1. Introduction.
In this paper, I present a new approach to the phenomenon of compensatory lengthening (CL). Previous analyses have viewed this kind of process as the result of the conservation of the moraic structure (Hayes 1989). Therefore, we will refer to these as moraic conservation accounts of compensatory lengthening. Traditionally, this type of lengthening has been rendered as opaque, due to the insertion of a mora without apparent motivation. The moraic account, either within rule-based theory or within Optimality Theory, handles this problem of opacity in different ways. We will show that neither of these offers a satisfying analysis of the phenomenon under study. Furthermore, data from Piro and Samothraki Greek show that the moraic approach underpredicts certain cases of compensatory lengthening in which deletion of an onset segment leads to lengthening.

I propose a departure from these moraic analyses that doesn’t face the problem of opacity as traditionally stated. Our analysis treats this phenomenon as a device to keep the same number of roots as in the input. Gemination repairs a banned structure deleting the features of the consonant while keeping the same number of input root. It will be clear that our account predicts all instances of compensatory lengthening, thus providing an analyses to a broader range of data that other treatments of the phenomenon.

2. Compensatory Lengthening: codas in East Andalusian Spanish.
Hayes in his 1989 paper defines compensatory lengthening as the lengthening of a segment triggered by the deletion or shortening of another nearby segment. Later, Kavitskaya (2002) explains that this kind of lengthening is characterized by the disappearance of an element accompanied by the lengthening of another segment. The common idea to the definitions of this phenomenon is that the lengthening is compensatory in so far as it is conditioned by the deletion of another segment. But the clearer way to understand what the term compensatory lengthening refers to is to exemplified it with an example, in this case, taken from one of the varieties of Spanish spoken in the eastern Andalusia region in South Spain (EAS). This variety presents deletion of coda obstruents together with gemination of the following consonant (Penny 2000, Romero 1995 and references there). The following examples show the difference between standard Peninsular Spanish (SPS) and the EAS variety:

(1)  

<table>
<thead>
<tr>
<th>SPS</th>
<th>EAS</th>
<th>“forest”</th>
<th>“apt”</th>
<th>“a bit”</th>
<th>“action”</th>
</tr>
</thead>
<tbody>
<tr>
<td>[bos.ke]</td>
<td>[bok.ke]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ap.to]</td>
<td>[at.to]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[piθ.ka]</td>
<td>[piθ.ka]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ak.θjon]</td>
<td>[as.sjon]</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1In EAS, the place feature of the interdental voiceless fricative /θ/ changes to alveolar /s/. This is a very common phenomenon in other Spanish dialects.
On the other hand, sonorant codas are comparable across dialects as the set of examples (2) shows (Gerfen 2001):

(2) \[ SPS \quad EAS \]
[par.ke] [par.ke] “park”
[teŋ.go] [teŋ.go] “I have”
[sol.te.ro] [sol.te.ro] “single”
[kam.po] [kam.po] “field”

Before moving on to the analysis, a relevant issue must be considered, namely the establishment of the inputs. I assume that the input is the same for both SPS and EAS, i.e., the coda obstruent is present underlying. This assumption is based on some morphological alternations found in EAS. The first piece of evidence comes from the plural formation. In Spanish, words ending in a consonant form their plural counterparts by adding the suffix /-es/. It is in these forms where the underlying obstruent surfaces as we can see in the following words. The segment in italics is the relevant obstruent:

(3) EAS-sing\(^2\) EAS-plural\(^3\) SPS-sing SPS-plural
[e.da] [e.da.des] [e.dad]\(^4\) [e.da.des] “age”
[la.pi] [la.pi.θes] [la.piθ] [la.pi.θes] “pencil”

Another piece of evidence for the proposed inputs is provided by the phonological alternation of some obstruent-ending prefixes. These prefixes display variation depending on the following segment, whether it is a consonant or a vowel. In the latter cases, the underlying obstruent surfaces. Let’s illustrate this fact with some examples containing the prefixes /des-/ and /sub-/:

(4) prefix ‘des-’ “un-”
\[ \text{root beginning w/ } C \quad \text{root beginning w/ } V \]
[de#n.ni.βel] “unevenness” [de.stå.en.fo.ka.do] “out of focus”

(5) prefix ‘sub-’ “under-”
\[ \text{root beginning w/ } C \quad \text{root beginning w/ } V \]
[su#m.ma.ri.no] “submarine” [su.b#or.di.na.do] “subordinate”

Finally, the behavior of borrowed forms is also relevant when establishing the inputs for EAS. These varieties adapt borrowings from English to their pronunciation, so that these

\(^2\) Notice that word-finally we find only deletion.
\(^3\) Note that the /s/ of the plural form is not realized.
\(^4\) Although an spirantization process occurs in many Peninsular varieties of Spanish and we might get [e.daθ].
words also undergo obstruent deletion and gemination. The following are some examples:

(6) EAS- variety A       EAS-variety B
    [eʰs.son]        [es.son]        “Epson”
    [peʰs.si]        [pes.si]        “Pepsi”
    [laʰt.toʰ]       [lat.to]       “laptop”

However, there seems to be no evidence to posit an underlying obstruent in forms such as [bok.ke] since there is no alternation where it surfaces. Although it should be noticed, that in careful style, coda obstruents may be pronounced due to influence of SPS which is the prestige variety.

3. Compensatory lengthening and opacity.
The term opacity refers to output forms shaped by generalizations that cannot be recovered from the surface. Under the moraic approach, compensatory lengthening is an instance of opacity since a mora is opaquely inserted. The output form contains a mora whose insertion does not seem to be motivated by any surface structure. If we assume that Weight-by-Position (WBP) (Hayes 1989) control the insertion of moras to coda segments, this rule seems to overapply since it introduces a mora even in the absence of a coda element.

3.1 Rule-based analysis of CL.
In order to clarify these ideas, we should consider the rule-based analysis of compensatory lengthening exemplified in the representation (7). First, syllabification applies and the relevant obstruent occupies the coda position, so that in the next stage, it is assigned a mora by WBP. Next, deletion of the coda obstruent takes place leaving its mora behind. In the final level, the floating mora spreads to the following consonant resulting in the gemination of the latter.

(7) σ  σ
    /μ  /μ                      1-Syllabification
    k a p.t a

    σ  σ
    /μ  /μ  /μ                     2-WBP
    k a p.t a
In this derivation, WBP and deletion stand in a counterbleeding relationship. If deletion applies first, WBP loses its chance to assign a mora to the coda consonant, since deletion removes this segment. Thus, WBP is rendered opaque in the surface representation. It seems to overapply. Its structural description, a coda consonant, is not apparent in the surface form. Kiparsky (1973) defines opacity as follows:

(8) A process of the form $A \rightarrow B/C_D$ is opaque to the extent that there are surface representations in the language having either:
   (i) $A$ in the environment $C_D$.
   (iia) $B$ derived by $P$ in environments other than $C_D$.
   (iib) $B$ not derived by $P$ in environment $C_D$.

The cases of compensatory lengthening accommodate to clause (iia) of Kiparsky’s definition. WBP is the relevant process $P$, which inserts a mora $B$ in the environment of a coda consonant. So, in CL we find an inserted mora in an environment that lacks a coda consonant.

In the rule-based approach, an intermediate stage in the derivation of CL is important, in that it supplies the context for WBP to apply. This kind of intermediate stages make the representation more abstract, in the sense that structures that never surface in the actual speech become relevant in the analysis. Optimality Theory (Prince and Smolensky 1993) proposes a departure from the serialist analyses and intermediate stages in the derivation. (see Kager 1999 for other problems of the rule-based theory).

3.2 Opacity in Optimality Theory.
Within OT, these phenomena involving intermediate stages seem problematic due to the parallelist character of the theory, where there are no intervening levels or stages. However, the domain of opacity is not so clear in OT. There are phenomena that do not accommodate to either of the definitions of opacity. Consequently, Itô and Mester (in press) have proposed that opacity is anything that classical OT cannot handle. Traditional OT makes use only of markedness and standard faithfulness constraints.
McCarthy (1999a, b) present an OT analysis of compensatory lengthening within the framework provided by Sympathy Theory as cumulativity. This theory offers a solution to cases of opacity that traditional OT cannot handle. Sympathy claims that, apart from the optimal output, a sympathy candidate, \( C \) candidate, becomes relevant. This sympathy \( C \) candidate is the most harmonic with respect to some designated faithfulness constraint called the selector constraint. The output is required to resemble the \( C \) candidate in some respect. In the cumulativity analysis, McCarthy proposes that the relationship of the \( C \) candidate and the output is monitored by a constraint, \( \text{SYM} \). This constraint demands the output to have a superset of the unfaithful mappings of the \( C \) candidate. This means that the optimal candidate will have all of the \( C \) candidate’s faithfulness violations and may add some of its own.

McCarthy presents a case of compensatory lengthening of a vowel with prenasalization from Luganda:

(9) /muntu/ [muu."ntu] “person”
/bantu/ [baa."ntu] “people”
/kalinda/ [ka.lii."nda] “to wait”

In this analysis, the motivation behind vowel lengthening is a mora inserted by WBP in the \( C \) candidate. This mora is transferred to the output by means of the \( \text{SYM} \). So in the cumulativity analysis, violation of DEP-\( \mu \) by insertion of a mora by WBP plays a crucial role. The following tableau exemplifies McCarthy’s account of Luganda.

(10) Luganda /mu-ntu/ → [muu.ntu]

<table>
<thead>
<tr>
<th></th>
<th>MAX</th>
<th>WBP</th>
<th>NO-CODA</th>
<th>( \text{SYM} )</th>
<th>( \star )UNIFORMITY</th>
<th>DEP-( \mu )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>!</td>
<td>*</td>
</tr>
<tr>
<td>e.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>!</td>
<td></td>
</tr>
</tbody>
</table>

\( C \) candidate (b) is the most harmonic candidate that satisfies the selector constraint \( \star \)UNIFORMITY. This \( C \) candidate incurs only one faithfulness violation, DEP-\( \mu \), due to the insertion of a mora to satisfy WBP. Consequently, candidate (a) is the optimal output since it is the most harmonic candidate that stands in a cumulative relation with \( C \) (b). The output incurs a violation of DEP-\( \mu \) and of UNIFORMITY, i.e., a superset of \( C \) candidate’s unfaithful mappings.

From the above explanation, we see that the constraint DEP-\( \mu \) is crucial for the Sympathy analysis of compensatory lengthening. However, the status of this faithfulness constraint is controversial (Campos 2003). The traditional prosodic faithfulness constraints give rise to unattested syllabification contrasts, such as /ak.la/ vs. /a.kla/ and to non-existent reduplication patterns, both within the same language. Thus, a new proposal is introduces according to which moras inserted by WBP do not violate the prosodic faithfulness
constraints. This line of research undermines the Sympathy approach, which relies in the violation of DEP-µ by the introduced mora. Further problems that Sympathy Theory in general faces are discussed in Itô & Mester (in press) and Kager (1999).

4. Underpredictions of the moraic conservation approach.

The moraic conservation analysis of compensatory lengthening predicts that only the deletion of mora-bearing segments can lead to this phenomenon. These segments are vowels and coda consonants. So this account foretells that deletion of onsets can never lead to compensatory lengthening since onsets are non-moraic. However, I present data below from two languages, Samothraki Greek and Piro, which show instances of compensatory lengthening triggered by the deletion of onset consonants.

Samothraki Greek is reported (Kavitskaya 2002, Newton 1972) to have lost *r* in all positions except word-finally. Deletion of *r* in a C_V environment, i.e., in onset position, and word-initially leads to compensatory lengthening of the following vowel:

(11) Standard Samothraki
a. ádras5 áda:s “man”
   samaθráki samaθá:ki “Samothraki”
b. rúxa ú:xa “clothes”
   róta ó:ta “ask!”

Piro is claimed to have only open syllables (Matteson 1965). It can have up to three-consonant clusters and neither of them stands in the coda position. Piro has a boundary vowel deletion rule. However, this deletion does not lead to compensatory lengthening. On the other hand, some consonant clusters are banned and the deletion of one of the consonants to satisfy the phonotactic constraints of the language gives rise to compensatory lengthening:

(12) Piro
a. suffixation, vowel deletion, no consonant deletion, no CL
   /nika-ja-waka-lu/ → [nikjawaku] “to eat it there”
b. suffixation, vowel deletion, consonant deletion and CL
   /nika-ka/6 → [ni:ka] “he is eaten”

So, these two languages provide evidence against a moraic account of compensatory lengthening. They present lengthening processes as a result of the deletion of onset segments. These segments are presumably non-moraic, but nevertheless, they cause lengthening of a vowel.

Hayes (1989) analyzes the examples in (46a) as cases of double flop. Double flop is defined as the deletion of a post-consonantal onset with subsequent resyllabification of the coda consonant in the onset. The dissociation of the coda consonant can lead to CL. However, this analysis cannot account for the data in (46b).

*kk is one of the banned consonant clusters in Piro.
5. Compensatory lengthening as root number preservation.
I propose an analysis that treats compensatory lengthening as the result of the requirement to preserve the same number of segment roots as in the input. This latter requirement is reflected in the faithfulness constraint MAX-IO that bans deletion. Thus, lengthening arises as a mechanism to keep the exact number of roots as in the underlying form satisfying MAX-IO. On the other hand, the fulfillment of this requirement is achieved at the expense of the loss of the featural content of the deleted segment. This loss involves violation of the set of constraints that ask for featural identity between correspondent segments, IDENTIFY(F)\(^7\) (McCarthy And Prince 1995). I further propose that a markedness constraint specific to each language determines the banned elements. The shape of these constraints is not crucial to the analysis of compensatory lengthening as root number preservation. We might have a constraint such as NoCoda or CodaCond, or a targeted constraint of the type developed by Wilson (2001).

Consequently, the interaction of a markedness constraint and MAX-IO, both in high ranked positions account for the compensatory lengthening phenomena. I illustrate the analysis with examples from Samothraki Greek and Piro. The first language only presents consonant deletion that leads to lengthening. Samothraki exemplifies the simplest case of compensatory lengthening where no other process interferes with this phenomenon. Piro presents a more complex situation since we encounter both consonant and vowel deletion but only the former gives rise to lengthening of the adjacent segment. Finally, I present the analysis of Luganda under the new approach. Thus, we see how the root number preservation account can be extended to cases of coda consonant deletion leading to compensatory lengthening.

6. Samothraki Greek compensatory lengthening as root number preservation.
First we have to pay careful attention to the data and find out what the banned element is in this Greek dialect. Intervocalic \(r\) is deleted without giving rise to compensatory lengthening (examples taken from Kavitskaya 2002):

(13) Standard       Samothraki
    tiri           tií           “cheese”
    kávuras       kávuas       “crab”
    forá\(^8\)    fuá           “time”

We also find deletion of coda \(r\). This is exemplified in (14).

(14) Standard       Samothraki
    xartí         xaití         “paper”
    karóïá        kaiôïa        “heart”

However, this process has an intermediate stage, as Kavitskaya points out, in which \(i\) was epenthesized between the consonant and \(r\). Then, intervocalic \(r\) is deleted as in the

\(^7\) IDENT(F) is a cover constraint for all the individual IDENT(F) constraints.  
\(^8\) In Samothraki Greek, like in other dialects of the northern Aegean Islands, mid vowels raise.
examples in (13). So the data in (14) do not show the entire process and the deleted \( r \) is not in coda position.

As we mentioned in section 4, \( r \) is deleted from onset position. I repeat the data from (11) here:

(15) Standard Samothraki

a. ádras áda:s “man”
samaɔráki samaɔá:ki “Samothraki”
b. rúxa ú:xa “clothes”
róta ó:ta “ask!”

The last set of data show retention of \( r \) word-finally. In fact, this is the only position in which \( r \) can be found.

(16) Standard Samothraki

parakóri paakór “maid”
samári samár “pack-saddle”

It should be noted that unstressed high vowels are deleted word-finally in Samothraki. This is the process that takes place in the data in (16). Notice that in this case, \( r \) is in intervocalic position in the standard form but it occupies the coda position in the output of Samothraki. So, from the data we can conclude that \( r \) is deleted whenever it occurs before a vowel, i.e., as onset. Consequently, we may posit a constraint against \( rV \) sequences:

(17) *\( rV \)

avoid prevocalic \( r \)

This markedness constraint is highly ranked in Samothraki Greek, together with the faithfulness constraint MAX-IO that leads to compensatory lengthening. But not all instances of \( r \) deletion lead to lengthening. This means that the markedness constraint has to be satisfied even at the expense of losing one root. In the ranking, this translates as domination of the markedness constraint over MAX-IO. In the set of examples (13) and (14), we do not see lengthening of the vowel preceding the deleted segment. If lengthening took place, a sequence of three vowels would occur. These clusters are generally dispreferred. So, a constraint against three vowels in a row (18) is active in Samothraki. In fact, Kavitskaya reports that examination of the data does not show any VVV clusters. Thus, a constraint that bans three moras in the nucleus seems to be active.

(18) *3µ-N

no sequence of three moras in the nucleus.

The fact that we introduced above with regards to unstressed high vowels is also reflected in a high ranked constraint in the language:
Another issue that we need to address is that vowel rather than consonant lengthening is obtained. It seems that there is a constraint against long vowels that prohibit the occurrence of these elements. None of these long segments are found in the language. The relevant constraint is *LONG-C (Holt 1997):

\[ \text{(20) *LONG-C} \]
\[ \text{no long consonants.} \]

So far, all the relevant constraints for our analysis of compensatory lengthening in Samothraki have been introduced. Let’s recapitulate them paying attention to their position in the ranking with respect to each other. The markedness constraints *i, *3µ-N and *LONG-C are undominated in this language, together with the markedness constraint *rV. This constraint dominates MAX-IO, since, as we saw above, deletion of the banned element always takes place even without compensatory lengthening. Finally, MAX-IO is satisfied by changing the features of the segment, so IDENT(F) is ranked below the constraint against deletion. (21) shows a constraint lattice for these relations:

\[ \text{(21) *i, *3µ-N, *LONG-C, *rV} \]
\[ \text{MAX-IO} \]
\[ \text{IDENT(F)} \]

The final ranking is the following:

\[ \text{(22) *i, *3µ-N, *LONG-C, *rV >> MAX-IO >> IDENT(F)} \]

It is relevant to analyze a word from each of the different sets of data that we saw above. The first example in tableau (23) involves deletion of \( r \) without lengthening of the preceding vowel.

\[ \text{(23) /tiri/ \rightarrow [tii]} \]

<table>
<thead>
<tr>
<th></th>
<th>/t₁i₂r₁i₄/</th>
<th>*i</th>
<th>*3µ-N</th>
<th>*LONG-C</th>
<th>*rV</th>
<th>MAX-IO</th>
<th>IDENT(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>t₁i₂r₁i₄</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>t₁i₃i₄</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>t₁i₂i₃i₄</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td>![x]</td>
<td></td>
</tr>
</tbody>
</table>

Candidates (a) and (c) are ruled out because they violate two of the undominated constraints, *rV and 3µ-N respectively. Notice that in this case the candidate that undergoes compensatory lengthening (c) is not the optimal output because it violates the
constraint against three moras in the nucleus. It is more important to satisfy this requirement than to keep the same number of roots as in the input. Tableau (24) shows an example of onset deletion resulting in compensatory lengthening of the following vowel.

(24) \(/r\text{x}\text{a}/ \rightarrow [u:x]\)

<table>
<thead>
<tr>
<th></th>
<th>*i</th>
<th>*3(\mu)-N</th>
<th>*LONG-C</th>
<th>*rV</th>
<th>MAX-IO</th>
<th>IDENT(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (r1u2x3a4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b. (u2x3a4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. (u1u2x3a4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d. (u1x2x3a4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

The most faithful candidate (a) is ruled out by the markedness constraint *rV. Similarly, candidate (d) with a geminate consonant fatally violates one of the top ranked constraints. MAX-IO is responsible for deciding between candidate (b) and (c). The former candidate incurs a violation of the anti-deletion constraint so candidate (b), with lengthening of the vowel wins over it.

Finally, tableau (25) represents the analysis of an example containing a prevocalic \(r\), which is kept in the surface form in the word-final coda position.

(25) \(/s\text{a}\text{m}\text{á}r\text{s}\text{i}\text{6}/ \rightarrow [\text{samár}]\)

<table>
<thead>
<tr>
<th></th>
<th>*i</th>
<th>*3(\mu)-N</th>
<th>*LONG-C</th>
<th>*rV</th>
<th>MAX-IO</th>
<th>IDENT(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (s1a2m3á4r5\text{s}\text{6})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*(!)</td>
<td></td>
</tr>
<tr>
<td>b. (s1a2m3á4r5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. (s1a2m3\á4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*<em>!</em></td>
<td></td>
</tr>
<tr>
<td>d. (s1a2m3\á4\á5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*!</td>
</tr>
<tr>
<td>e. (s1a2m3\á4\á5\á6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

Candidate (a) is ruled out due to its violations of two top ranked constraints, *i and *rV. Candidate (e) violates *LONG-C, an undominated constraint, so it loses with respect to the other candidates. Candidate (c) incurs one violation more of MAX-IO than candidates (b) and (d). Finally, IDENT(F) decides between (b) and (d), so that the form with \(r\) in word-final coda position is the optimal output. It is relevant to notice that the markedness constraint is silent in this candidate, since the form does not meet the structural description of the constraint, namely \(r\) does not appear in a prevocalic position.

The data from Samothraki Greek serve a basis to see how compensatory lengthening can be analyzed in terms of root number preservation. At this point, it is necessary to consider the status of the root node. We saw that MAX-IO can be satisfied by retaining the root node of the segment, even if the features are erased. Then, the features of the preceding vowel are spread to fill this empty node. For this analysis, we assume along the lines of Padgett (2002) that the root’s role is to capture the timing relation between the features. This means that the root itself is not composed of any feature content, moving away from previous approaches, where the root contained the features [sonorant] and [consonantal].
Padgett’s proposal (also see Hayes 1990) suggests that the root node is only responsible for the timing coordination.

From the exposition about the root node, it is clear that our analysis assumes a two-root representation of geminates. This kind of representation is developed by Selkirk (1991) who presents reasons for favoring the latter representation over one-root geminates. She presents evidence for this two-root theory of geminates from laryngeal fission rules that only modify the feature content of just one half of a geminate. The two-root representation correctly predicts that rules that involve delinking are not blocked. On the other hand, Keer (1999) argues for the one-root theory of gemination. However, he does not rule out two-root geminates. He allows for their existence but says that they require an extra layer of prosodic structure. Thus, our representation of geminates is supported by independence evidence.

7. **Piro compensatory lengthening as root number preservation.**

Before going into the details of the compensatory lengthening analysis of Piro, we need to present some relevant facts about the phonology of this language. Piro is an Arawakan language spoken in Eastern Peru and it has been described by Matteson (1965). This language is reported to have only open syllables and up to three consonant clusters in the onset position. However, there are some phonotactic constraints with respect to the consonants that can appear adjacent.

(26) banned consonant sequences in Piro
*rl, *rr, *ll, *lr
*fricative-fricative
*affricate-affricate
*ts-s, *ts-š, *ts-x, *tš-s, *tš-š
*x-ts, *x-tš

If any of these banned sequences is formed due to morpheme concatenation, the first consonant in the banned sequence is deleted and the preceding vowel is lengthened. Another important process in Piro that has some effect in the compensatory lengthening phenomenon is the so-called Boundary Vowel Deletion (BVD). BVD removes the final vowel of each lexical root and derived stem. So, BVD gives rise to consonant clusters that may be subject to the consonant sequences restrictions. However, BVD is blocked when the result would be a three consonant cluster, unless this cluster is later subject to compensatory lengthening. Let’s exemplify these facts with some data:

(27) a. nika+ya → [nikya] “to eat+loc” → BVD.
    b. koko+yma → [kokoyma] “with uncle” → blocking of BVD.
    c. hitsurukate+tši → [hitsuruka:tši] “chief” → BVD and CL.

---

9 Three consonant clusters are the result of morphological concatenation that involves monoconsonantal affixes.
10 A morphological condition marks arbitrarily some suffixes as non-triggers of BVD.
First, let’s consider what kind of segments are banned in Piro and what constraint regulates this prohibition. The banned sequences were introduced in (26). Whenever any of these sequences would arise as a consequence of BVD, the first consonant of the cluster is deleted and the previous vowel lengthened. We saw that the prohibited sequences involve obstruents and liquids with the same place of articulation and/or manner. Thus, there is a markedness constraint active in Piro against this kind of clusters. An OCP constraint may capture the combination restrictions in consonant sequences. This constraint occupies a high position in the ranking relevant for Piro.

The issue of why the first consonant in the cluster is deleted and not the second one is addressed by the targeted constraints (Wilson 2001). These constraints determine the banned elements and the repair the language prefers, in this case, deletion of the first consonant. However, I will exemplify my analysis making use of a traditional OCP constraint. Consequently, candidates where the second consonant is deleted are not taken into consideration. These candidates would be taken care of by a targeted constraint.

The deletion of boundary vowels is conditioned by a markedness constraint. An alignment constraint, requiring the right edge of the stem to be aligned with a consonant, seems to be responsible for the BVD processes. However, if we pay close attention to the data, we see that this is not the case. In fact, stems may end in a vowel, but this vowel has to be long. Example (27c), [hitsuruka:ʃ]stem[tʃi] shows an output that contains a long vowel at the end of the stem. So, we conclude that the left end of the stem cannot be aligned with a short vowel. One difference between long and short vowels is proposed by Zec (1994). She suggests that within a heavy syllable, the first mora dominating the nucleus segment is a strong mora, while the second mora dominating the coda consonant or the second phase of a long vowel is a weak mora. So, Piro seems to ban strong moras at the end of the stem. The following constraint captures this idea:

(28) BVD
do not have a strong mora at the end of the stem.

Although this constraint is high ranked, it is dominated by some other constraint since BVD is blocked when the result would be a sequence of three consonants. The following constraint bans three or more consonants clusters:

(29) *CCC
do not have three or more consonants in a cluster.

*CCC dominates BVD. Tableau (30) shows that this ranking gives us the correct output for the example in (27b). Candidate (b) violates *CCC so it is ruled out. Candidate (a), with blocking of BVD, is the optimal output.

(30) /koko+yma/ → [kokoyma]
<table>
<thead>
<tr>
<th>/koko+yma/</th>
<th>*CCC</th>
<th>BVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kokoyma</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

12
The next issue we need to address is why consonant deletion and not vowel deletion leads to compensatory lengthening. First, notice that the lengthened segment must be adjacent to the deleted element. It is beyond the scope of this paper to explain why compensatory lengthening usually affects adjacent segments\textsuperscript{11}. When a vowel is deleted, the adjacent segment that should be targeted by compensatory lengthening is a consonant. Correspondingly, if this consonant is lengthened, we end up with a sequence of three consonantal elements. As we saw above, the creation of these sequences is banned by *CCC. So, satisfaction of this constraint and also of BVD is achieved at the expense of MAX-IO, since we delete a segment root. *CCC and BVD dominate MAX-IO. Thus the ranking so far is the following:

\[(31) \text{OCP, } *\text{CCC} \gg \text{BVD} \gg \text{MAX-IO}\]

Tableau (32) shows how this ranking works with an example that undergoes BVD and no compensatory lengthening. Candidates (c, d) with lengthening of a consonant are ruled out because they violate the two top-ranked constraints. Candidate (a) does not satisfy the BVD constraint, so candidate (b) turns out to be the optimal output.

\[(32) /nika+ya/ \rightarrow [nikya]\]

<table>
<thead>
<tr>
<th>/nika+ya/</th>
<th>OCP</th>
<th>*CCC</th>
<th>BVD</th>
<th>MAX-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. nikaya</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>≠ b. nikya</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. nikkya</td>
<td>*(!)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. nikyya</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

The last component of our analysis of compensatory lengthening in Piro is the ranking of IDENT(F) constraints below MAX-IO, as we saw in the analysis of Samothraki Greek, to account for the loss of root features but not of the root itself. Thus, the final ranking is as follows:

\[(33) \text{OCP, } *\text{CCC} \gg \text{BVD} \gg \text{MAX-IO} \gg \text{IDENT(F)}\]

Let’s show the ranking in action for an example with BVD and compensatory lengthening.

\textsuperscript{11} A possible approach to the issue of adjacency is to say that lengthening of a non-adjacent segment incurs a violation of Linearity in the following way:

<table>
<thead>
<tr>
<th>/n1_i_k_a_y________ a_ a_</th>
<th>Linearity</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. n1i5k4y5a5a6</td>
<td>✓</td>
</tr>
<tr>
<td>b. n1i5k4y5a5a6</td>
<td>*</td>
</tr>
<tr>
<td>c. n1i5k4y5a5a6</td>
<td>*</td>
</tr>
</tbody>
</table>
(34) hitsurukate+tši → [hitsuruka:tši]

<table>
<thead>
<tr>
<th></th>
<th>OCP</th>
<th>*CCC</th>
<th>BVD</th>
<th>MAX-IO</th>
<th>IDENT(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. hitsurukate[tši]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. hitsurukat[tši]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. hitsurukaa[tši]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. hitsuruka[tši]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. hitsurukatt[tši]</td>
<td>*(!)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The most faithful candidate (a) is ruled out because it violates BVD, like candidate (d) with deletion of a CV sequence from the end of the stem. Candidates (b) with a banned consonant cluster and (c) with consonant lengthening violate the top-ranked constraints, OCP and *CCC. Candidate (c) satisfies all the high ranked constraints at the expense of incurring some violations of the lower constraints.

The data from Piro illustrates our analysis of compensatory lengthening and its interaction with other constraints active in the language. In this case, only consonants result in compensatory lengthening and not vowels. This is the result of some markedness constraints against consonantal clusters. If lengthening were motivated by moraic conservation, we would expect deletion of vowels and not of onset consonants to give rise to compensatory lengthening.

8. **Luganda compensatory lengthening as root number preservation.**

Luganda is an example of compensatory lengthening that involves an intervocalic cluster, formed by a nasal and a consonant, that surfaces as lengthening of the preceding vowel and prenasalization of the consonant (McCarthy 1999b, described by Clements 1986a). This means that in Luganda, compensatory lengthening is driven by coda deletion. We can see the phenomenon in the following words:

(35) /muntu/ → [muu.n tu]  “person”
/bantu/ → [baa.n tu]     “people”

Luganda is described as allowing no codas except geminate consonants (Clements 1986a). A markedness constraint bans all coda consonants but geminates.

(36) CodaCond

no coda consonants unless they are geminate.

This CodaCond together with MAX-IO are high in the ranking, crucially dominating IDENTITY(F), so that /n/-deletion and lengthening arise. So far, we see at play the ranking responsible for compensatory lengthening as root number preservation. The

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12 The reformulation of this markedness constraint as a targeted constraint explains why the first element of the cluster is deleted. I will not make use of targeted constraints in my analysis, so candidates involving deletion of the second element and lengthening of the first are not considered.
choice of vowel lengthening over consonant gemination is monitored by the ranking of 
*Long-C over *Long-V.

Keer 1999)
Avoid long vowels.

Consequently, the ranking for Luganda is the following:

(38) CodaCond, MAX-IO, *Long-C >> IDENT(F), *Long-V

Tableau (39) illustrates the analysis of compensatory lengthening in Luganda.

Tableau (39) illustrates the analysis of compensatory lengthening in Luganda.

<table>
<thead>
<tr>
<th>/muntu/</th>
<th>CodaCond</th>
<th>MAX-IO</th>
<th>*LONG-C</th>
<th>IDENT(F)</th>
<th>*LONG-V</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [mun.tu]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [muu.&quot;tu]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [mut.&quot;tu]</td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d. [mu.&quot;tu]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Candidate (a) violates the CodaCond. Candidate (c), although it satisfies the CodaCond since the coda consonant is a geminate, it is ruled out by *LONG-C. Candidate (d) fatally violates MAX-IO. But this tableau does not include candidates, such as [mũu."tu] where nasalization is realized in the lengthened vowel. An interesting part of compensatory lengthening in Luganda is the phenomenon of prenasalization of the following consonant. It seems that the language wants to keep the nasal feature of banned coda element. This is reflected in the satisfaction of a faithfulness constraint demanding no deletion of nasal features:

(40) MAX[nas]
no deletion of nasal features.

But this constraint alone does not explain why we get nasalization of a vowel rather than of a consonant. Here, the constraints banning nasalized vowels and consonants play an important role:

(41) *Vnasal
no nasal vowels.

(42) *Cnasal
no nasal/nasalized consonants.

Thus, *Vnasal outranks *Cnasal in Luganda. On the other hand nasal consonants may surface. This means that IDENTITY(F) is higher than *Cnasal, since Luganda prefers to keep feature identity even in a nasal segment. Now, we can establish the complete ranking for compensatory in Luganda:
The following tableau (44) exemplifies the final ranking for Luganda. Candidate (b) is the most harmonic. Note that the initial nasal consonant surfaces as such because of the requirement to keep the same feature specification, even if it is a nasal segment. Furthermore, when Luganda has to create a nasal segment from an input not specified for nasality, the language chooses a nasal consonant. The *Cnasal constraint is very low ranked so its effects against nasal consonants are not seen.

### Tableau (44) /muntu/ → [muu.ₙtu]

<table>
<thead>
<tr>
<th>/muntu/</th>
<th>CodaCond</th>
<th>Max-IO</th>
<th>Max(nas)</th>
<th>*Long-C</th>
<th>*Vnas</th>
<th>Ident(F)</th>
<th>*Cnas</th>
<th>*LongV</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[mun.tu]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>[muu.ₙtu]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>[muₙ.tu]</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>d.</td>
<td>[mu.ₙtu]</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>[mùù.tu]</td>
<td></td>
<td></td>
<td><em>!</em></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>f.</td>
<td>[muu.tu]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Candidates (a, c, d) lose on the top-ranked constraints CodaCond, *LONG-C and MAX-IO. Candidate (e) with nasalization on vowel segments fails on *Vnas. Candidate (f) deletes the nasal feature and violates MAX(nas). The optimal candidate (b) satisfies all the high ranked constraints.

Luganda provides an example of compensatory lengthening motivated by deletion of a coda consonant. The analysis presented in the previous sections for cases of onset deletion also captures this process. A markedness constraint is responsible for the deletion of the banned consonant and MAX-IO, in a high position, leads to lengthening in order to keep the same number of segment roots.

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13 *LONG-V is placed at the bottom of the hierarchy. However, its ranking w.r.t. IDENT(F) & *Cnas cannot be established. It’s place there for convention and ease of exposure.
8. Conclusion.

Our proposal does not depend upon the notion of opaquely inserted moras or the violation of DEP-µ constraint, so we do not face any of the problems that such approaches encounter. Compensatory lengthening arises as a device to maintain the same number of segments as in the input. This requirement is satisfied even if the feature content of the segment is changed. The fact that the lengthened elements are assigned a mora or remain non-moraic is an issue that the language specific rules of syllabification determine. We do not assume any restrictions in the input with regards to moraic specification.

Coming back to the issue of opacity, we see that according to our analysis, compensatory lengthening is not regarded as an opaque phenomenon in the traditional way (opaque mora insertion or WBP). Also, the explanatory power of our analysis is greater than that of the moraic approach and we are able to account for data involving compensatory lengthening derived from deletion of an onset.

Our analysis leaves the door open for the possibility that the deletion of any segment may lead to compensatory lengthening. However, the fact that coda rather than onset consonants seem to cause more often lengthening must be dealt with. One approach could be to argue that in general, coda consonants are more likely to be the target of phonotactic constraints, and thus, be deleted. But this issue needs further study.

REFERENCES:


IUWPL.