A Two-Root Theory of Length

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In earlier versions of autosegmental theory the feature content of a segment was represented on a melody tier. The quantity of a segment was represented on a skeletal tier composed of so-called timing units--C's and V's, or simply X's. Long segments were single melody units doubly linked to the skeletal tier:

(1) Skeletal Tier   V   V   C   C

       Melody Tier   a   b
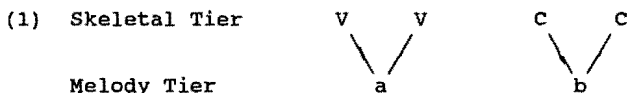
In this paper I want to consider the implications for the autosegmental theory of length of two recent developments in the theory of phonological representation. The first development concerns the representation of the melody, the second concerns the skeleton. These theoretical developments require us to examine the representation of geminates with new eyes, and call for the elimination of the skeletal tier in phonological representation.

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The 'melody' portion of a segment is no longer
viewed as a simple distinctive feature matrix.
Rather, features are now understood to be organized
into a structured representation, one which has
been referred to as feature geometry, following
Clements (1985). Clements proposes that within the
feature structure of a segment a root node
dominates all other features that specify a
segment. It is via the linear ordering of roots
that the features of phonological representation
are given a temporal organization (see Sagey 1986,
40ff). Following McCarthy 1988 I will assume that
the root node is made up of the major class
features Consonantal and Sonorant, so that we have
vocalic roots, consonantal roots, obstruent roots,
etc., as shown in (2):

(2)   RV: [-cons]   Robst: [+cons]
           [+son]   [-son]

       RC: [+cons]   Rson: [ucons]
           [uson]   [+son]

And I will assume for the moment the feature
organization in (3), again following McCarthy
1988:

(3)   RC

        Laryngeal   Nasal Place   Continuant
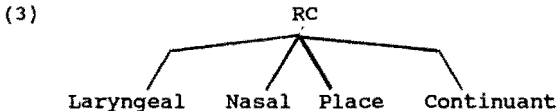
The theory of feature structure that I will assume
in this paper corresponds most closely to this
conception. I should point out that whether "Place"
stands for the Place node of feature-geometric
theories or for the primary place feature, which
dominates all other place features in a no-class-
node approach like Selkirk (1988, in preparation),
is immaterial for the present paper.

The basic autosegmental assumption that
phonological length involves a single melody unit
linked to two skeletal positions has been carried
over in all recent work on feature organization
(see e.g. Clements 1985, Sagey 1986, Schein and
Steriade 1986, Archangeli and Pulleyblank 1986).
These feature-geometric accounts assume that it is
a single root node, rather than a monolithic melody
unit, that is linked to the two skeletal positions
guaranteeing length.

Parallel to developments in the theory o   f feature structure, there have been important developments in the theory of the skeleton. The pioneering work of McCarthy 1979, 1981 on Semitic templatic morphology showed the necessity of separating the representation of a skeleton from that of the melody. In recent work, McCarthy and Prince 1986, 1988, 1990 have argued that the skeleta of templatic morphology are constituted solely of prosodic constituents, e.g. foot, syllable, mora. The claim is that no use is made in templatic morphology of a skeletal tier composed of C, V, or X. This paper provides support for the notion that there is no skeletal tier in phonological representation, in showing that it has no role in the representation of geminates.

Let us assume the McCarthy-Prince notion of the skeleton as constituted, in its lower reaches, by a syllable and mora structure, and lacking any representation of a skeletal tier. And let us assume the feature structure sketched above. Putting together the representations defined by these two theories, one sees that the root tier forms the interface between feature structure and the prosodic structure of the skeleton:

(4) The prosodic structure-feature structure interface

```
Syl                    Syllable tier
 / \
/   m                  Mora tier
 \   \
  \   \
RC    RV               Root tier
/_\   /_\              Other features
```
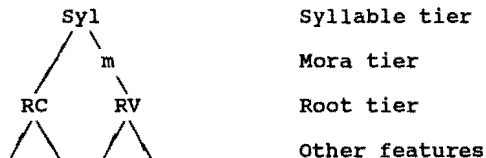
Now the question is: What is the representation of length in this prosodic structure-feature structure framework?. There are two logical possibilities. The first, attributable to Hyman 1985, McCarthy and Prince 1986 and Hayes 1989, to appear, is a one-root theory of length, whereby a single root node is doubly-linked to two different positions in a syllable-mora structure.

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(5)   A One-Root Theory of Length

      (Hyman 1985; McCarthy & Prince 1986;
      Hayes 1989, to appear)

      Geminate Vowel   Geminate Consonant

```
        Syl                     Syl   Syl
       /  \                    /  \   /  \
 .... m    m ....        ..... m   \ /    .....
       \  /                         V
        RV                         RC
        |                           |
      Place                       Place
```
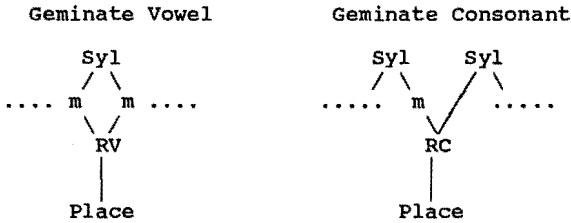
One-root theory continues in the autosegmental
tradition assuming that length involves a single
'melody' node linked to two skeletal positions: the
melody unit is a single root node and the double
links are to positions in syllable/mora structure,
now the characterization of the skeleton. As
articulated by McCarthy-Prince and Hayes, one-root
theory is moreover a moraic theory of length.
McCarthy-Prince and Hayes propose that in lexical
representation long segments consist of a single
root node linked to a single mora, and that the
double-linking of (5) is produced by general rules
of syllabification. This proposal makes
predictions about the distribution of geminates and
their behavior with respect to quantity-sensitive
phenomena that will be examined below in sections
4-6.

        An alternative, which I would like to argue
for here, is a two-root theory of length.
According to this theory, geminate entities involve
two identical root nodes and some amount of shared
feature specifications, including, crucially,
shared features for Place, as shown in (6):

(6)   The Two-Root Theory of Length

      Geminate Vowel   Geminate Consonant

```
      RV    RV                 RC    RC
        \  /                     \  /
         V                        V
      Place                     Place
```

The double-linking of place features shown in (6)
is common to all geminates, full or partial. Full

geminates involve the sharing of all features; partial geminates are structures where specifications for laryngeal features or nasality may differ in the two halves.

The two-root theory in (6) differs from one-root theory in representing the notion 'segment' within the feature structure of phonological representation. The segment count of a representation is identified with the root count, not with the number of positions in (or, more precisely, associations to) syllable-mora structure. On this theory it is the root tier that is the 'timing tier', if by 'timing tier' we mean the tier giving the segment count of the utterance. Geminate vowels and consonants consist of two (root) segments. From the point of view of the theory of phonological representation, two root theory could be seen as a revision of the early autosegmental theory in (1) where features of the melody are associated to two positions in a C/V tier or X tier. What distinguishes the present conception of the root tier from earlier conceptions of the C/V or X tier is that root nodes are understood to be part and parcel of the feature organization of the representation. The root is itself comprised of feature specifications, and the relations of these with other features in the representation is arguably governed by quite general constraints on feature representation (on this, see section 3 below). On this view the C/V tier of (1) is a proto-root tier, and properly belongs to feature structure.

In what follows I am going to present three arguments from melody phenomena, i.e, from phenomena having to do with feature structure, in favor of representing length with two root nodes, as in (6), instead of as in (1) or (5). At issue are the splitting of geminates by laryngeal fission, long vowel diphthongization, and the nature of geminate inalterability.

The lexical representations of two-root theory, in (6), themselves make no commitment as to the status of geminate vowels and consonants in a syllable/mora structure. The moraification and syllabification of geminates is presumed to be accomplished by general principles and rules in the grammars of individual languages, and hence the moraic status of geminates might vary from one language to another. In this way, two-root theory

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makes potentially different predictions from one-
root theory.   In the second part of the paper I
will try to sort out where the one-root and two-
root   theories   crucially   diverge   in   their
predictions about the behavior of geminate entities
with   respect   to   syllabification   and   quantity-
sensitive   phenomena   by   looking   at   compensatory
lengthening,   the   distribution   of   geminates   in
syllable phonotactics, and the role of consonantal
geminates in stress systems.

TWO-ROOT LENGTH AND FEATURE STRUCTURE

1.   Laryngeal Fission

        The first argument for a two-root theory of
length is due to Steriade.   In an unpublished paper
Steriade   (1987a)   presents   evidence   for   the
existence of rules which modify the feature content
of just one half of a geminate, leaving the other
half with different feature content, or no feature
content at all. The phenomena Steriade examines
involve laryngeal features, where the two halves of
geminates   are   differently   specified   for   voice,
glottalization, or aspiration. I'll refer to these
as   instances   of   <u>laryngeal   fission</u>.   Viewed   in
theory-neutral   terms,   the   existence   of   laryngeal
fission   is   simply   an   argument   that   the
representation   of   geminates   contains   two
sequentially   ordered   positions   of   which distinct
laryngeal   feature   specifications   could   be
predicated, but it does not indicate where in the
representation   these   two   sequentially   ordered
positions lie. One option would be to assign the
different   laryngeal   feature   specifications   to
constituents   of   prosodic   structure.   Allowing this
would violate the generalization that the root node
of   a   segment   dominates   all   the   features   that
characterize that segment.   I suggest we make this
a   principle,   call   it   the   Principle   of   Skeleton-
Melody Separation, written in (7), and use it to
rule out the possibility of assigning features to
moras or syllables.

(7)   Skeleton-Melody Separation

      The root dominates all features that specify a
      segment.

The reasons for adopting this principle are, first,
that   known generalizations about feature geometry
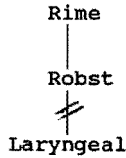not only conform to it, but probably depend on it,

and, second, that it restricts the set of possible representations in a desirable way.

Given skeleton-melody separation, there are two options for representing double laryngeal specifications for geminates in the prosodic structure-feature structure framework. According to one, a geminate has two root nodes, and each could become separately specified for laryngeal features. This is the analysis I will argue must be adopted. The alternative one-root theory of the geminate would require that the dual laryngeal specifications be assigned to a single root node. I will argue that this one-root solution is not a viable option, and thus that laryngeal fission gives support for a two-root theory of length. The two-root solution I am proposing to the problem of laryngeal fission is, from the point of view of the theory of phonological representation, a terminological variant of Steriade's (1987a) solution. Steriade assumes the existence of a C/V skeletal tier, and that geminates involve double-linking to two units of the C/V tier. The problem of laryngeal fission is solved by assuming that there is no root tier, and that the class nodes for laryngeal, place, and nasality features all directly link to the C/V tier. In the Steriade proposal the C/V tier in effect takes on the function of the root tier in feature representation. One could just as well understand Steriade as proposing that the C/V tier be abolished in favor of the root tier and that the root tier be the locus of the double-linking of geminates, as in my two-root proposal.

A particularly interesting case of laryngeal fission comes from Klamath (Barker 1964, Kingston 1985). Consonant length is contrastive in Klamath. Obstruents in Klamath are phonemically voiceless, glottalized and voiced: p t c k q ; b d j g G ; p't'c'k'q'.   Within the rime, however, this distinction is neutralized. Following Kingston and Steriade, I will assume there is a rule of laryngeal neutralization, which delinks any laryngeal feature from an obstruent in a rime, leaving it unspecified.
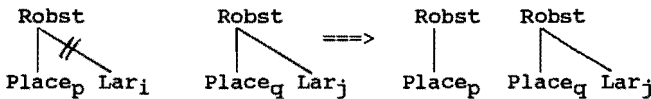
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(8)   Klamath Laryngeal Neutralization

```
                    Rime
                     |
                    Robst
                    ‡
                  Laryngeal
```

Assume that a default rule later fills in the
voiceless plain value observed in this position.
When the rule applies to a heterosyllabic obstruent
cluster, it will produce a derivation like that in
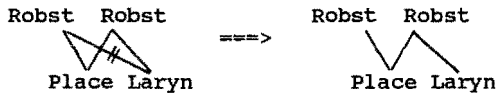(9).

(9)   Nongeminate obstruent clusters: p'k --> pk,

                              dk'--> tk',
                                etc.

```
Robst         Robst              Robst   Robst
  |\            \        ===>       |       \
  | #            \                  |        \
Place_p Lar_i   Place_q Lar_j     Place_p Place_q Lar_j
```

What's of interest is that the neutralization rule
affects the first half of geminate consonants, too,
creating a long consonant with a sequence of two
different laryngeal specifications, as shown in
(10).

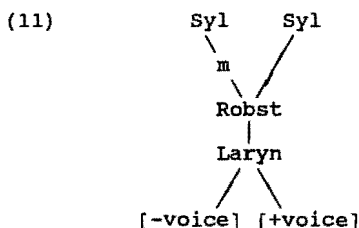(10) Geminate obstruents: p'p' --> pp', dd --> td,

                              etc.

```
Robst   Robst              Robst   Robst
  \  / \        ===>         \     /\
   \/   \                     \   /  \
   /\ # /                      \ /    \
Place  Laryn                  Place  Laryn
```

This happens with underlying geminates, as well as
with geminates that are created through
reduplicative gemination, or through morphological
concatenation. Consider for example the geminate-
producing reduplicative morpheme meaning 'intensive
action or state'. When it is an obstruent that gets
doubled, the result is a geminate with laryngeal
fission, e.g. [godi:la] 'goes under' vs. [gotdi:la]
'goes around under'. The point, then, is that all
heterosyllabic obstruent clusters in Klamath,
whether geminate or not, are laryngeally split.

This is straightforwardly representable with a two-root theory of the geminate.

Let us consider now how a one-root theory of the geminate would fare with Klamath. Given skeleton-melody separation, one-root theory will require the two different laryngeal specifications in geminates to be assigned to the same root node:

(11)   Syl   Syl
               \   /
                m /
                 \/
               Robst
                 |
               Laryn
               / \
        [-voice] [+voice]

(To make this solution workable for Klamath, the default laryngeal state 'plain voiceless' would have to be specified for the default [-voice]. Otherwise there would be no double specification.) The problem with (11) is that it fails to indicate that it is the part of the geminate that is in the rime which is realized as plain voiceless. How is such a representation interpreted in current feature tleory? If the analogy is to segments like labiovelars with multiple place articulations (discussed by Sagey (1986)), then both halves of the geminate in (11) would be realized with both laryngeal values. This would be wrong. Suppose instead the analogy is to affricates. In affricates two contrasting specifications of the feature [continuant] are attached to the root node, and are pronounced in the order stop-fricative. Lombardi (1989) shows, however, that the ordering within affricates cannot be phonological. Rather it must be introduced late in the derivation. Moreover, since the ordering is always the same, it is plausibly introduced by universal principles. In other words, putting together the results from Sagey and Lombardi, there is no independent basis for assuming that an ordering of feature specifications is possible under the root node. This important characteristic of feature structure could be named as follows:

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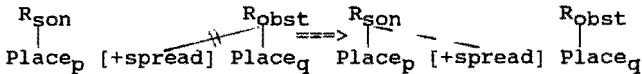(12) The No-Feature-Ordering Generalization

Features dominated by the same root node are
not phonologically ordered.

The one-root solution to laryngeal fission in (11)
violates this generalization. This problem would be
obviated if universal principles could be called on
to guarantee the proper ordering of the two
laryngeal specifications in geminate obstruents
(see Kingston 1985). Yet we are still left with the
necessity of seeing the ordering of the laryngeal
features in geminates and nongeminates in different
terms. And that is really the essential drawback.

    (Danish provides a parallel example of
laryngeal fission with long vowels. Syllables with
a stød locate this glottalization on the second
half of a long vowel, or on a syllable-final
sonorant consonant following a short vowel (Basbøll
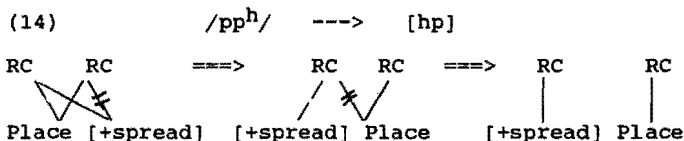1988).)

    Icelandic preaspiration (Thráinsson 1978a,
1978b) represents another case of geminate
laryngeal fission. Again, I follow Steriade in
concluding that the phenomenon requires a
representation of geminates as doubly-linked to two
feature-attachable nodes.   As Thráinsson 1978,
Steriade 1987a, Hermans 1985 and Kingston 1990 make
clear, preaspiration is by no means a phenomenon
restricted to geminates.   Rather, it involves the
delinking of aspiration ([+spread glottis]) from an
underlying aspirated stop and a transfer of that
aspiration to the preceding consonantal segment,
producing voicelessness (see also Einarsson 1927,
1967; Petursson 1972).   In southern dialects, for
example, all sonorant plus aspirated stop sequences
turn into a voiceless sonorant plus unaspirated
stop sequence. The derivation Steriade 1987a
proposes for such cases is given in (13).

(13)   /lp^h/   -->   [l̪p]

R_{son} R_{obst} R_{son} R_{obst}
  | ===> | | |
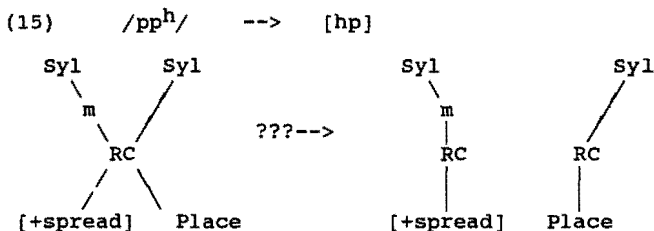Place$_p$ [+spread] Place$_q$ Place$_p$ [+spread] Place$_q$

Preaspiration in geminates involves a somewhat more
dramatic effect. The gemination of aspirated stops
gives rise to a sequence of h plus unaspirated
stop: /pp^h/ ---> /hp/. Still following Steriade,
the transfer of [+spread] to the initial half of a

geminate (in our terms, to the initial root of the geminate) is followed by a delinking of the place features, creating the h plus stop sequence:

(14)   /pp^h/   --->   [hp]

RC   RC   ===>   RC   RC   ===>   RC   RC
                                                     | |
Place [+spread]   [+spread] Place   [+spread] Place

The essential point is that a two-root representation of the geminate stops permits preaspiration in geminates to be subsumed under the more general phenomenon of preaspiration in consonant clusters. Whereas with a one-root theory of geminates it becomes a mystery why geminates should pattern with consonant sequences.

What would the derivation look like with a one-root theory? Somehow, the two differently featured segments of the surface form have to be derived from a single root source. (15) shows the presumed beginning and endpoints of the derivation:

(15)   /pp^h/   -->   [hp]

Syl   Syl   Syl   Syl
  \   /   \   /
   m   /   ???-->   m   /
    \   / | |
     RC   RC   RC
    / \ | |
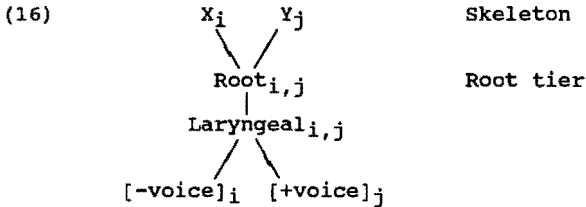[+spread]   Place   [+spread]   Place

How is this operation to be generalized with the more banal transfer of [+spread] from root to root in (13)? And what sort of operation is this in the first place? (On this question see Iverson (1989).) Even supposing the theory were to countenance meiotic division of this sort, what assures that the features end up where they do, with [+spread] on the first new root and the place features on the second. The one-root theory of the geminate raises more questions than it answers here.

Clements (1985) discusses Icelandic preaspiration. Though he in general assumes a one-root theory of geminates, he adopts a two-root theory of the Icelandic geminate in order to give expression to this laryngeal splitting. In the

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theory of length I am proposing here such options
are not available.   Length is always a matter of
two root nodes.

2.   Diphthongization

The two-root theory of length has been so far
motivated as a response to the problem of laryngeal
fission in consonantal geminates that would
preserve intact the generalization that features
(or nodes) dominated by the same root node are not
phonologically ordered, cf. (11).   Hayes to appear
responds to the same class of problems with a
proposal which allows for a limited set of
violations of the No-Feature-Ordering
Generalization. His proposal allows that two
features dominated by a single root node may be
ordered just when the root node is itself
associated to two positions in the skeleton. An
indexing notation is introduced to allow for formal
expression of the dependency of feature ordering on
ordering in the skeleton.   It is illustrated in
(16):

(16) X_i Y_j Skeleton
                  \ /
                 $Root_{i,j}$ Root tier
                   |
                $Laryngeal_{i,j}$
                  / \
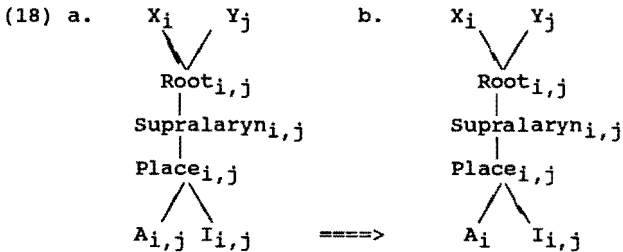 $[-voice]_i$ $[+voice]_j$

(Hayes suggests that it makes no difference whether
the positions in the skeleton to which the root
node is doubly linked are units of the C/V or X
skeletal tier or units of syllable/mora structure.
We will see below that in the theory he proposes,
those positions must be located in the skeletal
tier.)   The Hayes proposal is that positions in the
skeleton and the features and nodes of feature
structure all bear indices; these indexations are
governed by a principle of percolation such that a
feature or node must share an index with a root
node that dominates it, and the root shares indices
with each of the skeletal positions to which it is
linked. Thus if the root node is associated to two
skeletal positions X_i and Y_j, it may dominate two
ordered features, each one indexed for i and j,
respectively, as in (16).   The order of the
phonetic realization of the features is governed by

the order of the coindexed positions in the
skeleton. The Hayes theory thus predicts that no
ordering is possible among features or nodes
dominated by a root that is associated to a single
skeletal position. In that it coincides with the
predictions of the No-Feature-Ordering
Generalization. But it predicts that in geminates,
where a single root node is associated to two
skeletal positions, ordering is possible, amongst
<u>any</u> features or nodes, even those not immediately
dominated by the root node. In this it contrasts
with no-feature-ordering theory, which allows two
features or nodes to be ordered only if they are
dominated by distinct root nodes.

 Hayes sees vowel diphthongization as
providing crucial evidence against a no-feature-
ordering account, precisely because he assumes that
the vowel place features which are ordered in
diphthongization are "deeply embedded within the
tree", and hence are not dominated by distinct root
nodes. Let us consider a concrete example, the
rather commonplace diphthongization of <u>e:</u> to <u>ei</u> and
<u>o:</u> to <u>ou</u>, such as in Old French, discussed by
Hayes. Hayes assumes a feature geometry of the
Clements or Sageyan type, in which place features
are dominated not only by the class node Place but
also the class node Supralaryngeal. And he assumes
a theory of vowel features which is inspired, in
part, by the particle theory of Schane (1984) and
others. Particle theory ascribes the following
particle representations to vowels:

(17)   /i/ = I   /u/ = U
            /e/ = IA   /o/ = UA
                     /a/ = A

Adopting this view of the vowel particles, long <u>e:</u>
would be assumed by Hayes to be represented as in
(18), where the single root node is coindexed with
both skeletal positions to which it is associated,
and all the features and nodes dominated by that
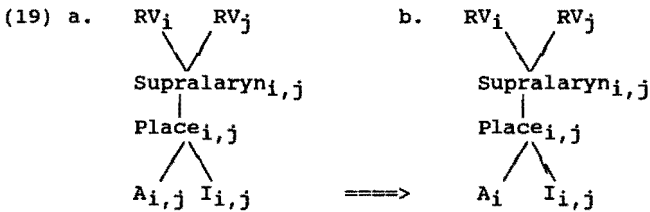single root share both of its indices:

(18) a. X_i Y_j b. X_i Y_j

$\text{Root}_{i,j}$ $\text{Root}_{i,j}$

$\text{Supralaryn}_{i,j}$ $\text{Supralaryn}_{i,j}$

$\text{Place}_{i,j}$ $\text{Place}_{i,j}$

$A_{i,j}\ I_{i,j}$ ====> A_i $I_{i,j}$

Given the Hayes indexing theory, vowel diphthongization is a matter of manipulating particles and their indices. Specifically, ei can be derived from $e{:}$ in (18) by depriving the A particle of the index j, which corresponds to the second skeletal position. This gives rise to an ordering of feature indices within the vowel-- A_iI_j (= e) followed by I_j (= i), in other words, a diphthong. Of course, this argument from vowel diphthongization against no-feature-ordering stands only insofar as the above assumptions about the representation of place features in feature organization hold up, and I believe they do not, as we shall see.

But suppose for the sake of argument that Hayes's assumptions about the representation of place do hold up, such that some version of ordering by coindexation is required in the theory. What are the implications of this for the argument I have mounted, following Steriade, for a two-root theory of length? The Hayes argument is that if ordering by coindexation is part of the theory of phonological representation, there is no motivation for a two-root theory of length. The argument does not go through, however. In the present section I show that a two-root theory of vowel diphthongization is preferable to a one-root theory of the phenomenon.

Consider a two-root approach to vowel diphthongization which makes the same assumptions about feature structure as in the approach in (18). The representation of $e{:}$ would be as in (19a) and the dipthongization to ei would be as in (19b).

(19) a. RV_i RV_j b. RV_i RV_j

     $Supralaryn_{i,j}$ $Supralaryn_{i,j}$

     $Place_{i,j}$ $Place_{i,j}$

   $A_{i,j}$ $I_{i,j}$ ====> A_i $I_{i,j}$

The correlation of feature ordering with length
that the Hayes theory tries to capture could now be
understood as a correlation of feature ordering
with number of root positions, instead of with
number of skeletal positions, obviating any
necessity for extending indexation to positions in
the skeleton. Therefore, one advantage of the two
root theory of the diphthong is that it would
permit a more restrictive theory of indexation, one
which would confine indexation to the nodes and
features of feature structure, and in this way
respect the spirit of the principle of skeleton-
melody separation. This is the first argument for a
two root theory of vowel diphthongization.

      But is the feature structure in (18) and (19)
well-motivated? Are we really forced to think of
place features as being so "deeply embedded within
the tree" that some kind of feature-ordering-by-
coindexation is required? I believe the answer is
no. McCarthy (1988) presents arguments against the
Supralaryngeal node. In Selkirk (in preparation) I
argue against the existence of the Place node. And
in Selkirk (1988, in preparation) I argue in favor
of a dependency representation between features for
place, in the sense of Mester (1986, 1989). So
assuming the same vowel place feature particles as
in the preceding treatment, and assuming a two root
theory of length, the representation of long e:
would be as in (20a), and the outcome of
diphthongization could be represented as either
(20b) or (20c):

(20) a. RV RV   b. RV RV   c. RV RV

      A   A   A I

      I   I   I
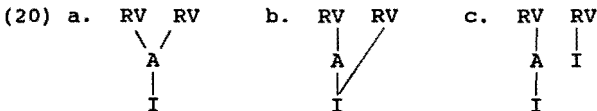
This case of dipthongization crucially involves (i)
a delinking of the primary vowel feature (here A)
from one of the root nodes and (ii) a spreading of

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the nonprimary vowel feature (here I) to the newly
placeless root node, as shown in (20b), banal
operations in the current theory. The
nonhomogeneous linking in (20b) could conceivably
give rise to the non-doubly-linked representation
in (20c), by mitosis. (Note that (20c) does not
show an OCP violation, since primary and secondary
vowel features are not feature- adjacent (see
Selkirk 1988, in preparation).) In (20b) or (20c)
the ordering of features is achieved simply through
direct domination by successive root nodes. Thus
the theory of feature organization assumed in (20),
in conjunction with two root length, makes ordering
by coindexation superfluous. If these assumptions
about feature organization do indeed prove well-
founded, the argument from diphthongization for a
two root theory of length is even stronger than in
the preceding paragraph. In this case a two root
theory of length would allow for feature ordering
to be eliminated entirely from feature structure,
as specified in the No-Feature-Ordering
Generalization, (11). The argument, then, is that
with either set of assumptions about feature
structure, the two root theory of length allows for
a more restrictive theory of feature ordering in
phonological representation. Whether feature
ordering can be eliminated entirely, as would be
allowed by the newer assumptions about the location
of place features in feature structure, is a
question that will be left open for the time being.

        The second argument from diphthongization for
a two root theory of length is based on the fact
that short diphthongs require a representation
distinct from long diphthongs. Hayes claims that
diphthongs only arise from long vowels, and that in
the unmarked case diphthongs count as long from the
point of view of quantity. He shows how one-root
theory would predict this. Actually, both the one-
root and the two-root theories of diphthongs
sketched above predict this. With two root theory
(in either of the versions sketched) the feature
ordering in diphthongs can only arise in a
structure with two root nodes, and long vowels have
this property. Thus diphthongs could not arise
from short vowels. Moreover, in two root theory a
diphthong would normally be represented as
bimoraic, or long in quantity. This is because, in
the unmarked case, each vocalic root node in a
representation is moraified, whether a short vowel
or part of a long vowel, a diphthong, a sequence of
vowels:

(21) a. short   b.   long, diphthong, or sequence

```
      m                      m    m
      |                      |    |
      RV                     RV   RV
```

(On principles of syllabification and moraification
in two root theory, see section 6.) What now of the
representation of short diphthongs? Hayes claims
that short diphthongs arise historically from
original long diphthongs, and that they are rare,
ie., highly marked. Let us assume that what it
means for a diphthong to be short is that it is
monomoraic. Within a two root theory of diphthongs,
the difference between short and long dipthongs
would be represented at the feature structure-
prosodic structure interface, as in (22).

(22) Two root theory of diphthongs

       a.   long diphthong   b.   short diphthong

```
      m      m                          m
      |      |                        /   \
      RV_i   RV_j                   RV_i   RV_j
```
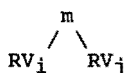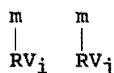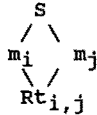
Both long and short would have two distinct root
nodes, RV_i and RV_j. But whereas in the former each
root is moraic, in the short diphthong both root
nodes are linked to a single mora. Such structures
are in principle possible in two root theory, but
marked, since, as we said, in the unmarked case
each vocalic root node would be separately
moraified.

        How would a one root theory of diphthongs of
the sort Hayes describes represent the difference
between long and short diphthongs, assuming that
the latter are monomoraic?   Recall that in the
ordering by coindexation theory proposed by Hayes
feature ordering in diphthongs is possible only if
there are two distinct positions in the skeleton to
which the single root node of the vowel diphthong
is linked.   Therefore, both short and long
diphthongs must be represented with two distinct
positions in the skeleton. But those two distinct
positions cannot be moras, since short diphthongs
are assumed to be monomoraic.   What could those
positions be? It might seem to be an option to
assume that the single root node of a short
diphthong is linked both to a single mora position

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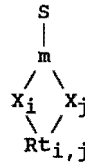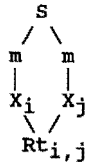and to the syllable node, as in (23b):

(23) One root theory of diphthongs- Version I

   a. long diphthong   b. short diphthong

$$
\begin{array}{cc}
\text{S} & \text{S}_j \\
/\;\backslash & \\
\text{m}_i \quad \text{m}_j & \text{m}_i \\
\backslash\;/ & \\
\text{Rt}_{i,j} & \text{Rt}_{i,j}
\end{array}
$$

But this option is ruled out since the i,j
positions in the skeleton in (23b) are not
temporally ordered, and therefore the ordering of
features in the diphthong could not be derived by
coindexation. The only other option appears to be
to assume the existence of an additional skeletal
tier in phonological representation, a revival of
the C/V or X tier which this paper is arguing can
be eliminated. This tier would mediate between the
root nodes of feature structure and the mora and
syllable nodes of prosodic wtructure and provide
the basis fov the ordering of short diphthong
features through coindexation, as in (24b).

(24) One root theory of diphthongs- Version II

   a. long diphthong   b. short diphthong

$$
\begin{array}{cc}
\text{S} & \text{S} \\
/\;\backslash & | \\
\text{m} \quad \text{m} & \text{m} \\
| \quad | & /\;\backslash \\
\text{X}_i \quad \text{X}_j & \text{X}_i \quad \text{X}_j \\
\backslash\;/ & \backslash\;/ \\
\text{Rt}_{i,j} & \text{Rt}_{i,j}
\end{array}
$$

The point then is that assuming a one root theory
of diphthongs requires this extra-rich theory of
phonological representation, while a two root
theory of diphthongs permits the skeletal tier to
be done away with. This is obviously an argument in
favor of a two root theory of diphthongs, and of a
two root theory of vowel length, if there is no
independent motivation for this extra skeletal
tier.

     To sum up, two arguments have been made for a
two root theory of length on the basis of vowel
diphthongization. The first is that it allows for
a more restrictive theory of feature ordering than

a one root theory does. The second argument is
that two root theory permits one to maintain the
theory of the prosodic structure-feature structure
interface given in (4), which lacks the arguably
otiose C/V or X skeletal tier.

3.   The Nature of Geminate Inalterability

It is by now a well-known fact that geminates
may fail to be affected by certain phonological
rules which would alter the featural content of
segments. For example, the rule spirantizing
postvocalic stops in Tiberian Hebrew does not apply
to geminate stops:

(25) Tiberian Hebrew postvocalic spirantization
     (Hayes 1986, McCarthy 1981, Leben 1980, Prince
     1975, Barkai 1974, Sampson 1973)

     a.   melex (<melek)   malka
          'king'   'queen'

          mixtav (<miktab)   kaatav
          'letter'   'he wrote'

     b.   giddel   gadal
          'he brought up,   'he grew up'
             educated'

          libbi   lev
          'my heart'   'heart'

                               levavot
                               'hearts'

(Underlining indicates spirantization.)   This
inalterability of geminates has been quite
generally attributed to their representation as a
doubly-linked structure (Steriade 1982, Hayes 1986,
Schein and Steriade 1986).   The influential
treatments of geminate inalterability by Hayes and
Steriade and Schein understand it to be the
consequence of a constraint which restricts the
applicability of a rule to a representation.   In
this section it will be argued instead that cases
of geminate inalterability are a consequence of
properties of the phonological representation
itself. Specifically, it will be argued that three
distinct elements of the theory of phonological
representation combine to give geminate
inalterability as a result.   These are (i) the
theory of the organization of features (aka feature

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geometry), and more specifically the assumption of
Place-Stricture Dependency, (ii) the two-root
theory of length, and (iii) a general constraint on
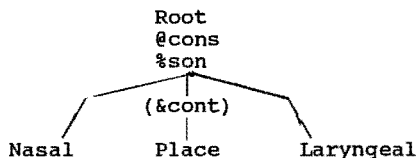multiple linking within feature structure.

McCarthy 1988 does away with a number of the
class nodes of earlier feature geometry and posits
the feature organization in (2) and (3), given
above. In the McCarthy proposal, Place is directly
dominated by the major class features [sonorant]
and [consonantal]. Evidence that I will present
below supports this dependency of Place on the
stricture features of the root node. But we will
see moreover that there are good reasons for
assuming that when a segment is specified for the
feature [continuant], Place is dependent on the
feature [continuant], rather than on the root. The
hypothesis that Place depends on the stricture
features in this way I will refer to as Place-
Stricture Dependency:

(26) Place-Stricture Dependency:

    a.   Place is dependent on the feature
          Continuant.

    b.   In the absence of Continuant, Place is
          dependent on the root node, analyzed as a
          complex of the features Consonantal and
          Sonorant.

The picture of feature organization that will
emerge is therefore that in (27):

(27) Feature Structure incorporating Place-
      Stricture Dependency

                    Root
                    @cons
                    %son

          /   (&cont)   \
                     |
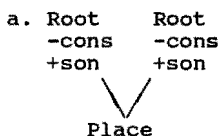   Nasal   Place   Laryngeal

As for the representation of length, I
proposed above that the length of geminate
consonants and vowels is represented within feature
structure, with two root nodes. The proposal made
above in (6) must be elaborated slightly in view of
Place-Stricture Dependency. I will assume geminate
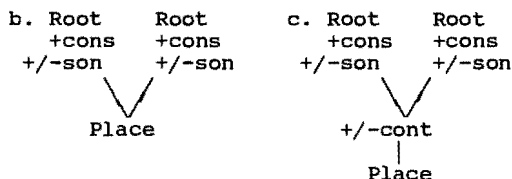vowels are represented as in (28a), geminate

A TWO-ROOT THEORY OF LENGTH   143

consonants without a [continuant] specification are
represented   as   in   (28b),   and   those   with   a
[continuant] specification are as in (28c):
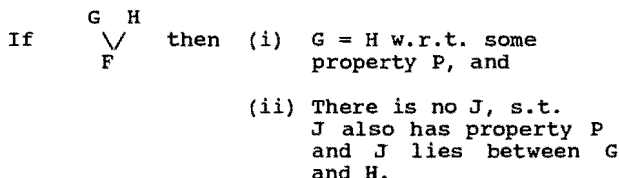
(28) The Two-Root Theory of Length

        Geminate Vowel

    a. Root   Root
        -cons   -cons
        +son   +son
             \/
             /\
           Place

        Geminate Consonants

    b. Root   Root   c. Root   Root
       +cons   +cons   +cons   +cons
      +/-son   +/-son   +/-son   +/-son
            \/   \/
            /\   /\
          Place   +/-cont
                                   |
                                 Place

        Finally, it is generally assumed that any
multiple linking in feature structure is subject to
well-formedness constraints. These have been most
notably articulated as constraints on the locality
of multiple linking (Steriade 1987c, Archangeli and
Pulleyblank 1986, 1987). In general, I think it can
be argued that constraints on multiple linking have
the form in (29):

(29) Multiple Linking Constraint (general form)

            G H
    If   \/   then (i) G = H w.r.t. some
             F   property P, and

                          (ii) There is no J, s.t.
                               J also has property P
                               and J lies between G
                               and H.

What this says is that in a feature structure
configuration where an element F is a multiply
linked dependent of heads G, H: (i) G and H are
must be identical with respect to some property P,

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and (ii) G and H must be P-adjacent, that is, no
other element with property P may intervene between
G and H.   (Def. A feature or node B is a dependent
of a feature or node A iff A immediately dominates
B. In this case, A is the head of B.
(Mester 1986, 1989))   The formulation of this
constraint on locality in multiple linking is
closest in spirit to the notion of locality posited
in Archangeli and Pulleyblank 1986, 1987.

     As is well known, adjacency is a notion
requiring parameterization (see Archangeli and
Pulleyblank 1986, 1987; Steriade 1987c; Selkirk
1988; Odden 1990).   It is implied by the
formulation of the Multiple Linking Constraint in
(29) that the parameters of adjacency amount to
specifying what the relevant properties P are in
universal grammar.

     In the particular case where the heads of a
multiply linked configuration are stricture
features, there are reasons to think that,
universally, the relevant dimension of identity,
i.e. property P, is feature content. That is,
identity of features seems to be required in such
a configuration.   I will call this constraint on
linking to stricture features Homogeneous Stricture
Linking:

(30) Homogeneous Stricture Linking (provisional)

          G H
    If   \/   and G, H ∈ {STR},
          F

    then (i)   G = H = STR$_i$

         (ii) No instance of STR$_i$ intervenes
               between G and H

{STR} = {+cons, -cons, +son, -son, +cont, -cont}

What this constraint rules out is any multiple
linking to stricture features where the stricture
feature specifications are not identical.
The analysis of geminates given in (28) conforms to
this constraint.

     In what follows I will show first that
assuming that geminate inalterability results from
a constraint on multiple linking-- of whatever
form--allows a better theory of which types of

rules _fail_ to show inalterability than either the
Steriade and Schein (1986) or Hayes (1986)
approaches. Then I will show that assuming
Homogeneous Stricture Linking, along with the
representational assumptions of two root length and
Place-Stricture Dependency, allows us to narrowly
characterize just which rules _are_ subject to
inalterability. Finally I will show that the same
set of assumptions about the representation,
together with Homogeneous Stricture Linking permit
an explanation for why lenition and degemination
should go hand in hand in some languages, a
phenomenon which the Schein and Sterade (1986) and
Hayes (1986) theories of geminate inalterability
are quite unable to explain. Degemination will be
argued to be a repair strategy, in the sense of
Singh (1984) and Paradis (1988a, 1988b), a response
to the creation of an ill-formed representation
when a lenition process does apply to part of a
geminate. In other words, it will be argued that
while geminate inalterability is an instance of the
blocking effect of a constraint on well-formed
representations, degemination is an instance of the
repair-motivating effect of a constraint on well-
formed representations.

### 3.1   Geminate Inalterability and Constraints on Multiple Linking

If a constraint on multiple linking in
feature structure-- in whatever form--is
responsible for the phenomenon of geminate
inalterability, then only rules which would _create_
an ill-formed _multiple_ _linking_ would belong to the
set that could block when applying to geminates.
One important prediction of this approach,
therefore, is that rules which involve a _delinking_
operation would never be blocked from applying to
geminates. Delinking in a doubly-linked feature
configuration would create at most a singly linked
structure, which is of course compatible with any
constraint on multiple linking, be it Homogeneous
Stricture Linking or any other. The hypothesis that
a constraint on multiple linking is at play in
geminate inalterability also predicts that any rule
which leaves the wellformed double-linking in
geminates intact will fail to be blocked from
applying.

Recall now the case of delinking in Icelandic
which went by the name preaspiration. It is a
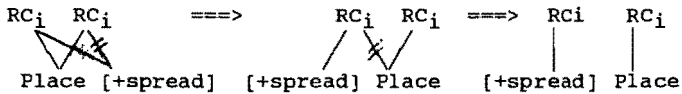
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rule which delinks the feature [+spread glottis]
from a consonant root that is preceded by another
consonant root, as in (31):

(31)   Icelandic preaspiration

              Root   Root
              +cons   +cons
                          |
                          +spread
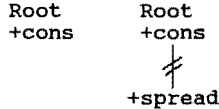
As pointed out above, preaspiration is not
restricted to geminates. Rather, it involves the
delinking of aspiration ([+spread glottis]) from
any underlying aspirated stop which follows another
consonant and a linking of that aspiration feature
to the preceding consonantal segment, producing
voicelessness in that segment. In geminates it
involves an additional effect, the delinking of
place from the first half:

(32)   /pp^h/   --->   [hp]

RC$_i$ RC$_i$ ===>   RC$_i$ RC$_i$ ===>   RCi   RC$_i$

Place [+spread]   [+spread] Place   [+spread] Place

The fact that the delinking of [+spread] and of
Place can apply in the case of geminates is
explained under the approach I am proposing here,
since these delinkings at no time create an
illformed multiple linking in the phonological
representation.

     In comparison, both the Schein and Steriade
(1986) and Hayes (1986) theories of geminate
inalterability predict that delinking rules would
block with geminates, unless the structural
description of the rule explicitly mentions the
double linking. The rule of preaspiration in
Icelandic is not specific to geminates, and so does
not mention any double linking. Therefore these
approaches predict that the delinking of [+spread]
should be blocked from applying to the lefthand
representation in (32). Recall that both these
theories understand geminate inalterability to be
due to a condition on the applicability of a rule
to a representation. The fact that delinking rules
in general-- be they rules delinking laryngeal
features, or tone features, or features for place--

seem not to be subject to geminate inalterability
indicates that inalterability should not be traced
to the structural description of a rule, as in the
Hayes 1986 and Schein and Steriade 1986 theories.

The other class of rules that a constraint on
multiple linking predicts should not be subject to
geminate inalterabilmty are rules that would alter
any part of the representation of geminates that is
not involved in the doubly linked configuration.
Consider the two-root representations of geminate
vowels and consonants in (28). Any rule which
affected the features dominated by Place would do
nothing to alter the wellformed double linking
within these geminate representations, and so would
never be blocked by the Homogeneous Stricture
Linking principle. Examples of the application of
such place-altering rules with geminates have been
discussed in connection with the issue of
inalterability.   They   include   consonant
palatalization in Luganda (Hayes 1986), final vowel
lowering in West Greenlandic Eskimo (Hayes 1986),
final a rounding in Javanese (Dudas 1976,
Kenstowicz 1985, Steriade 1987b), various sorts of
vowel harmony (Schein and Steriade 1986), and
Sanskrit nati (Schein and Steriade 1986).   These
rules affect both simple segments and geminates
alike, and thus behave as the general hypothesis
given in (11/13) would predict.   The Hayes Linking
Constraint also predicts such rules should be free
to apply to geminates, as long as their structural
descriptions make no mention of the links of the
Place node to the root tier. The Schein and
Steriade UAC predictions are similar (though not
identical). So on this score the multiple-linking
constraint hypothesis makes much the same
predictions as other current theories of geminate
inalterability.

Consider for example the case of
palatalization in Luganda.

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(33)   Luganda palatalization (Hayes 1986, Clements 1986)

a. kiintu ˜ ciintu   'thing'
   bwoogi ˜ bwooji   'sharpness'
   oluggi ˜ olujji (*olugji)   'door'

b. RC_i RC_i RV/G

      Place   Place
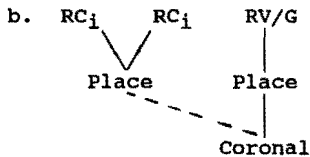
            Coronal

Here the coronality of the high vowel i spreads to the preceding segment, palatalizing it. The rule is happily ignorant of whether "Place" is doubly linked or not, and so applies equally to geminates or simple segments.

To sum up, the hypothesis that I have been pursuing up to this point is that geminate inalterability is to be traced to a constraint on multiple linkings within feature structure. The predictions of this general hypothesis have been borne out so far. In contrast, the Hayes (1986) and Schein and Steriade (1986) theories fail to predict the behavior of delinking rules. They fail to explain why it should be that delinking rules may apply to doubly-linked structures such as are found with geminates.

2.0   Rules which may be blocked from applying to geminates

Let us consider next the predictions that a constraint on multiple linking would make about which types of rules <u>are</u> subject to blocking when applied to geminates. There is actually only one logical possibility, given the two-root representation of geminates in (28). Only rules that would alter stricture features, those features upon which the doubly-linked Place or [Continuant] are dependent, would have the capacity to create ill-formed multiple-linkings out of the well-formed ones in a geminate structure. And we will see below, in this section, that it is precisely rules that do introduce a change in stricture features that are subject to blockage with geminates. In the next section we will see that when a stricture-

feature-altering rule <u>does</u> apply to a geminate, its illformed output is submitted to a further change, an apparent case of a 'repair' motivated by a constraint on well-formed representations.

The Multiple Linking Constraint in its general form (29) requires that the heads in a multiply linked structure must be identical with respect to some property P.   The more specific Homogeneous Stricture Linking (30) requires that in a multiple linking involving stricture features, the stricture features must be identical in feature content. Given Place-Stricture Dependency and the two root representation of geminates, Homogeneous Stricture Linking requires that the stricture features to which "Place" or [continuant] are linked in geminates must be identical.   Therefore any rule which changes the value of the features [consonant] or [sonorant] in just one half of a geminate will give rise to a multiple linking that is illformed according to Homogeneous Stricture Linking, and such rules are predicted to be subject to blockage with geminates.   Moreover any rule which results in a multiple linking of "Place" to opposite specifications of the feature [continuant] creates an illformed representation and is predicted to be subject to blockage. The predictions appear to be borne out. For example, the great majority of the rules showing geminate blockage that are discussed in the Hayes article turn glides into vowels, vowels into glides, obstruents into sonorants, sonorant consonants into vowels, or stops into continuants. (Churma 1988 underlines the importance of the fact that the rules showing inalterability are largely weakening rules.)

Consider the case of sonorantization in Hausa that goes by the name of Klingenheben's Law, a case discussed by Hayes (1986). Historically, syllable-final consonants all became sonorants in Hausa, and there are also reflexes of this process in synchronic alternations (Klingenheben 1928; Newman 1970; Schuh 1972, 1974; Venneman 1972):

(34) Klingenheben's Law

a.   velars ˉ w

'left side'   hawni / behago   'lefthanded one'
'poverty'   talawcii / talaka   'poor person'
'a twin'   batawyee / tag^{w}ayee 'pair of twins'

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b.   coronals ⁻ r

'to count'   kirga / kididdiga   'to reckon'
'merchant'   farke / fataake   'merchants'
'under'   k'ark'asin / k'asa 'earth'
'very fast'   marmaza / maza   'fast'

c.   labials ⁻ w

'barking'   hawsii / hapsii   (dialectal)
'a blind one,   makawniya / makaafo   'a blind one,
  m.'   f.'

The rule may be given the formulation in (35):

(35) Klingenheben's Law in Hausa

$$(\ldots \text{Root})_{Syl} \implies (\ldots \text{Root})_{Syl}^{+son}$$

I should say here that I am not assuming that the rule <u>changes</u> the +/-value of the feature [sonorant], but rather that it assigns, or <u>adds</u>, the property represented by the feature specification [+sonorant] to the coda consonant of a syllable, causing the deletion of any [-sonorant] specification that might be present. In general, it seems quite likely that the category of feature-coefficient-changing rules should be excluded from grammar. This becomes all the more likely, as more and more features turn out to be mono-valued. In the present paper, I am assuming for the sake of convenience the bivalency of stricture features, but want to formulate the rules, and constraints on representation, in such a way that they do not depend on this property.
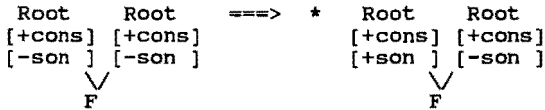
     Now, Klingenheben's Law does not affect geminate consonants, though the first half of a geminate would satisfy the structural description of the rule:

(36)   tukkuu   'crest'
          taffa   'ginned cotton'
          buddari   'skunk'
          babba   'a big one'

The explanation offered for this blockage by Homogeneous Stricture Linking is that the application of Klingenheben's Law to a geminate obstruent would give rise to an ill-formed

representation, with the Place or [continuant] feature doubly linked to root nodes with opposite specifications for the feature [sonorant]. The ill-formed representation is shown in (37), where F stands for either Place or [continuant]:

(37) Klingenheben's Law applied to geminate obstruents

```
Root    Root    ===>   *   Root    Root
[+cons] [+cons]            [+cons] [+cons]
[-son ] [-son ]            [+son ] [-son ]
     \/                         \/
     F                          F
```

The figures in (37) are intended to notationally represent the double linking of the dependent feature F to the complex of [sonorant] and [consonant] features that comprise the root node, not a double linking of F to the two instances of the feature [sonorant]. In other words, the nonidentity of the feature specifications for [sonorant] on the right in (37) is not <u>directly</u> responsible for the violation of Homogeneous Stricture Linking, rather it is the nonidentity of the entire root complex, which is assumed to be the head of F in (37), which is responsible for the illformedness created.

To make the status of the Root node in this configuration entirely clear, the set (STR) of stricture feature heads mentioned in the statement of Homogeneous Stricture Linking, (30), should be modified to include root complexes as members:

(38) Homogeneous Stricture Linking (revised)

$$\text{If} \quad \begin{matrix} G\ H \\ \vee \\ F \end{matrix} \quad \text{and } G, H \in \text{(STR)},$$

then (i) $G = H = STR_i$
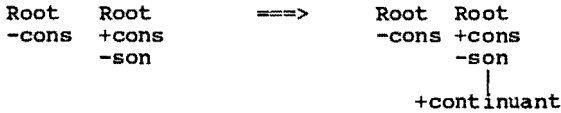
      (ii) No instance of STR_i intervenes
            between G and H

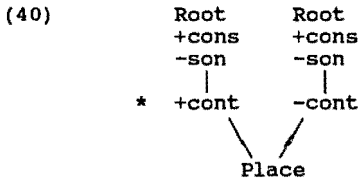(STR) = (+/-cons, +/-son, +/-cont, Root)

The other main body of rules which this theory predicts to be subject to blockage with geminates are rules which change the value of the feature [continuant]. Tiberian Hebrew postvocalic

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spirantization, formulated in (39), is an example
of this sort.

(39) Tiberian Hebrew Postvocalic Spirantization

```
    Root   Root         ===>      Root   Root
    -cons  +cons                  -cons  +cons
           -son                          -son
                                          |
                                   +continuant
```

(The rule has the function of assigning the feature
specification [+continuant] to the postvocalic
consonant; it is not a rule which merely changes
the coefficient of any existing [continuant]
specification from '-' to '+', cf. discussion of
(35).) Blockage in cases of spirantization would
not predicted by Homogeneous Stricture Linking if
the feature [continuant] were simply a sister to
the Place and Laryngeal nodes in feature structure,
as in the McCarthy proposal in (3). But suppose we
instead adopt the view in (27), where Place is
dependent on the feature [continuant] in feature
structure, as called for by Place-Stricture
Dependency, (26). This dependency is presupposed
in the two root representation of geminates in
(28c). A spirantization rule applying to just one
half of a geminate would produce an ill-formed
double-linking. An example of this is given in
(40), which shows the effect of spirantization on
Tiberian Hebrew geminates.

(40)
```
            Root      Root
            +cons     +cons
            -son      -son
             |         |
     *     +cont     -cont
                \     /
                 Place
```

This is ruled out by Homogeneous Stricture Linking.

        To sum up, the central cases of geminate
inalterability all appear to involve rules which
introduce alterations in the specifications of the
stricture features [consonantal], [sonorant], and
[continuant]. Any theory of geminate inalterability
should provide an explanation for this fact. The
explanation I am proposing relies on three
assumptions about phonological representation: (i)
that length is represented within feature

structure, with two root nodes, (ii) that features
are organized according to Place-Stricture
Dependency, and (iii) that the Multiple Linking
Principle, and more specifically, Homogeneous
Stricture Linking, governs linkings in feature
structure. It follows from these three assumptions
that rules which produce alterations in
specifications for the stricture features should be
subject to inalterability with geminates. The Hayes
(1986) and Schein and Steriade (1986) theories of
inalterability provide no such explanation for why
it is predominantly rules affecting these features
that are subject to blockage with geminates.

3.2 Lenition and Degemination

As a constraint on wellformed representations,
Homogeneous Stricture Linking may either serve to
block the application of illformedness-creating
rules to geminates, as in the case of inal-
terability, or it may allow an illformed
representation to be derived, but then serve to
guarantee that the illformedness be repaired
(Paradis 1988a, 1988b). Note that the OCP
manifests itself in a similar multitude of ways
(see McCarthy 1986; Borowsky 1986, 1987; Yip 1988;
Myers 1987, 1988). I suspect that evidence of the
repair-motivating role for Homogeneous Stricture
Linking with geminates comes from languages which
pair up lenition and degemination, as in Finnish
(Vainikka 1988) or Old French (Jakobs and Wetzels
1989). In these languages, in just the contexts
where a simple segment undergoes sonorantization or
spirantization, geminates are simplified to one.

In Finnish, under certain morphological
circumstances, a lenition process referred to as
'gradation' weakens a stop which is in the onset of
a closed syllable if that stop is preceded by a
sonorant (see e.g. Karlsson 1983, Prince 1984,
Vainikka 1988). I will argue that the rule should
be formulated as follows:

(42) Gradation in Finnish (Karlsson 1983, Prince
     1984, Vainikka 1988)

$$
\begin{array}{ccc}
\text{Syl} & & \text{Syl} \\
\diagup \mid \diagdown & & \diagup \mid \diagdown \\
\text{+son -cont -cons +cons} & \Longrightarrow & \text{+son +son -cons +cons}
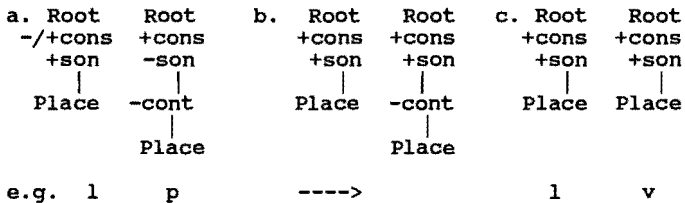\end{array}
$$

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When this onset stop is preceded by a vowel, or by a nonhomorganic sonorant, we find the following alternations:

(43) p/v: tapa/tavan 'custom', halpa/halvan 'cheap'

    t/d: kota/kodan 'Lappish tent'

    k/w, k/j, k/∅:   luku/luwun 'chapter',
                     kulke/kuljen 'to go',
                     pyrki/pyrin 'to strive'

The segments represented orthographically as v, d, j and w are all sonorant continuants, at least in the dialects (d is a stop in the standard). The exact conditions for the variations in the gradation of k will not concern us here (see Vainikka 1988, Cathey 1988). Clearly the gradation rule introduces the feature [+sonorant] into the representation of the onset consonant (the stophood of d in the standard I take to be a secondary effect). I will assume this introduction of [+sonorant] has the automatic result of eliminating any [-sonorant] already present, as shown in (44b):

(44) Sonorant + Stop becomes Sonorant + Sonorant

```
a. Root   Root    b.  Root   Root    c. Root   Root
  -/+cons +cons       +cons  +cons      +cons  +cons
   +son   -son        +son   +son       +son   +son
    |      |           |      |          |      |
  Place  -cont       Place  -cont      Place  Place
          |                  |
        Place              Place

e.g.  l      p       ---->               l      v
```

The elimination of the specification [-continuant] on the gradated segment, shown in (44c), I assume to be a quasi-automatic effect. Sonorants would normally lack a specification for continuancy.

    Let us now settle some of the details of the formulation of the rule above. The gradation rule affects only stops. The sole fricative of Finnish, s, remains unaltered in the gradation environment:

(45) No gradation of s:

    naise 'woman', naiselta 'from the woman'

For this reason, the formulation of the rule in

(42) specifies that the onset consonant must be [-continuant]. That gradation is restricted to contexts where a sonorant segment precedes the target stop is shown by examples like those in (46):

(46) No gradation when an obstruent precedes

> matka/matkan 'trip'
> piispa/ piispan 'bishop'

The onset stop remains unlenited when another obstruent precedes. There's one final detail which I will leave till later, namely the articulation of the adjacency conditions that a rule with such a structural description presupposes.

Note next that when a homorganic sonorant consonant precedes a stop in the gradation environment, the stop assimilates completely to the sonorant:

(47) Gradation after homorganic sonorant

> rampa/ramman 'lame
>
> kanta/kannan 'heal'
> valta/vallan 'power'
> parta/parran 'beard'
>
> laŋka/laŋŋan 'thread'

The explanation for this alternation relies on assuming that the gradation rule does indeed apply in these cases, just as we would expect, given the presence of a preceding sonorant. The intermediary representation produced by gradation is then submitted to additional changes, which can be analyzed as repairs of illformednesses in representation that are produced by gradation in these cases. (See Selkirk(1990) for details.)
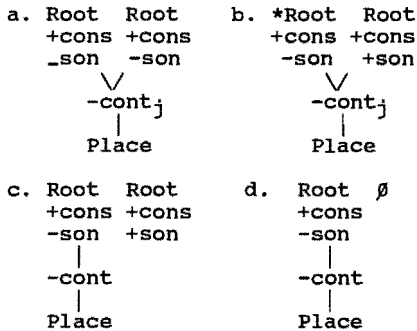
Finally, we come to the treatment of geminate stops under gradation. In just the same gradation environment as we have examined above, a geminate stop is degeminated:

(48) lappu/lapun 'piece of paper'

    muuttaa/muutan 'move/I move'

    virkkaa/virkan 'utter/I utter'

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These alternations between geminate and simple stop
can be ascribed to the operation of the same rule
of gradation given in (42), if we assume that
Homogeneous Stricture Linking is at play here, and
motivates repairs to any ill-formed representations
introduced by gradation. Gradation applies to the
second, onset, half of the geminate, eliminating
the identity between the heads of the doubly linked
dependent [-continuant], as shown in (49b), and
thereby creating a multiple linking that is ill-
formed according to Homogeneous Stricture Linking:

(49) Gradation with Geminates, and Degemination

```
    a. Root   Root    b. *Root   Root
       +cons +cons       +cons +cons
       _son  -son        -son   +son
           \/                \/
          -cont_j           -cont_j
            |                 |
          Place             Place

    c. Root   Root    d.  Root   Ø
       +cons +cons        +cons
       -son  +son         -son
         |                  |
       -cont              -cont
         |                  |
       Place              Place
```

I suggest that this ill-formed representation is
'repaired' by eliminating the double-linking,
specifically, through eliminating the link to the
onset consonant, as shown in (49c). This results
automatically in the loss of a Place specification
for the onset consonant. And this loss of a Place
specification has as a consequence the deletion of
the Root itself, as shown in (49d), for a segment
cannot be realized without a Place specification.
In other words, the geminate stop is reduced to a
single stop as a consequence of the application of
gradation to the geminate. (For further discussion
of the application of gradation to geminates, see
Selkirk 1990.)

So here we have a coherent story for all the
phenomena which go under the name gradation in
Finnish. Of course the account crucially relies on
theoretical proposals for which independent
independent motivation is required: Homogeneous
Stricture Linking (and more generally the Multiple

Linking Constraint), Place-Stricture Dependency, and the two-root theory of length. This paper is concerned only with providing general motivation for the two-root theory of length. As for the other theoretical proposals, here I can only assert their well-foundedness, and draw the consequences for the theory of geminate inalterability. Earlier theories of geminate inalterability (Steriade 1982, Schein and Steriade 1986 and Hayes 1986) have absolutely nothing to say about the pairing of lenition and degemination that is to be found in Finnish and other languages. Indeed, they predict unequivocally that gradation should be blocked from applying to geminates in Finnish. The existence of degemination alongside gradation, in exactly the same prosodic and morphological contexts, must simply be construed as accidental. In order to capture the gradation/degemination relation, it seems that theories like that of Hayes and Schein and Steriade will have to be abandoned, and that a theory tracing the behavior of geminates to constraints on wellformed representations, such as has been proposed here, should be adopted.

I have not shown here that all the cases of geminate inalterability discussed in the literature submit to the reanalysis offered here. And indeed I could not do so. The Schein and Steriade article presents certain recalcitrant cases. My bet is that these will end up falling under the purview of yet other conditions on representational wellformedness. In any case, the approach outlined here goes a great deal further than both the Hayes and Schein and Steriade approaches in predicting the behavior of rules with respect to multiply-linked structures, including geminates, and shows the value of giving general wellformedness conditions on representation a central role in phonological description.

TWO-ROOT LENGTH AND SYLLABLE/MORA STVUCTURE

4. Compensatory Lengthening

It now seems securely established that the phenomenon of compensatory lengthening depends on a moraic representation of quantity, not a segmental representation, as with Ingria 1980 and Leben 1980. Hock 1986 and Hayes 1989 have laid out the basic arguments for this. Hock, McCarthy-Prince and Hayes articulate the moraic theory of compensatory

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lengthening assuming a one-root theory of length.
But this is not necessary.   I want to show here
that a two-root theory of length allows just the
same   insights   into   the   moraic   character   of
compensatory lengthening.

     The basic   tenet   of   the   moraic   theory   of
compensatory   lengthening   is   that   only   segments
which have moraic status in prosodic structure are
compensated for when lost.   Deletion of a segment
will leave behind the mora it was associated with.
Compensatory   lengthening   is   viewed   as   a   way   of
giving   segmental   anchoring   to   the   mora   left
floating by the deletion.   For simplicity's sake
let's look at the most typical sort of compensatory
lengthening case, rather than the more exotic ones
discussed   by   Hock   and   Hayes. The   deletion   of   a
syllable-final moraic consonant sets the stage, as
shown in (50).

(50)

                                                        Deletion
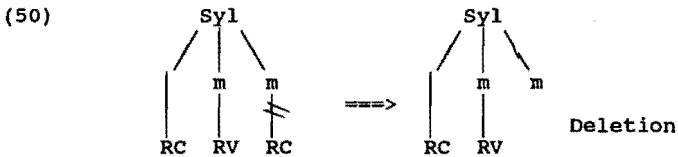
According to one-root theory, the vocalic root node
then   simply   associates   to   the   floating   mora,
creating a long bimoraic vowel, as shown in (51).

(51) A One-Root Approach

                    Spreading of the Root Node
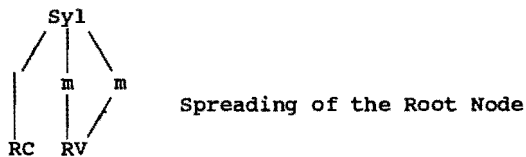
But   there   is   another   possible   scenario.   The
floating mora could be supplied segmental content
through the epenthesis of a root node, as shown in
(52). The remaining features for the epenthesized
root   would   be   obtained   by   spreading   from   a
neighbor.   I   have   illustrated   this   approach   with
vocalic   root   node   epenthesis.   There   are   also
instances   of   compensatory   lengthening   where
consonantal root node epenthesis would be in order.

(52) A Two-Root Approach: Mora-motivated Root
                            Epenthesis
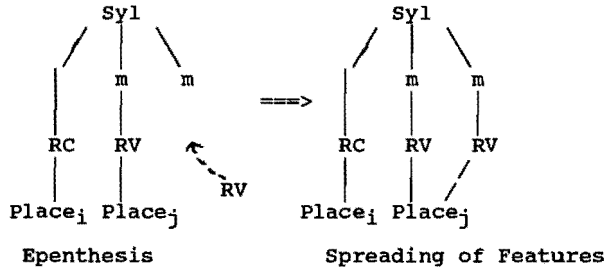
Root epenthesis, then, provides an account of
moraic compensatory lengthening that is consistent
with a two-root theory of length.

A plausible case can be made that all
epenthesis is root epenthesis, and exists to
satisfy prosodic structure conditions (see Itô
1986, 1989). Epenthesis that is motivated
specifically by mora structure has ample
independent motivation in grammar aside from its
utility in compensatory lengthening. For example,
it is likely that Shona (Myers 1987), Lardil
(Wilkinson 1986) and Campa (Levin 1985, Itô 1989)
all require a word to be minimally bimoraic in
size.   (See McCarthy and Prince 1986 on bimoraic
word templates.) When the output of the morphology
is a lone monomoraic stem, epenthesis supplies the
extra vowel that will allow the bimoraic word
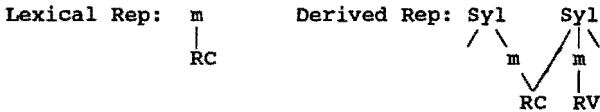template to be satisfied.

We see, then, that understanding compensatory
lenghthening in moraic terms in no way implies a
one-root theory of length. Epenthesis and the two-
root theory of length it presupposes are equally
viable as an account of moraic compensatory
lengthening.

5.   The Distribution of Geminate Consonants

According to the one-root theory of length
put forth by McCarthy-Prince 1986, 1988, 1990 and
Hayes 1989, long segments are lexically represented
as a single root node preassociated to a mora. The
double-linking that is the hallmark of a long
segment is produced as part of the syllabification
process, which associates the already-moraified

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root node to some other syllabic position. Let us
call this gemination-by-syllabification. It is
illustrated for geminate consonants in (53):

(53)   The One-Root Theory of Geminate Consonants
       (McCarthy-Prince, Hayes)

Lexical Rep: m   Derived Rep: Syl   Syl
               | / \   /|\
               RC   m / m
                                        \/ |
                                        RC   RV

There are two fundamental claims made with this
analysis. The first is that a geminate consonant
counts as a mora in the syllable that it closes.
This claim will be evaluated in the last section.
The second is the claim that geminate consonants
are located only where general principles allow for
the presence of moras. A geminate may be
heterosyllabic, as in (53), where its lexical mora
occupies a position in the latter part of the first
syllable. Conceivably, a geminate consonant could
also be entirely contained within a rime. But it
is categorically ruled out that a geminate could be
contained in the onset of a syllable. Given the
gemination-by-syllabification theory, for there to
be a double association of a single root consonant
to two positions in the onset, one of those
positions would have to be the lexically associated
mora. But this is an impossible syllable/mora
structure.

     It does seem to be quite generally the case
that geminates fail to appear in onsets. But this
nonetheless does not lead us to favor the one-root
theory just sketched over the two root theory that
has been defended up to now. Suppose the lexical
representation of geminate consonants consisted of
two consonantal roots, doubly linked for the
relevant features, as in (6) or (28). Is there a
principled means of ruling out the presence of
geminates within the onset of a syllable?
Certainly, other sequences of consonant roots are
permitted within the onset in some languages. Yet
we know that there are often severe cooccurrence
restrictions on those sequences. The consonants of
onset sequences are typically required to be
different in kind. Constraints on the minimal
sonority difference (Selkirk 1984, Steriade 1982)
required between adjacent consonants are more
severe within onsets than within codas. Sequences

of stop-stop, fricative-fricative, etc. are typically avoided. Therefore geminate consonants, which on two-root theory consist of a sequence of identical root/stricture feature specifications, will be excluded by standard minimal sonority difference requirements. If the banning of geminates from onsets is indeed to be attributed to minimal sonority difference considerations, then it is predicted that a language with geminates which does allow stop-stop, nasal-nasal or other sequences in the onset will also allow geminates to appear there. Further research will allow us to see whether this prediction, one which distinguishes between the moraic one-root theory of length and the two-root theory, is borne out.

6.   Geminates and Stress

       The version of one-root theory that is put forth by McCarthy-Prince and Hayes holds that geminate consonants are universally represented as moraic in lexical representation, as shown in (53) above.   This means that syllables with a short vowel that are closed by a geminate consonant are predicted to be universally bimoraic: one mora from the vowel and one from the geminate consonant. Nongeminate consonants which close short vowel syllables are not necessarily moraic. They will not be moraic unless a language-particular rule assigns mora status to them.   Such a rule will be called Weight-by-Position, following Hayes (1989). Its effects are illustrated in (54).

(54) Weight-by-Position (language-particular)

```
        Syl                        Syl
       / |                        / | \
      /  m        ===>           /  m  m
     /   |                      /   |  |
    RC   RV  RCₐ               RC   RV RCₐ
```
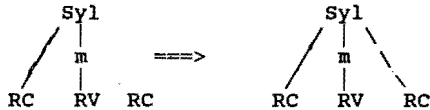
(RCₐ may designate particular consonant types, e.g.sonorant consonants, as in Kwakiutl (Bach 1975), or Danish (Basbøll 1988).)

If a consonant is not assigned morahood by this rule, it could simply be syllabified as a nonmoraic coda by the Coda Rule, as shown in (55).

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(55) Coda Rule (the default case)

```
      Syl                       Syl
     / |                       / | \
    /  m      ===>            /  m  \
   /   |                     /   |   \
  RC   RV  RC               RC   RV   RC
```

So short vowel syllables that are closed by a nongeminate consonant come in two varieties, depending on the language: monomoraic or bimoraic. As for syllables with long vowels, they are necessarily bimoraic in one-root theory, just as short vowelled open syllables are monomoraic. These assumptions of one-root theory about the moraic quantity of the various syllable types are summed up in the table in (56).

(56)   Moraic Quantity of Syllable Types-- One-Root Theory

Universally bimoraic: CV_iV_i, $CVC_i.C_i$

Monomoraic or bimoraic: $CVC_i.C_j$

(depends on whether a language has Weight-by-Position)

Universally monomoraic: CV

There are two interrelated predictions about the behavior of geminate consonants with respect to stress that are made by this theory. The first is that there should not exist languages with geminate consonants which treat only long vowel syllables as bimoraic. A syllable closed by a geminate is necessarily bimoraic and thus must pattern with a long vowel syllable, also necessarily bimoraic. The second is that long vowel syllables and short vowel syllables closed by a geminate consonant can form a natural class on their own and behave differently from short vowel syllables closed by a nongeminate consonant. This would be the case in a language which did not assign Weight-by-Position.

The first prediction crucially differentiates the one-root moraic theory of length from two-root theory. In two-root theory no segment is lexically moraic, at least in the normal case. A language will have general rules for assigning morahood to vowels and consonants. I presume that each vowel root is normally assigned moraic status, though

there are plausibly cases where a sequence of two
vocalic roots is monomoraic, as with short
diphthongs, discussed above. Morahood is certainly
not necessarily assigned to consonants.   For
consonant roots to be moraic, whether the first
half of a geminate or not, Weight-by-Position, rule
(54), must apply.   If Weight-by-Position doesn't
apply, then the only bimoraic syllables in the
language, if there were any at all, would be those
with long vowels. In this way, then, two-root
theory predicts the existence of a class of
languages whose existence is denied by the one-root
moraic theory of length.

Evidence relevant to deciding between these
theories will come _inter alia_ from the word stress
systems of the world, in particular those that are
transparently mora-counting. Mora-counting stress
systems are those in which bimoraic heavy syllables
function on a par with pairs of monomoraic light
syllables.   These latter will show an alternating
pattern.   What we need to look at are
languages which (i) have geminates, (ii) have long
vowels, (iii) have a mora-counting stress system.
Possible languages of this sort are the different
varieties of Eskimo or Uto-Aztecan languages like
Southern Paiute, Tubatulabal or Cahuilla. They have
alternating patterns of stress and probably treat
only long vowels as heavy. But the status of
geminates in these languages needs to be clarified
before they stand as counterexamples to the one-
root moraic theory of length. It is languages of
this sort--call them 'C-languages' ('C' for
'crucial')-- that will provide evidence
distinguishing between the lexically moraic one
root theory of length and the two root theory of
length.

The second prediction made by one-root theory
is that a language may treat long vowel syllables
and short vowel syllables closed with a geminate as
a natural (bimoraic) class, distinguished from
(monomoraic) short vowel syllables closed with a
nongeminate consonant. But this prediction does not
distinguish between the two theories, as John
McCarthy has pointed out to me.   Two-root theory
could in principle derive this pair of natural
classes as well. In two-root theory the morahood of
consonants is always derived by the rule of Weight-
by-Position.   Suppose that on a language-particular
basis Weight-by-Position were to be constrained so
as to apply only to geminate consonants.   This

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could perhaps be accomplished by some analogue of
the Coda Condition (Itô 1986, 1989), which
guarantees that only the first half of geminates
(partial or total) may be syllabified as a coda in
some languages.   The idea is that Weight-by-
Position could be so constrained, but applications
of the Coda Rule (52) not. This would derive the
bimoraicity of short vowel syllables closed by
geminates, alongside the monomoraicity of other
short vowel syllable types.   Hence the natural
classes sanctioned as well by one-root theory. Of
course if Weight-by-Position were not so
constrained, then short vowel syllables closed by
any consonant of the same type-- whether geminate
or simple-- would be treated in the same fashion.
Both would either be bimoraic, or monomoraic,
depending on whether Weight-by-Position applied.
     The predictions about natural classes made by
two-root theory are summed up in (57).

(57)   Moraic Quantity of Syllable Types-- Two-Root
       Theory

       Strong universal tendency towards
       bimoraicity: CVV

       Monomoraic or bimoraic: $CVC_i.C_i$, $CVC_i.C_j$

       (depends on whether a language has Weight-by-
       Position, and whether W-by-P is governed by
       something like the Coda Constraint)

       Universally monomoraic: CV

The two-root theory thus allows for a flexibility
in the quantitative status of geminate consonants
(and vowels as well). It is the C-languages that
will allow us to decide whether this flexibility is
required.

CLOSING REMARKS

     I undertook this investigation in the hopes
of understanding more clearly the nature of the
interface between feature structure and prosodic
structure in phonological representation.   In
particular, I wanted to see whether the so-called
skeletal tier--the one composed of C's and V's or
X's-- had any place in the representation. I think
this paper provides support for a theory in which
there is no skeletal tier mediating between feature
structure and prosodic structure, as illustrated in

(4).

      Since the purpose of this paper has been to
investigate the theory of length from the point of
view of phonology, by looking at what operations on
phonological representation tell us about the
representation of long consonants and vowels,
issues concerning templatic morphology have not
been dealt with. Yet the two-root theory of length
has obvious implications for the theory of prosodic
morphology. Let me name just two in closing.
First, given that two-root theory in effect encodes
length in the 'melody', namely in the root nodes,
so-called transfer effects in reduplication
(McCarthy & Prince 1988) probably fall out without
mention. (Thanks to Armin Mester for pointing this
out to me.) Second, the multiple linking of root
nodes to the skeleton, assumed, for example, for
Semitic templatic morphology, can not be an
enduring property of the phonological
representation that is derived from the
morphological mapping of melody to skeleton.
Rather it must simply be an ephemeral step in the
morphological mapping procedure, one which is
followed by a 'tier conflation' producing in all
cases representations of the sort that have been
argued for here, wherein each root has a single
association to the syllable/mora structure of the
skeleton.

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