Ponapean Labiovelarized Labials: Evidence for Internal Segment Structure

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0. Introduction

This paper focuses on the structure and phonological patterning of consonants with secondary articulation, sounds such as [p^w, t^y, k^w]. The traditional view of secondary articulations as described in Ladefoged (1982) is: "...Velarization involves the addition of an [u]-like sound..., palatalization involves the addition of an [i]-like sound..., labialization involves the addition of lip rounding..." (pp. 210-211). A formal theory of segment representation is adequate to the extent that it reflects this type of description.

Ponapean, a Micronesian language described in Rehg and Sohl (1981), provides an interesting set of cases within which the structure and phonological patterning of consonants with secondary articulations can be examined. Within the labial series, Ponapean contrasts /p/ with /p^w/ and /m/ with /m^w/. Both the simple labials and the labiovelarized labials are characterized by a single consonantal articulation--labial closure. In contrast to simple labials, however, labiovelarized labials are characterized by the raising and backing of the dorsum (velarization) and lip protrusion and rounding (labialization) superimposed on this articulation. Three phonological rules of Ponapean--Labial Delinking, Epenthetic Vowel Assimilation and Vowel Dorsalization--selectively target the labiovelarized labials to the exclusion of the simple labials. These rules provide a context within which theories of segment representation can be examined.

The formal structure of secondarily articulated consonants may further be examined in contexts where consonants with secondary articulations and vowels interact. Studies have shown that consonants with secondary articulations andvowels commonly pattern together in phonological rules and constraints. For example, Archangeli (1985) discusses a rule which spreads the feature [+high] in Nyungumarda. This rule is triggered both by vowels and by palatalized consonants. Steriade (1982) discusses the prosodically-conditioned patterning of the [w] component of the Latin labiovelars which she analyzes as single, multiply articulated segments. In certain preconsonantal environments, the [w] component of the labiovelar is deleted. In other contexts, the secondary articulation is mapped to an inserted vowel slot and the originally complex [k^w] surfaces as a [k - u] sequence. The interaction between vowels and consonants with secondary articulations leads to the conclusion that the correct representation of these two classes of segments will allow them to be representationally distinct and yet function as a natural class.

Multiply articulated consonants, such as the Ponapean labiovelarized labials, have been called complex segments (Campbell 1974, Steriade 1982, Clements 1985, Sagey 1986). The general claim concerning complex segments is that, while they are characterized by multiple articulatory gestures, they constitute a single phonological unit. Sagey's (1986) proposal's are particularly insightful with respect to complex segments generally. Her analysis of secondarily articulated consonants does not, however, recognize an inherent, structural distinction between a primary and a secondary articulation. Rather, primary versus secondary status is represented by a pointer which links the degree of stricture features with the primary articulation. The degree of stricture features of secondary articulations are determined by a language particular rule or a universal default rule which assigns [-cons] to secondary articulations.

However, as Selkirk (1988) demonstrates, Sagey's model is inadequate in explaining the differential behavior of primary and secondary articulations with respect to co-occurrence constraints. Additionally, there is no independent motivation for the pointer. Consider for example, a segment such as Ponapean [p^w] which Sagey would represent as involving both the Labial (dominating the terminal feature [+round]) and the Dorsal (dominating the terminal feature [+back]) articulator nodes. The primary status of the Labial articulation is indicated with the pointer. Thus, the Dorsal articulator, lacking a pointer, is secondary. Compare the representation of Ponapean [p^w] with a representation of Nupe [kp^w] (Smith 1961). Nupe [kp^w] is derived from /kp/ by a process which adds a secondary articulation to /p, k, kp/ when followed by a back rounded vowel. Within Sagey's framework, /kp/ involves both a Labial articulator and a Dorsal articulator and both are primary and therefore both are linked to the degree of stricture features involving two instances of the pointer. The derivation of [kp^w], which Sagey proposes, adds the terminal features [+round] and [+back] from a following [+back], [+round] vowel. In this respect, the representation of the secondary articulation of Ponapean [p^w] and Nupe [kp^w] are distinct with respect to the pointer. However, the property which they have in common, and which, in actuality, characterizes the secondary articulation, are the terminal features [+round] and [+back].

There are two primary motivations for making a structural distinction between a primary and a secondary articulation. First, one must adequately account for the full range of segment types in a non-arbitrary fashion. Second, one must allow phonological rules and constraints to refer to one of the articulations (either the primary or secondary) to the exclusion of the other.

In this paper I focus specifically on consonants which are accompanied by a secondary, or vocalic, articulation to the exclusion of other types of complex segments. However, the analysis of secondary articulations which is developed in the context of the Ponapean data has direct implications for the representation of complex segments generally.

In the following Sections, I examine the rules of Labial Delinking, Epenthetic Vowel Assimilation and Vowel Dorsalization in that order. After presenting the facts relevant to each of these rules, I will propose both a representation of Ponapean [p^w, m^w] and an analysis of each of the rules . This analysis draws on a model of feature structure proposed in Clements (to appear). I will then compare the proposed analysis with an analysis constructed within a dependency model of secondary articulations such as proposed in Mester (1986) and Selkirk (1988). I will argue that a model such as that proposed by Selkirk cannot correctly account for the Ponapean facts.

The structure of the argument is the following. The first rule, Labial Delinking, forces a modification of Selkirk's proposed representation. Given this modification, I demonstrate, in the context of Epenthetic Vowel Assimilation, that a dependency model cannot account directly for the blocking effects of vowels with respect to the assimilatory behavior of the secondary articulation. Finally, a dependency representation predicts rules such as Vowel Dorsalization to be non-existent. Thus, the three rules of Ponapean, taken together, constitute an argument for a representation that not only makes a structural distinction between primary and secondary articulations, but also allows the articulations to function independently.

1. The Characterization of Ponapean /p^w, m^w/

Rehg and Sohl (1981:27) characterize the Ponapean labiovelarized labials as follows:

> . . . like [p] [and [m]], [p^w] [and [m^w]] are made by stopping the flow of air from the lungs with the two lips. But [p^w], unlike [p], is also velarized. Therefore, while making this sound, the back of the tongue is raised close to the back part of the roof of the mouth, called the velum. In addition, the lips are slightly rounded and protruded.

An adequate representation will account for the fact that the lip-closure of /p^w, m^w/ must be characterized as the primary articulation accompanied by simultaneous velarization and lip rounding as secondary articulations.

Structures based on proposals by Clements (1989) and Selkirk (1988) for such segments are illustrated in (1).

(1) Primary/Secondary Articulations on Separate Tiers

(a) Clements 1989

```
      pʷ
      |
      .             Root Node
      |
      .             C-Place (Primary)
     / \
Labial   .          V-Place (Secondary)
        / \
  Labial Dorsal
```

(b) Selkirk 1988

```
 pʷ
 |
Labial      Primary (Head)
 |
Dorsal      Secondary
            (Dependent)
```

The general claims within the model illustrated in (1a) are that the place features of consonants and vowels are drawn from the same set of features and arrayed on non-overlapping tiers. Such an organization accounts for the fact that vowel features typically spread freely across consonants but consonantal place features are prevented from freely spreading across vowels by the presence of a C-Place node in a vowel's representation. Terminal features of consonantal specifications are relatively free to spread. The representation allows the addition of a V-Place node to any consonant as a characterization of secondary articulation. Given such a representation, the secondary articulations of consonants are predicted to interact with vowels since the two groups of segments share features on the same tier.

Selkirk (1988) proposes the representation in (1b) for consonants with multiple articulations including secondarily articulated consonants. The primary versus secondary status of the articulations is defined, in Selkirk's framework, in terms of head and dependent. The head in (1b) is the primary articulation and the dependent is the secondary articulation. The dependent or secondary articulation occupies a tier of its own. Further, tiers are defined in terms of heads. Thus, two features occupy the same tier iff they are dependent on the same head.[1]

2. Labial Delinking

Rehg and Sohl (1981:27) describe the rule which deletes the lip protrusion or rounding component of [pʷ, mʷ] as follows:

(2) Labial Delinking

> ...[in word-final position,] except in very careful speech, [pʷ] [and [mʷ]] are made without the lip rounding that occurs when [pʷ] is at the beginning or middle of words. The raising of the back of the tongue, however, still takes place.

In (3) I illustrate the contrasting occurrence of the labiovelarized labials in word-final position:

(3)	a. /kom/	'to pull in a net'	c. /komʷ/	'you'
	b. /kap/	'bundle'	d. /kapʷ/	'new'

The rule of Labial delinking is stated in (4a) and the effect of this rule is illustrated in (4b). The result is a primary Labial with secondary Dorsalization.

(4) Labial Delinking Formalized:

(a) C
:
:
Delink: [Labial]V-Place]Word

(b)

```
pʷ                     ->        pʷ
|                                |
.                                .            C-Place
/ \                             / \
Labial  .                  Labial  .          V-Place
       ≠\                          |
Labial Dorsal                    Dorsal
```

The rule as stated in (4a) has the effect of delinking the Labial specification dominated by V-Place on word-final consonants. It is important to note that the secondary Dorsal articulation remains even though the lip-rounding is deleted in word-final position.

Consider the rule of Labial Delinking as it would apply to the structure proposed by Mester (1986) and further developed in Selkirk (1988). Given the representation in (1b), the rule of Labial Delinking cannot be formulated to give the correct results within a dependency characterization of the Labial and Dorsal articulations of Ponapean /p^w, m^w/. If the rule which delinks the Labial articulation, as stated in (4), applies to the representation in (5) the result will be (5b), a segment with no feature content. If the rule is restated to delink the terminal Dorsal articulation, the result will be a simple Labial as in (5c). Both of these alternatives are incorrect.

```
(5) a. pʷ        b.  *pʷ        c.  *pʷ        d. pʷ
       |              ≠              |             |
     Labial         Labial         Labial        Labial
       |              |              ≠             |
     Dorsal         Dorsal         Dorsal        Dorsal
                                                   |
                                                 Labial

     =[pʷ]           =[ø]           =[p]         = [pʷ]
```

I conclude that the dependency structure must be modified to correctly express the results of Labial Delinking. The Ponapean labiovelarized labials might be represented as illustrated below in (5d). Such a representation characterizes /p^w, m^w/ as primary labials with multiple secondary dependents.

The rule of Labial Delinking can now be formulated as the deletion of a Labial specification when it is dominated by a Dorsal specification as in (6):

```
(6)              C
                 :
                 :
             [Dorsal]
                 |
   Delink:   [Labial] ] word
```

Thus, a dependency representation of the Ponapean labiovelarized labials must first of all be modified to involve two dependent or secondary articulations. Without this modification, the rule of Labial Delinking cannot be correctly formulated.

Labial Delinking, as it applies to the Ponapean labiovelarized labials, provides insight into the component parts of these segments. Within a model which represents secondary articulations as overlaid vocalic articulations, the rule can be formulated to delete the Labial component of the secondary articulation without affecting either the primary Labial component or the additional secondary articulation of velarization.

3. Epenthetic Vowel Assimilation

In (7), I give data which illustrate the effects of Epenthetic Vowel Assimilation. In forms beginning with a nasal plus consonant cluster, an epenthetic vowel is optionally inserted before the consonant cluster. Epenthetic Vowel Assimilation is triggered by two distinct sets of segments, back rounded vowels and labiovelarized labials.

(7) Epenthetic Vowel Assimilation

Underlying			With Optional <u>Epenthetic [i]</u>	Gloss
a. /mpe/	[mpɛ]	~	[impɛ]	beside it
b. /ŋkap^{w}an/	[ŋkap^{w}an]	~	[iŋkap^{w}an]	a while ago
c. /mpaai/	[mpaay]	~	[impaay]	submissive
d. /nta/	[nta]	~	[inta]	to say
e. /ntʃa/	[ntʃa]	~	[intʃa]	blood
f. /nsɛn/	[nsɛ]	~	[insɛn]	will
g. /ntil/	[ntil]	~	[intil]	torch
h. /ŋket/	[ŋket]	~	[iŋket]	roof with thatch

			With Optional Epenthetic [u]	
i. /ŋkɔl/	[ŋkɔl]	~	[uŋkɔl]	to make sennit
j. /mʷpʷer/	[mʷpʷɛr]	~	[umʷpʷɛr]	twin
k. /mʷpʷa/	[mʷpʷa]	~	[umʷpʷa]	hermit crab
l. /mʷpʷe/	[mʷpʷe]	~	[umʷpʷe]	curve, bend
m. /mʷpʷi/	[mʷpʷi]	~	[umʷpʷi]	leaky
n. /mʷpʷul/	[mʷpʷul]	~	[umʷpʷul]	flame
o. /mʷmʷen/	[mʷmʷen]	~	[umʷmʷen]	fish species
p. /nsɔŋe/	[nsɔŋe]	~	[unsɔŋe]	look for yams
q. /ŋkopʷ/	[ŋkopʷ]	~	[uŋkopʷ]	species of crab
r. /mpɔke/	[mpɔke]	~	[umpɔke]	to kiss

As these examples illustrate, the epenthesized vowel surfaces as [i] in examples (7a) through (7h) and as [u] in (7i) through (7r). In the examples where the epenthetic vowels surfaces as [u], the word begins with a labiovelarized labial or the first vowel to the right is a rounded vowel. Simple labial consonants do not trigger the assimilation of the epenthetic vowel. This can be seen by comparing examples (7a) and (7r). Examples (7h) and (7i) illustrate that vowel assimilation must be attributed to the back rounded vowels since no other trigger appears in the form. Thus, the back rounded vowels and the labiovelarized labials function as a natural class to the exclusion of the simple labial consonants and the low back vowel [a]. The data below in (8) illustrate vowel epenthesis and assimilation in reduplicated forms. The reduplication cases involve the same pattern of epenthetic vowel assimilation as the examples in (7). The epenthesized vowel assimilates in backness and rounding when followed by either a labiovelarized labial consonant or a back rounded vowel.

(8) Obligatory vowel epenthesis in reduplication:

Stem	With epenthetic [i] Reduplicated	Gloss
a. mmed	mm-i-mmed	full
b. ŋŋet	ŋŋ-i-ŋŋet	to plant
c. ŋŋar	ŋŋ-i-ŋŋar	to see
d. mpek	mp-i-mped	to look for lice
e. nda	nd-i-nda	to say
f. nseen	ns-i-nseen	to snare
g. ntiŋ	nt-i-ntiŋ	to write
	With epenthetic [u]	
h. mʷmʷus	mʷmʷ-u-mʷmʷus	to vomit
i. ŋkɔl	ŋk-u-ŋkɔl	to make sennit
j. mʷpʷul	mʷpʷ-u-mʷpʷul	to flame

Reduplication, in these examples, involves copying the initial consonant cluster to the left of the stem. A vowel slot is inserted obligatorily and this vowel receives its feature specification from either a following rounded vowel, labiovelarized labial or by default.

Before stating the rule of Epenthetic Vowel Assimilation, I give the proposed feature characterization of Ponapean consonants and vowels in (9). The labiovelarized labials are characterized by V-Place features [Labial] and [Dorsal]. This groups them together with the back rounded vowels as a natural class.

(9) Characterization of Ponapean consonants and vowels:

(a) Consonants

	p	m	p^w	m^w	t	tʃ	n	s	l	r	k	ŋ
<u>C-Place</u>												
Labial	+	+	+	+	-	-	-	-	-	-	-	-
Coronal	-	-	-	-	+	+	+	+	+	+	-	-
Dorsal	-	-	-	-	-	-	-	-	-	-	+	+
<u>V-Place</u>												
Labial			+	+								
Dorsal			+	+								

(b) Vowels

	i	e	ɛ	u	o	ɔ	a
Labial	-	-	-	+	+	+	-
Dorsal	-	-	-	+	+	+	+

By characterizing both vowels and consonants with the same set of features, the fact that the Ponapean labiovelarized labial consonants and the back rounded vowels pattern together as a natural class with respect to the rule of Epenthetic Vowel Assimilation is expected. However, the fundamental point rests on the structural distinction made between primary articulations and secondary articulations and between consonants and vowels, not on the feature characterization per se.

For the purposes of this paper, I state the rule of Epenthesis in (10).[2]

(10) Epenthesis:

(a) ø -> V/ #__CC..]w (initial)
(b) ø -> V/CC__CC (reduplication)

This rule (a) optionally inserts an empty vowel slot word initially before a consonant cluster (b) obligatorily inserts an empty vowel slot after the second consonant in a four consonant cluster which arises through reduplication.

(11) Epenthetic Vowel Assimilation:

Spread:	V-Place
Trigger:	Labial]V-Place
Target:	V
Direction:	Right-to-Left

The rule of Epenthetic Vowel Assimilation, as stated in (11), spreads the entire V-Place node to the inserted vowel slot. It is important to point out that the rule does not simply spread the terminal feature Labial. Under the assumption that the spreading of the V-Place node triggers the interpolation of all predictable superordinate structure, the rule, as stated, results in a vowel characterized by both a Labial and a Dorsal specification.

If the rule of epenthesis fails to apply, the epenthetic vowel will be specified as [i] by the default rules given in (12).

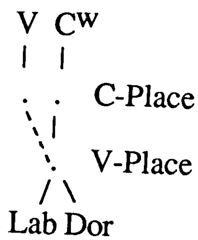
(12) Default V-Place specifications:

a. [ ] -> [+high]
b. [ ] -> [-Dorsal]

Since the rule of Epenthetic Vowel Assimilation spreads only place features the [+high] specification will be automatically inserted in all cases. However, the [-Dorsal] specification will be inserted only in cases where Epenthetic Vowel Assimilation fails to apply.

To illustrate how the proposed analysis derives the facts of Epenthetic Vowel Assimilation I give the following derivations. In (13), the epenthetic vowel surfaces as [u] when it immediately precedes a labiovelarized labial (7j-o).

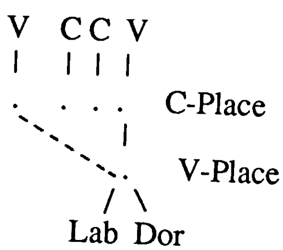
(13) Case 1: Consonant to vowel assimilation from an immediately adjacent labiovelarized labial (excludes simple labials):



/m^w p^w ɛ r/	'twin'
V m^w p^w ɛ r	Epenthesis
u m^w p^w ɛ r	Assimilation
[u m^w p^w ɛ r]	output

In (14), the epenthesized vowel surfaces as [u] when followed by a rounded vowel. This vowel may be separated from the epenthesized vowel slot by one or more consonants as long as they do not involve a secondary articulation (7 i, p-r).

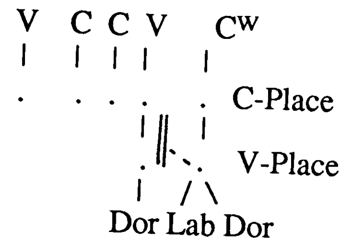
(14) Case 2: Vowel-to-Vowel assimilation across intervening simple consonants:



/ŋ k o p^w/	'species of crab'
V ŋ k o p^w	Epenthesis
u ŋ k o p^w	Assimilation
[u ŋ k o p^w]	output

In (15), the epenthesized vowel is followed by a labiovelarized labial. However, in this case the labiovelarized labial is separated from the epenthesized vowel slot by an intervening vowel and the epenthetic vowel surfaces as [i] (7b).

(15) Case 3: Rule defined on terminal [Labial] specification but does not apply across intervening vowels:



/ŋ k a pʷ a n/	'a while ago'
V ŋ k a pʷ a n	Epenthesis
[i ŋ k a pʷ a n]	Assimilation N.A.

The presence of an intervening vowel blocks the spread of the V-Place features from the following, secondarily articulated consonant to the epenthesized vowel slot. The failure of the V-Place specifications of the labiovelarized labial to spread to epenthetic vowel slot follows straightforwardly from the structural representation and the formulation of the rule.

In summary, the rule of Epenthetic Vowel Assimilation illustrates that consonants and vowels characterized by the V-Place features [Labial] and [Dorsal] pattern together in the rule of Epenthetic Vowel Assimilation defined on the V-Place tier. Simple labials predictably do not participate in the rule. Furthermore, the fact that the V-Place node dominating secondary articulations does not spread across vowels follows from the representation and can be attributed to the Line Crossing Prohibition (Goldsmith 1976).

I will now examine the rule of Epenthetic Vowel Assimilation within a model such as proposed by Mester (1986) and Selkirk (1988). Labiovelarized labials must be represented as having two secondary dependents based on the rule of Labial Delinking. In order to allow the back rounded vowels to be grouped together with the labiovelarized labials, I assume the following representation.

(16) a. Labiovelarized Labial

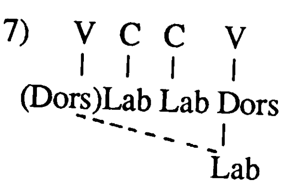
```
C
|
Labial
|
Dorsal
|
Labial
```

b. Back Rounded Vowels

```
V
|
Dorsal
|
Labial
```

This representation relates the labiovelarized labials and the back rounded vowels by means of a common substructure. Such a representation also allows the Labial feature of the vowel to correctly spread across simple labial consonants as illustrated in (17):

(17)



/mpɔke/	'to kiss'
V m p ɔ k e	V epenthesis
u m p ɔ k e	V assimilation
[umpɔke]	output

The rule of Epenthetic Vowel Assimilation may now be stated as in (18). In these examples the interpolated Dorsal node is enclosed in parentheses.

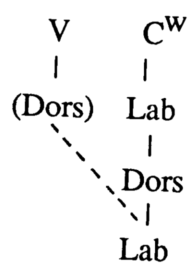
(18) Epenthetic Vowel Assimilation within a Dependency Framework:

Spread:	Terminal Labial
Trigger:	Labial]Dorsal
Target:	V
Direction:	Right-to-Left
Interpolate:	Dorsal

This rule says that a terminal Labial articulator dominated by a Dorsal articulator spreads to an empty vowel slot. As the examples illustrate, the rule of Epenthetic Vowel Assimilation derives the high back rounded vowel [u] in the cases where it applies. Since the terminal Labial feature is a dependent of the Dorsal articulator in both vowels and labiovelarized labials, a Dorsal node must be interpolated on the empty vowel slot in order to serve as the head and dominate the dependent Labial articulation.

Consider the following derivations. In (19), where the trigger is an immediately adjacent labiovelarized labial, the rule of Epenthetic Vowel Assimilation applies correctly.

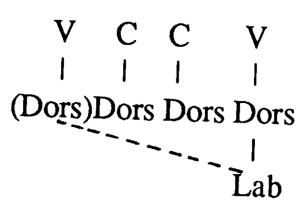
(19) Case 1: C^w to V assimilation:



/m^w p^w ɛ r/	'twin'
V m^w p^w ɛ r	Epenthesis
u m^w p^w ɛ r	Assimilation
[u$m^w$$p^w$ɛr]	output

As (20) illustrates, the dependency representation also accounts correctly for the case of vowel-to-vowel assimilation.

(20) Case 2: V-to-V assimilation:



/ŋ k o p^w/	'species of crab'
V ŋ k o p^w	Epenthesis
u ŋ k o p^w	Assimilation
[uŋkop^w]	output

In (21), however, the representation of the labiovelarized labials (forced by the rule of Labial Delinking) freely permits the terminal Labial feature of the secondary articulation to spread across all intervening segments. This is incorrect and something more must be said to explain the failure of the terminal Labial specification to spread to the empty vowel slot.

(21) Case 3: Blocking effects of intervening vowels:

```
    *V     C    C    V    Cʷ
     |     |    |    |    |
  (Dors) Dors Dors Dors Lab
      `- - - -         |
              - - -   Dors
                   - -.|
                      Lab
```

/ŋ k a pʷ an/	'a while ago'
V ŋ k a pʷ a n	Epenthesis.
u ŋ k a pʷ a n	Assimilation
*[uŋkapʷan]	output

The failure of the terminal Labial feature of [pʷ] to spread to the vowel in this case may plausibly be attributed to locality. However, the rule of Epenthetic Vowel Assimilation in Ponapean is not a strictly local rule. In the case of vowel-to-vowel assimilation, the assimilating feature may spread across up to two intervening consonants. The relevant generalization is that the terminal Labial feature must spread to the first unspecified V-slot to its left. If the first vowel position to the left is a specified vowel, the rule is blocked from applying. The rule cannot, however, be defined simply on the vowel projections since in this example the terminal feature is spreading from a consonant. The vowel [a] which intervenes in (21) must be specified as an illicit bearer of Labiality. A standard formulation of such cooccurrence restrictions (following Archangeli and Pulleyblank 1989) is given in (22).

(22)
```
      * V
        |
     Dorsal
      /   \
  [+low] Labial
```

This statement prohibits the feature Labial from occurring on Dorsal vowels which are [+low].

A dependency analysis is forced to state that, because the Dorsal vowel [a] is not a bearer for the feature Labial in (21) above, locality is violated. While the rule of Epenthetic Vowel Assimilation argues for the representation of back rounded vowels and the labiovelarized labials as Labial dominated by Dorsal, a dependency analysis cannot explain the failure of the secondary articulation to spread across vowels on the basis of tier structure. This result is obtained automatically under the alternative analysis where vocalic features characterize both vowels and consonants with secondary articulations and such features define a tier of their own.

4. Vowel Dorsalization

The rule of Vowel Dorsalization causes front vowels to be realized as central vowels in the environment of the labiovelarized labials. This rule is non-structure preserving and creates a new series of central (or back) unrounded vowels.

(23) a.	/tip^{w}isou/	->	[t ɨ p^{w} ɨ sou]	'thing'
b.	/tip^{w}ɔp^{w}/	->	[t ɨ p^{w}ɔp^{w}]	'tree species'
c.	/lim^{w}aa/	->	[l ɨ m^{w}aa]	'prep., next to'
d.	/lip^{w}ɔr/	->	[l ɨ p^{w}ɔr]	'to scold'
e.	/rip^{w}irip^{w}/	->	[r ɨ p^{w} ɨ r ɨ p^{w}]	'fish species'
f.	/sim^{w}/	->	[s ɨ m^{w}]	'to swarm'
g.	/sip^{w}e/	->	[s ɨ p^{w} ə]	'to hold in contempt'
h.	/tʃip^{w}a/	->	[tʃ ɨ p^{w}a]	'to be cut with scissors'

In (24) I formalize the rule of Vowel Dorsalization within a model which represents vowel features via a dominating V-Place node.

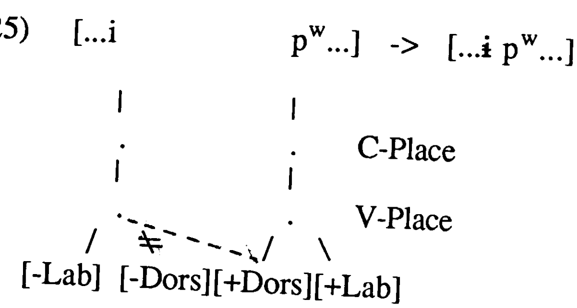
(24) Vowel Dorsalization Formalized

Target: V-Place
Trigger: C
:
:
[Dorsal]$_{\text{V-Place}}$
Spread: Bidirectionally

This rule says that the V-Place feature Dorsal will spread bidirectionally to the V-Place node of adjacent vowels. It will apply vacuously to underlying back vowels.

In (25) I illustrate the results of this rule.

(25)



The spreading of the [+Dorsal] specification from the labiovelarized labial triggers the delinking of the [-Dorsal] specification of front vowels, in this case [i]. In order for the correct results to be obtained, I assume that vowels characterized as [+Dorsal, -Labial] are realized as central unrounded vowels in Ponapean. Within a model of feature structure which represents place features as dominated by a higher node, the independence of the individual components of the secondary articulation is unsurprising.

Consider now the predictions made within a dependency representation of the multiple secondary articulations of the Ponapean labiovelarized labials.

(26) Vowel Dorsalization: a dependency representation

```
[...i      pʷ...]    ->    *[...ʉ pʷ...
    \      |
     \     |
      \  Lab
       \ |
       Dors
         |
        Lab
```

I am sidestepping the question of how front vowels and their centralized counterparts are represented within a dependency framework. However, if the Dorsal articulator subsumes the [+/-back] function, then within a dependency representation, the dominating Dorsal node cannot spread without taking all dependents with it. Vowel Dorsalization must spread the Dorsal node in order to characterize the backing of front vowels. We then expect the vowel to surface as a central, rounded vowel. Following this view, there is no way of representing the labiovelarized labials which will allow an account of the backing of front vowels without accompanying rounding. Ponapean Vowel Dorsalization is presented as representing a whole class of cases that a dependency framework, under this interpretation, predicts not to exist.

5. Conclusions

The representation of secondary articulations, such as labiovelarization, on the same tier as vocalic articulations characterizes them as a natural class which will pattern together in phonological rules. The patterning together of the back rounded vowels and labiovelarized labials in Ponapean strongly supports such a representation. Furthermore a model which represents vocalic place features and features characterizing secondary articulations on the same tier predicts that the only segments which will block the spreading of vocalic tier articulations are other vowels and secondarily articulated consonants. The facts of Ponapean confirm this prediction.

A dependency analysis does not offer a straightforward account of the patterning together of vowels and secondary articulations. It is possible to represent the labiovelarized labials and the back rounded vowels with a common substructure, but this does not account for the failure of secondary articulations to spread across vocalic features. Further, the rules of Labial Delinking and Vowel Dorsalization together show that, in cases where more than one feature may characterize a secondary articulation, the features must be able to function independently.

Notes

*I would like to thank Nick Clements, Abby Cohn and David Silva and especially the Cornell Phonetics Lab Summer Support Group for their help. All errors are, of course, my own.

1. Mester (1986, p. 23) characterizes Ponapean [p^w] with the feature [back] and the same sort of dependency structure as that illustrated in (1b). Selkirk (1988) proposes to replace the feature [back] in this function with the Dorsal articulator node which makes a comparison with Clements' proposal more straightforward.
2. The rule of epenthesis has been discussed by Itô (1986) within the context of a Prosodic Theory of epenthesis. McCarthy and Prince (1985) discuss epenthesis in the context of reduplication as being a property of the reduplicative template.

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