OCP Effects in Optimality Theory

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1. A Problem in Autosegmental Phonology

One of the central constraints on autosegmental representations is the Obligatory Contour Principle (Leben 1973, 1978; McCarthy 1986).

(1) Obligatory Contour Principle (OCP)
At the melodic level, adjacent identical elements are prohibited.

In the domain of tone, for example, the OCP rules out representations such as that in (2):

```
(2) *H   H
     |   |
     σ   σ
```

Three different effects have been attributed to the OCP. First, it has been interpreted as a morpheme structure constraint. According to this interpretation, no morpheme can have a violation of the OCP, e.g. (2), as part of its underlying representation. Thus a sequence of high toned syllables within a morpheme must be represented underlyingly with a single multiply linked high tone, and never with two high tones as in (2). Considerable evidence has accumulated in favor of this interpretation: Leben (1973), McCarthy (1986), Hyman (1987), Kenstowicz and Kidda (1987), Myers (1987).

Second, the OCP has been interpreted as a derivational constraint in the sense of Kisseberth (1970). According to this interpretation, the application of a phonological rule is blocked if it would create a violation of the OCP. In Shona, for example, a high tone spreads onto a following toneless syllable, as illustrated in (3a). This spread is blocked, however, if the syllable following that toneless syllable is also high, as in (3b,c). Application in that case would create an instance of (2), a violation of the OCP.

```
(3)  a.   á-rí kú-gara                    H
          3sg-cop inf-stay              /  \    \
          "he/she is staying"          a   ri   ku gara
          (cf. árí "he/she is",  kugara "to stay")

     b.   á-rí    ku-téngá               H           H
          3sg-cop inf-buy               /  \          / \
          "he/she is buying"           a   ri   ku te nga
          (cf. kuténgá "to buy")

     c.   *á-rí    kú-téngá               H           H
                                        /   \    \   /   \
                                       a   ri   ku te nga
```

Evidence for the OCP as a derivational constraint is presented first and foremost in McCarthy (1986), but furthermore in Archangeli (1986), Itô and Mester (1986), Borowsky (1987), Myers (1987) and Yip (1988).

Third, the OCP has been interpreted as a rule trigger (Yip 1988). According to this interpretation, if a violation of the OCP arises in the derivation through morphological or syntactic concatenation, some rule or operation must intervene to "repair" the violation. For example, if a H-final expression is juxtaposed with a H-initial expression, something must happen to convert that OCP-violating representation into a representation that conforms to the OCP. In Shona, what happens is that the first high tone is retracted, as in (4), or, if that is not possible, the second high tone is deleted as in (5).

```
(4)  Tone Slip:   H  H        H     H
                 / \  |        |     |

                σ  σ σ --> σ  σ  σ
```

```
  a. á-ka-téngá                 cf. á-ká-vérenga
     3rdsg./pst-rem-buy             3rdsg/past-rem-read
     "he/she bought" (/téng/)       "he/she read" (/vereng/)

  b. bánga gúrú                 cf. bángá          c. ákaténga bángá          cf. (a,b)
      knife  big                      "knife"           "he bought a knife"
      "a big knife"
```

(5) Meeussen's Rule: H --> ø / H ___ (Phonological Word)

```
    a. í-banga    cf. bángá "knife"                  b.  vá-sekuru   cf. sékúru "grandfather"
       cop-knife                                          2a-grandfather
       "(it) is a knife"                                  "grandfather (honorific)"

   c. ndi-chá-tengesa   cf. ku-téngésá "to sell"     d.  v-á-tengesa   cf. ku-téngésá "to sell"
      1stsg-fut-sell                                      3pl-past-sell
      "I will sell"                                       "they sold"
```

However, in Rimi, another Bantu language, a sequence of high tones is resolved by deletion of the first tone (Goldsmith 1984). Yip (1988) argues that OCP violations can also be resolved by epenthesis of an element in between the identical specifications, as in the ɨ ~ ø alternation in the English past and plural inflections.

The problem is that while the passive interpretations of the OCP (as morpheme structure constraint and derivational constraint) can be applied in the same way to all languages, it is not possible to generalize the active instantiations. One cannot predict on any general basis how the OCP violation will be resolved in a given language; one can only predict that it will be. It is very common for authors to say that a rule of dissimilation is "triggered" by the OCP, but nobody has yet shown what this means.

Yip (1988) addresses this problem. She argues that the OCP is the default context for phonological rules, so that the structure it describes (e.g. (2)) can be left out of the structural description of dissimilatory rules. All that needs to be specified then is the structural change.

There are two problems with this proposal. First, if the OCP is the default rule context, then dissimilation should be the default rule. This is clearly not the case. Second, Yip's informal rule format obscures a covert recapitulation of the OCP in the dissimilatory rule. A rule of glottal dissimilation, for example, (p. 76) has the structural change "Delete second". This is intended to mean "delete the second of two laryngeal articulations that violate the OCP." It conveys this information only because of the anaphoric possibilities of ellipsis in English. Any more formal statement of this change would have to refer to the sequence of two glottal stops in order to express which one is affected, which would simply be a recapitulation of the OCP. This is therefore not in fact a model in which dissimilatory effects are truly derived as effects from the OCP.

Myers (1991), on the other hand, pessimistically concludes that the passive interpretation of the OCP is the only universal one. This is clearly unsatisfactory, since it misses the generalization that when a representation violates the OCP something always happens.

The same problem occurs with other constraints. The Clash Filter (Prince 1983) prevents stress clashes, and it also motivates destressing and stress movements. Exhaustive Syllabification or Prosodic Licensing (McCarthy 1979, Selkirk 1981, Itô 1986) blocks rule applications that would have unsyllabifiable results, but it also "triggers" operations such as epenthesis. Structure Preservation and constraints on feature co-occurrence constrain the application of phonological rules (Kiparsky 1982, 1985), but they also motivate language-particular "repair strategies" (Paradis 1988, Myers 1991). Most current work in generative phonology relies on such constraints. It is therefore important that they be assigned a coherent interpretation that actually derives all the effects attributed to them.

2. Optimality Theory

Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993a,b) is a model of constraints and constraint interaction that allows both active and passive effects of constraints. In Optimality Theory (OT), a given input representation is mapped by a set of optional structure-building operations to a set of candidate output representations. This mapping is referred to as GEN. The outputs of GEN are evaluated with respect to an ordered set of constraints in accordance with the Harmonic Ordering of Forms (HOF):

(6) Harmonic Ordering of Forms (HOF)

The actual output is the optimal one, where

(i) Form A is more optimal than Form B with respect to constraint C iff Form B contains more violations of C, and

(ii) Form A is more optimal than Form B if it is more optimal than B with respect to the highest constraint in which they differ in optimality ("Strict Domination").

The optimal output for a given input can include violations of constraints, as long as those violations are less serious than those in the other candidates. This is the crucial innovation in the theory.

In OT, both active and passive effects of constraints can be derived straightforwardly from constraint interaction. To see, this, let us see how OT handles Exhaustive Syllabification, the constraint that requires all segments to be incorporated into syllable structure (McCarthy 1979, Selkirk 1981, Itô 1986).

A basic syllable theory in OT works as follows (cf. Prince and Smolensky 1993). Input representations are, as in the standard model, unsyllabified. They are submitted to GEN, which for each input will generate outputs with every conceivable syllabification . These outputs are all then evaluated by reference to constraints on syllable structure such as ONS, which requires each syllable to have material preceding the first mora. They are also evaluated with respect to an important set of constraints called the Faithfulness Constraints:

(7) a. *STRUCTURE (Root): *Root
b. PARSE (Root): Every root node must be associated with a syllable or mora.

The Faithfulness Constraints in (7) play the crucial role in the theory of insuring that any deviation from underlying representation must be motivated. *STRUCTURE assigns a violation for each root node, but this constraint only has decisive effects on nonunderlying, epenthetic root nodes. There is no deletion in GEN, so all outputs will include all the root nodes of the input. An epenthetic root node adds one violation to this irreducible baseline, inducing a worse violation of *STRUCTURE than in outputs without this addition. This constraint, then, opposes the unmotivated addition of material to the underlying representation.

PARSE (Root) in (7c) requires that all segments be incorporated into prosodic structure. It thus corresponds to Exhaustive Syllabification. Segments that aren't incorporated into syllable structure are phonetically uninterpreted, so this constraint presses for underlying material to be maintained unchanged in surface pronunciation.

The Faithfulness Constraints correspond to the principle in an input-oriented theory that no change in the representation occurs unless it meets the structural description of some rule: the default is to do nothing. A language particular process of insertion or deletion can result only if some constraint dominates one of the Faithfulness Constraints. Epenthesis results if *STRUCTURE is the dominated constraint. Deletion through nonparsing results if PARSE is dominated.

PARSE, like the OCP, has both an active and a passive interpretation. In its passive interpretation it blocks rules such as syncope if they would create unsyllabifiable outputs. In its active interpretation, it triggers operations such as epenthesis and consonant cluster simplification . Prince and Smolensky (1993) demonstrate that both effects are captured in a natural and formally coherent way in OT.

Let us first consider the case in which PARSE triggers an operation. In Classical Arabic, for example, glottal stop is inserted to fill empty onsets. Underlying /alqalamu/ thus surfaces as [ʔalqamu] (Prince and Smolensky 1993: 24-26). Glottal stop is inserted only if it eliminates violations of PARSE and ONS. This pattern can be expressed in OT by ordering ONS over *STRUCTURE, as in (8), and examples such as (8c) show that PARSE must also dominate *STRUCTURE. In these representations the box "❑" represents a featureless root node interpreted phonetically as ʔ, and unparsed material is bracketed by "<..>".

(8) **/alqalamu/ --> [ʔalqalamu]**

Candidate	PARSE	ONS	*STRUCT
a. ☞.❑al.qa.la.mu			*********
b. .al.qa.la.mu		*!	********
c. <al>.qa.la.mu	**!		********
d. .❑al.qa❑.la.mu			**********!

In this tableau, and henceforth, constraints are ordered left to right in order of priority, except that columns separated by a dotted line (such as PARSE and ONS in (8)) do not conflict and so are not crucially ordered. The asterix indicates a violation of the constraint in that column, and an empty box indicates no violation. A decisive violation is marked by "!", and shading of a box indicate the information in that box is rendered irrelevant by a violation of a higher constraint.

The pointing finger indicates the optimal representation. The representation (8a) with initial epenthetic onset is more optimal than the one in (8b) without an initial onset, because while (8a) includes one more root node than (8b), and so violates *STRUCTURE more seriously, (8b) violates the higher ranked constraint ONS against onsetless syllables. Representation (8a) is better than (8c), in which the first segments are simply left unsyllabified, because (8c) violates the constraint PARSE requiring exhaustive syllabification. Finally, (8a) is to be preferred to representations such as (8d) with multiple epentheses, since these contain more violations of *STRUCTURE than (8a).

*STRUCTURE generally suppresses epenthesis by penalizing extra root nodes. However, when such a violation of *STRUCTURE prevents a violation of the higher ranked constraints PARSE or ONS, the optimal representation will violate *STRUCTURE, i.e. it will include epenthetic material. PARSE thus triggers epenthesis by overriding the Faithfulness Constraint that prevents it.[1]

The same logic applies to cases in which PARSE "blocks" an otherwise general process in a language. An example of this pattern is the widespread deletion of an weak vowel in the doubly open syllable environment: VC __CV. McCarthy (1979, 1987) has suggested that this can be thought of as context-free deletion of unstressed vowels, subject crucially to syllabifiability.

Consider syncope in Yawelmani. An example of the syncope is given in (9a) (Archangeli 1984: 184), while (9b) is a case in which a medial light syllable is left unaffected. Kisseberth's (1970) formulation of the rule is given in (10).

(9) a. p'um'naʔ
p'um'-in-aʔ
full - mediopass.-noun
"full-blooded one"

b. dubʔun'ay
dub-CxCC+(ʔ)in'ay
"while leading by the hand"

(10) V-> ø / V C _____ C V
[-long]

In terms of OT, the deletion of a vowel could be expressed as nonparsing of a mora into syllable structure, in violation of the Faithfulness Constraint PARSE (Mora), stated here as (11a). This violation is forced by a constraint (11b) which, by penalizing each syllable node, minimizes the number of syllables in a form. This constraint can in turn be overruled by higher constraints: PARSE (Root), *COMPLEX and ALIGN (11c) (Prince and Smolensky 1993: 103, McCarthy and Prince 1993b).

(11) a. PARSE μ: Every mora must be parsed into a syllable.
b. *STRUCT(σ): *σ
c. *COMPLEX: Only one element can be in onset or in coda position.
d. ALIGN: $Wd] = \sigma\,]$

The ranking of the constraints is: *COMPLEX, PARSE (Root) >> ALIGN >> *STRUCT (σ) >> PARSE (μ). Candidate outputs for the example (9a) are evaluated in (12).

(12) p'um'na?

<table>
<tr><th>Candidates</th><th>*COMP</th><th>PARSE(R)</th><th>ALIGN</th><th>*STRUCT (σ)</th><th>PARSE(μ)</th></tr>
<tr><td>a.
σ σ σ
/\ /\ /\ \
/ μ | μ | μ μ
| | | | | | |
p' u m' i n a ?</td><td></td><td></td><td></td><td>***!</td><td></td></tr>
<tr><td>b.
σ σ
/\ /\\
μ | μ | μ μ
| | | | | |
p' u m' i n a ?</td><td></td><td>*!</td><td></td><td>**</td><td>*</td></tr>
<tr><td>c.
σ σ
/\ \ /\\
I μ μ μ | μ μ
☞ | | | | | | |
p' u m' i n a ?</td><td></td><td></td><td></td><td>**</td><td>*</td></tr>
</table>

In (12), candidate (12a) is the most faithful, since it has everything parsed into prosodic structure. It is less optimal than (12c), however, because it has three syllables instead of two. Candidate

(12b), on the other hand, also has only two syllables, but fatally violates PARSE (Root). The optimal output is the one with a medial unparsed mora, i.e. syncope.

Compare the tableau for example (9b), where syncope does not take place:

(13) <u>dub?unay</u>

<table>
<tr><th>Candidates</th><th>*COMP</th><th>PARSE(R)</th><th>ALIGN</th><th>*STRUCT (σ)</th><th>PARSE(μ)</th></tr>
<tr><td>a.
σ σ σ
/\ \ /\ /\\
l μ μ| μ | μ μ
☞| | | | | | | | |
d u b ? u n a y</td><td></td><td></td><td></td><td>***</td><td></td></tr>
<tr><td>b.
σ σ
/\\ /\\
l μ μ μ | μ μ
| | | | | | |
d u b ? u n a y</td><td></td><td>*!</td><td></td><td>**</td><td>*</td></tr>
<tr><td>c.
σ σ
/\\ / \\
l μ μ μ| μ μ
| | /\ l l l l
d u b ? u n a y</td><td>*!</td><td></td><td></td><td>**</td><td>*</td></tr>
</table>

In (13), the optimal candidate (13a) has no unparsed moras. It has more syllables than the other candidates, in violation of *STRUCT (σ), but in this case any attempt to remedy this fault by nonparsing of moras leads to worse violations of PARSE (Root) in (13b) and *COMPLEX in (13c). In (13), PARSE (Root) has blocked nonparsing (syncope) by overriding *STRUCT (σ).

Both the active and the passive interpretations of Exhaustive Syllabification / PARSE (Root) follow straighforwardly from a single coherent interpretation of the constraint, in interaction with other constraints. In general, the trigger and blocking patterns will be as in (14):

(14) a. <u>Constraint C triggers a process</u> ("Do something only if..."):
C crucially dominates a Faithfulness Constraint.

b. <u>Constraint C blocks a process</u> ("Do something except if..."):
C crucially dominates another constraint C' and C' crucially dominates a Faithfulness Constraint.

In Classical Arabic, PARSE (Root) triggers epenthesis by dominating the Faithfulness Constraint *STRUCTURE that opposes it. In Yawelmani, PARSE (Root) blocks syncope by dominating *STRUCTURE (σ) and so preventing it from overriding the Faithfulness Constraint PARSE (μ).

3. Autosegmental Phonology in Optimality Theory: A Problem and a Proposal

Because Optimality Theory allows a straightforward expression of both the active and the passive interpretations of a constraint, it should allow us to do both for the OCP. But there is a problem in applying the theory to autosegmental phonology, i.e. to the phonology of features.

It is crucial in optimality theory that all operations in GEN be structure-building, not structure-changing. McCarthy and Prince (1993a) state this as a principle called <u>Containment</u>:

(15) No element may be literally removed from the input form. The input is thus contained in every candidate form. (McCarthy and Prince 1993a: 20)

According to Containment, GEN cannot include any operation, such as deletion or substitution, which removes information present in the input. GEN is monotone increasing.

Containment is crucial to the model because it is what allows the Faithfulness Constraints to keep track of how far the output deviates from the input. If structure-changing operations such as deletion or feature-changing were allowed in GEN, there would be no way to limit these operations to particular contexts, since there would be no way of appraising their effects on the basis of output representations alone. Looking just at the output, one could not tell the difference between a form in which a vowel **i** was deleted, and one in which it was absent underlyingly. To make such appraisals, one would require access to input representations as well as output representations, as in many two-level constraint systems (e.g. Goldsmith 1993, Lakoff 1993).

It is fairly easy to obey Containment in the domains of syllabification and footing, since syllables and feet are predictible and so underlyingly absent. These areas of phonology more or less obey Containment even in derivational models, since they involve the building of predictible structure on top of the underlying representations. To get the effect of consonant deletion, for example, Prince and Smolensky (1993) arrange that the consonant in question fails to get parsed into syllable structure. They can do this because syllable structure is structure added to the input representation, and an underparsed representation is simply one with less structure added.

It is not immediately apparent, however, how featural phonology can be restricted to structure-building operations. Much of the information dealt with in autosegmental phonology must be underlyingly present. It is not predictible in English, for example, whether or not a morpheme contains the specification [+voice], and it is not predictible where in the morpheme such a specification must occur. There must be underlying specifications and underlying associations, and these must both be subject to neutralization in particular environments. One cannot arrange to delete a tone by failing to associate it, as one deletes a consonant by failing to syllabify it, since many tones that delete are ones the association of which is unpredictible and so underlying.

What we need is a system in which underlying specifications and associations are recognized and in general respected, but are also tentative and subject to evaluation. Let us represent underlying specifications and associations in a notation distinct from that for output specifications and associations. Then the analogue to syllable parsing will be the substitution of output notation for input notation. I choose here the convention of writing underlying feature specifications in lower-case, and parsed specifications in upper-case. Underlying associations will be written with dotted lines, and parsed associations with solid lines. These conventions are summarized in (16).

(16) a. Input Representations — b. Parsed (realizable) representations

a. Input Representations			b. Parsed (realizable) representations		
Association	:	(dotted line)	Association	|	(solid line)
Features	h	(lower-case)	Features	H	(upper-case)

As in syllable theory, only parsed material is interpreted phonetically. If a feature specification is unparsed, it is not pronounced. If an association between a specification and a p-bearing unit is unparsed, the specification will not be pronounced on that particular unit. Parsing is to be interpreted as adding the property of being parsed to the parsed element, so that **H** is **h** plus parsing, and **|** is **:** plus parsing. We have thus generalized the notion of "parsing" to mean not just association, but "incorporation into phonetically realizable representation".

GEN for tone, and *mutatis mutandis* for any other feature, can then be tentatively formulated as in (17):

(17) GEN for tone (first approximation)

a. Associate

ⓗ   h
      |
σ --> σ

b.Keep (Assoc)

h   h
: |
σ --> σ

c. Keep (T)

h --> H

Associate links tones to syllables. Note that because **h** is a subrepresentation of **H**, this operation applies both to parsed and to unparsed tones. Keep (Assoc) trades in underlying association for output association, and Keep (T) does the same for tones. All these operations are unordered and optional. All are also structure-building: (17a) adds association lines to the representation, and (17b) and (17c) add the property of parsing. For any input, these operations will generate every conceivable pattern of linking between tones and syllables, except that they cannot literally eliminate underlying tones and associations.

The random associations introduced by these conventions are then subject to the following Faithfulness Constraints.

(18) Faithfulness Conditions

a. PARSE (T) : A tone must be parsed.

b. PARSE (A): An association must be parsed.

c. *FLOAT: A tone must be associated by a parsed association with some tone bearer.

d. *STRUCT (A): There must be no association.

PARSE (T) assigns a "*" for each instance of a lower-case **h**. This constraint thus insures that if all else is equal, underlying tones will be realized. PARSE (A) assigns a "*" for each dotted line. This constraint requires tones to stay where they are underlyingly located, unless higher constraints dictate otherwise. *FLOAT, which corresponds to the second clause of Goldsmith's (1976) Well-Formedness Condition, assigns a "*" for each floating tone. *STRUCT (A) assigns a "*" for each association, whether parsed or unparsed. As with *STRUCT (Root) in syllable theory, *STRUCT (A) opposes any association, but for any input the associations that survive from that input will be constant, so the only effect of this constraint is to weigh additional associations. It opposes association or spread unless required by higher constraints.[2]

If no constraint was ranked higher than these Faithfulness Constraints, the optimal output representation would differ from the input representation only in having association of underlyingly floating tones. In the next section, we will demonstrate how tone alternations can arise due to constraints such as the OCP dominating Faithfulness.

4. Shona: The Tonology of the Phonological Word

In this section we will consider the tonal alternations of the phonological word level in Zezuru Shona, a Bantu language spoken in Zimbabwe. The tonology of this language has been described by Fivaz (1970), Fortune (1985), Myers (1987) and Hewitt (1991). The closely related Karanga dialect has been studied by Odden (1980, 1981). It is relevant to the issue of how the OCP is implemented in that many of the tonal alternations in this language have been argued to be triggered or blocked by the OCP (Myers 1987). This is because many of the phonological patterns involve a sequence of separate high tones, as in (2).

In Shona, as in most tone languages, floating tones are associated to the left edge of their domain. The tone of the verb radical, for example, is predictibly associated with the first syllable of the stem, as in (19a). Floating inflectional tones like the copula and the participial associate with the first syllable of the the inflectional sequence that contains them, as in (19b) and (19c).

(19) Floating tone associates with the leftmost syllable in its domain.

a.. H Radical / teng/	**té**ng-és-ér-a buy-caus-appl-fv "sell!"	(*tengésérá)
b. Copula /H/	í-sádza cop-porridge "(it) is porridge"	cf. sadza 5/porridge "porridge"
c. Participial /H/	nd**í-**cha-téng-a 1stsg/part-fut-buy-fv. "I having bought"	cf. ndi-chá-teng-a 1sg-fut-buy-fv "I will buy"

GEN, as formulated in (17), will produce outputs with the floating tones associated with the leftmost syllable in the domain, as well as outputs in which it is associated with the other syllables. We need a constraint that selects the left edge as the preferred locus. We can formulate this as in (20), stating it as a member of the ALIGN family (Prince and Smolensky 1993, McCarthy and Prince 1993b).

(20) ALIGN (H, L, PWd, L)

A violation of ALIGN is recorded for every tone bearer that separates a parsed tone from the left edge of the phonological word.[3] All else being equal, this constraint favors representations with a tone on the first syllable of a domain over representations in which the first tone is on a later syllable. In the case of a floating tone, as in (19b), this will be enough to put the H on the first syllable:

(21) **í-sádza** Input: / H /
/ + i + sadza /

<table>
<tr><th>Candidates</th><th>ALIGN</th></tr>
<tr><td>a.
☞ H
/ \
i sadza</td><td></td></tr>
<tr><td>b.
H
/ \
i sadza</td><td>*!</td></tr>
<tr><td>c.
H
|
i sadza</td><td>**!</td></tr>
</table>

However, tones that are underlyingly associated do not gravitate to the left edge, nor do they delete if they are non-initial. This means that PARSE (A) and PARSE (T) must take precedence over ALIGN, as illustrated in the following tableau, for **badzá** "hoe".

(22) **badzá** Input: / h /
:
/ badza /

<table>
<tr><th>Candidates</th><th>PARSE (T)</th><th>PARSE (A)</th><th>ALIGN</th></tr>
<tr><td>a.
H
☞ |
badza</td><td></td><td></td><td>*</td></tr>
<tr><td>b.
h
|
badza</td><td>*!</td><td></td><td></td></tr>
<tr><td>c.
H
/ :
badza</td><td></td><td>*!</td><td></td></tr>
</table>

In (21), with a floating tone, all three candidates had a single underlying tone and a single non-underlying association. They were thus equal with respect to PARSE (T) and PARSE (A), which allowed ALIGN to decide the issue. In (22), on the other hand, no representation satisfying ALIGN is to be found that doesn't violate these higher constraints.

This alignment of tones to the left edge plays a role in another alternation. A high tone span at the beginning of a stem is lowered if it occurs after a high toned syllable within the phonological word . Examples of the alternation are given in (23).

(23) a. í-banga cf. bángá "knife"
cop-knife
"(it) is a knife"

b. vá-sekuru cf. sékúru "grandfather"
2a-grandfather
"grandfather (honorific)"

c. ndi-chá-tengesa cf. ku-téngésá "to sell"
1stsg-fut-sell
"I will sell"

d. v-á-tengesa cf. ku-téngésá "to sell"
3pl-past-sell
"they sold"

Myers (1987) formulates the rule responsible for the alternation as in (24a), and names it "Meeussen's Rule", following Goldsmith (1984). The result of this rule applies to (23a) is shown in (24b) (assuming that low tone is default).

(24) a. H --> ø / H ___ (Phonological word)

```
b.  H    H           H
    |   / \          |
    i  ba nga  --->  i ba  nga
```

As noted above in Section 1, this is an example of a rule that is "triggered" by the OCP, in the sense that it takes a representation that violates the OCP and converts it into one that doesn't violate the OCP. We can express this in OT terms by having the OCP dominate PARSE (T). This will lead to nonparsing (and nonpronunciation) of a tone in case of an OCP violation.

The question is then what decides that it is the second tone that should be left unparsed. I propose to relate this directional asymmetry to the one just noted in direction of association. The Meeussen's Rule context is another case in which neutralization of higher constraints allows lowly ALIGN to play a crucial role. In a juxtaposition of high-toned morphemes, as in (22), the OCP is violated in the input representation. To account for the response to this violation, we must slightly reformulate the OCP as follows:

(25) OCP (Revised): *F F , where F is a parsed feature specification.

In other words, the OCP is sensitive only to parsed representational elements. Furthermore, we will consider two tones to be adjacent only if they are associated by parsed associations with adjacent tone-bearers (Myers 1987).

Leaving one of two adjacent high tones unparsed will then alleviate an OCP violation, but is it better to leave out the left one or the right one? Either choice violates PARSE (T), but failing to parse the left tone also violates ALIGN. The optimal representation is thus (26a), with the right high unparsed.

(26) **íbanga**

```
Input: / h          h    /
                    :  :
     /      +  i  + banga  /
```

Candidates	**OCP**	**PARSE (T)**	**ALIGN**
a. ☞ **H h** **| / ** **i banga**		*	
b. **h H** **| / ** **i banga**		*	*!
c. **H H** **| / ** **i banga**	*!		

In this analysis, dissimilatory tone lowering follows from the OCP, in its interaction with PARSE (T) and ALIGN. The OCP triggers a change by dominating a Faithfulness Constraint, PARSE (T), which opposes change.

The OCP is also relevant to tone spread. If a high-toned syllable is followed at the phonological word level by a toneless syllable, the high tone spreads onto that toneless syllable, as in (27):

(27) a. í-sádza "(it) is porridge"   cf. sadza "porridge"
b. nd-a-ká-véreng-a "I read (yesterday or before)"   cf. ku-vereng-a "to read"
c. ti-chá-véreng-a "we will read"   cf. ku-vereng-a "to read"

Tone spread adds structure to the representation, and so leads to violations of *STRUCT (A). Some constraint must crucially dominate this Faithfulness Constraint.

Following Prince and Smolensky (1993: 212-213) we could motivate spread with a constraint against HL sequences: *óo. But they are talking about an unbounded tone spread, and it turns out that such a constraint does not in fact have the result of forcing bounded rightward spread. Consider, for example, the following tableau for (27b):

(28) **ndakávérenga** Input: / h /
:
/ nd-a-ka-vereng-a /

Candidates	***ó o**	***STRUCT**
a. **H** **|** **nd-a-ka-vereng-a**	*!	*
b. **H** **/ ** **nd-a-ka-vereng-a**	*!	**
c. **H** **/ ** **nd-a-ka-vereng-a**	*!	**
d. **H** ☞ **/ / \\ ** **nd-a-ka-vereng-a**		****

Local spread in either direction does not diminish the number of HL sequences in the form. Only spread onto the final syllable does that, so the optimal representation is, incorrectly, the one with unbounded spread: (28d).

Another promising approach that does not in fact work is to force spread with a constraint against single linking of high tones, as in (29):

(29) A tone must be associated with more than one tone bearer.

If this constraint dominates *STRUCT (A), it will insure that a tone will spread, and will spread only one syllable over. Further spread will not improve a representation with respect to (29), and it will introduce unmotivated violations of *STRUCT (A). However, (29) will be satisfied by leftward spread as in (28b) just as well as by the rightward spread in the actual output (28c).

To allow output constraints to keep track of the direction of spread, we must have a distinction in output representations between "original" associations and those added by spread. Prince and Smolensky (1993) do this with the informal notation of **ő** for an underlying high and **ó** for any other. What this misses is that floating tones spread in just the same way as tones that are underlyingly associated.

Let us say that for each tone span there is at least one association that is the head association of the span. We will mark this by underlining the tone-bearer that stands in this relation to the tone. We can assign heads by revising GEN. "Associate Free Tone" (30a) only applies to unassociated tones, and it outputs a head association. The more general "Associate" (30b) applies to any tone, and outputs a non-head association. The revised "Keep Association" now outputs a head association.

(30) GEN for Tone (Revised)

a. Associate Free Tone.	b. Associate Tone.	c. Keep Association.	d.Keep Tone
h h	h h	h h	h --> H
|	|	: |	
σ --> σ	σ --> σ	σ --> σ	

The result of this revised version of GEN is that only underlying associations and initial associations of floating tones will be marked as head associations, and all others must be nonheads.

Given this notation, we can then state the constraints that motivate spread as in (31):

(31) High tone spread

a. LEFT-HD: The leftmost tone-bearer of a tone span must be a head.

b. T-BIN: A tone span can have at most one non-head (in a domain).

c. FILL (σ): A syllable must be associated with a tone.

d. LEFT-HEAD, T-BIN >> FILL (σ) >> *STRUCT

Spread is motivated by FILL (σ), which assigns a "*" for each toneless syllable. This constraint corresponds to the first clause of the Well-Formedness Condition of Goldsmith (1976), and to FILL in the syllable theory of Prince and Smolensky (1993). Spread is constrained by (31a), which requires that it be rightward from the head, and by (31b), which limits spread to one syllable. Domination must be as in (31d). LEFT-HD and T-BIN are unviolated and so undominated. FILL (σ), on the other hand, is violated frequently - by every toneless syllable. Toneless syllables are left in a domain with a high tone either if they are to the left of the head (LEFT-HD >> FILL (σ)) or if they are further than one syllable to the right of the head (T-BIN >> FILL (σ)). FILL (σ) dominates *STRUCT (A); otherwise there would be no spread at all.

The analysis is illustrated in (32), a tableau for (27b).

(32) **ndakávérenga** Input: / h /
:
/ nd-a-ka-vereng-a /

Candidates	LEFT-HD	T-BIN	FILL (σ)	*STRUCT
a. **H** **|** **ndakaverenga**			****!	*
b. **H** ☞ **/ ** **ndakaverenga**			***	**
c. **H** **/ ** **ndakaverenga**	*!		***	**
d. **H** **/ \\ ** **ndakaverenga**		*!	**	***

(32a), which corresponds to the input representation, is less optimal than (32b) because it has worse violation of FILL (σ). (32c), with leftward spread, is equal to (32b) with respect to FILL (σ), but it violates the higher ranked LEFT-HD. (32d), with spread more than one syllable rightward, is better than (32b) with respect to FILL (σ), but it violates T-BIN. Thus the actual output (32b), with spread of the underlying high one syllable to the right, is correctly selected as the optimal output.

As noted above in Section 1, tone spread in Shona is blocked if it would create an OCP violation. Thus while we get tone spread in the copular form **í-sádza** "(it) is porridge" (cf. **sadza** "porridge"), we do not find spread of high tone onto the syllable before a high-toned syllable:

(33) a. í-badzá "(it) is a hoe" (cf. badzá "hoe")
b. í-shumbá "(it) is a lion" (cf. shumbá "lion").

This is a straightforward case of the OCP blocking a rule. The OCP blocks spread because it dominates the constraint FILL (σ) which dominates the Faithfulness Constraint *STRUCTURE (A).

(34) **íbadzá** Input: / h h /
:
/ + i + badza /

Candidates	OCP	PARSE(T)	FILL (σ)
a. **H H** **| |** ☞ **i ba dza**			*
b. **H H** **/ \ |** **i ba dza**	*!		
c. **H h** **/ \ |** **i ba dza**		*!	

To insure that the OCP violation introduced is not cleared up by nonparsing of a tone, as in (34c), we also rank PARSE (T) over FILL (σ).[4]

In rule terms, the ungrammaticality of (34c) shows that Spread cannot feed Meeussen's Rule. It is also true that Meeussen's Rule cannot feed Spread, although it produces the appropriate sequence of a high toned syllable followed by toneless syllables. Thus **/í-bángá/** becomes **[í-banga]** by Meeussen's Rule, but it is not then further changed to ***[í-bánga]**, although the structural description for Spread is met. In a rule system, this counterfeeding is guaranteed by ordering Spread before Meeussen's Rule.

In OT, things look somewhat different. The high tone is not deleted in such forms; it is merely left unparsed. Meeussen's Rule therefore does not, in this analysis, produce the environment for spread.

To see this, we first make explicit the unviolated constraint (35) against contour tones in Shona. The relevant tableau is then (36) (cf. (26) above).

(36) *COMPLEX (T): A tone-bearer must not be associated with more than one tone.

(36) **íbanga**

```
Input: / h              h     /
                         :   :
          /     +  i  + banga   /
```

Candidates	OCP	*COM-PLEX (T)	PARSE (T)	FILL (σ)
a. ☞ H h | / \\ i banga			*	
b. H h / \\ / \\ i banga		*!	*	

There is no question of spreading here, since there are no toneless syllables.[5]

The third and final tone alternation at the phonological word level is illustrated in (37):

(37) a. á-ka-téngá — 3rdsg./pst-rem-buy — "he/she bought" (/téng/)
cf. á-ká-vérenga — 3rdsg/past-rem-read — "he/she read" (/vereng/)

b. bánga gúrú — knife big — "a big knife"
cf. bángá — "knife"

c. ákaténga bángá — "he bought a knife"
cf. (a,b)

This alternation occurs, like that induced by Meeussen's Rule, when two high tones come together. The difference is that in this case the left high tone has more than one syllable associated with it. In this case, that tone is simply retracted, and there is no tone deletion. We can formulate the rule as in (38):

```
(38) Tone Slip:   H   H         H   H
                 / \  |         |   |
                σ  σ σ --> σ σ σ
```

This rule takes precedence over Meeussen's rule, so it must be ordered before that rule.

In optimality terms, the OCP is in these cases forcing a violation of PARSE (A). To give Tone Slip priority over Meeussen's Rule, we rank PARSE (T) over PARSE (A). The tableau for (37a) is then as in (39):

(39) **ákaténgá** Input: / h h /
: : : :
/ a-ka - teng-a /

Candidates	OCP	LEFT-HD	PARSE (T)	PARSE(A)
a. **H H** / \ / \ **[a ka][te nga]**	*!			
b. **H H** / : / \ ☞ **[a ka][te nga]**				*
c. **H H** / \ : \ **[a ka][te nga**		*!		*
d. **H h** / \ / \ **[a ka][te nga]**			!*	

Leaving underlying tones and associations alone, as in (39a), brings on a fatal violation of the OCP. Failing to parse the last association of the first tone, as in (39b), renders the two high tones non-adjacent as far as the OCP is concerned, since the OCP only cares about parsed tones and associations. Nonparsing of this association in (39b) is more optimal than nonparsing of tone as in (39d), since PARSE (T) is stronger than PARSE (A). Retracting the association of the first tone, as in (39b), is preferred to retraction of the second tone, as in (39c), because the latter induces a violation of LEFT-HD. The optimal output is thus (39b), with retraction of the first tone.

If delinking takes precedence over tone deletion, how can the Meeussen's Rule alternation occur at all? We return to our example of Meeussen's Rule, and see that the added constraints do not change the optimal output there:

(40) **íbanga** Input: / h h /

```
        :   :
/     + i  + banga  /
```

Candidates	OCP	LEFT-HD	*FLOAT	PARSE (T)	PARSE (A)
a. H H | / \\ i banga	*!				
b. H h | / \\ ☞ i banga				*	
c. H H : / \\ i banga			*!		*
d. H H | : \\ i banga		*!			*

Delinking in this case, as in (40c), leaves the left tone unassociated, in violation of *FLOAT as well as PARSE (A). Delinking of the right tone in (40d) leads, as before, to a violation of LEFT-HD. The optimal representation is thus still (40b), with the Meeussen's Rule effect.

To summarize, we have posited the following constraints in the following ranking.

(41) Hierarchy of Constraints for Shona Tone (Phonological Word)

OCP, LEFTHD, T-BIN, *COMPLEX(T), *FLOAT >>
PARSE (T) >>
FILL (σ), PARSE (A) >>
ALIGN, *STRUCTURE

The topmost constraints are unviolated and so undominated. OCP must dominate PARSE (T), since PARSE (T) is violated only if that violation prevents an OCP violation. That PARSE (T) dominates FILL (σ) is shown by the fact that spreading a tone doesn't ever lead to Meeussen's Rule effects. PARSE (T) dominates PARSE (A) because nonparsing of associations is preferred over nonparsing of tones as a means of avoiding OCP violations. PARSE (T) and PARSE (A) must dominate ALIGN to insure that underlying tones are not forced to the first syllable of the domain. FILL (σ) must dominate *STRUCT or it would have no effect at all.

This analysis has three important advantages over the ordered rule analysis. First, the OT analysis captures both the active and the passive effects of the OCP. The OCP triggers alternations because it dominates the Faithfulness Constraints PARSE (T) and PARSE (A). It blocks otherwise general spread because it dominates FILL (σ) and so in case of conflict prevents that constraint from overpowering the Faithfulness Constraint *STRUCT. Unlike the derivational analysis, the optimality analysis relates the tonal dissimilation to the universal OCP.

Second, the optimality analysis captures some generalizations that are inexpressible in the derivational analyis. It is true that there are more constraints in the optimality model than there are rules in the derivational model, but this is not the appropriate level of comparison. There are in the optimality model fewer language-particular stipulations that one has to make to get the appropriate results. For example, the sequence of two high tones that is written into the formulations of Meeussen's Rule and Tone Slip can be factored out as the OCP. The leftward bias of both Meeussen's Rule and Association can be factored out as ALIGN. Each rule corresponds to a battery of constraints, but this fragmentation leads to a certain economy, in that overlap in patterns can be maximally exploited.

Third, the interaction of tone lowering and tone spread, which in the rule analysis had to be stipulated by means of rule ordering, falls out here as an inevitable consequence of the representations. Nonparsing of H, which is here the analogue of Meeussen's Rule, cannot feed spread because it creates no toneless syllables. In this case persistence of underlying structure, forced by the principle of Containment, has just the right effect.

5. Shona: OCP Fusion

There is a further OCP-motivated operation in Shona that does not occur at the phonological word level. If two high-toned morphemes are juxtaposed at a lower level than the phonological word, tone lowering never results. The tone delinking expressed by Tone Slip still occurs at this lower level, but if that is not applicable, then both high-toned morphemes remain high-toned, as in (42). High-toned morphemes are underlined, and the morphological word domain (Myers 1987) is delimited by brackets.[6]

(42) a. [ku]-[mú-téngéséra]
inf-obj-sell to
"to sell to him/her"

b. [ku]-[mú-véréngera]
inf-obj-read to
"to read to him/her"

c. [tí-téngésé]
we/subj-sell
"we should sell"

d. [tí-táríse]
we/subj-look
"we should look"

It would appear at first glance that in these constructions violations of the OCP were simply tolerated. There is evidence, however, that the OCP-violating sequences are subject to a fusion operation, which converts the violating sequence into a single multiply-linked high tone. This evidence is provided by constructions in which forms such as (42c) are put in the Meeussen's Rule context at the phonological word level.

(43) a. há-[ti-tengese]
hort-we/subj-sell
"let us sell"

b. há-[ti-tarise]
hort-we/subj-look
"let us look"

The hortative forms (43a) and (43b) consist of the subjunctive forms (42c) and (42d), respectively,with the hortative prefix há-. The two subjunctive forms differ in that (42c) has two underlying high tones, while (42d) only has one. This distinction is neutralized in the Meeussen's Rule context in (43), though; in each case the whole high-toned span is lowered (i.e. left unparsed).

Myers (1987) accounts for these facts by positing a cycle-final operation of OCP Fusion: **H H --> H**. Such an operation has been motivated in other tone languages (Leben 1978, Kenstowicz and Kidda 1987), and McCarthy (1986) argues that such a fusion is built into Tier Conflation. But such an operation is structure-changing and so unavailable in Optimality Theory. We posit instead a unification operation that takes two feature matrices and turns them into one feature matrix combining the specifications of both. Alternatively, we can think of this as an operation associating two tone specifications to a single tonal root node (Inkelas 1987, Yip 1989).

(44) Unify: $T_i \; T_j \;\; => \;\; T_{i,j}$

Unify is part of GEN, and, like all operations in GEN, it is optional, unordered and structure-building. Constraints that limit the effects of Unify will be sensitive to multiple specifications in a feature matrix (i.e. associated with the same tonal root node):

(45) *COMPLEX (Spec): *[αF, βF] (where F is a feature)

*COMPLEX (Spec) penalizes unification. It will allow Unify to have an effect only if some higher constraint overrides it. One such constraint would be the OCP, since if two adjacent high tones were fused into a single high tone, the result would not have an OCP-violating sequence of high tones.

Constraint (45) must be sensitive to morphological level, since whether Fusion occurs depends on level. There are potentially a number of ways one could introduce such reference to domains into optimality models. One way would be simply to link up optimality systems in a chain, such that the output of one is translated into an input representation in the other. This is the strategy chosen by McCarthy and Prince (1993a: 146-173). This approach corresponds to the "mini-phonologies" view of early Lexical Phonology, or to the chains of two-level constraint systems in Goldsmith (1993) or Lakoff (1993).

Another way of dealing with domains is perhaps more in the nonderivational spirit of the optimality model. Let us say that a constraint can have a domain, in the following sense:

(46) If a constraint C has a domain D, a violation of C is only assessed if D is the smallest domain including the whole violating structure.

We will indicate domain restrictions by superscripting the domain label to the end of the constraint name. Then we can limit Unify in the appropriate way by limiting (45) to the phonological word level and ordering it above PARSE (T). Nonparsing of tone will then be less costly than unifying tones at that level, but will be more costly at other levels.

With this proviso, the tableau for (42c) is as in (47).

(47) títéngése Input: / h h /

: : :

/ ti-teng-es-e /

Candidates	OCP	*COMP(S)	PARSE(T)
a. H H | / \\ ti-tengese	*!		
b. H h | / \\ ti-tengese			*!
c. [H, H] ☞ | / \\ ti-tengese			

The results at the phonological word level will be unchanged, since violation of *COMPLEX(Spec) at that level will be worse than either nonparsing of tone or nonparsing of association.

Tone unification is a third active response in Shona to OCP violations, in addition to nonparsing of tones and of associations.

6. OCP!: An Extension

Some languages display dissimilatory processes that are less local than the ones we have been considering in Shona. In Japanese, for example, a word in the native Yamato vocabulary may not contain more than one nonredundant voicing specification (Itô and Mester 1986: 67). Thus **futa** "lid" is possible, with no nonredundant (i.e. obstruent) voicing, and **fuda** "sign" and **buta** "pig" are possible with just one such specification. But ***buda**, with two voiced obstruents is not a possible Yamato morpheme. This restriction also has the effect of blocking rendaku, a process that leads to voicing of a word-initial obstruent in the second member of a compound.

Itô and Mester (1986) point out that this principle "has a close affinity to the intuitive idea behind various versions of the Obligatory Contour Principle". But there is a striking difference between these effects and the OCP effects we have been discussing. In Shona, two tones are only treated as adjacent if they are associated with adjacent tone bearers. I would suggest that this is the general definition of adjacency in phonology (following Myers 1987):

(48) An element A is structurally adjacent to an element B iff:
 a. A and B are associated with p-bearing units A' and B', respectively, and no unit intervenes between A' and B', or
 b. if either A or B is unassociated, and no element intervenes between A and B on the p-tier.

Assuming that phonological processes are only triggered if the trigger is adjacent to the target (McCarthy and Prince 1986), this definition implies that processes will not generally affect elements that are associated with nonadjacent elements, even if there is a tier in which those two elements are not separated by any element.

High tones in Shona, for example, are the only specifications on the tone tier in that language. There is thus no element on the tone tier between the two H's in a HLH form such as **íbadzá** "(it) is a hoe" (cf. (33)). But H's only interact in this language if they are adjacent syllables. Nothing happens to disturb the high tones in forms such as **íbadzá**. I would claim that this is the usual case.

There are cases such as that in Japanese voicing, however, in which there is interaction at a greater distance. I would propose that such cases involve a constraint related to the OCP, but without an adjacency requirement. I will refer to this constraint as the OCP!:

(49) OCP!: Two identical specifications must not occur in the same domain.

In Japanese, this constraint holds in the domain of Yamato morphological structure, and it dominates the PARSE constraint on voicing. The result will be that no optimal form will have two parsed voicing specifications within the same Yamato morphological unit.

In tone the OCP! would be active if a domain cannot contain two tone specifications, regardless of their positions. In Chichewa, for example, a stem can include at most one H (Carleton and Myers 1993). In such a system, the OCP! must dominate PARSE (T).

The OCP! is a stronger condition than the OCP, since it applies to non-adjecent as well as adjacent specifications. But while the OCP might well be universally undominated, it is clear that the OCP! is frequently violated.

7. Conclusion

I have argued that an optimality-theoretic approach to autosegmental phonology makes it possible to derive from the OCP those phonological processes that convert an OCP violating representation into an OCP-obeying one. The example I have used has involved only tonal features, but the parallel arguments can be constructed for any other feature, since all features show OCP effects.

I have also argued that featural neutralization patterns do not pose a problem for OT, if we distinguish in feature specification and association between underlying and realizable notations.

The analysis has also provided evidence for the Well-Formedness Condition of Goldsmith (1976). Goldsmith states this principle as in (50) (Goldsmith 1976: 27):

(50) Well-Formedness Condition

(a) All vowels are associated with at least one tone.

(b) All tones are associated with at least one vowel.

(c) Association lines do not cross.

Clause (a) is reflected in our analysis in the constraint FILL (σ) (31c). Clause (b) is recapitulated in *FLOAT, in (18c) above. Clause (50c) has been assumed implicitly throughout. Goldsmith notes explicitly that these are not to be interpreted as filters, ruling out representations, but as targets to be satisfied with minimal distortion of the input forms. Optimality theory offers an explicit way of encoding Goldsmith's intuition.

The arguments that have been presented in the literature against the Well-Formedness Condition do not hold against the optimality-theoretic re-interpretation of it. Pulleyblank (1986), for example, has shown that there must be toneless vowels, in violation of (50a). Clements and Ford (1979) have argued that in languages without contour tones, some tones are left unassociated. In the current model these cases are easily accomodated if we assume that a constraint can crucially dominate SPREAD (the analogue of (50a)) or PARSE (T) (the analogue of (50b)). The constraints of the Well-Formedness Condition are violable, but they still play a crucial role in shaping optimal outputs.

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1 An alternative constraint which has the same effect would penalize each root node that does not belong to a morpheme (McCarthy 1993). Elements added by GEN are not members of any morpheme.

2 As in the case of *STRUCTURE (Root), an alternative would be to posit a constraint that penalizes associations that are not members of any morpheme.

3 Kirchner (1993) proposes that only parsed features are relevant to ALIGN. A parsed feature is for him simply one that is associated, but we would maintain that his restriction on ALIGN holds also when the notion "parsed" is redfined as we have done here.

4 Carleton (1993) shows that the opposite constraint ranking holds in another Malawian Bantu language, ChiYao. In this language, tone spread does feed Meeussen's Rule, so FILL(σ) must dominate PARSE (T).

5 A high tone spreads more than one syllable to the right if the toneless syllables to the right of the high-toned syllable are class markers, as in (a):

(a) sá-chí-gáro	cf. chi-garo
1a-7-chair	7-chair
"chairman"	"chair"

Each class marker is a stem, and so forms a tonological domain (Myers 1987). TBIN allows at most non-head in each domain, so it allows a non-head for each class marker. The unbounded spread in (7) better satisfies FILL (σ) than spread one syllable rightward would have, and it does not violate TBIN any worse.

6 In these lower domains, a high tone spreads <u>two</u> syllables to the right, leading to tone spans of three high-toned syllables. This spread does not interact with the OCP, so we won't go into it in detail. One approach to it would build on the analysis of Hewitt (1991). Let us define a Minimum Word, a disyllabic foot, at the beginning of the morphological word domain. If this Min Word counts as a domain for T-BIN (30b), then there will be non-heads within the Min Word and outside it in the next bigger domain. The result would be spread two syllables to the right.