would be simply not to include the placeless nasal into the structure. That this option is not taken is due to the general requirement that segments should be incorporated into prosodic structure, that is, the constraint \textsc{Parse}, listed in (1.6) and repeated below.

(2.17) \textsc{Parse}: A segment has to belong to syllabic or moraic structure.

This constraint ranks higher than the constraint prohibiting placeless nasals, (\textsc{NoPlacelessCons}), which accounts for the retention of a placeless nasal in the structure, as shown in the following tableau, which lists candidate forms for \textit{hāNsati}:

(2.18)

<table>
<thead>
<tr>
<th></th>
<th>\textsc{NoPlaceInCoda}</th>
<th>\textsc{No[+cont]Nasal}</th>
<th>\textsc{Parse}</th>
<th>\textsc{NoPlacelessCons}</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textit{hāNsati}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>\textit{hansati}</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\textit{hasati}</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>\textit{hamsati}</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The relative ranking of the constraints governing the distribution of segments at the right margin of the syllable is given in (2.19):

(2.19) Constraint ranking

\[
\textsc{NoPlaceInCoda} \rightarrow \textsc{No[+cont]Nasal} \rightarrow \textsc{Parse} \rightarrow \textsc{NoPlacelessCons}
\]

Both \textsc{NoPlaceInCoda} and \textsc{No[+cont]Nasal} rank higher than \textsc{Parse} and \textsc{NoPlacelessCons}. Moreover, \textsc{Parse} ranks higher than \textsc{NoPlaceInCoda}, while the two higher ranking constraints are undominated.

2.2 \textsc{MoraicProminence} and the pattern of consonant gemination

The set of constraints proposed thus far is not sufficient to account for the complex pattern of consonant gemination resulting from morpheme concatenation. Most of the forms listed in (2.6) contain sequences of unsyllabifiable consonants which are “resolved” in the following fashion: one of the consonants is lost and the other geminates. Crucially, the lost consonant leaves a trace, so to speak, as indicated by the gemination of the survivor. But, while the constraints posited thus far account for consonant loss, they do
not account for gemination, since both the wellformed *sutta in (2.18b) and the illformed *suta in (2.18c) (see (2.6e)) conform to this set of constraints.

(2.20) a. sup + ta p.p. sup 'to sleep'
   b. sutta
   c. *suta

The two forms fare equally well, as shown in the following tableau:  

<table>
<thead>
<tr>
<th></th>
<th>NOPLACE INCODA</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>sr</em></td>
<td>sutta</td>
<td>*</td>
</tr>
<tr>
<td>supia</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>suta</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

The same is true of the forms in (2.20): both (2.20b) and (2.20c) are evaluated as equally wellformed, yet only the former is a possible surface form.

(2.22) a. kar + tuN inf. kar 'to make'
   b. kattuN
   c. *katuN

In sum, the constraints proposed thus far are neutral as to whether the survivor consonant is geminated or not. It is at this point that MORAICPROMINENCE, stated in (1.4), needs to be recognized as an important player, since it is crucial in explaining the gemination pattern.

MORAICPROMINENCE accounts for the "trace" left by the unparsed consonant; this consonant projects a mora, and is thus responsible for a prosodic position that it may not fill. Note that there is no sonority threshold on moraicity in Pali, that is, any segment may project a mora as long as it adheres to MORAICPROMINENCE. In addition, we need to invoke the constraint FILL, introduced in (1.7) and repeated below, whose high ranking is essential in accounting for gemination.

(2.23) FILL: A mora must be filled with (i.e., must dominate) a segment.

---

10A form like suCta, in which C stands for a placeless obstruent, would fare better than sutta, since the former violates NOPLACELESSCONS, which ranks lower than PARSE. This is obviously the wrong result, which suggests that the ban against placeless consonants has to be factored out into at least two constraints, one for obstruents, the other for nasals. The former would rank higher, and the latter lower, than PARSE. In other words, NOPLACELESSCONS, as ranked here, refers only to nasals.
We now turn to forms in (2.20), whose relevant output candidates are evaluated in (2.24). Note that, in this case, only Parse is violated, yielding to the higher ranked NoPlaceInCoda. A mora is projected by the unparsed segment, and also filled, which results in satisfying both MoraicProminence and Fill.\footnote{I am assuming that geminates are necessarily weight-bearing, represented as linked both to a moraic and syllabic position (Hayes 1989). An alternative view is presented in Selkirk (1990), according to which geminates are represented as segments with two root nodes.}

### (2.24) Best-formed output: sutta (sup+ta)

<table>
<thead>
<tr>
<th></th>
<th>Moraic Prominence</th>
<th>NoPlace InCoda</th>
<th>Fill</th>
<th>Parse</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram 1" /></td>
<td><img src="image2.png" alt="Diagram 2" /></td>
<td><img src="image3.png" alt="Diagram 3" /></td>
<td><img src="image4.png" alt="Diagram 4" /></td>
<td><img src="image5.png" alt="Diagram 5" /></td>
</tr>
</tbody>
</table>

This tableau shows that both MoraicProminence and NoPlaceInCoda are undominated. Parse is dominated by both MoraicProminence and NoPlaceInCoda, while the ranking of Fill is unclear. The second candidate, which is eliminated due to the violation of Fill, does not shed any light on whether Fill ranks higher or lower than Parse. (I placed Fill among undominated constraints since I have not encountered any evidence to the contrary.) The tableau (2.24) crucially shows that the best-formed candidate has to satisfy MoraicProminence, the constraint which we consider responsible for the
gemination effect. The tableau for the forms in (2.22) is given in (2.25), and illustrates the same point as the previous one.

(2.25) Best-formed output: kattuN (kar+tuN)

<table>
<thead>
<tr>
<th>MORAIC PROMINENCE</th>
<th>NOPLACE INCODA</th>
<th>FILL</th>
<th>PARSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Diagram 1]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>![Diagram 2]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>![Diagram 3]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>![Diagram 4]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The crucial role of MORAICPROMINENCE is further corroborated by the behavior of different root shapes, listed in (2.27) - (2.30). Relevant at this point is the prohibition against superheavy syllables, which is added to the list of constraints:

(2.26) *SUPERHEAVY: A syllable may have at most two moras.

Several predictions are made under the assumption that MORAICPROMINENCE is responsible for the gemination pattern. A single intervocalic consonant should not geminate, and consequently, no gemination should be evidenced in the case of CV and CVV roots. This is supported by the CV root listed in (2.27), and the CVV root given in (2.28); in neither case does the intervocalic consonant geminate when the root combines with a consonant-initial suffix.
(2.27) CV root: hi ‘send’
   -ta (past.part)
   hi + ta        hita        cf. hi(n)ati

(2.28) CVV root: ghaa ‘smell’
   -ta (past.part)
   ghaa + ta      ghaata      cf. ghaayati
   -tuN (infinitive marker)
   ghaa + tuN     ghaatuN     cf. ghaayati

Unlike vowel-final roots, consonant-final roots should induce gemination as well as consonant loss. We have already seen that this is the case with CVC roots when they combine with a consonant-initial suffix, as in (2.29).

(2.29) CVC root: sup ‘sleep’
   -ta (past.part)
   sup + ta       sutta       cf. supati

This same scenario is responsible for gemination in a CVVC root: the root-final consonant projects a mora before a consonant-initial suffix, in order to comply with MORAICPROMINENCE, as shown in (2.30). Moreover, in this case, consonant gemination is concomitant with vowel shortening, in compliance with the bimoraicity requirement, stated in (2.26).

(2.30) CVVC root: bhaas ‘speak’
   -ta (past.part)
   bhaas + ta     bhaṭṭha     cf. bhaasati
Candidate output forms for (2.30) are evaluated in the following tableau:

(2.31) Constraint satisfaction in bhaṭṭha (bhaas + ta)

<table>
<thead>
<tr>
<th>MORAIC PROMINENCE</th>
<th>NOPLACE INCODA</th>
<th>*SUPER HEAVY</th>
<th>FILL</th>
<th>PARSE</th>
<th>PARSE MORA</th>
</tr>
</thead>
<tbody>
<tr>
<td>bh a &lt;s_i&gt; t a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bh a &lt;s&gt; t a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bh a s_i + t a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bh a &lt;s_i&gt; t a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note that, in several candidates, including the optimal one, PARSEµ is violated as well; the first syllable of these forms include only two of the three available moras. One of the moras—the second half of the long vowel—is unparsed, due to *SUPERHEAVY. The excess of moras results from the compliance of this form with MORAICPROMINENCE, which requires that the consonant s project a mora. This case, I believe, presents a particularly convincing argument for associating the gemination pattern with the weight system of the language, and attributing it to MORAIC PROMINENCE.
To summarize, I have proposed the set of constraints listed in (2.32), to account for the pattern of consonant loss and gemination in Pali. The constraints in (2.32a) are not violated in any of the forms we have evaluated, while those in (2.32b) are.

(2.32) Constraint ranking:

a. undominated

\[ \text{Moraic Prominence} \]
\[ \text{No Place in Coda} \]
\[ \text{No [+cont] Nasal} \]
\[ \text{Fill} \]
\[ \ast \text{Superheavy} \]

b. dominated

\[ \text{Parse} \]
\[ \text{No Placeless Cons} \]
\[ \text{Parse II} \]

The resulting patterns are due to intricate interactions among the proposed constraints.\textsuperscript{12} The fact that certain configurations are wellformed in some environments but not in others is viewed as a consequence of constraint ranking, that is, the systematic way in which constraints override each other.

3 Japanese

In several respects, the properties of Japanese syllables are strikingly similar to those in Pali, most importantly, in the pattern of consonant loss and gemination. The present analysis is based on the accounts of Japanese in Martin (1952), McCawley (1968), Kuroda (1979), Poser (1984, 1985), Itô (1986, 1989), Itô and Mester (1986), Vance (1987), and Taub (1988).

As stated in (3.1), Japanese admits at most one consonant in the coda, either a nasal or the first half of a geminate; and, in addition to light and heavy syllables, it also allows superheavy syllables.

(3.1) a. light CV vs. heavy CVV, CVC
b. at most one coda consonant, either a nasal or first half of a geminate
c. super heavy (CVVC) syllables are possible

Moreover, the coda nasal is either placeless, or homorganic with the following stop, as stated in (3.2):

\[ \text{\textsuperscript{12}Another important aspect of constraint satisfaction in Pali is selection of the onset consonant, which is outside the scope of this paper. For a detailed account, see Zec (1993).} \]
(3.2) Consonants permitted in the coda:
   a. nasal (placeless, or homorganic with the following consonant)
   b. first half of a geminate consonant

This set of properties is illustrated in (3.3): forms in (3.3a) have placeless nasals in syllable-final position, those in (3.3b) contain syllables closed with a geminate, and those in (3.3c), a nasal homorganic with the following consonant.

(3.3) a. seN  'thousand'
     hcN  'book'

     b. kippu 'ticket'
        kitte 'stamp'

     c. mondai 'problem'
        domburi 'bowl'
        daNgo 'dumpling'
        keNka 'fight'
        sampo 'stroll'

This set of properties is captured by positing a set of constraints that restrict the occurrence of segments at the right margin of the syllable. Constraint (3.4) prohibits the occurrence of place in syllable-final position, and is stated here after Itô (1989) (see also Yip 1991), while that in (3.5) prohibits placeless consonants. These two constraints replicate those posited for Pali. Another constraint is needed, however, one that requires a nasal in syllable-final position (originally proposed in Itô 1986), as in (3.6).

(3.4) NoPLACEINCODA: Consonantal place is prohibited syllable-finally

\[ * \ 
\quad \quad \quad \quad \quad \quad = \sigma \]
\quad \quad \quad \quad \quad Place

(3.5) NoPLACELESSCONS: A consonant has to be linked to [Place].

\[ [+cons] \]
\quad \quad \quad \quad [ Place ]

(3.6) CODANASAL: A syllable may be closed only by a nasal consonant

\[ [Nasal] \sigma \]

These three constraints, together with PARSE, are sufficient to account for the forms in (3.7), as shown in the following tableau for hoN::
(3.7) Constraint satisfaction:

<table>
<thead>
<tr>
<th></th>
<th>NoPLACE INCODA</th>
<th>CODA NASAL</th>
<th>PARSE</th>
<th>NoPLACE LESSCONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ô</code></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>ô</code></td>
<td><code>ô</code></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>ô</code></td>
<td><code>ô</code></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As in Pali, PARSE overranks NoPLACE LESSCONS. CODA NASAL may appear to be superfluous at this point; its relevance will become obvious once we look at the more complex interactions at the right syllable margin.

However, the set of constraints proposed thus far is not sufficient to account for the phenomena at the right syllable margin that involve consonant loss and gemination, as exemplified by the verbal paradigm, intensified adverbs, and hypocoristic forms (cf. McCawley 1968, Kuroda 1979, Poser 1985, 1990, Itô 1986, Itô and Mester 1986, Taub 1988). We focus here on the verbal paradigm, presented in (3.8):

(3.8) Verbal paradigm:

<table>
<thead>
<tr>
<th>Stem</th>
<th>Present</th>
<th>Past</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(-ru/-u)</td>
<td>(-ta)</td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mi</td>
<td>miru</td>
<td>mita</td>
<td>'look at'</td>
</tr>
<tr>
<td>tabe</td>
<td>taberu</td>
<td>tabeta</td>
<td>'eat'</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ŝin</td>
<td>ŝinu</td>
<td>ŝinda</td>
<td>'die'</td>
</tr>
<tr>
<td>kam</td>
<td>kamu</td>
<td>kanda</td>
<td>'chew'</td>
</tr>
<tr>
<td>yom</td>
<td>yomu</td>
<td>yonda</td>
<td>'read'</td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tob</td>
<td>tobu</td>
<td>tonda</td>
<td>'fly'</td>
</tr>
<tr>
<td>yob</td>
<td>yobu</td>
<td>yonda</td>
<td>'call'</td>
</tr>
<tr>
<td>d.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kat</td>
<td>katsu</td>
<td>katta</td>
<td>'win'</td>
</tr>
<tr>
<td>mat</td>
<td>matsu</td>
<td>matta</td>
<td>'wait'</td>
</tr>
<tr>
<td>e.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kar</td>
<td>karu</td>
<td>katta</td>
<td>'cut'</td>
</tr>
<tr>
<td>tor</td>
<td>toru</td>
<td>totta</td>
<td>'take'</td>
</tr>
<tr>
<td>yor</td>
<td>yoru</td>
<td>yotta</td>
<td>'approach'</td>
</tr>
<tr>
<td>kuw</td>
<td>kuu</td>
<td>kutta</td>
<td>'eat'</td>
</tr>
<tr>
<td>kaw</td>
<td>kau</td>
<td>katta</td>
<td>'buy'</td>
</tr>
<tr>
<td>f.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kak</td>
<td>kaku</td>
<td>kaita</td>
<td>'write'</td>
</tr>
<tr>
<td>kag</td>
<td>kagu</td>
<td>kaida</td>
<td>'sniff'</td>
</tr>
</tbody>
</table>

Crucial in this set of forms is the fact that CV and CVC roots behave differently when followed by a consonant-initial suffix. In the latter case, the root-final consonant is lost, and the consonant of the suffix geminates. This is exemplified by roots ending in an
obstruen; as in (3.8d), and those ending in a liquid or glide, as in (3.8e); examples from these two classes are repeated in (3.9) and (3.10). (Forms with a nasal in root-final position, as in (3.8b), are not subject to such drastic phonological changes.)

(3.9) kat + ta  ‘win’
    a. katta
    b. *kata

(3.10) kar + ta  ‘cut’
    a. katta
    b. *kata

In (3.9) and (3.10), both the a. and the b. forms adhere to all constraints proposed thus far, since none of them possesses consonantal place in the coda, yet only the a. forms are acceptable. As in Pali, this is due to MORAIC PROMINENCE, which is satisfied in the a. forms but not in the b. forms. In other words, MORAIC PROMINENCE is again a central player, together with FILL and PARSE.

A comment is in order regarding the sonority conditions on moraicity in Japanese. I am assuming that, in this case as well, there is no sonority threshold on the set of segments that may project a mora; restrictions on the occurrence of segments in codas is ascribed to the set of constraints in (3.4) - (3.6). Thus, I do not associate the privileged occurrence of nasals in this syllabic position with their relatively high sonority. In fact, the relatively free occurrence of nasals in the coda may well be due to their potential placelessness.

The role of MORAIC PROMINENCE is shown by evaluating sets of candidate forms for (3.9) (in tableau 3.11) and (3.10) (in tableau 3.12). Note that, in the wellformed candidates, only PARSE is violated.14

(3.11) katta (kat+ ta)

\[
\begin{array}{c}
\sigma \\
\mu \\
\mid \\
k \\
\mu_i \\
\mu \\
\| \\
a <t_i> + t \\
a
\end{array}
\]

---

13 For a different view, see Itô and Mester (1993.)
14 Although disfavored, trimoraic syllables are possible in Japanese. Thus, when combined with a consonant-initial suffix, CVVC roots result in a trimoraic syllable, as in koor + ta, yielding kootta. As noted earlier, forms of this shape in Pali surface with a short vowel, due to a strongly bimoraicity condition. I am grateful to Junko Itô for pointing this out to me.
Thus far we have accounted for the forms in (3.8d) and (3.8e). To account for the remaining forms, several more constraints need to be posited. First, the obstruent following a nasal has to be voiced (in the Yamato vocabulary) (see Itô, Mester and Padgett 1995). The statement of this constraint in (3.13) is summary, but is sufficient for our purposes. It covers several constraints proposed in Itô, Mester and Padgett (1995), which pertain to the licensing of voice in the environment of a nasal.15

(3.13) NC: In a nasal + obstruent cluster, the obstruent has to be voiced.

Next, Japanese exhibits the stability of the feature Voice, which is parsed even though the segment that the feature originally belongs to is left unparsed. This constraint, stated in (3.14), ranks above Parse. The most obvious case of this is presented by the form in (3.8f) (*kag + ta) which transfers the voice of the voiced dorsal segment, which is left unparsed, to the consonant in the suffix yielding kaida.

(3.14) LARYNGEAL STABILITY: Parse [Voice]

---

15 The set of constraints proposed in Itô, Mester and Padgett (1995) due to which an obstruent preceded by a nasal is voiced are: LICENCE (VOICE), which is violated by a nasal linked to Voice (since nasals are redundantly voiced), and NASAL VOICE, requiring voicing on nasals. Both constraints are satisfied in a nasal + obstruent cluster, since the obstruent is a licit licenser of voice.
Finally, as stated in (3.15), only voiceless obstruents may be geminated in Japanese:16

(3.15) NoVoicedGemInates: Only voiceless obstruents may appear as geminates.

We first evaluate a form belonging to class (3.8b), whose root ends in a nasal. Note that the wellformed candidate satisfies all constraints; the t in the suffix is voiced by virtue of the NC constraint.17

(3.16) Constraint satisfaction for yonda (yom + ta) ‘read’:

<table>
<thead>
<tr>
<th></th>
<th>MORAIc PromInence</th>
<th>NoPlACE InCoda</th>
<th>Fill</th>
<th>NC</th>
<th>ParsE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ε* yonda</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yomda</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yota</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yonta</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yoda</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Next, we focus on forms in class (3.8c), evaluated in (3.17). Here, not only NC, but also LaryngealStability, and the constraint on geminates are playing a significant role. In the wellformed candidate, all constraints other than Parse are satisfied. Note that NasalCoda is satisfied by this form as the only available way of filling the moraic position projected by the unparsed b; gemination is prohibited in this case by NoSon/VoicedGem, since the potential filler is voiced by virtue of LaryngealStability, that is, it inherits the Voice feature from the unparsed b.

(3.17) Constraint satisfaction for yonda (yob + ta) ‘float’:

<table>
<thead>
<tr>
<th></th>
<th>MORAIc Prom</th>
<th>NoPl PLACE InCoda</th>
<th>Fill</th>
<th>NC</th>
<th>LAR Stabil</th>
<th>NoVc Gem</th>
<th>CODA Nasal</th>
<th>ParsE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ε* yonda</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yodba</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yoda</td>
<td>*!</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yonta</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yodba</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yoda</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Finally, we turn to roots ending in r, which according to Mester and Itô (1989) is a placeless consonant. The presence of r in the coda is thus prohibited by the violation of

---

16This constraint is stated as a ban on voiced geminates, but eliminates only voiced obstruent geminates, because of the redundant status of Voice in sonorant consonants. For a detailed discussion, see Itô and Mester (1986), Taub (1988), and Itô, Mester and Padgett (1995.)

17The optimal candidate, yonda, violates Parse-PLACE, and so does yonta. Parse-PLACE has a very low ranking.
CODANASAL, rather than NOPLACEINCODA, which crucially argues for positing both constraints. Again, only PARSE is violated in the wellformed candidate.

(3.18) Constraint satisfaction for totta (tor + ta) 'take':

<table>
<thead>
<tr>
<th></th>
<th>MORAIc PROM</th>
<th>NOPLACE INCODA</th>
<th>FILL</th>
<th>CODANASAL</th>
<th>PARSE</th>
<th>NOPLACE ESSCON</th>
</tr>
</thead>
<tbody>
<tr>
<td>* tors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>totta</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tota</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to†da</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The proposed analysis is corroborated by evidence from intensified adverbs. The gemination pattern has been attributed here to an empty moraic position projected by a segment that may not be parsed. Intensified adverbs contain a morphologically induced empty moraic position, which is filled in exactly the same fashion as the empty position projected by an unparsed segment.\(^{18}\) This is shown by the forms in the second column of (3.19): a voiceless obstruent geminates, as in (3.19 a), while CODANASAL takes effect when gemination is prohibited, as in (3.19 b, c, d).

(3.19) Medial gemination in intensified adverbs:

a. basa bassari  'with one stroke'
   hiso hissori  'quietly, still'
   bata battari  'suddenly'
   supo supporti 'entirely, clear'
   uka ukkari  'carelessly'

b. boya bonyari  'vacantly'
   fuwa funwari  'lightly'

c. maji manjiri  'with a wink of sleep'
   nobi nobiriri 'relieved, at ease'
   zabu zamburi  'with a splash'

d. sina sinnari  'pliantly'
   gun†ya gunyari  'flaccidly'

To summarize, the set of constraints that govern the pattern of consonant loss and gemination are given in (3.20); those in (3.20a) are not violated in any of the forms, while those in (3.20b) are. Interestingly, the two violated constraints are the same as those that may be violated in Pali.

---

\(^{18}\)If the medial consonant is r, no gemination takes place, since r may not geminate (e.g., fura vs. furari 'swaying').
(3.20) Constraint ranking:

a. undominated
   MORAICPROMINENCE
   NOPLACEINCODA
   FILL
   NASAL+VOICEDOBSTR
   LARYNGEALSTABILITY
   NOSON/VOICEDGEM
   CODANASAL

b. dominated
   PARSE
   NOPLACELESSCONS

Thus, the pattern of gemination and consonant loss in Pali and Japanese results from the interactions of MORAICPROMINENCE, PARSE, and FILL with other constraints operating in the two languages. The pattern of consonant loss is due to strict constraints on the occurrence of consonants in syllable-final position; consonant gemination, on the other hand, is directly related to MORAICPROMINENCE. However, the effect of MORAICPROMINENCE is obscured in these languages, due to low ranking of PARSE and high ranking of FILL: by virtue of MORAICPROMINENCE, an unparsed segment leaves a trace, so to speak, in the form of a weight position, which in its turn is filled by a licitly parsed segment, giving rise to gemination.

We now turn to Piro, which presents the same type of case, yet may not appear as such due to a markedly different set of constraints that governs the parsing of segments.

4 Piro

Piro, an Arawakan language spoken in the Montaña region of eastern Peru, presents essentially the same type of compensatory lengthening as the cases discussed in the previous sections, with one important difference: in this case, both the lost and the geminated segment is a vowel. The analysis to be presented is based on the facts in Matteson’s (1965) grammar. Previous work on the phonology of Piro includes Li (1987), Yip (1992), and Hayes (1995).

4.1 The data

This case of compensatory lengthening arises amidst a fairly complex set of phonological facts. Piro has a five vowel system—i, u, e, o, a—with no contrastive vowel length. Except for a small number of onomatopoeic forms, all long vowels result from
compensatory lengthening (Yip 1992). Next, out of the sixteen Piro consonants, listed in (4.1), only four, those in (4.2), appear as geminates.

(4.1) Piro consonants:

<table>
<thead>
<tr>
<th>Obstruent</th>
<th>Labial</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>p</td>
<td>t</td>
<td></td>
<td>k</td>
<td></td>
</tr>
<tr>
<td>Affricate</td>
<td>ts</td>
<td>tš</td>
<td>tx</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>s</td>
<td>ŝ</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonorant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td>h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>l, r</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>w</td>
<td></td>
<td>y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(4.2) Geminates: mm, nn, ww, yy

The number of forms with underlying geminates is in fact very small; the list in (4.3) includes practically all forms that appear in the dictionary of Matteson’s grammar.

(4.3) Geminate consonants:
-

yy: -tayy (or -ta), suffix (exclamatory)
nn: wanna ‘they’; hannata ‘pineapple’; hannata ‘to have an appetite for’; hannatu ‘cold wind’; menuu ‘mole, beauty spot’; nniphya ‘breath, wind’; nnu ‘tongue, soft, fleshy object’; yonnu-ta ‘(proud flesh) to develop’.

mm: kammane-ta ‘to wait for another to grow up to become one’s spouse’.

Piro roots, as well as suffixes, end in a vowel. Suffixes fall into two classes, those that suppress the final vowel of the stem, and those that induce no such effect. Both types of suffixes are shown in (4.4): the suffixes -ya and -lu suppress the stem-final vowel, as in (4.4 a, c, d), while -Vnu does not, as shown in (4.4 b, d). (Following Matteson, the latter class is marked diacritically with a V.)

---

19Yip (1992) lists the following forms with an underlying long vowel: ha:li, si:, yo:, so:, su:, ške:, to:, which are all onomatopoeic, as well as tši:le/tšiyle ‘lungs’. In addition, I found the form hipo:še-ta ‘to crack (as drying mud)’ which, I believe, is monomorphemic.

20Stems may be simplex or complex; if a vowel-suppressing suffix is added to a complex stem, the stem-final vowel will belong to the preceding suffix.

21Each affix is associated with the class number assigned to it in Matteson’s description.
(4.4) Combinations of neta (n + hata) with -ya (Locative), -Vnu (Anticipatory), and -lu (O-03 ‘him’) (p.36):\(^{22}\)

a. netya neta + ya ‘I see there’
b. netanu neta + Vnu ‘I am going to see’
c. netlu neta + lu ‘I see him’
d. netanru neta + Vnu + lu ‘I am going to see him’

Additional examples are given in (4.5) and (4.6). While in (4.5) both suffixes suppress the stem-final vowel, none of the suffixes in (4.6) does.

(4.5) npintmaklu ‘I would have given medicine to him.’
n- pinita-maka -lu
S-01 ‘I’ v.tr. ‘to give medicine to’ 76 O-03 ‘him’

(4.6) wsalewnananatnalkali ‘We have been suffering now.’
w- salewnanata-Vnu-Vtkka-Vli
S-05 ‘we’ verb intr. 71 Detrimental 81 ‘now’ 103

However, the stem-final vowel may be preserved under certain conditions. Triconsonantal clusters are prohibited in Piro, and whenever the suppression of the stem-final vowel would result in such a cluster, the vowel is retained. In (4.7) and (4.8), for example, the stem-final vowel exceptionally remains in the structure before -lu (compare (4.4) and (4.5) above); had -lu suppressed the preceding vowel, the triconsonantal clusters ktl and tkl would have resulted.\(^{23}\)

(4.7) tkatakatalu ‘She somehow, somewhere bathed someone.’
t- kata-Vkta -lu
S-04 ‘she’ tr. ‘to bathe’ 77 O-03 ‘him’

(4.8) kaspukatalu ‘Then he released him.’
kaspuka -Vtkka -lu
tr. ‘to release’ 81 O-03 ‘him’

The same is shown by the suffix -he, which suppresses the final vowel in (4.9), but not in (4.10), where the resulting structure would contain a triconsonantal cluster.

(4.9) puknokluhe ‘Did you abandon him?’
p- hiknoka -he
S-02 ‘you’ tr. ‘to abandon’ O-03 ‘him’ 102

---

\(^{22}\) The form neta in (4.4) is morphologically complex, consisting of the prefix n- and the stem hata. The segment h, described in Matteson as a nasal glide, is lost after another consonant, as exemplified in (4.4) (also, (4.9) and (4.10) below); the quality of the following vowel is affected in some cases as well.

\(^{23}\) As observed in Li (1987), triconsonantal clusters are permitted in only one type of forms, those containing the suffix -m, which suppresses the final vowel and is invariably followed by -Vta, for example rasukamtna (rasuka + m + Vta + na) ‘they ran right away’.
(4.10) papokhe\textsuperscript{24} ‘You have arrived?’
\text{p-}hapoka\textsuperscript{-he}
S-02 ‘you’ intr. ‘to arrive’ 102

The facts reported thus far all serve as a background for compensatory lengthening, which we now turn to. At this point, only the cases with a suppressed stem-final vowel are relevant. If the suppressed vowel is flanked either by identical consonants, or any of the consonant pairs listed in (4.11), the first consonant is lost and the preceding vowel lengthened.\textsuperscript{24}

(4.11) Prohibited consonant sequences:
\begin{itemize}
  \item a. any two identical consonants
  \item b. any of the following consonant pairs
  \begin{itemize}
    \item t ts, t t\textcircled{s}, t tx, t s
    \item ts t\textcircled{s}, ts tx, ts s, ts s
    \item t\textcircled{s} ts, t\textcircled{s} tx, t\textcircled{s} s, t\textcircled{s} s, t\textcircled{s} x
    \item tx ts, tx t\textcircled{s}, tx x
    \item s \textcircled{s}, s x
    \item s\textcircled{s}, s x
    \item x ts, x t\textcircled{s}, x s, x s
    \item h p, h t, h ts, h t\textcircled{s}, h tx, h s, h s
    \item l r
    \item r l
  \end{itemize}
\end{itemize}

Thus, in (4.12 a,b,c), due to the suppression of the final vowel, the suffix -\textit{ka} is adjacent to the consonant \textit{k}; this consonant is lost in this collocation, and the vowel to its left lengthened. The example in (4.12d) illustrates the case in which no illicit sequence arises, so that the suppression of the final vowel results simply in a consonant cluster.

(4.12) Combinations with -\textit{ka} (Passive, 51)
\begin{itemize}
  \item a. ni:\textit{ka} nika + \textit{ka} ‘he is eaten’
  \item b. rani:\textit{ka} ranika + \textit{ka} ‘he is taken’
  \item c. ruta:\textit{ka} ratak + \textit{ka} ‘he was put’
  \item d. homkahitka homkahita + \textit{ka} ‘to be followed’
\end{itemize}

Another set of examples is given in (4.13). In (4.13b,c), the suffix -\textit{t\textcircled{s}i} causes the final vowel to disappear; since this results in an illicit consonant cluster, the final consonant of the root is lost and the preceding vowel lengthened. In (4.13a) no illicit cluster arises, and in (4.13d), the final vowel is parsed to avoid a triconsonantal cluster.

\textsuperscript{24}At least in some cases, the excluded clusters clearly induce an OCP violation, but in certain others, more seems to be going on. For example, ts t\textcircled{s}, ts tx, t\textcircled{s} tx, t\textcircled{s} x, s s, sx, s x, l r are excluded symmetrically, that is, the order in which they appear is not playing a role. The clusters t ts, t t\textcircled{s}, t tx, t s, ts s, ts s, t\textcircled{s} s, t\textcircled{s} s, s ts, t x, t x, however, are banned only in this order, while the reversed order causes no violation. I leave this problem for future research.
(4.13) Combinations with -tši (Absolute, 29), also -ne (Genitive of utilization, 38) and -Vte (Genitive of ownership, 39)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. yhaltši</td>
<td>yhale + tši</td>
<td>‘someone's eye’</td>
</tr>
<tr>
<td>b. ximeka:tši</td>
<td>ximeka + Vte + tši</td>
<td>‘someone's manioc’</td>
</tr>
<tr>
<td>c. xi:tši</td>
<td>xitxi + tši</td>
<td>‘foot’</td>
</tr>
<tr>
<td>d. tumlexnetši</td>
<td>tumlexi + ne + tši</td>
<td>‘someone's flute’</td>
</tr>
</tbody>
</table>

4.2 Vowel lengthening

This set of facts calls for several types of constraints, in addition to MORAIProcitects, which again plays a central role. To begin with, the suppression of the final vowel suggests that vowels are disallowed at a constituent edge.\(^{25}\) Assuming that the relevant constituent is the prosodic word, this is captured by positing a constraint which prohibits the parsing of a final vowel within this constituent.\(^{26}\)

(4.14) **Final Vowel:** In a prosodic word ending in a vowel, the final vowel is not parsed.  
\(<v> \text{ PrWd} \)

The two types of suffixes (illustrated in (4.4) and (4.5)) differ, then, in whether or not they impose prosodic subcategorization (Inkelas 1989, McCarthy and Prince 1993a). Only the suffixes that suppress the final vowel are prosodically subcategorized; they impose a prosodic word boundary by virtue of the subcategorization frame in (4.15):

(4.15) \( \text{ PrWd} \)

This yields the following representations for morphologically complex forms in which the final vowel is suppressed; below are given representations for (4.4a) and (4.4c).

(4.16) a. net \(<a> \text{ PrWd} \text{ ya} \) netya
b. net \(<a> \text{ PrWd} \text{ lu} \) netlu

Next, the prohibition against triconsonantal clusters reflects a restriction on consonant clusters within the syllable, and is accounted for straightforwardly by assuming that

\(^{25}\) Compare a similar constraint posited for Lardil (Prince and Smolensky 1993).

\(^{26}\) Vowels are suppressed in word-final position as well, as in [[mæptʃir<]] [kamalexite] 'the boa's magic herb', which is rendered as mapəšir kamalexite. The first prosodic word loses its final vowel because its right edge coincides with a prosodic word margin. The final vowel remains in the second word; note, however, that its right edge corresponds to more than one prosodic margin, that of a prosodic word as well as at least one higher prosodic constituent. It appears that higher prosodic constituents impose stronger parse requirements than the prosodic word, which gives rise to the observed asymmetry.
syllables in Piro may possess at most one consonant at either of the margins, as expressed in (4.17) (following Prince and Smolensky 1993):\textsuperscript{27}

\begin{equation}
(4.17) \quad \#\text{COMPLEX: Consonant clusters are prohibited at syllable margins.}
\end{equation}

This constraint ranks higher than {	extsc{finalvowel}}, as shown by the following tableau, in which the wellformed candidate violates {	extsc{finalvowel}} but satisfies \textsc{#complex}. The inspected form is taken from (4.7) above.

\begin{equation}
(4.18)
\begin{array}{|c|c|c|}
\hline
\text{ew} & \text{[tkatakta lu]} & \#\text{COMPLEX} \quad \#\text{FINALVOWEL} \\
\text{ew} & \text{[tkatakta<\textsc{a}> lu]} & \star  \\
\hline
\end{array}
\end{equation}

Before turning to compensatory lengthening, we need to state a constraint against the set of illicit clusters in (4.11). The \textsc{clusterconstraint} in (4.19) places a restriction on sequences of parsed consonants:\textsuperscript{28}

\begin{equation}
(4.19) \quad \text{\textsc{clusterconstraint}}:
\end{equation}

Parsed consonant clusters may not match any of the sequences in (4.11).

An illicit consonant cluster is “resolved” by a failure to parse one of its members, which indicates that \textsc{parse} ranks lower than \textsc{clusterconstraint}.\textsuperscript{29} \textsc{parse} ranks lower than \textsc{finalvowel} as well, since illicit consonant sequences may not be “resolved” by retaining the final vowel within the structure (although -\textsc{si} belongs to the class of suffixes that suppress the final vowel). This is summarized in the following tableau, which lists the candidate forms for (4.13c):

\begin{equation}
(4.20)
\begin{array}{|c|c|c|}
\hline
\text{ew} & \text{[xitxi] \textsc{si}} & \text{\textsc{clusterconstraint}} \quad \#\text{FINALVOWEL} \quad \text{\textsc{parse}} \\
\hline
\text{ew} & \text{xitxi} & \star  \\
\text{ew} & \text{xitxsi} & \star  \\
\hline
\end{array}
\end{equation}

\textsuperscript{27}However, consonant clusters are permitted word-initially.
\textsuperscript{28}At least in some cases, the excluded clusters clearly induce an OCP violation, but in certain others, more seems to be going on. For example, ts \textsc{ti}, ts \textsc{tx}, ts \textsc{tx}, ts \textsc{x}, ts \textsc{x}, ts \textsc{x}, ts \textsc{x}, 1 r are excluded symmetrically, that is, the order in which they appear is not playing a role. The clusters ts \textsc{ts}, ts \textsc{ts}, ts \textsc{tx}, ts \textsc{x}, ts \textsc{x}, ts \textsc{x}, ts \textsc{x}, ts \textsc{x}, ts \textsc{tx}, ts \textsc{x}, however, are banned only in this order, while the reversed order causes no violation. I leave this problem for future research.
\textsuperscript{29}Another constraint is needed to insure that, in the optimal candidate, the leftmost member of the cluster is left unparsed.
To summarize, the rankings we have established thus far are those in (4.21):

(4.21) Ranking:  
*COMPLEX >> *FINALVOWEL  
CLUSTERCONSTR >> PARSE  
FINALVOWEL >> PARSE

The wellformed output in (4.20), xi:§i, is subject to compensatory lengthening, generally encountered when both the final vowel and the preceding consonant are left unparsed. Although this may suggest that vowel lengthening is triggered directly by consonant loss, I will argue that the culprit, in this case, is the lost vowel. Most importantly, it is unclear on what grounds the unparsed consonant is associated with a mora. MORAIICPROMINENCE is not of help here, since the unparsed consonant is immediately followed by a vowel, that is, by a more sonorous segment, as in (4.22).

(4.22) *   \sigma   \sigma  
      \mu   \mu_i  \mu  
[ [ x i <t\tau_p><i>_p] § i ]

It seems more plausible to assume that the unfilled moraic position is projected by the final vowel, as in (4.23), by virtue of MORAIICPROMINENCE which in this case operates licitly. That this vowel is not to be parsed is irrelevant, of course, since we have seen that an unparsed segment may be scanned by MORAIICPROMINENCE.

(4.23) \sigma   \sigma  
      \mu   \mu_i  \mu  
[ [ x i <t\tau><i>_p] § i ]

FILL is then satisfied by "spreading" from a nearby parsed vowel, in this case, the vowel in the first syllable. Note, however, that this vowel is not adjacent to the segment that projects μ_i, which raises the question whether it constitutes a licit filler. In other words, the configuration in (4.23) may be in conflict with STRUCTURALCOHERENCE, a general constraint on structural wellformedness stated in (1.10), which requires that moras be filled locally. In order to be reduced to other cases of FILL satisfied locally, this case calls for an additional proviso: an intervening unparsed segment is allowed, since it does
not induce the crossing of association lines, or a violation of STRUCTURAL_COHERENCE for that matter.

Yet, the loss of final vowel fails to trigger compensatory lengthening when no consonant is lost, say, in the following form ((4.4c) above), which does not contain any illicit consonant clusters:

\[(4.24) \quad \begin{array}{l}
a. \quad [[n e t<\alpha>] l u] \\
b. \quad *[[n e: t<\alpha>] l u]
\end{array}\]

In this case, STRUCTURAL_COHERENCE does take effect. The mora projected by the final vowel is trapped between two linked moras, and FILL can be satisfied only at the expense of violating STRUCTURAL_COHERENCE, as in (4.25):

\[(4.25) \quad * \quad \begin{array}{c}
  \sigma \\
  \mu \\
  \mu_i \\
  [[n e t<\alpha>] l u]
\end{array} \quad \begin{array}{c}
  \sigma \\
  \mu \\
  [[n e t<\alpha>] l u]
\end{array}\]

In the wellformed case, the mora coindexed with the final vowel remains unfilled, and is also unparsed, since Piro places a strict ban on the violations of FILL.

\[(4.26) \quad \begin{array}{c}
  \sigma \\
  \mu \\
  \mu_i \\
  [[n e t<\alpha>] l u]
\end{array} \quad \begin{array}{c}
  \sigma \\
  \mu \\
  [[n e t<\alpha>] l u]
\end{array}\]

In sum, both FILL and MORAIC_PROMINENCE appear to be undominated, which prohibits candidate forms in which the mora projected by the final vowel remains unfilled; or those in which MORAIC_PROMINENCE does not take effect, so that the final vowel is not paired with a moraic position. The relevant candidate forms for (4.4c) are listed in the following tableau:
(4.27)  

<table>
<thead>
<tr>
<th></th>
<th>MORAIC-PROM</th>
<th>FILL</th>
<th>STRUC-COHER</th>
<th>PARSE μ</th>
</tr>
</thead>
<tbody>
<tr>
<td>əə</td>
<td>¬μ&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>net&lt;α&gt;[l]u</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>σ</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>μ&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>net&lt;α&gt;[l]u</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When a consonant, as well as the final vowel, is unparsed, the fill path is free, and STRUCTURAL-COHERENCE is duly observed, as shown in the following tableau, which lists candidate forms for (4.13c) that have not been excluded in (4.20) (those that satisfy FINAL-VOWEL and CLUSTER-CONSTR, but violate PARSE).

(4.28)  

<table>
<thead>
<tr>
<th></th>
<th>MORAIC-PROM</th>
<th>FILL</th>
<th>STRUC-COHER</th>
<th>PARSE μ</th>
</tr>
</thead>
<tbody>
<tr>
<td>əə</td>
<td>µ&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xi&lt;tx&lt;ci&gt;ši</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>σ</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>əi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xi&lt;tx&lt;ci&gt;ši</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xi&lt;tx&lt;ci&gt;ši</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3 Consonant gemination

Compensatory lengthening may also be manifested as consonant gemination, as shown in (4.29):

(4.29)  
a. penekannotši  
p- + heneka + -Vnu + -no + -Vtši  
‘Give it to me, please’
(‘you’ + ‘give’ + ‘Antic.’ + ‘me’ + ‘politeness marker’)

b. xemmaka  
xema + -maka  
‘he would hear’
(‘he hears’ + ‘Subjunctive’)


c. waneyyi  
\[\text{wane + -Vya + -yi} \quad \text{‘you have’}\]
\[\text{‘there’ + ‘to’ (42) ‘you’}\]

d. rawwu  
\[\text{rawa + wu} \quad \text{‘he takes us’}\]

Only the types of geminates found underlyingly, those listed in (4.2), \textit{nn, mm, ww} and \textit{yy}, may result from compensatory lengthening. The only permissible clusters with sonorant consonants are those containing two identical members (see (4.11)), which explains why the lost consonant and the survivor are always identical.\(^1\)

Moreover, according to Matteson (p.34), forms with derived geminate glides are in free variation with forms containing a lengthened vowel followed by a simplex consonant. Thus, (4.29c) and (4.29d) freely alternate with (4.30a) and (4.30b) respectively.

(4.30)  
\begin{align*}
\text{a. wane:yi} \\
\text{b. ra:wu}
\end{align*}

As these facts strongly suggest, geminates in (4.29) arise from compensatory lengthening. In this case, as well, the unfilled mora which gives rise to compensatory lengthening is projected by the final vowel. The two manifestations of compensatory lengthening are treated as parallel here, the only difference being the selection of the filler: (4.31a) represents (4.29d), in which compensatory lengthening is manifested as consonant gemination, and (4.31b) represents the variety with a lengthened vowel in (4.30b).

(4.31)  
\begin{align*}
\text{a.} & \quad \sigma \\
& \quad \mu \quad \mu_i \quad \mu \\
& \quad [[r \quad \text{a} \quad \text{<w><a_i>}] \quad \text{u} \quad \text{w}] \\
\text{b.} & \quad \sigma \\
& \quad \mu \quad \mu_i \quad \mu \\
& \quad [[r \quad \text{a} \quad \text{<w><a_i>}] \quad \text{w} \quad \text{u}]
\end{align*}

The relevant moraic position may not be projected by the unparsed consonant in either of these cases, since that would constitute a violation of MORAICPRONINENCE.

\(^1\)With the exception of \textit{l} and \textit{r}, which may not form a cluster with each other. Note also that liquids do not occur as geminates.
Of interest here is the fact that the set of underlying geminates corresponds exactly to the set of geminates derived in (4.29). This may simply be a constraint on geminates. But, given that only sonorant consonants occur as geminates, another alternative suggests itself: this appears to be a case of sonority threshold on the set of segments that may potentially project, and fill, the second mora of the syllable. Thus far we have only seen that sonorant consonants can fill a moraic position. The realization of word-initial consonant clusters suggests that sonorant consonants may also project a mora.

Illicit consonant clusters in word-initial position are simplified, as shown in (4.32) - (4.33). In addition, the cluster consisting of sonorants results in a geminate, as in (4.32).2

(4.32) a. nnika n- + nika ‘I eat’ (n- ‘I’, nika ‘eat’)
    b. wwuhenë w- + wuhenë ‘our child’ (w- ‘our’, wuhenë ‘child’)
(4.33) a. pawata p- + pawata ‘you make a fire’ (p- ‘you’)
    b. tshiyahata t- + tshiyahata ‘she weeks’ (t- ‘she’)

Gemination in (4.32) can be reduced to what is by now a familiar scenario: the initial consonant projects a mora, in accordance with MORAICPROMINENCE, as in (4.34); this consonant remains unparsed due to the CLUSTERCONSTRAINT, and the projected mora is filled by the following onset consonant.3

(4.34)

\[ \sigma \]

\[ \mu \]

<np>n i k a

To summarize, in addition to constraint interactions in (4.21), we can further observe that PARSEÇI is dominated by MORAICPROMINENCE, STRUCTURALCOHERENCE and FILL.

---

2 Otherwise, consonant clusters are formed, as in pšikalwatu (p- + šikalwata + -Vnu) ‘Sing!’ and nyatka (n- + ya + -Vka + -Vka) ‘I’m going now’.

3 On the basis of these facts we should conclude that syllables closed with sonorants are heavy, and those closed with obstruents are light. However, the evidence is pretty meagre in this respect. The stress system, as characterized in Hayes (1995), is quantity insensitive, exhibiting the pattern of syllabic trochees, and as such sheds no light on the weight of CVC syllables. It is beyond doubt that syllables containing long vowels may occupy weak positions within the foot, but the few examples listed in Matteson do not reveal whether this is also true of syllables closed with geminates. Yip (1992) suggests that the quantity insensitivity of the stress system does not need to be stipulated if all syllables are taken to be light, which is tenable under two assumptions: that consonants are not weight-bearing, and that compensatory lengthening is ordered after stress assignment. The first assumption is consistent with the gemination facts only if no correlation is assumed between the presence of geminates in a language, and the weight-bearing status of its consonants.
Moreover, the facts presented here suggest that these three constraints are undominated, together with *COMPLEX and CLUSTERCONSTRAINT. Thus, the only violable constraints for this set of data are FINALVOWEL, and the two PARSE constraints, PARSE (segment) and PARSE μ.

Piro thus further corroborates the generality of the pattern in which an unparsed segment may cause compensatory lengthening, by projecting a moraic position which it cannot fill. As in the previous cases, here again, the pattern is due to the low ranking of PARSE, and high rankings of FILL and MORAICPROMINENCE.

5 Residual issues

The proposed analysis of compensatory lengthening induced by segment loss sheds light on another issue highly relevant in this context: the status of geminate segments with regard to general constraints on moraicity. An accurate characterization of compensatory lengthening crucially depends on the representation of both long vowels and geminate consonants as weight bearing, with two weight units in the former, and one in the latter case, as in (5.1):

\[ (5.1) \quad \begin{array}{c}
(\text{a}) \\
\sigma \\
/ \ \\
\mu / \\
\mu \\
\mu \\
a \\
\mu \\
\sigma \\
/ \\
t
\end{array} \]

Due to their structural properties, the two types of “long” segments in (5.1) are a natural result of compensatory lengthening. But to what extent is this outcome governed by constraints on moraicity?

The weight-bearing status of segments is controlled by several independent constraints. One of these is MORAICPROMINENCE, which has played a central role in characterizing the type of compensatory lengthening investigated here. This constraint affects singleton segments but not geminates; while a singleton is associated with a mora by virtue of MORAICPROMINENCE, an underlying geminate is lexically affiliated with a mora. This is shown by the hypothetical cases in (5.2), in particular, by the contrast between (5.2a,c) on the one hand, and (5.2b) on the other.
Due to its "special" status, the lexical mora in (5.2b) is exempted from the effect of \textsc{MoraicProminence}, which crucially distinguishes it from any projected mora (see Rosenthal 1994 and Sherer 1994).

\textsc{MoraicProminence} is not the only condition on moraic structure. Equally relevant is the sonority threshold on moraicity. In order to be admitted in a weight-bearing prosodic position, any simplex segment has to meet a minimal sonority requirement, that is, satisfy the constraint(s) on sonority threshold (Prince 1983, Zec 1988). To begin with, the cases studied here strongly suggest that the sonority threshold on moraicity is identical for singletons and geminates: any segment that occurs as a geminate, either "underlying" or "derived," is also a potential mora projector. The occurrence of consonants in the coda is highly constrained in both Japanese and Pali, yet we can deduce, on the basis of mora projection, that any consonant in these two languages is moraic; the sets of geminates in the two languages are equally unrestricted by sonority considerations.\footnote{Other constraints may affect geminates as well, for example the requirement in Japanese that geminates be voiceless.} We have concluded, likewise, that in Piro only sonorants are moraic, due to their ability to project a mora, and to occur as geminates. Again, the same sonority threshold holds for singletons and geminates alike.

Moreover, the ability of a segment to fill a moraic position strongly correlates with its moraic status. In languages such as English, any mora projector is also a possible mora filler. It is thus reasonable to assume that the projection and filling of a moraic position fall under identical sonority threshold conditions. This is not as directly observable in the three case studies presented here, due to the interreference of the "coda" constraints. But in these cases, the corroboration comes from another source. Pali, Japanese and Piro all possess geminates which display what is known as structure preservation: any segment that occurs as an "underlying" geminate is also potentially a mora filler. If mora projectors and ("underlying") geminates fall under the same sonority constraints, and so do "underlying" geminates and potential fillers, it then follows that projectors and fillers are subject to identical sonority threshold as well. In sum, the actual occurrence of a singleton in a
weight-bearing position is only one type of evidence in support of the moraic status of a segment.

This conclusion, however, goes against the claim that geminates may override requirements on sonority threshold that regulate the weight-bearing properties of segments (Inkelas and Cho 1993). This claim is based on cases such as Italian, in which the only singleton consonants admitted in the coda are sonorants and s, yet no such restrictions hold of geminate consonants, which freely appear in the coda (Saltarelli 1970, Muljačić 1972, Vogel 1977, Chierchia 1982, 1983, Itô 1986). But, looked at from our vantage point, Italian falls in line with the other cases studied here. In what follows, I sketch out an analysis of Italian which obviates the need for granting a special status to geminate consonants with respect to moraicity.

In light of cases such as Pali and Italian, the nonoccurrence of singleton obstruents (other than s) in the coda of an Italian syllable does not in itself constitute evidence against the moraic status of obstruents. An account of this distributional gap is in fact readily available: singleton obstruents may not appear in the coda due to the following cluster constraint, of the type proposed in Yip (1991):

(5.3) In clusters [-son ] [- son ], the first segment has to be s.

This cluster constraint restricts possible consonant sequences regardless of syllable boundaries: both word-initial and word-internal clusters of two obstruents necessarily contain s as their first member. That this cluster constraint is indeed at work can be shown by inspecting word-internal clusters. According to Klajn (1967) and Davis (1990), the following biconsonantal sequences are found word-initially:

(5.4) Word-initial clusters:
   a. stop + liquid
      pretes
      bravo
      croce
      platano
      gloria
      drastico

   b. f/v + liquid
      freno
      fluido

---

5The clusters in (5.4a,b) occur in the onset word-externally as well, as in capra, celebre, sacro, replica, madre, sigla, cifra, riflesso. This, however, is not the case with the clusters in (5.4c) (see note 29).
c. s + any consonant (other than affricate)

spia
sbaglio
stare
sdegno
scala
sgabello
sfera
svanire
sregolato
slitta
smania
snello

Thus, a sequence of two obstruents (which is not s-initial) is prohibited in word-initial position. This same sequence is also prohibited word-ternally, as shown by the list of possible medial heterosyllabic clusters.\(^6\)

(5.5) Medial heterosyllabic clusters:

a. liquid + any consonant

cor.po
er.ba
or.to
bor.go
al.to
sol.do
fal.co

b. nasal + any consonant (other than liquid)

lam.po
gam.ba
san.to
an.dare
ban.co
fan.go

c. s + any consonant (other than affricate)

ves.pa
bisbiglio
as.ta
disdire
es.ca
dis.guido

\(^6\)S-initial clusters are heterosyllabic word-medially. Evidence for this comes from forms such as \(pasta\), in which the vowel in the stressed syllable is short (Chierchia 1982, 1983). A stressed syllable is necessarily bimoraic, which triggers vowel lengthening in open, but not in closed, syllables. The absence of vowel length before \(s\) in \(pasta\) and other forms of this type is thus an argument for its syllable-final position.
However, obstruent geminates occur freely in intervocalic position, as in (5.6), which is to be expected, since a geminate does not violate the cluster constraint:

(5.6) a. lab. bro  
     b. grap. pa  
     c. ap. pla. di re  
     d. tut. to  
     e. at. tore

Klajn (1967) also lists the so-called anomalous clusters, those which are prohibited in native words but figure in unassimilated loans. Obstruent clusters which violate the cluster constraint are found in loan words both initially and medially:

(5.7) Anomalous clusters:

<table>
<thead>
<tr>
<th>pt</th>
<th>ptero-</th>
<th>captare</th>
</tr>
</thead>
<tbody>
<tr>
<td>ps</td>
<td>psicologo</td>
<td>capsula</td>
</tr>
<tr>
<td>bd</td>
<td>bdellio</td>
<td>subdolo</td>
</tr>
<tr>
<td>kt</td>
<td>ctonio</td>
<td>factotum</td>
</tr>
<tr>
<td>ks</td>
<td>xilofono</td>
<td>uxoricida</td>
</tr>
</tbody>
</table>

However, some of the loan forms have assimilated versions. According to Migliorini et al. (1969), words such as xilofono may be pronounced either [ks]ilofono or [s]ilofono (the latter spelled silofono). Medial clusters may also be simplified, but this time, the result is a geminate. The word taxi has both assimilated and unassimilated forms, [tassi] (spelled tassì) and [taksi] respectively. Migliorini et al. (1969) lists other doublets, such as uxoricida / ussoricida and capsula / cassula.

Single consonants in word-final position do not fall under the jurisdiction of the cluster constraint, for the obvious reason, and we may expect to see the sonority threshold on moraicity imposed in this position. However, native Italian words do not end in a consonant, and loan words, such as those in (5.8), may end in sonorants and obstruents alike:

(5.8) a. gas  
     b. club  
     c. bazár  
     d. autobús / ótobus  
     e. chik  
     f. mammút  
     g. álcol  
     h. zénit / zenít

---

7 In Italian, consonants are prohibited in word-final position. The constraint that regulates the occurrence of segments at the right margin of words is relevant only for native vocabulary, and is disobeyed by loan words.
The cluster constraint in (5.3) thus explains the fact that singleton obstruents are not admitted in syllable-final position, while geminate obstruents are. In other words, the absence of singleton obstruents from syllable-final position in native Italian vocabulary does not have to be viewed as a reflection of the sonority threshold on moraicity. Moreover, since any consonant may occur as a geminate, it should follow that all segments are moraic in Italian, including obstruents. But what evidence do we have that obstruents are indeed moraic?

It would be crucial to show that obstruents may act as mora projectors. Although evidence for this is meager, since the majority of forms have been reanalyzed in accordance with the cluster constraint, there are still some phenomena that can plausibly be interpreted in this light. According to Saltarelli (1970:30) and Trumper, Romito and Maddalon (1991:332), cluster simplification is encountered at morpheme boundaries, in a restricted set of verbal past participial forms. In (5.9), the gemination of -t, which corresponds to the participial suffix, is due to the loss of the root-final consonant.

(5.9)   a. detto  dec + t + o  cf. dico ‘I say’, dice
       b. cotto  coc + t + o  cf. cuoco, cuoce
       c. condotto  condoc + t + o  cf. conduco ‘I lead’, conducente ‘conductor’

The emergence of a geminate in these cases can be reduced to the scenario proposed in the previous sections: the first member of the cluster resulting from morpheme concatenation projects a mora, but does not link to this mora due to the cluster constraint. This is schematized below for (5.9a):

(5.10)

\[
\begin{array}{c}
\sigma \\
\mu_i \\
\mu \\
\text{d e} <c_i> \text{t o}
\end{array}
\]

In (5.10), a consonant-final root combines with a consonant-initial suffix; combinations with a vowel-initial suffix, such as dico, do not result in gemination.

This scenario is relevant, of course, only for consonant-final roots. In vowel-final roots, as in (5.11), the suffixal t is manifested as a singleton:

---

8It would, in fact, be odd to have to claim that sonorant segments and s form a sonority class of moraic segments, and under the present analysis, there is no need for such a claim.
(5.11) a. portato  cf. portare  
b. dormito  cf. dormire  
c. finito  cf. finire  

Participial forms in (5.9) belong to an unproductive class. However, we do observe a phonological regularity here, which makes it less than desirable to treat the alternations in (5.9) as a case of suppletion.  That this phonological regularity extends beyond the restricted class of participial forms is corroborated by the assimilation of loan words discussed above. Crucially, we observe an asymmetry in the simplification of initial and medial anomalous clusters, as in (5.12):

(5.12) Unassimilated  vs.  Assimilated  
    a. [ksj]lofono  vs.  [sj]lofono  
    b. ta[ks]j  vs.  ta[ss]j  
    c. ca[ps]ula  vs.  ca[ss]ula  

The emergence of a geminate in medial position can again be reduced to the familiar scenario. In the assimilated version of (5.12c), for example, the first member of the cluster projects a mora, but does not link to this mora due to the cluster constraint:

(5.13)  
\[ \sigma \ \sigma \ \sigma \]
\[ \mu \ \mu \ \mu \]
\[ c \ a \ <p> \ s \ u \ l \ a \]

From this we can conclude, tentatively, that obstruents may serve as mora projectors, which then leads to the further conclusion that all Italian segments are moraic.

Obstruents may also serve as mora fillers. Two types of evidence bear upon this. First, the forms in (5.14) contain the prefix -ad- which has the form as in (5.15), with a vowel followed by an unfilled mora.

---

9 According to Inkelas and Cho (1993), obstruents are not moraic in Italian, and as a consequence, derived geminate obstruents arise only in forms with underlingly presupposed moras. Thus, they analyze the form *citta* as composed of *cit* + *ta*, the root-final *v* being prelinked to a mora, which it subsequently donates to \( t \), making it into a derived geminate. If *citta* is indeed morphologically complex, the analysis proposed here accounts for it straightforwardly, obviating the need for analyzing *v* as prelinked to a mora: we simply assume that the root-final *v* projects a mora, which is filled by \( t \), since \( v \) cannot be parsed. In sum, it is not advantageous to treat this, or other cases of derived geminates in Italian by resorting to presupposition, as proposed in Inkelas and Cho.
(5.14) a. bottone  abbottonare
 b. casa  accasare
c. fettà  affettare
d. punta  appuntire
e. rendere  arrendere
f. ridere  arridere
g. esca  adescare
h. opera  adoperare
i. ombrare  adombrare

(5.15) a µ

A consonant-initial stem combined with this prefix yields forms as in (5.16), in which the stem-initial consonant is geminated:

(5.16) a µ + casare  accasare

In the case of vowel-initial stems, I assume that d is epenthized, to avoid onsetless syllables (cf. Sluyters’s 1990:93 claim that d is the default consonant in Italian).¹⁰

That any segment may act as a mora filler is further corroborated by Raddoppiamento Sintattico, a case of consonant gemination at word boundaries, exemplified in (5.16) (Chierchia 1982, 1983, Nespor and Vogel 1986):

(5.17) a. città + vechia  città [vv]e[chi[a] ‘old city’
b. palto + pulito  palto [pp]ulito ‘clean coat’
c. caribù + nani  caribù [nn]ani ‘dwarf caribous’

The present account relies on the analysis proposed in Chierchia (1982, 1983). Stressed syllables in Italian have to be bimoraic, yet long vowels are prohibited word-finally. As a result, any word ending in a stressed vowel will have an unfilled mora, which is then filled by the initial consonant of the following word, as in (5.18):¹¹

(5.18) \[ \sigma \sigma \sigma \\
\mu \mu \mu \mu \mu \\
\sigma \sigma \sigma \\
\alpha \text{vech} \text{ia} \]

¹⁰ According to Trumper, Romito and Maddalon (1991:330), the form of this prefix is adjective, and gemination is caused by the loss of d in preconsonantal position. This however is not plausible, given that gemination is encountered even in r-initial stems, as in arriderere (5.14f), although dr is a possible onset cluster.

¹¹ Note that gemination does not take place if the second word begins with an s+consonant cluster, as in città straniere ‘foreign city’ (*città [ss]traniere) (Chierchia 1982, 1983). This again suggests that s-initial clusters are included into the onset only under duress.
In this case, as well, any consonant may serve as a filler, which presents a further argument for the moraic status of all Italian segments.\footnote{It is worth noting that certain types of Raddoppimento Sintattico, attested dialectally, furnish additional evidence for compensatory lengthening induced by consonant loss. According to Laporcaro (1988), in the dialect spoken in Florence, Raddoppimento Sintattico takes place after truncated infinitives, forms such as amà(re), vidé(re), pèrde(re) and spénde(re), which have lost the final syllable (widespread in the dialects of central Italy and parts of Tuscany). Several points are important here. While the vowel of the lost infinitival ending is not part of the form, the “lost” consonant may emerge in some contexts, notably, when the truncated infinitive is followed by a vowel-initial word. The consonant does not emerge utterance finally, but triggers doubling when followed by a consonant-initial word. Most importantly, cases of doubling arise even if stress is on a nonfinal syllable: pe spénde(r) kwattri:n yields pe spénde kkwattri:ni ‘to spend money’. Laporcaro also observes that, in some of the southern dialects, those of the Lausberg zone, which preserve the verbal endings -s and -t, the loss of these endings may cause gemination in the following consonant-initial form, as exemplified by the alternation [kândatə na kandzːə:n] vs. [kândə nna kandzːə:n] ‘sing a song’. Note that the final syllable of the truncated form is not stressed; the final ə in kândatə is assumed here to be epenthetic.}

We thus conclude, on the basis of facts pertaining to the projection and filling of moraic positions, that in Italian, the constraint on moraicity threshold holds for geminates and singletons alike. We also conclude that the situation in Italian is essentially the same as in Pali and Japanese; although not abundant, the available evidence clearly points in this direction.

6 Concluding remarks

This paper proposes a new perspective on compensatory lengthening arising from segment loss, which is advantageous in several respects. By taking Optimality Theory as its frame of reference, the proposed account singles out the set of constraints relevant for characterizing this phenomenon, both those that impose strict requirements and those that allow for variable realizations. Next, by identifying the right set of constraints, this account resolves the paradox noted in the introductory section, which presents a potential problem for constraint-based approaches to compensatory lengthening: an empty prosodic position, which is a prerequisite for compensatory lengthening, may arise only if a segment satisfies two conflicting constraints, one requiring its presence, the other its absence, from syllable structure. The solution offered here is to factor out the projection of prosodic positions and the inclusion of segments into prosodic structure. In other words, the near-absolute requirement to project weight positions maximally has to be attributed to a principle other than prosodic licensing. This role has been assigned here to MORAIC-PROMINENCE. Most importantly, being nonprocedural, the proposed account captures all aspects of (the relevant type of) compensatory lengthening in a parallel fashion, with no recourse to ordering mechanisms, which characterize most of the earlier accounts.
7 References


McCarthy, J. and A. Prince. (1993a) *Generalized alignment*. Ms, University of Massachusetts, Amherst and Rutgers University.


