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1. Introduction

Nonlinear phonology imposes strict requirements of locality on phonological rules. These requirements are expressed in various forms—examples include the line-crossing prohibition of Goldsmith (1976), the notion "adjacent elements" in the Obligatory Contour Principle (Leben (1973), Goldsmith (1976), McCarthy (1981; 1986a,b)), and the primacy of binary feet in stress assignment (Hayes (1980)). Fundamentally, locality in its various forms ensures that the elements referred to in phonological transformations and constraints are adjacent at some level of representation.

When we combine locality with the observation that in fact phonological operations frequently affect segments that are not string-adjacent, we see that locality imposes strong preconditions on the adequacy of theories of phonological representation. Two basic responses to these preconditions have been pursued within the theory.[1]

The first is the notion of tier segregation, introduced by Goldsmith (1976). Separate tiers are linked to one another directly or through any other nonskeletal tier, as in (1):

(1) Skeleton   x x x
                  | | |
                  A B C
                  | |
                  q   r
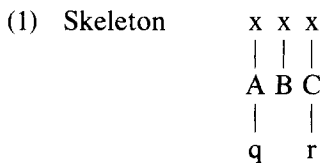
Although the elements A and C are not string-adjacent, they are specified, via association lines, for properties q and r that can be adjacent to one another by virtue of the segregation of q and r on their own autosegmental tier. The locality requirement for any operation on A and C referring to q and r is met by virtue of this segregation.

The second response to locality requirements is the idea of plane segregation, introduced by McCarthy (1979). Separate planes are linked independently to the skeleton, as in (2):

    [1] Here and below I consistently observe the terminological distinction between tiers and planes introduced by Archangeli (1985).

(2)   B
                                 |
        Skeleton   x x x
                        | |
                        A   C

Locality for operations on A and C is met by virtue of planar segregation: A and C are adjacent on the plane containing them, even though they are nonadjacent in the represented string ABC.

These two different modes of ensuring locality, as well as a variety of other consequences of the representational distinction, present a difficult challenge: by what criteria can we select between them in individual cases? Two answers to this question appear in the literature. The first, in McCarthy (1979; 1981; 1982), is what I will refer to as the *Weak Morphemic Plane Hypothesis* (WMPH):

(3)   *Weak Morphemic Plane Hypothesis*

      If separate morphemes, then separate planes.

That is, planar segregation as in (2) is required if AC is a different morpheme from B. If they are not different morphemes, then the WMPH is silent about whether (1) or (2) is appropriate.

The WMPH later developed into the much more restrictive claim made by the biconditional *Strong Morphemic Plane Hypothesis* (SMPH) of Steriade (1986), Archangeli (1987), Archangeli and Pulleyblank (1986), and Cole (1987):

(4)   *Strong Morphemic Plane Hypothesis*

      Separate morphemes if and only if separate planes.

This says that the representation (2) is required just in case AC and B are separate morphemes; in all other circumstances (1) is the only option.

The most pervasive and important examples where planes have been proposed are those in which vowels and consonants—or more correctly the melodic or featural content of vowels and consonants—occupy separate planes. This phenomenon, which I will call *planar V/C segregation*, will be closely examined in the course of this article. Another class of cases where separate planes seem appropriate is represented by the single, morphologically functioning feature in Cole's (1987) analysis of certain harmony systems. Although I will not discuss this evidence in detail, I will show that it is the expected result of the claims I make.

My argument is essentially reductionist. I first show that the SMPH is false by demonstrating that planar V/C segregation is required even when vowels and consonants are not separate morphemes. This result, I will show, must hold unless we are willing to give up many very fundamental results of nonlinear phonological theory. I then turn to the WMPH and show that, although it expresses a valid generalization, it has no independent status as a principle of phonological theory. My argument at this juncture

hinges on two observations: (i) planar segregation expresses the lack of inherent linear order relations between the two planes, whereas tier segregation does not; and (ii) the morphemes of nonconcatenative morphological systems are unordered. With this result about the difference between plane and tier segregation in hand, I then turn back to the cases that were adduced as evidence against the SMPH. Pursuing several observations by Prince (1987) about template/melody relations and linear order in templatic systems, and combining them with the logic of underspecification and with an interpretation of planar representations, I show that planar V/C segregation is required whenever there are no unpredictable linear order relations between vowels and consonants. I then turn to a possible case of planar V/C segregation solely under the auspices of rigid syllable structure, and I look at fake linear order relations that can appear from overly zealous underspecification. Finally, I briefly examine how these results bear on the examples of Cole (1987) and proposals about Plane Conflation (Younes (1983), McCarthy (1986a,b)).

2. Against the SMPH

To falsify the SMPH, it is sufficient to display a case where biplanar representation is required in the absence of morphological justification. Clearly we need to establish plausible criteria for both aspects of the demonstration before proceeding.

Biplanar representation is required when the locality of phonological operations and conditions cannot be otherwise maintained. "Locality" in phonology is, informally, the requirement that the affected and affecting elements be adjacent somewhere in the representation. A particularly important aspect of locality is expressed by the conjunction of two ideas: (i) all assimilation rules are accomplished by association-line spreading; (ii) association lines do not cross. Thus, biplanar representations are unavoidable when a fundamental violation of locality—crossing association lines—would arise by spreading in a uniplanar representation.

A familiar case of this sort is presented by the Arabic form *samam* 'poisoned'. Comparing the uniplanar representation in (5a) with the biplanar one in (5b), we see that separate spreading of vowels and consonants without regard to one another necessitates biplanarity:

(5) a.   b.   a
                                                    /\
    *C V C V C   C V C V C
     | \ /\ / | \/
   s   a m   s   m
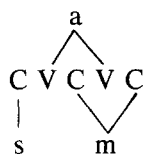
As we will discover below, various elaborations of the theory of feature geometry (Clements (1985)) make arguments of this sort slightly more difficult to construct. Nevertheless, it will emerge that biplanarity is unavoidable in Arabic and other cases under any plausible geometry of phonological features.

"Separate morphemes" is relatively unproblematic. If we have a regular pattern where, as in Arabic, vowels and consonants make distinct contributions to the meaning of the whole, then we can regard marginal cases as exhibiting the kind of virtual morphology demonstrated by Aronoff (1976) for English *permit*. In other words, we shall accept planar V/C segregation as morphologically justified if there is at least some evidence that vowels and consonants constitute separate morphemes in the Bloomfieldian sense, even if not all cases are analyzable in that way.[2] We therefore give the SMPH a generous opportunity to succeed.

The first case we examine is Yawelmani, which, according to Archangeli (1983; 1984), involves planar V/C segregation. The evidence for biplanar representation in Yawelmani comes from a pervasive phenomenon of V/C metathesis induced solely by the need to fill positions in a morphologically determined skeletal template. In different morphological circumstances (selected by a suffix), we find stem alternations like *diyl/ dyiil* 'guard', *bniit/bint* 'ask', and *ʔamc'/ʔmaac'* 'be near'.[3] The phenomenon at issue is the transparency of the medial stem consonant to permutations of the stem vowel.

No support for morphological separation of vowels and consonants can be found in this language. Yet Archangeli's analysis, depending as it does on planar V/C segregation, provides a straightforward account of the phenomenon. The vowel can associate on either side of the medial consonant purely in conformity with the requirement that positions in the morphological template be filled:

(6) a.   i   b.   i
              C C V V C   C V C C
              b n   t   b   n t
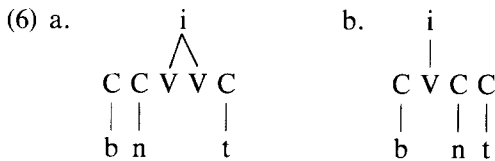
Thus, Yawelmani constitutes a prima facie counterexample to the SMPH: the V/C metathesis phenomenon—analyzed as an effect of template filling—requires planar V/C segregation, yet vowels and consonants are not separate morphemes in this language. What are the alternatives?

The fundamental problem Yawelmani presents is one of locality: in a uniplanar representation the *n* and *i* of *bniit/bint* cannot exchange places without line crossing. There are three possible accounts of this phenomenon that do not make use of planar V/C segregation. One is Steriade's (1986) hypothesis that the permutations of vowels and consonants in Yawelmani are a consequence of biplanarity via infixing reduplication (Broselow and McCarthy (1984)), rather than V/C segregation:

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[2] See Prince (1987) for cogent discussion of this point.

[3] These do not exhaust the available stems, and in some analyses a disyllabic stem with copied vowel is one member of the basic set of possibilities. I follow earlier treatments of Yawelmani in using constructed examples for expository convenience.

(7) a. b n   i   t   b. b n i   t
        | | /\ | | \ |
        C C V V C   C V C C
                                      \
   b n i t

This proposal is examined in exhaustive detail by Prince (1987); the arguments against it are numerous and persuasive.

A second alternative is to invoke a morphological metathesis rule. I dismiss this alternative for a very basic reason: it is unable to express Archangeli's insight that Yawelmani "metathesis" is the same sort of template filling or satisfaction that is found in the templatic morphological system of Arabic.

The third possibility, with considerably greater merit, is an elaboration of the theory of feature geometry along lines suggested initially by Clements (1985) and pursued in somewhat different ways by Sagey (1986), Archangeli and Pulleyblank (1986; 1987), and Steriade (1987a). The fundamental idea in all these approaches is that locality requirements can be observed without planar V/C segregation if vowels and consonants are characterized by sufficiently disjoint sets of features within a single plane (Prince (1987)). In lieu of planar segregation, these approaches account for the V/C transparency effects like Yawelmani metathesis by separating the features characterizing vowels and consonants onto separate tiers within a single plane. We will examine Sagey's theory first.

In this theory, the Place node of Clements (1985) is split into three articulator features, corresponding to the lips, the tongue blade and tip, and the tongue body. Each articulator feature then dominates additional features that characterize the finer distinctions made with that articulator, as in the following subtree of the entire feature complex:

(8)   Place node

        [labial]   [coronal]   [dorsal]

        [round]   [ant]   [dist]   [high] [low] [back]
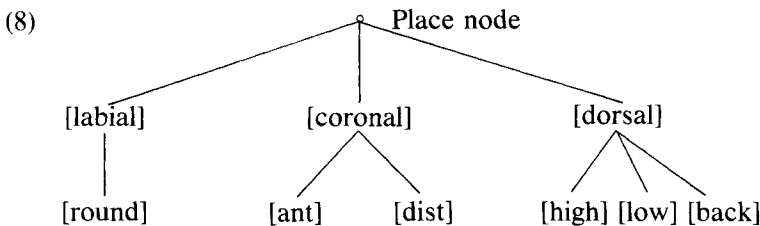
Each node in the tree defines a separate autosegmental tier; thus, there is a tier containing only the feature [labial], distinct from the tier containing [coronal]. The novel feature [dorsal] characterizes gestures of the tongue-body articulator.

As Sagey (1986) points out, this instantiation of feature geometry accounts for the fact that velar consonants are generally transparent to a process like backing harmony in vowels without the exercise of planar V/C segregation. Velar consonants are characterized as [dorsal], but unspecified for the features subordinate to [dorsal]. Because

they lack specification for [back], velar consonants are transparent to the spreading of that feature among the vowels.

But this approach cannot be generalized to the case of Yawelmani. A fundamental premise of feature geometry—in fact, the essential argument for the theory's existence— is the idea that an operation on a set of features is in fact an operation on the node dominating that set of features. For example, a basic argument for feature geometry is the hypothesis that place assimilation is an operation spreading or associating the Place node of the tree, entailing association of the features subordinate to the Place node.

Archangeli (1984) argues that the four-vowel system of Yawelmani is characterized by the set of features [round] and [high]. This means that the association operation responsible for the metathesis phenomenon of Yawelmani is an operation on the Place node—because a set of features is characterized by the node dominating that set. Yet the consonant that the vowel must pass over also has a Place node, so the association operation is impossible without a violation of the locality requirement in the form of the line-crossing prohibition:[4]

(9)

             *C   C   V   V   C

Place   ʔ
nodes   c'

                [dorsal] [labial]

                  [− high]
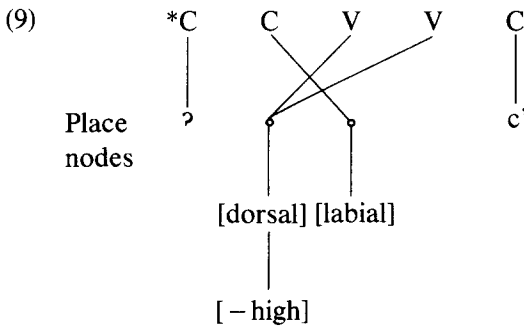
      (intended result: ʔmaac')

We see, then, that the V/C metathesis phenomenon of Yawelmani is incompatible with a geometry like (8).

At this point it is appropriate to dismiss three alternatives. First, suppose the operation in Yawelmani were "Associate (individually) the terminal features dominated by the Place node." This incurs no violation of the line-crossing prohibition, since Yaw-elmani consonants can be treated as nondistinctive for the two vowel features, [high] and [round]. But it exacts a severe price: feature geometry is no longer a characterization of the structural relations among features; instead, it is nothing more than a notation for arbitrary subgroupings of features that exist apart from the geometry itself. The point of the geometry is to allow characterization of phenomena like place assimilation by spreading the Place node—paralleling the spreading of individual features, which are themselves nodes in the tree. A predicate like "the set of features dominated by the Place node" puts the lie to this fundamental claim.

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[4] Irrelevant feature structure between the skeleton and the Place node has been suppressed.

The second alternative is somewhat different. It would express the operation in Yawelmani as "Associate (individually) all accessible nodes," where *accessible* is understood to refer to those nodes or features that can be linked without violating the line-crossing prohibition. Because the tongue-body features and the [round] specification of the vowel are accessible in this sense, they can associate correctly. The effect of this move on the claims the theory makes is even worse than that of the previous suggestion. The set of nodes that happen to be accessible is an arbitrary subset of the features, rather than a well-defined construct of the geometry. Nonexistent rules that simultaneously assimilate place and laryngeal features, but not manner features, are predicted to exist.

The third alternative is a rule like "Associate [high] and associate [round]." This presupposes a major weakening of the fundamental claim of feature geometry theory that rules can cross-classify features only by mentioning the nodes that dominate them, relegating that claim to tendential rather than absolute status. Yet even this much flimsier hypothesis makes an untrue prediction. It says that the grammar of Yawelmani would be more highly valued were it to contain only "Associate [high]" or "Associate [round]." But the known cases of templatic metathesis like Yawelmani never show a pattern of loss of distinctions that the more highly valued grammar would give us.

The problem, then, is that no coherent characterization of what is involved in Yawelmani metathesis is possible within a uniplanar representation. Even somewhat different conceptions of the underlying Yawelmani vowel system run into the same problem. If we characterize the Yawelmani vowels exclusively with tongue-body features [high] and [back], the same line-crossing problem arises not with any nonlaryngeal consonant at all but exclusively with the velars: to "move" the vowel, we must associate [dorsal], but velar consonants are themselves [dorsal]. This approach therefore makes the prediction—false for Yawelmani and unknown cross-linguistically—that the templatic metathesis effect could be restricted to consonants other than velars. So far, then, Yawelmani requires planar V/C segregation even though vowels and consonants are not separate morphemes.

Specifying the Yawelmani vowel system with tongue-body features alone yields somewhat better results with another theory of feature geometry, however. Steriade (1987a) proposes a bifurcation of the functions of the tongue body into two logical articulators, corresponding to one physical one. The [velar] articulator characterizes velar consonants; the [dorsal] articulator characterizes vowels:

(10)
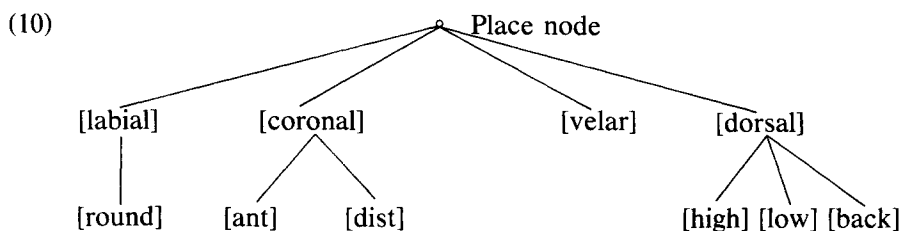
Since this proposal achieves a complete disjunction in featural specification between

consonants and the tongue-body features for vowels, it is successful in expressing the properties of the Yawelmani metathesis phenomenon (if vowels are distinctive for just [high] and [back]). The operation can now be described as "Associate [dorsal]"; no line crossing ensues, since no consonant, even a velar, bears a specification for [dorsal].

To achieve this result, though, we were careful to exclude [round] from the underlying specification of the Yawelmani vowels; otherwise, we would be back in the position of trying to associate the Place node across consonants that themselves have Place nodes. This proposal therefore predicts that languages in which rounding is distinctive in vowels cannot display the Yawelmani templatic metathesis phenomenon.

This prediction is false, as the analysis of Sierra Miwok by Smith and Hermans (1982) and Smith (1985) shows. The Miwok morphological system is virtually identical to that of Yawelmani; in different morphological circumstances, we find related stems like *kowat/kowta* 'to bump into', *hasul/haslu* 'to ask', *ʔenup/ʔenpu* 'to chase', *hi:sok/hisko* 'hair'. As in Yawelmani, all consonants are transparent to associations of all vowels, and vowels and consonants are not separate morphemes.

Miwok's vowel system is richer than Yawelmani's in an important way. Rounding is contrastive in this language:

(11)   i   ɨ   u
          e   a   o

It follows, then, that Miwok must associate the Place node to achieve V/C metathesis, with consequent offense against the line-crossing prohibition. This is not to say that (10) is wrong, but rather that it is inadequate to account for the templatic metathesis phenomenon of Miwok without planar segregation.

There are two possible reconstructions of feature geometry that get around this problem in Miwok. One, a modification of (10), would transplant the feature [round] from [labial] to [dorsal]:

(12)
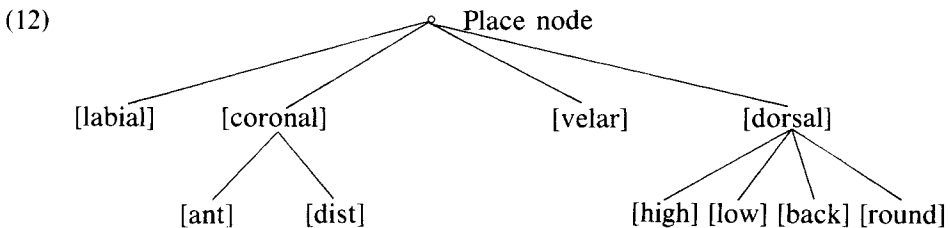
At this point [dorsal] is no longer an articulator node at all, but rather a cover feature for the acoustic properties normally exploited in vowel systems. I shall continue to call it [dorsal], however. In this theory even the richer vowel system of Miwok is characterized by [dorsal] and its daughters, so "Associate [dorsal]" will not run afoul of the line-crossing prohibition.

The second approach that is successful in accounting for Miwok is one like that of Clements (1985) or Archangeli and Pulleyblank (1986; 1987) that posits a Secondary Place

node that dominates both the tongue-body features and [round], abjuring the articulator-based characterization of the consonants:

(13)

Place node

[dist] [ant] [cor]   Secondary Place node

[high] [low] [back] [round]
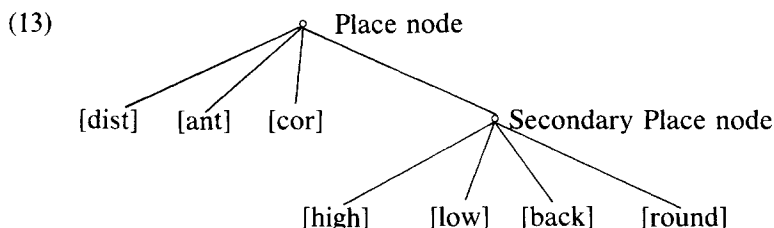
In this account, the characterization of places of articulation for consonants is accomplished, as in Chomsky and Halle (1968), by specifying appropriate values of the features [anterior] and [coronal]. Miwok, then, can associate the Secondary Place node without impediment from any consonants.

One problem is common to these two accounts: the lack of a relation between [labial] and [round]. These two features obviously invoke similar articulatory machinery, but that is not the reason that they are in a dependency relation in feature geometry theories like (8) and (10). Rather, there is an array of purely phonological arguments for a connection between these two features. A large number of cases from historical and synchronic processes are cited by Campbell (1974, 53); they typically involve languages where k^w becomes p. This process has a natural interpretation in the theories in which [round] depends on [labial], as Sagey (1986) points out. k^w necessarily involves both the [labial] and [dorsal] articulators, the former entailed by the fact that the segment is [round]. Simplification of this complex segment by loss of the [dorsal] articulator, then, is the fundamental process in the change.

Other evidence for the same conclusion comes from very different domains. In Ponapean and Mokilese, as Mester (1986) observes, a phenomenon of rounding harmony in labial consonants can be straightforwardly explained by the dependency of [round] on [labial]. Mokilese distinguishes four labial consonants, m, m^w, p, and p^w. Within a root, the labial consonants must agree in rounding.[5] If we assume (i) that [round] depends on [labial], (ii) that [labial] is on a separate tier from other features, and (iii) that the Obligatory Contour Principle (OCP) ensures that there can be only one [labial] feature in a root, then this distributional constraint follows:
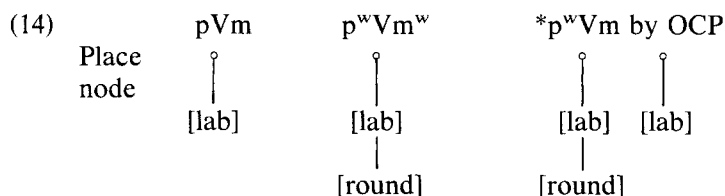
(14)   pVm $p^w V m^w$ *p^wVm by OCP

Place
node   [lab]   [lab]   [lab]   [lab]

                            [round]   [round]

The second and third assumptions are not especially controversial. The second (that articulator features like [labial] define their own autosegmental tiers) is accepted in all versions of feature geometry. The third accounts for a wide variety of constraints on homorganic consonants within roots in different languages (McCarthy (1985), Mester (1986), Yip (1987a,b)). The first is the one at issue, and it is clearly essential to the characterization of this phenomenon in Ponapean.

Another sort of constraint on the structure of morphemes is presented by Yip's (1988) account of consonant-vowel cooccurrence in Cantonese. In that language labial consonants and round vowels may not appear in the same syllable; the constraint is, in terms of theories like (8) and (10), a prohibition on having two instances of [labial] within the syllable.

Finally, in languages like Warlpiri (Nash (1979)), Igbo (Hyman (1975)), and Tulu (Campbell (1974), Sagey (1986)) processes of rounding harmony or assimilation treat labial consonants as opaque elements. This, then, is spreading of the [labial] node; parallel cases where labial consonants are transparent to harmony can be regarded as spreading of the [round] node.

The point of this brief examination of [labial] and [round] is made most forcefully by Campbell (1974): there is a recurrent association of the labial place of articulation with lip rounding that is not expressed by conventional feature theory or, for that matter, by approaches to feature geometry that dissociate these two features. Furthermore, since lip rounding and labial place have quite different acoustic effects, we cannot explain the association of [labial] and [round] by appeal to perceptual factors that might be outside the purview of the feature geometry. For this reason the feature geometry theories like (12) and (13) that divorce [round] from [labial] should be rejected.

Another set of problems is peculiar to theories like (13). This model of feature geometry exploits [anterior] and [coronal] to characterize places of articulation in consonants. This move is crucial, because by rejecting the articulator-based characterization of consonants in (8), it allows velars to be transparent to vowels. Velars can be characterized as [−anterior, −coronal], without invoking the tongue-body features.

There are three distinct classes of problems with this approach.

First, by virtue of its lack of the feature [labial], it fails to account for the evidence from multiply articulated segments that led to the introduction of the feature [labial] in the first place (Anderson (1971)). As Sagey (1986) shows in a comprehensive survey, multiply articulated segments are exactly that—consonants with more than one simultaneous articulator, rather than consonants with a primary place of articulation and some secondary characterization to be obtained with other features.

Second, this account places crucial reliance on the feature [anterior] in its full cross-classificatory sense (rather than its restricted use as a dependent of [coronal] in Sagey (1986)). This feature is dubious, since it cannot be given a unified characterization in either articulatory or acoustic terms. Furthermore, [anterior] appears to function only in its definitional role of characterizing place distinctions; it does not, by itself, char-

acterize a natural class in any phonological process, as Kenstowicz and Kisseberth (1979) have noted. It is appropriate, then, to consider it an ad hoc feature.

Third, evidence from morpheme structure constraints on the cooccurrence of consonants in Semitic (McCarthy (1985)), Javanese (Mester (1986)), and a variety of other languages investigated by Yip (1987a,b) provides strong support for articulator-based feature geometries like those of (8) and (10) over the array of [coronal] and [anterior] values. Yip's survey reveals that such constraints are characteristically prohibitions on the repetition of an articulator within the root, from which she concludes that the articulator-based characterization is superior. This evidence also points to the correctness of the overall program of dividing the Place node into distinct articulators, providing another kind of evidence for treating [round] as a dependent of [labial].

We must conclude, then, that feature geometry cannot supplant planar segregation of vowels and consonants as an account of the Southern Sierra Miwok metathesis phenomenon. Success in treating Miwok is bought only at the price of giving up many of the most attractive results that feature geometry has obtained. Therefore, the analysis of Miwok is inconsistent with the SMPH.

An additional example reveals a further problem with approaches like (12) and (13), or for that matter all specimens of feature geometry we have examined. Common to feature geometry approaches is the idea that the V/C transparency phenomenon is asymmetrical for structural reasons: consonants are often transparent to processes involving vowels, but not conversely. For example, [back] harmony in vowels is common, but place harmony in consonants is not. Backing assimilation of vowels across consonants can be straightforwardly understood without violations of the line-crossing prohibition. But spreading the Place node of a consonant across a vowel is not possible in a uniplanar representation; it is impeded by the Place node of the vowel itself.

Nevertheless, there are cases that appear to involve exactly that or even worse. Many of the Mayan languages are subject to a version of the following constraint, first observed to my knowledge for Tsotsil by Weathers (1947, 111) and subsequently for Chontal by Keller (1959, 49), for Yucatec by Straight (1976, 49), and for Tzutujil by Dayley (1985, 31).[6]

(15)   In C_1VC_2 roots, if C_1 and C_2 are both glottalized, then they must be identical in all respects.

CVC is the normal form of native roots in these languages. These languages have triangular five-vowel systems (*i e a o u*), and any vowel can occur distinctively in the medial position of the CVC root. All the languages for which this constraint has been reported have at least *p', t', c', č',* and *k'* as glottalized consonants; Tzutujil adds to these *q'*. "Identical in all respects" in the context of these systems of glottalized con-

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[6] Here and subsequently I disregard the voiced ejectives that are reported for these languages; they do not appear to participate in this constraint and have unusual phonological properties that suggest they are derived.

sonants means that C_1 and C_2 must agree in all place distinctions (in particular to distinguish alveolar c' from palatoalveolar $\check{c}'$ or k' from q') and in the value of [continuant] (to distinguish the stop t' from the homorganic affricate c').

There is nothing unusual about this constraint on the well-formedness of roots; similar constraints appear in many other languages (McCarthy (1985), Mester (1986), Yip (1987a,b)), and in fact Yucatec Mayan roots are subject to two other conditions of like character (Straight (1976)). A straightforward characterization of this constraint in terms of feature geometry is available along the same general lines described above for Mokilese. To see this, we must first examine the geometry above the Place node.

Gestures of the larynx—voicing, aspiration, and glottalization—are expressed by features dominated by a single Laryngeal node. The Laryngeal node is distinct from the Place node, because laryngeal assimilation can occur independently of place assimilation, and conversely. For similar reasons, the feature [continuant] is independent of both the Place and Laryngeal nodes. The following model, based on proposals by Clements (1985) and Sagey (1986), expresses these observations. I have simplified it in ways that are irrelevant to the discussion:

(16)   . . . CVC . . .   Skeleton

                                              Root node

                                                   [cont]

       Laryngeal node   Place node

       [. . . laryngeal features . . .]   [. . . place features . . .]
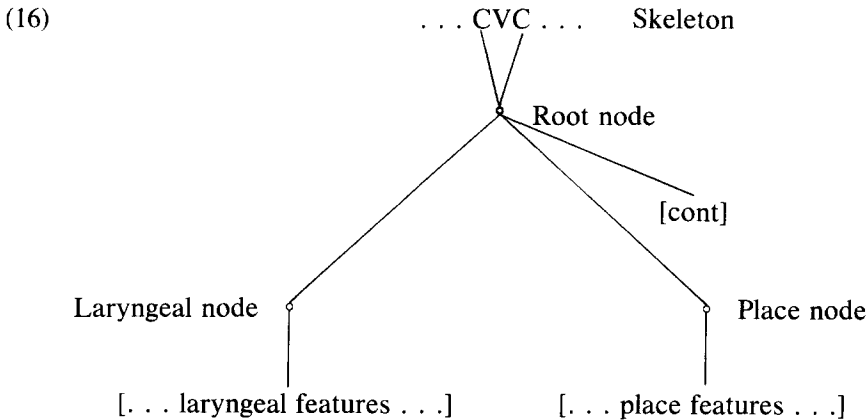
The Root node corresponds to the traditional notion "segment" or, more precisely, to its autosegmental counterpart "single melodic element." All features are dominated by the Root node, so two segments that share a single Root node are, in fact, identical in all respects.

The Mayan constraint, it will be recalled, says that if both consonants in the root are glottalized, they must be identical in all respects. The requirement "if both are glottalized" reduces to saying that they share a single Laryngeal node. This follows from the fact that glottalization is expressed by the feature [constricted glottis], dominated by the Laryngeal node, and the premise that plain consonants lack a Laryngeal node entirely (Clements (1985)).[7] The consequent "are identical in all respects" can only mean

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[7] The languages under discussion only contrast plain voiceless and glottalized consonants. The evidence that plain voiceless consonants lack a Laryngeal node is abundant: it comes from the widespread phenomenon of neutralizing voicing and glottalization distinctions in favor of this type (Clements (1985)).

that the two consonants share a single Root node: in light of the premise that identity (as in assimilation) is always a result of association line spreading, the shared Root node is the only way to express the observation that the two root consonants agree in both place of articulation and the manner feature [continuant].

In summary, the only permissible representation for a root like *p'Vp'* is the following ([cg] abbreviates the feature [constricted glottis]):

(17)   CVC   Skeleton

                                   Root node

                                              [−cont]

Laryngeal node   Place node

        [cg]   [lab]
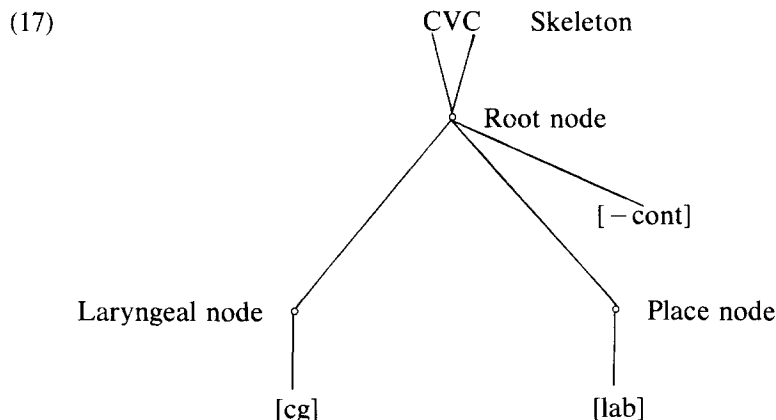
To ensure this result, we must exclude possible representations of an illicit root like *p'Vt'*. One possibility would have two Root nodes, each linked to separate Laryngeal nodes, each Laryngeal node dominating a separate feature [constricted glottis]. This is excluded by the OCP, as in the analysis above of Mokilese. The second possibility also has two Root nodes, sharing a single Laryngeal node. No contravention of the OCP occurs in this case, so we must exclude it by language-particular stipulation:

(18)   *   Root node

                 Laryngeal node
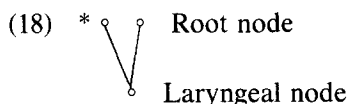
A language that happened to lack this constraint would, then, also lack the restriction on cooccurrence of glottalized consonants observed in these Mayan languages. This is correct; the Mayan constraint is certainly not universal.

One could imagine other ways to encode this restriction. Nevertheless, any theory in which assimilatory processes are regarded as spreading—a fortiori theories of feature geometry—must analyze the predicate "identical in all respects" by something equivalent to the shared Root node.

Let us now bring this analysis to bear on the SMPH. In Mayan the constraint on root structure holds of two consonants separated by a vowel in the CVC root canon. The intervening vowel is distinctive in a triangular five-vowel system, and, significantly, there is no evidence that vowels and consonants constitute separate morphemes. The intervening vowel is transparent to association lines stemming from the Root node of the consonant; from this it follows that the Root node of the vowel cannot be represented

on the same tier as the Root node of the consonant. But Root nodes on separate tiers are, by definition, separate planes. Therefore, planar V/C segregation is necessary even in the absence of morphological support for the separation.

This evidence does not come from a single isolated fact. The constraint itself is evidently an historically stable part of the grammars of several related languages. As I have noted, in the one case where a careful search for well-formedness conditions on root structure has been done (Yucatec by Straight (1976)), several others of the same general character emerge. Furthermore, the Mayan languages exhibit an array of V/C transparency effects in affixation that are entirely expected under planar V/C segregation (McCarthy and Prince (1986; forthcoming)): affixes with an unspecified V or C slot are filled by autosegmental spreading.

It follows, then, that the root well-formedness condition of Mayan, as well as related observations, is inconsistent with the SMPH. In these languages, despite the lack of morphological distinctions between vowels and consonants, even the Root nodes of vowels and consonants cannot appear on the same autosegmental tier. No possible elaboration of feature geometry can account for this; therefore, these Mayan languages require biplanar representation.

I conclude, then, that the SMPH is false. Although there are reconstructions of feature geometry that are consistent with a uniplanar analysis of Yawelmani, they cannot be generalized to Miwok without giving up fundamental results stemming from the association of [round] and [labial]. And, most strikingly, no possible feature geometry can account for the Mayan constraint without reneging on basic premises of the nonlinear phonological program. Yet in all these languages no morphological basis for the necessary planar segregation of vowels and consonants is available.

Before we leave this topic, it is useful to dismiss one apparent problem with planar V/C segregation. It might be suggested that phonological processes applying across the V/C barrier, like palatalization, are simply inconsistent with separate planes. In fact, this observation is neither probative nor true. It is not probative because it actually fails to distinguish a theory with planar segregation from a theory with an articulated feature geometry like (10). In both cases, through different formal mechanisms, vowel and consonant distinctions are divorced from one another. The observation is false because it makes the unwarranted assumption that the notion of adjacency in phonological processes is always defined on tiers or planes and never on the skeleton. I take this question up again in section 8.

I will now examine the WMPH and then turn to the explanation for why planar V/C segregation is possible, even without the support of a morphological distinction, in languages like Yawelmani, Sierra Miwok, and the Mayan group.

3. Against the WMPH

I begin by considering the original argument in support of the WMPH. In McCarthy (1979; 1981; 1986a) the complete intertransparency of vowels and consonants with re-

spect to one another in Semitic (see (5)) was identified with the morphological distinction between vowels and consonants: the vocalism indicates inflectional notions like 'perfective active', and the consonantism stands for fundamental lexical meanings like 'write'. This intertransparency phenomenon is not reanalyzable in feature-geometric terms for exactly the same reasons adduced in the discussion of the Mayan constraint: all distinctive properties of consonants (manner, place, and laryngeal features) spread through vowels as a single unit. Semitic vowels and consonants, then, like those of Mayan, are disjoint at the level of Root nodes and therefore must be on separate planes. The observation that vowels and consonants are in fact distinct morphemes, combined with the WMPH, ensures this result.

My goal in this section is not to show that the WMPH is false but rather to demonstrate that this hypothesis is a necessary consequence of other assumptions about how morphology and the lexicon work. In order to do this, it is first necessary to achieve a deeper understanding of what biplanar representations mean and how they differ from uniplanar ones.

Compare the following two representations of a string like *pat*:

(19) a. Biplanar   b. Uniplanar

       a   C V C
       | | | |
   C V C   p a t
   | |
   p   t
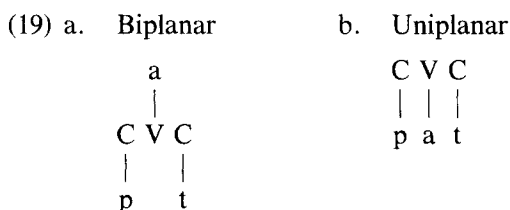
The crucial character of the distinction between the two types of representations, I suggest, is what they say about the linear order of the segments in *pat*. In the biplanar representation the only *inherent* linear order relation is $p < t$; the orders $p < a$ and $p < t$ are *derived* by interpretation of the association lines linking melodic elements with the CVC skeleton. In the uniplanar representation the inherent linear orders are $p < a$ and $a < t$, $p < t$ being deducible from the transitivity relation. In other words, elements on separate planes do not have inherent linear order relations to one another.[8]

Let us now turn to morphology. If we consider the English morphemes *in* and *credible* in isolation, it obviously makes no sense to ask what the linear order relation is between *n* and *c*. Because these segments are part of separate morphemes inspected before word formation, they can have no inherent linear order relation. This essentially follows from the classical definition of a morpheme—a unit pairing sound and meaning—because additional linear order relations would be additional impositions on the "sound" half of the definition. After we form the word *incredible*, the question of linear order at least makes sense. If morpheme concatenation is an operation on skeleta (so that the actual melodies *in* and *credible* themselves are not concatenated), then *n* and *c* have an

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[8] Sagey (1986; 1988) provides a cogent discussion of the relation between linear order and the properties of autosegmental association lines.

ordering relation derived by morpheme concatenation and interpretation of the association lines. If morpheme concatenation is an operation on melodies, then n and c have a direct linear order relation derived by morpheme concatenation alone.

Our concern here, however, is not with the results of morpheme concatenation or the appropriateness of multiplanar representations in concatenative morphological systems; evidence bearing on this issue is not abundant. Let us therefore turn to a morphological system where morphemes are not concatenated, Semitic. Consider the three morphemes that make up the word *kattab*: the root *ktb*, the vocalism *a*, and the template CVCCVC (or its equivalent in other skeletal theories). Again, there are no linear order relations of any kind between the segments of the morpheme *ktb* and the morpheme *a*, prior to word formation. Even after word formation, because the fundamental operation that builds words is autosegmental association rather than morpheme concatenation, linear order relations in *kattab* are still derived rather than inherent: linear order can be determined only by inspection of the association lines in the structure that represents *kattab*.

We have, then, arrived at the following premises. First, separate planes express the absence of inherent order relations between the two planes. Second, bare morphemes, before word formation, have no linear order relations to one another. Third, at least in systems where word formation is not accomplished by morpheme concatenation, even after word formation separate morphemes have no inherent linear order relations to one another. This lack of inherent linear order relations is exactly what planar segregation expresses.

The upshot of this is that the WMPH is entirely superfluous as an independent principle of the theory. Its effects are obtained by these three premises. In a language like Arabic, planar V/C segregation is morphologically based, but not because of the WMPH. Rather, it follows from the fact that vowels and consonants lack linear order relations initially as separate morphemes—because all separate morphemes are unordered with respect to one another—and subsequently because morphemes are not concatenated. The lack of inherent linear order relations across the V/C boundary is exactly what planar segregation expresses.

In light of these considerations, we see that morphemic distinctness and nonconcatenative morphology will always ensure planar segregation without the interposition of the WMPH. Our options remain open for concatenative morphology, even without the WMPH. If we can show that concatenative morphemes end up on separate planes, then morpheme concatenation is an operation on skeleta. If concatenative morphemes are uniplanar, then morpheme concatenation is an operation on melodies. The evidence from reduplication is on the side of the operation on skeleta (Marantz (1982)). Furthermore, the claim that the original and copied melodies in reduplication are on separate planes (Broselow and McCarthy (1984), McCarthy and Prince (1986; forthcoming)) is consistent with this: linear order relations between the original and copied melodies are also derived by skeletal association, rather than being inherent. In fact, reduplicative affixation must be a concatenation operation on skeleta rather than melodies, since

reduplicative affixes are unendowed (or underendowed) with melodic content. This case of planar segregation, which demanded a tortuous interpretation of the WMPH, follows naturally from the formulation here.

Let us sum up the argument to this point. We have seen that the SMPH is falsified by counterexample. The WMPH—formerly crucial to the understanding of the Semitic cases—has not been falsified, but it has been shown to have no status as a principle of linguistic theory. The effects of the WMPH follow from the observation that planar segregation means nothing more than the lack of inherent linear order relations and from elementary considerations of linear order among separate morphemes in nonconcatenative morphological systems.

4. Linear Order Relations and Planar V/C Segregation

The advantage of the SMPH is that it restricts planar V/C segregation to a narrow class of cases—overly narrow, as it turns out. Since this type of representation is obviously not freely available to all languages, we must naturally ask what stands in the place of the defunct SMPH.

Comparing the Semitic case with Yawelmani or Sierra Miwok, we see that, although they lack the commonality of separate morphological function for vowels and consonants, they share the property of having systems of templatic morphology. This is undoubtedly important, as Prince (1987) points out: templatic morphology allows us to accomplish V/C segregation in a coherent way, since the template itself defines the organization of vowels and consonants. In other words, the associations to the template supply the linear order relations among vowels and consonants in Yawelmani and Miwok.

Although we cannot say that Yawelmani or Miwok vowels and consonants lack lexical linear order relations because they are separate morphemes, we can say that they lack linear order relations because such relations would be entirely redundant. Prince's (1987, 499) observation is particularly cogent: all information about the relative order of the vowel *a* and the consonants *ʔmc'* in the Yawelmani stem forms *ʔamc'/ʔmaac'* is derived by association to the skeleton. We can take this further, forcing the issue: incorporating linear order into the Yawelmani lexical entry would violate the requirement that the lexicon is the repository only of unpredictable (or nonredundant) information (Kiparsky (1982), Archangeli (1984), Steriade (1987b)). To conform to this requirement, the lexical entry must contain the two unordered strings, /a/ and /ʔmc'/, whose linear order relations are derived only by the nonconcatenative morphological process of association to a template.[9]

The idea that planes express the lack of inherent linear order relations implies that templatic morphological systems like those of Arabic, Miwok, and Yawelmani will always exhibit planar V/C segregation. Because such templatic systems render the linear

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[9] In fact, one indication of the redundancy of linear order information between vowels and consonants in Yawelmani and Miwok is the difficulty of choosing an order for the lexical entry: *ʔamc'* and *ʔmac'* never contrast, so both are possible.

order relations redundant, those relations are removed from the lexical entries. In the absence of inherent linear order relations, planar segregation is the only option consistent with removing noncontrasting specifications from the lexicon.

These considerations have the added benefit of explaining an observation that has not heretofore been accounted for: systematic templatic morphology always implies planar V/C segregation. Planar V/C segregation, together with templatic morphology, would be impossible in a language like English that contrasts *bilt* and *blit*, with plainly different V/C ordering within the syllable.

An interesting implication of these results comes from a comparison of Semitic with Yawelmani or Miwok. In Semitic there are separate lexical entries for the morphemes /a/ and /ktb/. In Yawelmani a single lexical entry contains the separate strings /a/ and /ʔmc'/. Both systems are templatic. Since, in our conception, templatic morphology is logically prior to V/C segregation, it follows that the Semitic system should have emerged historically from one more like Yawelmani: templatic morphology induced V/C segregation, which predisposed the Semitic languages to taking the further step of assigning separate morphological function to a string like /ktb/. Traces of this earlier system— where /a/ and /ktb/ were two separate strings of a single morpheme in a single lexical entry—remain in the characteristic vowels of the first derivational class of the verb. These vowels contrast within a range of possibilities delimited partly by semantic considerations: *ḍarab/ḍrib* 'beat/will beat'; *katab/ktub* 'wrote/will write'; *ʕalim/ʕlam* 'knew/ will know'; *ħasun/ħsun* 'was beautiful/will be beautiful'.

We have seen that a templatic morphological system alone is sufficient to require planar V/C segregation. What, then, do we say about the Mayan languages? Although they do not have templatic morphological systems, they have something just as good instead: a very rigid canonical shape for roots. Essentially all native Mayan roots are formed on a template CVC,[10] and in such a template the linear order of vowels and consonants is just as redundant as it is in Yawelmani or Miwok. It follows, then, that Mayan roots will have planar V/C segregation for essentially the same reasons as the other languages considered: vowels and consonants lack inherent order.

Let us look at this in a different way. The CVC root canon means that underlying roots /tka/, /tak/, and /atk/ cannot contrast. This absence of contrast means that the only lexical representation consistent with eliminating redundancy from the lexicon is the bifurcated /a/, /tk/, without inherent ordering. From this we obtain the planar V/C segregation required by the analysis of the Mayan root structure constraint.

We have seen, then, that planar V/C segregation emerges from the redundancy of linear order relations between vowels and consonants in languages with templatic morphology or sufficiently rigid constraints on canonical form. Although we have focused on a few languages, others could be cited in support of this conclusion. For example,

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[10] I ignore here an irrelevant complication: the CVC template can incorporate vowel length and laryngeal prosody, still within the limits of monosyllabism.

Goodman (in press) argues for Takelma, as I have done for Yawelmani and Miwok, that the mutual intertransparency of vowels and consonants in this templatic morphological system can be expressed only by planar segregation and not by feature geometry. And Moira Yip has pointed out to me that a number of aspects of Chinese phonology, in particular the special character of the language games in Yip (1982), make greater sense if we presuppose planar segregation as a consequence of CVC root structure.

Let us now sum up the claims. In the theory I have presented planar segregation is taken to represent the lack of inherent linear order relations between elements on the two planes. There are three bases on which vowels and consonants must dispense with linear order: (i) the WMPH cases like Semitic, where the definition of morpheme ensures the absence of linear order; (ii) templatic morphology, where linear order of vowels and consonants is redundant; and (iii) sufficiently restrictive root structure constraints, which also make linear order redundant. The three classes are even more closely related to one another than this typology suggests. Root structure constraints can be thought of as a particular instance of templatic morphology in which there is only one template. And since Semitic morphemic segregation presupposes prior templatic morphology, all three cases are subsumed under the logic of underspecification: linear order between vowels and consonants is redundant under these conditions. With the interpretation of biplanarity as lack of inherent linear order, planar segregation of vowels and consonants is forced when the criteria are met.

The claims can be made somewhat tighter by pinning down two issues. First, why are vowels and consonants especially privileged to suffer planar segregation? The answer to this is provided by Prince (1987): the V/C distinction is the one that the skeleton necessarily refers to. So far as I know, all theories of the skeleton make a primary distinction between C-like and V-like elements; skeletal associations must always take cognizance of that distinction. This point follows even more essentially from the proposal made here, since all planar segregation is referred to linear order relations that ultimately depend on the source or form of the skeleton.

Second, how can we exclude illusory planar segregation in a language like English that would be accomplished by full lexical specification of the skeleton? For example, we could lexically represent *blit* as {*i, blt*, [CCVC]} and *bilt* as the same, but with the skeleton [CVCC]. At the very least, this case, although it may not be excluded in principle, represents a marked situation in which every lexical entry is accompanied by an essentially gratuitous specification of its skeletal shape. Furthermore, this example relies on positing a skeleton composed of segment-sized units; a comparable move is impossible in moraic terms (Hyman (1984), McCarthy and Prince (1986; forthcoming)). Finally, if lexical skeletal specifications are limited to information about quantity and syllabicity (McCarthy and Prince (1988), Hayes (forthcoming)), again the illusory planar segregation is impossible.

This completes the major argument. We now turn to the consideration of some residual matters.

5. Linear Order and Planar Segregation in CV Languages

The provable cases of planar V/C segregation are those languages (or families) like Semitic, Miwok, or Mayan in which rigid constraints on templatic form render linear order redundant. In a much more tentative and speculative vein, however, I will pursue the idea of redundancy to derive some results about languages that have only CV syllables and no others.

For a C_1V_1 sequence in a language with CV syllables only, the linear order of the two component segments is totally redundant information—we can predict the relative order of C_1 and V_1 purely from knowledge of the syllable structure of the language.

Now consider the longer sequence $C_1V_1C_2V_2$. Linear order relations within the pairs C_1V_1 and C_2V_2 are again predictable from the syllable structure. But linear order relations are not entirely predictable; four distinct surface arrangements are possible: $C_1V_1C_2V_2$, $C_1V_2C_2V_1$, $C_2V_1C_1V_2$, and $C_2V_2C_1V_1$. To distinguish among these, we specify $C_1 < C_2$ and $V_1 < V_2$. In other words, the nonredundant information we require in the lexical representation of $C_1V_1C_2V_2$ is that V_1 precedes V_2 and C_1 precedes C_2; the rest is predictable.

That V_1 precedes V_2 and C_1 precedes C_2 is exactly what a biplanar representation of vowels and consonants encodes. Biplanarity says that linear order relations between vowels and consonants are not directly represented in the linear order of elements within a single plane but are derivative of skeletal associations. In our hypothetical language, then, the lexical representation of $C_1V_1C_2V_2$ will contain the two strings $/V_1V_2/$ and $/C_1C_2/$, encoding only the unpredictable linear order relations and deriving the rest from syllabification.[11]

If the language were to have richer syllabic structure, CV(C), then $C_1V_1C_2V_2C_3$ and $C_1V_1C_2C_3V_2$ could contrast. This is self-evidently a contrast in the linear order of V_2 and C_3 and thus precludes planar V/C segregation.

In summary, exclusive CV syllables, unaided by other templatic or canonical form restrictions, render V/C linear order relations redundant, with consequent planar V/C segregation.

I know of no language that permits only CV syllables and no others, but the near-miss (C)V is presented by some Oceanic languages like Rotuman and Kwara'ae in underlying representation. An unusual phenomenon that, as Laycock (1982) and Sohn (1980) note, is virtually unique to these languages is unrestricted CV → VC metathesis. In Rotuman this process has been morphologized, whereas in Kwara'ae it is an active, stress-conditioned phonological rule that until recently was limited to fast speech:

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[11] A special case arises where $V_1 = V_2$, $C_1 = C_2$, and the OCP applies to both. Under those conditions we could not distinguish, say, *pa* from *papa*; both would be represented by the lexical entry composed of the two strings /a/ and /p/. And if the language were to have V syllables as well as CV, we could not distinguish *apo* from *pao*, both being represented lexically as /ao/ and /p/.

(20) a. Rotuman

    Complete Phase   Incomplete Phase

    pure   pu͡er   'to decide'
    tiko   ti͡ok   'flesh'
    hosa   ho͡as   'flower'

  b. Kwara'ae

    Underlying   Derived

    selo   seol   'sail'
    kado   kaod   'thin'
    maʔu   mauʔ   'fear'

In another language cited by Laycock, Ririo, historical reanalysis in favor of the metathesized forms has occurred. In many cases reduction or coalescence applies to the output of metathesis, with some differences across languages. In no case from these languages do any consonants act as opaque to the metathesis of any vowels, regardless of their featural similarities.

In Ultan's (1971) extensive typological survey, this sort of metathesis is quite isolated—V/C metathesis without regard to the identity of the vowels and consonants is otherwise unknown, except in templatic systems like Semitic, Yawelmani, and Miwok.[12] Yet these languages are not templatic; in fact, the Kwara'ae metathesis rule is arguably nothing more than a special case of compensatory lengthening (McCarthy (forthcoming)), in which an underlying form like /selo/ receives penult stress and then substitutes for the resulting disyllabic foot a single bimoraic syllable. Evidence from Rotuman indicates that a similar reduction process has been historically morphologized in that language.

How then are we to account for the fact that just this family of languages has developed such an unusual rule of metathesis as an expression of an equally unusual way to accomplish reduction of unstressed syllables? A theory of feature geometry like (10) is capable of expressing the metathesis effect by reassociation, if vowels are unspecified for rounding.[13] But by attributing the metathesis effect to the universal feature geometry, (10) predicts that all languages with comparable vocalic and consonantal systems could have the same metathesis phenomenon as these (C)V languages. This is false—this sort of unrestricted V/C metathesis is unique to these languages, yet these languages have normative underlying segmental systems with five vowels in a triangular arrangement and labial, coronal, and velar stops.

If we attribute the metathesis effect to planar V/C segregation (essentially along the lines suggested by Saito (1981) and McCarthy (1986a)), we make a far tighter prediction.

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[12] Restricted types of V/C metathesis do occur, typically involving vowels and adjacent sonorant consonants or apparent metathesis through palatalization or labialization (Sagey (1986)). See Ultan (1971) and McCarthy (forthcoming) for discussion.

[13] This requirement is necessary in the feature-geometric analysis because round vowels and labial consonants freely permute: Rotuman /lipo/, *liop* 'sand eel'; Kwara'ae /baboula/, *baobwəl* 'thick'.

In Rotuman and Kwara'ae there is no evidence for morphological distinctions between vowels and consonants or templatic morphology, and little evidence for rigid constraints on canonical form. But there is the highly restricted (C)V syllable structure that could conceivably render the linear order of vowels and consonants redundant. Because vowels and consonants are unordered, they are free to give the appearance of reordering without an overt metathesis rule.

The argument for planar V/C segregation in Rotuman or Kwara'ae is not an argument from necessity; a theory like (10) can accomplish metathesis by association with just the apparatus of feature geometry. Rather, the logic of the argument is that the feature-geometric approach incorrectly licenses free V/C metathesis in just about any language rather than just these few.

The argument from Rotuman and Kwara'ae is not ironclad. First, these languages were at least originally subject to a CVCV root structure constraint, so they may fall under the same rubric as Mayan. Second, they have (C)V rather than CV syllables, so the parallel with the hypothetical case is inexact. Third, as I observed in footnote 11, effects of the OCP present problems under certain conditions. Nevertheless, the evidence is at least suggestive that rigid CV syllables might have the same consequences for biplanarity that templates do.

6. Fake Effects on Linear Order

Up to this point we have looked at linear order contrasts in a rather unsubtle way; we have simply asked whether in general linear order contrasts are possible and derived planar segregation from the answer to this. So far the answer has been apparent. If we now examine certain special cases, we see that it is not always so.

The problem arises from what we might call the "placeholder" function of linear order. Suppose we analyze the Arabic consonant ʔ as completely unspecified in lexical representation, supplied by a default rule. This analysis has merit; ʔ is the consonant that fills empty onsets in the phonology. How then will we represent lexically the word ʔabbad 'caused to serve'? By our assumption, the root is represented as /bd/, since the consonant is completely unspecified. But this means that we will require a special mode of association to the CVCCVC skeleton, to avoid deriving *baddad, which we expect by the general rules (compare sammam from /sm/). We might then adopt lexical linear order of vowels and consonants in this case, claiming that this word is underlyingly /abad/. Linear order holds the place for the consonant ʔ that has not yet been specified.

This is an absurd analysis; Arabic roots containing glottal stops participate in the same morphology as roots without them. The placeholder effect must be achieved without recourse to this fake use of linear order. One possibility, which follows from Steriade's (1987b) persuasive proposals about underspecification, is to say that such complete underspecification is not a possibility. Steriade argues that underspecification is required of completely redundant feature values (like the value of [high] in [+low] vowels, or the value of [back] and [round] in the [+low] vowel of a triangular vowel system), but

it is forbidden for feature values that are in contrast. Since any segment contrasts with at least one other, none can ever be completely unspecified. Another move, along the lines suggested by Borowsky (1985), is to regard Arabic ʔ as "[ ]," pure segmentism without feature values. In terms of feature geometry, this would be a bare Root node without any of its daughters. In fact, in the version of feature geometry proposed by Sagey (1986), the Root node is not bare; it is composed of the features [consonant] and [sonorant]. This looks like the right approach: just these major class features never assimilate without taking the entire segment along with them (Schein and Steriade (1986)). At this point the two hypotheses become very similar to one another: both grant to ʔ a considerable portion of phonological substance, even in underlying representation.

A case like Miwok is not different in kind from Arabic. In Miwok ʔ and ɨ are the default consonant and vowel, respectively, as Smith (1985) shows. Each intrudes by occupying the rightmost position when the consonants or vowels of the base are insufficient to fill the available slots of the template (autosegmental spreading is not usually permitted in Miwok). Yet, just as in Arabic, these default segments are also real segments as well, occupying places in the root and filling the template in positions other than the rightmost one. Just as in Arabic, we do not suppose that linear order of vowels and consonants is stipulated in these cases; instead, we conclude again that complete underspecification is not an available option. In fact, the pattern predicted by complete underspecification is unknown to me: a templatic language in which the default consonant never appears in roots, emerging only when the template is not otherwise satisfied.

The Mayan languages present a similar problem. ʔ is an ordinary consonant with free distribution inside words. Yet a hypothetical root like ʔap is generally taken to be /ap/ underlyingly, because the initial ʔ is not in contrast with Ø and may be absent under some conditions. This presents the same placeholder problem: in our terms, underlying /a/, /p/ could represent the contrasting surface forms *pap* and *(ʔ)ap*. (The remaining logical possibility, *pa*, is excluded independently; the final C of the CVC root canon is obligatory.) From this we might conclude that linear order relations are encoded in Mayan lexical entries, with /pap/ and /ap/ differing. The lesson we draw from Arabic is appropriate here; total underspecification is not an option. We therefore need not appeal to placeholding by linear order to circumvent this problem. The underlying representations are /a/, /p/ for *pap* and /a/, /ʔp/ for *(ʔ)ap*, perhaps with ʔ specified as only a Root node.

A converse fake effect on linear order arises in cases of the empty C phenomenon first described by Clements and Keyser (1983) and subsequently by many others. This phenomenon is suggested by the observation that, in some languages, some vowel-initial (or vowel-final) morphemes behave phonologically as if they were consonant-initial, whereas others behave as expected. The analysis posits a purely skeletal contrast between the two types of morphemes:

(21) a.   Normal Cases   b.   Empty C Cases

       V C   C V C
       | | | |
       a p   a p

The problem arises when we think about how this distinction is encoded lexically. So far as I know, this important question is not addressed in the literature, but it seems clear that the lexical entries of these two morphemes must contain the full skeleton. But if every lexical entry contains a full skeleton, we are in exactly the same position as with languages like Miwok or Mayan, where the skeleton is supplied by the morphology or a root-structure constraint. We are then left with the strange result that the empty C phenomenon implies planar V/C segregation.

As I noted at the conclusion of section 4, McCarthy and Prince (1988) and Hayes (forthcoming), developing the skeletal theory of Hyman (1984) and McCarthy and Prince (1986), restrict lexical specification of skeleta to those properties that are distinctive—quantity and sometimes syllabicity—encoded by moras. This highly restricted conception of lexical skeletal specification is insufficient in itself to render V/C linear order relations redundant. (For example, it cannot distinguish *blit* from *bilt*.) But the empty C phenomenon, to express the contrast between C and ∅, seems to require complete specification of skeleta lexically. Then, *blit* must be represented as {/i/, /blt/, /CCVC/} and *bilt* as {/i/, /blt/, /CVCC/}.[14]

McCarthy and Prince (1986) and Hayes (forthcoming) observe that the empty C phenomenon seems to be equally well accounted for along approximately the same lines as the other fake linear order effect described earlier. A provable empty C requires evidentiary conditions that are rarely if ever met: it must be impossible to ascertain any properties of the invisible segment by familiar phonological argumentation. At a minimum, we can in general establish values for some of the major class features ([consonantal] in particular), and so we can supply this empty segment with melodic content in the form of a Root node. This case would then differ from the earlier one in that the incomplete segment is never filled out (or perhaps is never syllabified), in which case it remains unexpressed phonetically. Since the independently required theory of feature geometry offers this as an option, there is no reason to suppose that invisible segments are in fact empty Cs. The problems attendant on lexical specification of skeleta in these cases therefore disappear.
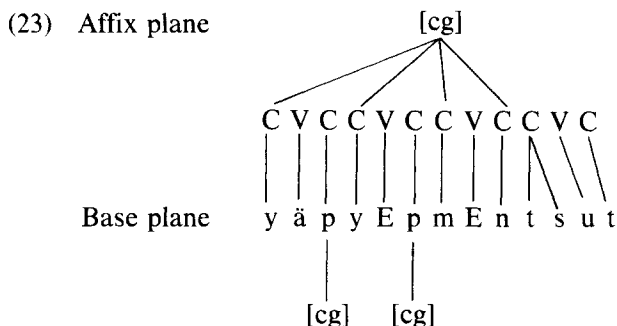
7. Planar Segregation of Features

Cole (1987) presents evidence that morphologically governed harmony processes do not exhibit the blocking effects that we find in purely phonological harmony, and from this she concludes that the harmonizing feature, as a morpheme in its own right, occupies a separate autosegmental plane. This proposal is not uncontroversial, but nevertheless it is worth examining in the light of the results obtained here. In Coeur d'Alene (Cole (1987, 77ff.)), for example, diminutive consonant symbolism involves glottalizing all

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[14] It may be possible to construct a coherent theory in which only morphemes like /Cap/ are endowed with lexical skeleta. Again, the literature is silent on this point. This would seem to predict an unobserved cross-linguistic preference for restricting quantitative contrasts, which require lexical specification of the skeleton, to morphemes with empty Cs, which also require lexical specification.

sonorant consonants within a word:

(22) yäp'-yEp'-mEn-tsut → y'äp'-y'Ep'-m'En'-tsut 'he rocked'

What distinguishes a case like this from phonological harmony is that the *p*'s, which are already specified for glottalization, are transparent to the assimilatory spread of the morphologically triggered glottalization.[15] Cole explains this by biplanarity: diminutive glottalization, represented by the feature [constricted glottis], is a different morpheme from the lexical glottalization inherent to *p*':

(23) Affix plane   [cg]

```
                          ___-----/ | \___
                   C V C C V C C V C C V C
                   | | | | | | | | | /|\\
Base plane         y ä p y E p m E n t s u t
                       |       |
                       |       |
                     [cg]    [cg]
```

Purely phonological assimilation by spreading of [constricted glottis] from either direction would encounter a *p*' lexically specified as [constricted glottis], and so further spreading would be blocked by the line-crossing prohibition.

This case is covered by the same rubric as Arabic, even though the morphology is not templatic. The affixal [constricted glottis], considered before word formation, is not linearly ordered with respect to the base. Because affixal [constricted glottis] is not concatenated with the base, there is no possibility of linear order by virtue of morpheme concatenation either. Therefore, affixal [constricted glottis] is on a separate plane from the base—they lack inherent linear order relations to one another.

8. Transplanar Adjacency

Adjacency effects (assimilation or the OCP) between elements on different planes have sometimes been referred to a principle of Plane Conflation. Younes (1983) and McCarthy (1986a,b) argue that the separate morphological planes of Semitic are conflated into a single plane at some point in the derivation. Plane Conflation therefore creates inherent linear order relations out of the linear order relations that formerly could only be deduced from inspecting the associations of the two planes with the skeleton. It also splits so-called long-distance geminates (McCarthy (1986b)). The effect of Plane Conflation is that phonological derivations in languages with planar segregation are bifurcated into two very different notions of adjacency, with a sharp demarcation between the two.

In McCarthy (1986a) Plane Conflation was identified with Bracket Erasure, the

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[15] Cole (1987, 50ff.) presents arguments that consonant symbolism phenomena are in fact to be analyzed as harmony processes rather than context-free rules of the form [+ sonorant] → [+ constricted glottis].

principle that information about prior morphological structure persists for only a limited time in the derivation. Although the results presented here are not incompatible with this, the fact that planar segregation is no longer attributed directly to morphological identity suggests that the identification of Plane Conflation and Bracket Erasure should be reexamined. Cole (1987) has done this, and suggests that the association is at best a loose one.

Although this question cannot be fully resolved here, it is appropriate to point out that the notion of Plane Conflation is predicated on the idea that adjacency relations for phonological processes like assimilation or constraints like the OCP are always defined on melodic tiers or planes. This assumption has been called into question in recent work by Archangeli and Pulleyblank (1986; 1987) and Myers (1987). These authors argue that adjacency of melodic elements depends in some cases on the adjacency of the associated skeletal elements, either always or on a parametrized basis. For example, in a biplanar representation like (19a), the p and a are adjacent (for example, for the purposes of an assimilation rule) by virtue of the adjacency of their associated skeletal elements, without the mediation of Plane Conflation.

The particular significance of this work lies in the fact that this new characterization of adjacency has consequences in areas that Plane Conflation cannot address at all. For example, Myers (1987) shows that Meeussen's Rule in Shona—deletion of the first of two high tones only when they are linked to adjacent syllables—requires just this notion of adjacency. Because adjacency is relativized to skeletal associations, two high tones, even though represented on the same plane, are adjacent in this technical sense only if they are linked to string-adjacent syllables. In that case alone, the first high tone is deleted. Similar results are presented by Archangeli and Pulleyblank (1987).

These results eliminate one source of evidence for Plane Conflation: the fact that elements on different planes can be treated as though adjacent by phonological rules. Two other sources of evidence remain. First, as Younes (1983) shows, geminate integrity—the resistance of geminates to epenthesis—holds postlexically in Palestinian Arabic just as it does in languages without planar V/C segregation. Since geminate integrity depends on the line-crossing prohibition, the explanation of this phenomenon requires that the epenthetic vowel be represented on the same plane as the consonants. The theory presented here suggests a different interpretation of this result—since the epenthetic vowel is inserted by rule between two consonants, it must be linearly ordered relative to them and therefore must occupy the same plane. The other remaining case for Plane Conflation comes from the different effects of geminate inalterability lexically and postlexically on long-distance geminates in Chaha (McCarthy (1986b)). I have nothing to add to this here.

9. Conclusion

In this article I have argued that morphological distinctions play no direct role in planar segregation, and in concert with this I have shown that planar segregation occupies a

somewhat more prominent role in phonology than is sometimes conceived. In the place of the WMPH and SMPH, I present the observation that the elements on separate planes have no inherent linear order relations to one another, and I show that, in those cases where planar segregation is required, the elements on separate planes are unordered at the lexical level. Lack of inherent order is shown to be a consequence of the logic of underspecification carried through to words formed on templates.

References

Anderson, S. R. (1971) "On the Description of 'Apicalized' Consonants," *Linguistic Inquiry* 2, 103–107.

Archangeli, D. (1983) "The Root CV-Template as a Property of the Affix: Evidence from Yawelmani," *Natural Language and Linguistic Theory* 1, 348–384.

Archangeli, D. (1984) *Underspecification in Yawelmani Phonology and Morphology*, Doctoral dissertation, MIT, Cambridge, Massachusetts.

Archangeli, D. (1985) "Yokuts Harmony: Evidence for Coplanar Representation in Nonlinear Phonology," *Linguistic Inquiry* 16, 335–372.

Archangeli, D. (1987) "Keley-i Consonant Assimilation," in P. Saka, ed., *Coyote Working Papers in Linguistics* 6, University of Arizona, Tucson.

Archangeli, D. and D. Pulleyblank (1986) *The Content and Structure of Phonological Representations*, ms., University of Arizona and University of Southern California.

Archangeli, D. and D. Pulleyblank (1987) "Maximal and Minimal Rules: Effects of Tier Scansion," in J. McDonough and B. Plunkett, eds., *Proceedings of the 17th Annual Meeting of NELS*, GLSA, Department of Linguistics, University of Massachusetts, Amherst.

Aronoff, M. (1976) *Word Formation in Generative Grammar*, MIT Press, Cambridge, Massachusetts.

Bliese, L. (1981) *A Generative Grammar of Afar*, Summer Institute of Linguistics, Arlington, Texas.

Borowsky, T. (1985) "Empty and Unspecified Segments," in J. Goldberg, S. MacKaye, and M. Wescoat, eds., *Proceedings of the West Coast Conference on Formal Linguistics* 4, Stanford Linguistics Association, Stanford, California.

Broselow, E. and J. McCarthy (1984) "A Theory of Internal Reduplication," *The Linguistic Review* 3, 25–88.

Campbell, L. (1974) "Phonological Features: Problems and Proposals," *Language* 50, 52–65.

Chomsky, N. and M. Halle (1968) *The Sound Pattern of English*, Harper and Row, New York.

Clements, G. N. (1985) "The Geometry of Phonological Features," *Phonology Yearbook* 2, 225–252.

Clements, G. N. and S. J. Keyser (1983) *CV Phonology*, MIT Press, Cambridge, Massachusetts.

Cole, J. (1987) *Planar Phonology and Morphology*, Doctoral dissertation, MIT, Cambridge, Massachusetts.

Dayley, J. (1985) *Tzutujil Grammar*, University of California Press, Berkeley.

Goldsmith, J. (1976) *Autosegmental Phonology*, Doctoral dissertation, MIT, Cambridge, Massachusetts.

Goodman, B. (in press) "Takelma Verbal Morphology," to appear in *Proceedings of the 18th Annual Meeting of NELS*, GLSA, Department of Linguistics, University of Massachusetts, Amherst.

Hayes, B. (1980) *A Metrical Theory of Stress Rules*, Doctoral dissertation, MIT, Cambridge, Massachusetts.

Hayes, B. (forthcoming) "Compensatory Lengthening in Moraic Phonology," *Linguistic Inquiry*.

Hyman, L. (1975) *Phonology: Theory and Analysis*, Holt, New York.

Hyman, L. (1984) *A Theory of Phonological Weight*, Foris, Dordrecht.

Keller, K. (1959) "The Phonemes of Chontal (Mayan)," *International Journal of American Linguistics* 25, 44–53.

Kenstowicz, M. and C. Kisseberth (1979) *Generative Phonology*, Academic Press, New York.

Kiparsky, P. (1982) "Lexical Phonology and Morphology," in Linguistic Society of Korea, ed., *Linguistics in the Morning Calm*, Hanshin, Seoul.

Laycock, D. (1982) "Metathesis in Austronesian: Ririo and Other Cases," preprint from Konferensi Internasional Linguistik Austronesia Ketiga, Denpasar, Bali, 19–24 January 1981.

Leben, W. (1973) *Suprasegmental Phonology*, Doctoral dissertation, MIT, Cambridge, Massachusetts.

McCarthy, J. (1979) *Formal Problems in Semitic Phonology and Morphology*, Doctoral dissertation, MIT, Cambridge, Massachusetts.

McCarthy, J. (1981) "A Prosodic Theory of Nonconcatenative Morphology," *Linguistic Inquiry* 12, 373–418.

McCarthy, J. (1982) "Prosodic Templates, Morphemic Templates, and Morphemic Tiers," in H. van der Hulst and N. Smith, eds., *The Structure of Phonological Representations*, Foris, Dordrecht.

McCarthy, J. (1985) "Features and Tiers: The Structure of Semitic Roots," talk presented at MIT, Cambridge, Massachusetts.

McCarthy, J. (1986a) "OCP Effects: Gemination and Antigemination," *Linguistic Inquiry* 17, 207–263.

McCarthy, J. (1986b) "Lexical Phonology and Nonconcatenative Morphology in the History of Chaha," *Revue québécoise de linguistique* 16, 209–228.

McCarthy, J. (forthcoming) "Metathesis and Coalescence in Rotuman and Kwara'ae."

McCarthy, J. and A. Prince (1986) "Prosodic Morphology," ms., University of Massachusetts, Amherst, and Brandeis University.

McCarthy, J. and A. Prince (1988) "Quantitative Transfer in Reduplicative and Templatic Morphology," in Linguistic Society of Korea, ed., *Linguistics in the Morning Calm 2*, Hanshin, Seoul.

McCarthy, J. and A. Prince (forthcoming) *Prosodic Morphology*, MIT Press, Cambridge, Massachusetts.

Marantz, A. (1982) "Re Reduplication," *Linguistic Inquiry* 13, 435–482.

Mester, A. (1986) *Studies in Tier Structure*, Doctoral dissertation, University of Massachusetts, Amherst.

Myers, S. (1987) *Tone and the Structure of Words in Shona*, Doctoral dissertation, University of Massachusetts, Amherst.

Nash, D. (1979) "Warlpiri Vowel Assimilations," in K. Safir, ed., *MIT Working Papers in Linguistics* 1, Department of Linguistics and Philosophy, MIT, Cambridge, Massachusetts.

Prince, A. (1987) "Planes and Copying," *Linguistic Inquiry* 18, 491–510.

Sagey, E. (1986) *The Representation of Features and Relations in Nonlinear Phonology*, Doctoral dissertation, MIT, Cambridge, Massachusetts.

Sagey, E. (1988) "On the Ill-Formedness of Crossing Association Lines," *Linguistic Inquiry* 19, 109–118.

Saito, M. (1981) "A Preliminary Account of the Rotuman Vowel System," ms., MIT, Cambridge, Massachusetts.

Schein, B. and D. Steriade (1986) "On Geminates," *Linguistic Inquiry* 17, 691–744.

Smith, N. (1985) "Spreading, Reduplication, and the Default Option in Miwok Nonconcatenative

Morphology," in H. van der Hulst and N. Smith, eds., *Advances in Nonlinear Phonology*, Foris, Dordrecht.

Smith, N. and B. Hermans (1982) "Nonconcatenatieve woordvorming in het Sierra Miwok," *GLOT* 5, 263–284.

Sohn, H.-M. (1980) "Metathesis in Kwara'ae," *Lingua* 52, 305–323.

Steriade, D. (1986) "Yokuts and the Vowel Plane," *Linguistic Inquiry* 17, 129–146.

Steriade, D. (1987a) "Locality Conditions and Feature Geometry," in J. McDonough and B. Plunkett, eds., *Proceedings of the 17th Annual Meeting of NELS*, GLSA, Department of Linguistics, University of Massachusetts, Amherst.

Steriade, D. (1987b) "Redundant Values," in A. Bosch, B. Need, and E. Schiller, eds., *Papers from the 23rd Regional Meeting of the Chicago Linguistic Society*, Part 2, Chicago Linguistic Society, University of Chicago, Chicago, Illinois.

Steriade, D. (1987c) "Vowel Tiers and Geminate Blockage," ms., MIT, Cambridge, Massachusetts.

Straight, H. (1976) *The Acquisition of Maya Phonology: Variation in Yucatec Child Language*, Garland, New York.

Ultan, R. (1971) "A Typological View of Metathesis," in *Working Papers on Language Universals* 7, Stanford University, Stanford, California.

Weathers, N. (1947) "Tsotsil Phonemes with Special Reference to Allophones of *b*," *International Journal of American Linguistics* 13, 108–111.

Yip, M. (1982) "Reduplication and CV Skeleta in Chinese Secret Languages," *Linguistic Inquiry* 13, 637–662.

Yip, M. (1987a) "Feature Geometry and Co-occurrence Restrictions," ms., Brandeis University, Waltham, Massachusetts.

Yip, M. (1987b) "La structure des traits distinctifs et les restrictions de co-occurrence en javanais et cambodgien," handout, Brandeis University, Waltham, Massachusetts.

Yip, M. (1988) "The OCP and Phonological Rules: A Loss of Identity," *Linguistic Inquiry* 19, 65–100.

Younes, R. (1983) "The Representation of Geminate Consonants," ms., University of Texas, Austin.

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