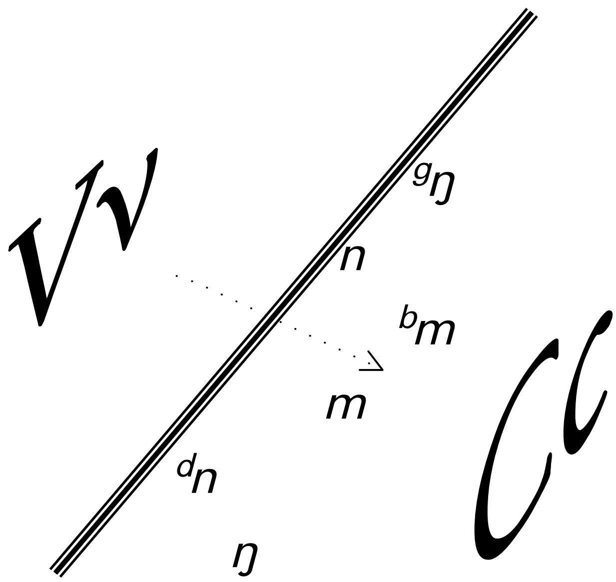
Mamaindé pre-stopped nasals:

an optimality account of vowel dominance

and a proposal for the Identical Rhyme Constraint



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2003
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1. INTRODUCTION

1.1 The language

The northwestern border of Mato Grosso state, Brazil, is homeland to the Nambiquara language family. The Nambiquara nation is divided into numerous small bands, each speaking their own lect. These lects can in turn be grouped into three general linguistic speech communities; the dominant Southern Nambiquara language, the smaller Northern Nambiquara language, and the almost extinct Sabané. One of the Northern Nambiquara lects, Mamaindé is spoken by some 180 people. It is the largest surviving of the original lects of this language, the other three still in existence being Negaroté, Latundê, and Lakondê[1].

The data used in this paper comes from the author's field experience among the Mamaindé people between 1994-2002 under the auspices of the Summer Institute of Linguistics.

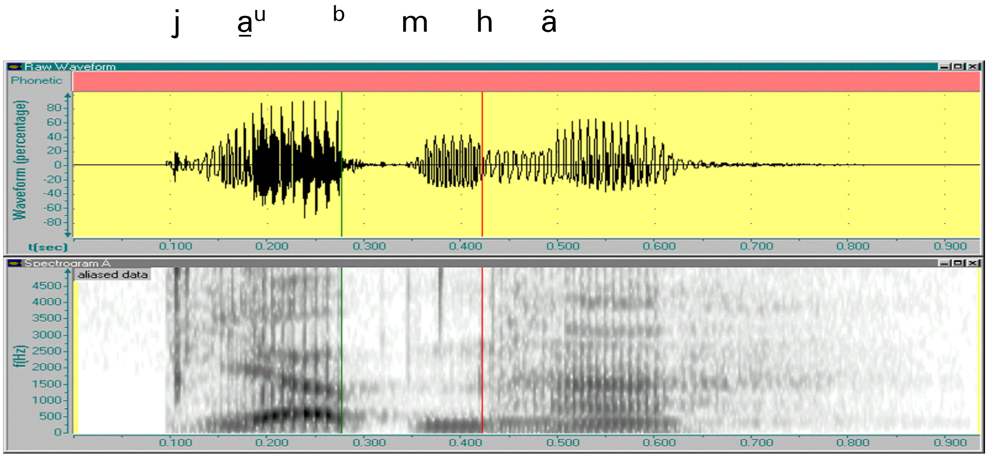
1.2 A brief description of pre-stopped nasals

This paper will attempt to arrive at an understanding of the phenomenon of pre-stopped nasals in Mamaindé. By pre-stopped nasals I am referring to those nasal consonants whose onset is a voiced, oral stop, such as those in: [*da*^{ub}*mdu*] "tail", [*walek*^{h}*a*^{d}*ndu*] "chief", [*he*^{ig}*ŋlat*^{h}*wa*] "he washes". (The pre-stop segment will always be indicated by a raised obstruent throughout).

The only phonetic difference between a pure nasal consonant and a pre-stopped nasal consonant is one of timing; in the latter the opening of the velic is delayed until after the tongue has assumed its place of articulation. Notice in the spectrogram below that there is vocal closure for the labial pre-stop /^{b}/ before the onset of the nasal formant in the word /ja̲^{ub}mhã/ 'are you there?'. (The pre-stopped nasal segment /^{b}m/ is selected between the two cursors in the spectogram below. Underlined vowels are creaky voice. Dipthongs are represented by raised vowels.)

[1] Lakondê apparently has only one surviving speaker. See Telles for a recent treatment of the phonology and grammar of Latundê and Lakondê.

(1)



While many languages contain pre- or post-nasalized stops (such as [^{n}d] and [d^{n}]), fewer seem to exhibit pre- or post-stopped nasals.[2] These latter segments are phonetically identical to the former ones, yet differ fundamentally in that their underlying form consists of the nasal as opposed to the oral segment[3]. Pre-stopped nasals have been attested to in various Australian languages (Ladefoged and Maddieson, 1996, p. 128) as well in a number of Macro-Gê languages such as Apinaye, Kaingang, Maxakalí, and Xokleng (Anderson 1974:268-274, D'Angelis 1994; Mullen, pers. comm.; Wetzels 1995)[4]. Their phonetic form is described more fully in Ladefoged & Maddieson (1996:128).

Since post-nasalized stops seem to be more common cross-linguistically, a first look at the Mamaindé data might tempt us to consider the stops as underlying, and the nasal part as derived. However, the data below show us that in Mamaindé, it is the nasal portion of the stop-nasal sequence that is underlying, for it is the only part that can stand alone intervocalically.

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[2] Another way to think of these segments is to view the complex oral-nasal coda as the product of de-nasalization.

[3] Post-stopped nasals on the other hand, can often be treated as intrusive stops, and seem to be rather common. From a diachronic perspective many European languages contain post-stopped nasals; French /tremulare/ > [trembler], Spanish- /venira/ > [vendra], Italian /memorare/ > [membrare], Ancient Greek /gam-ros/ > [gambros], English /thunor/ > [thunder]. (Data borrowed from Wetzels, 1995, pg.86) But these forms show post nasal segments which are separate from the nasal since they occur in separate syllables.

[4] Wetzels prefers the term "post-oralized nasals" (pg. 85)

(2) /n/ —> [^{d}n]:

root + article
han + *ãni* -->*hanãni* ‘the fish (type of)’
han + *tu* -->*ha^{d}ndu* ‘a fish (type of)’

/n/ —> [^{g}ŋ]:

root + article
sin + *ãni* --> *sinãni* ‘the meat’
sin + *tu* --> *si^{g}ŋdu* ‘meat’

/n/ –> [^{b}m]:

root + article
ta^{u}n + *ãni* —-> *da^{u}nãni* ‘the tail’
ta^{u}n + *tu* —-> *da^{ub}mdu* ‘a tail’

We must therefore describe these stop-nasal sequences in Mamaindé as pre-stopped nasals, which are surface variants of underlying simple nasal consonants. This is in line with the work of Kingston (1973, 1976, 1979), the only other linguist to have studied this language, who also saw these pre-stopped nasals as allophones of the alveolar nasal. It also agrees with research in the other Nambiquara language, Southern Nambiquara, where the stop/nasal sequence has been attested to (Kroeker 1963, Price 1976, Lowe 1997). Each of these authors have treated these stop/nasal sequences as variants of the simple nasal. Furthermore, we will treat them as single contour segments filling one of the positions in the coda.[5] The last coda segment, if there is one, will always be a glottal stop.

Presented below is the Mamaindé syllable template, which is a revision of my first analysis of syllable structure (Eberhard 1995:5-9). Here I am considering sequences such as [a^{i}] and [e^{u}] to be diphthongs occupying a single vowel position instead of using glides.[6] The need to include vowel length (:) in the coda of the template is due to the quantity sensitive nature of the Mamaindé stress system, which considers syllables with lengthened vowels to be heavy syllables (Eberhard 1995:5-26,78-80). And the word final appendix (Ω) is due to coda licensing and argued for in Eberhard, 1995:5-26.

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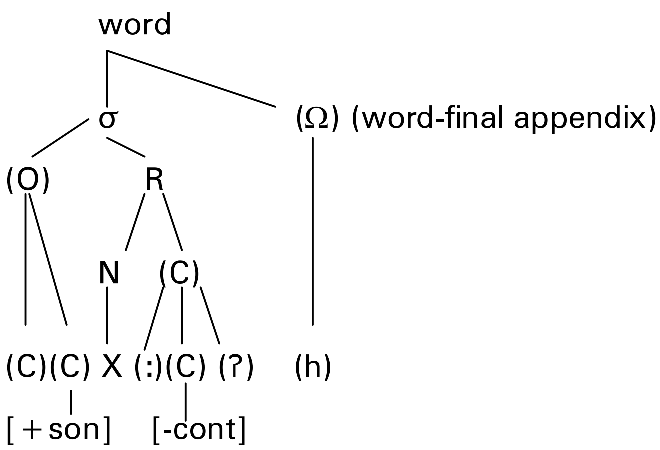
[5] Kingston (1979, p.7-10) posits that all coda segments in Mamaindé, particularly the nasal codas, could have at one time been separate morphemes in their own right. Unfortunately, the lack of any hard diachronic data makes this position difficult to verify. Regardless of their historical roots, these nasal forms function as codas in the present-day language, and will be studied as such in this paper.

[6] See section 6.7 for further comments on diphthongs. Footnote #17 in that section discusses the pros and cons of glides vs. diphthongs in Mamaindé.

(3) THE MAMAINDÉ SYLLABLE TEMPLATE

(The X represents either vowels or syllabic nasals in the nucleus position. The colon represents vowel length. The middle coda position licenses only [-continuant] segments. Only the glottal can fill the last coda position, and only the /h/ appears as an appendix. Coda segments will not co-occur with the appendix.)



Here are some examples of different surface syllable types in Mamaindé.

(4)

V	**a**.*la^{i}:.ru*	= sloth
N	*-de^{i}ʔ.**n**.daʔ*	= connective - 'in order to'
VC	***at**.t^{h}a.t^{h}wa*	= he fishes
CV	***na**.we^{i}k.tu*	= his child
CV:	***du**:.la.t^{h}wa*	= he gets
CV:C	***wa:n**.la.t^{h}wa*	= he returns
CVC	*ja.**lãn**.du*	= toucan
CVC	*ja.**da^{d}n**.du*	= deer
CVC	*ka.**de^{ub}m**.da.la.t^{h}wa*	= it is alive
CVʔ	***-jeʔ***	= certainly
CCV	*ʔa^{i}:.la.**t^{h}wa***	= he goes
CCV:	*du.**kwa:**.la.t^{h}wa*	= he brings
CVCʔ	***mãnʔ**.du*	= hill
CVCʔ	*wa.**sa^{ig}ŋʔ**.du*	= stuff
CVCʔ	*na.ga.**ja^{d}nʔ**.du*	= person
CCVCʔ	***kwãnʔ**.ti.ru*	= tarantula
CVΩ	*na.**t^{h}oh***	= however

(Examples of each syllable pattern are underlined. Periods separate syllables. Lengthened vowels are marked with a colon)

The pre-stopped nasals occupy the same position in the coda as the simple nasal segments. We can verify this by comparing the placement of stress in the forms below. Here I use the underline to mark the stressed syllable.

(5)

CVC	*ja.<u>lãn</u>.du*	= toucan
CVC	*ja.<u>da^{d}n</u>.du*	= deer
CCVCʔ	*<u>kwãnʔ</u>.ti.ɾu*	= tarantula
CVCʔ	*na.ga.<u>ja^{d}nʔ</u>.du*	= person

Since this is a quantity sensitive language which assigns stress according to the number of moras per syllable, the above data shows that syllables with pre-stopped nasal codas are considered on equal grounds for stress placement with other syllables which have a simple nasal in the coda. The addition of the pre-stop does not add any extra length or weight to the syllable, nor does it create an additional syllable. (Eberhard 1995:6).

Notice that this language allows for simple nasal onsets to be re-syllabified and occupy the nucleus position in contracted forms where vowel ellision has occurred (such as in /-te^{i}ʔnata̱ʔ/ > [-de^{i}ʔnda̱ʔ]). Pre-stopped nasals, however, are never considered syllabic, even though they may appear to be syllabic at the phonetic level. Kingston (1979:8-9) argues for the syllabicity of certain nasal codas such as [na.ho.n] "water". Likewise, a word such as [wada^{d}nʔniɾu] – 'kettle', could be taken as having five syllables instead of four [wa.da.^{d}nʔ.ni.ɾu]. But as was pointed out in Eberhard 1995:30,69-71, the stress system in Mamaindé clearly shows this to be a quantity sensitive language, one in which stress is attracted to syllables with codas. Therefore, the primary stress placement on the second syllable of [waDA^{d}Nʔni] is a strong indication that this syllable has a coda, /^{d}nʔ/. The pre-stopped nasals must therefore remain in the coda position, attracting stress so that stress placement will occur correctly, stressing those syllables which are heavy.[7] Another bit of evidence is that in slow speech, Mamaindé speakers consistently make syllable breaks after the nasal codas, and never before. This means that nasal prestops are considered intuitively to be part of the preceding syllable. To indicate that we are viewing them as single contour segments, they will be written with a raised oral stop preceding the nasal coda ([^{b}m, ^{d}n, and ^{g}ŋ]).

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[7] Pre-stopped nasals are regarded by the stress system as simply adding one more mora to the previous syllable, just as any coda would do. Phonetically at least, there appears to be more emphasis and length given to nasal codas which are NOT preceded by the prestop than to those that are.

1.3 Basic research questions

This study of Mamaindé nasals is built on a considerable amount of previous work done by Kingston (1974, 1976, 1979). The reason for going beyond Kingston's analysis is because his focus was primarily descriptive, and there has never been any attempt to delve into the mystery of why these pre-stopped nasal forms occur, and exactly how they get their place features. This is what I intend to do in this paper, using an optimality approach. I will occasionally include autosegmental representations when they might prove helpful for us to better visualize certain processes.

The Mamaindé nasal forms raise some interesting questions regarding nasal/oral spreading and place spreading, both on the language specific level and the theoretical level. **The first question is simply, "What motivates the formation of these contour oral-nasal segments?"** I will argue that the major motivation comes from a constraint I will call the Identical Rhyme[nasal] constraint, which forces the sharing of oral/nasal features throughout the domain of the rhyme. This constraint, coupled with the high ranking of FaithV and low ranking of FaithC[nasal], will not only account for the various pre-stopped nasal forms, but also shows us a language where vowels are more faithful than consonants, and where the nucleus position affects the coda in interesting ways.

The second question is "How do these pre-stopped forms acquire their place features?". We will soon see the difficulty of this latter question, since the adjacent consonants rarely have anything to do with the place features of the pre-stopped nasal. Again I will posit a constraint referring to the rhyme, the Identical Rhyme[place] constraint, which attempts to enforce identical place features throughout the rhyme. And once again, we find that it is the vowel which is most dominant here, remaining faithful to its place features while the coda is most affected, assuming the place feature of the nucleus.

A third question then suggests itself. Do these processes in Mamaindé shed any light on current phonological theory? By the end of this paper, I plan to show that the Mamaindé data is relevant to current theory in many ways, the four main ones being:

1. First, it requires an analysis which employs binary instead of unary values for nasality, and, to use autosegmental terminology, the spreading of the oral feature from vowels to nasals.
2. Secondly, it will be shown that Mamaindé associates the [+hi] vowel feature with a [Dorsal] articulation in consonants. This second point will

cause us to reconsider the vowel features currently available in universal grammar, allowing for the return to some of the more traditional SPE place features for both vowels and consonants.
3. Thirdly, the data shows that underspecification is needed in order to correctly analyze place spreading to codas in this language.
4. Finally, we will demonstrate the need for a family of constraints which enforce identicalness within the rhyme as a whole, thus motivating such phonological phenomenon as the Mamaindé pre-stopped nasal coda. Whether or not such constraints have been proposed up until now I do not know, but the need for them will be shown in this paper.

As the title of this paper suggests, the overall picture will be one of a language in which vowels play a dominant role in the articulation of coda consonants in general, and nasal codas in particular.

The basic outline of our discussion will be:

1. Introduction
2. Nasality: underlying or derived?
3. The data and the problem
4. Universal motivation: the IRC family of constraints
5. Pre-stopped nasal formation and the IRC
6. Place feature spreading and the IRC
7. Combining the constraints
8. Other codas
9. Exceptions to the IRC
10. Conclusion: some theoretical implications

    Appendix

These discussions will assume the reader to have a basic understanding of autosegmental phonology, feature geometry, and optimality theory.

2. NASALITY: UNDERLYING OR DERIVED?

In order to talk about such things as *nasal vowels* and *nasal consonants* we must first decide whether they are underlying notions or derived forms.

2.1 Consonants

The 14 consonant phonemes in this language can be divided into 12 oral consonants: /p,t,k,p^h, t^h, k^h,s,l,j,w,h,ʔ/,[8] and 2 nasal consonants: /m, n/. The /n/ and /m/ can easily be distinguished as underlying in syllable initial position (*[nã̠ⁱn?du]* 'shell', *[mã̄ⁱndu]* 'pet') although in coda position an [m] is always derived from the alveolar /n/. The velar [ŋ], and the pre-stopped nasal segments [^{b}m, ^{d}n, ^{g}ŋ], occur only in the coda, and as we will show in this paper, they are also derived from the alveolar nasal form. We will assume that the nasal phonemes /n, m/ are associated to the feature [+nasal] at the lexical level.

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[8] The set of stops used in the orthography differs from the actual set of phonemes described here. Phonological alternations to the phonemic stops include the following:

A. The current speech of the Mamaindé uses the voiced set of stops [b,d,g] in free variation with the voiceless set [p,t,k] in the word initial, unstressed position. The voiceless, unaspirated set of stops, however, will always become voiced in an onset position between two voiced segments or when filling the onset position of a stressed syllable. These stops could of course be analyzed as either voiced or unvoiced underlyingly, depending on whether we posit a voicing or a devoicing rule. I will follow Kingston's lead here (Kingston, 1979) and assume that the voiceless segments are underlying and that the following voicing rule applies:

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   C –> +voice /  {X  __   X}
 [-cont]          +vc     +vc
 [-asp]
 [-constr. gl]          OR

                       __V
                         +strs
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B. The /t/ will also be realized as [ɾ] intervocalically when it occurs as the onset of an unstressed syllable.

C. The voiceless, unaspirated stops /p,t/ have traditionally been realized as their voiced imploded counterparts [ɓ, ɗ] in word-initial, stressed environments. However, these imploded forms are now falling out of use with the younger generation.

2.2 Vowels

The Mamaindé vowel system consists of the 5 pure vowels /a,e,i,o,u/, as well as their nasalized and laryngealized (creaky voice) counterparts, producing a total set of 18 contrastive, simple vowels (5 pure vowels /a,e,i,o,u/; 5 nasal vowels / ãẽĩõũ/; 5 laryngealized vowels /a̱e̱i̱o̱u̱/; and 3 nasal plus laryngeal vowels, /ã̱, ĩ̱, ũ̱/). The neutralized vowel, [ə], is an allophone of /a/ and /o/ whenever these occur in non-primary stressed positions.[9] There are also the five diphthongs, /a^{i}, e^{i}, a^{u}, i^{u}, e^{u}/, which have their five nasal counterparts /ã^{i}, ẽ^{i}, ã^{u}, ĩ^{u}, ẽ^{u}/, and their five creaky voice counterparts / a̱^{i}, e̱^{i}, a̱^{u}, i̱^{u}, e̱^{u}/, as well as three dipthongs which are both nasal and creaky voice /ã̱^{i}, ã̱^{u}, ĩ̱^{u}/. This makes a total of 18 contrastive dipthongs as well. Combining the dipthongs to the simple vowels, we get the complete set of 36 contrastive vowels in Mamaindé, which makes the vowels an easy majority in terms of the total phonemic segments in this language.

Earlier proposals by Kingston (1976), concluded that nasality is an underlying feature of the nasal vowels. This is due to the fact that nasal and oral vowels are frequently contrastive.

(6)

hãnlat^{h}awa	*[hãn.la.t^{h}a.wa]*	it is white
hanlat^{h}awa	*[ha^{d}n.la.t^{h}a.wa]*	it wiggles
hãnaʔwa	*[hã:.naʔ.wa]*	I am white
hanaʔwa	*[ha:.naʔ.wa]*	I wiggle
jalãntu	*[ja.lãn.du]*	a toucan
jatantu	*[ja.da^{d}n.du]*	a deer
jalãnãni	*[ja.lã:.nã.ni]*	the toucan
jatanãni	*[ja.da:.nã.ni]*	the deer

Although there is some diachronic evidence in Mamaindé that nasal vowels could have originally been derived from nasal codas,[10] the need to distinguish

[9] The nasal /ã/ is always weakened to a central nasal vowel, even in stressed position.
[10] Possible evidence for earlier spreading of nasality from the nasal coda to the nucleus comes from the majority of the nasal vowels which are followed by a nasal coda. And for many of the nasal vowels without a following nasal coda, there also exists an older form of the same morpheme which does include the nasal coda. For instance, /hĩ̱ˈ/, 'then', has an older form /hĩ̱nˈkalu/, which is only used by the older speakers. However, forms such as /ˈjãih/, 'sad', /wãha/, 'wait', /t^{h}ã/, 'thing', and /jãˈ/, 'continue', among others, make it difficult to posit nasal spreading in a synchronic fashion. Nasal spreading in a diachronic analysis is still a possibility.

between the contrastive nasal and oral vowels as illustrated in (6) will force us to posit a [+nasal] as an underlying feature of the nasal vowels in the present day language. The faithfulness of vowels in respect to orality/nasality will become a crucial issue in the remainder of this paper.

3. THE DATA AND THE PROBLEM

3.1 Pre-stopped nasal formation

When and why do the pre-stopped nasals in Mamaindé occur?

(7)

root + article

a .taun + ãni	*> daunãni*	the tail
b. taun + tu	*> dau^{b}mdu*	a tail
c. tun + ãni	*> dunãni*	the flute
d. tun + tu	*> du^{d}ndu*	a flute
e. sin + ãni	*> sinãni*	the meat
f. sin + tu	*> si^{g}ŋdu*	meat (indefinite nominal)

It quickly becomes apparent that these special nasal forms occur in a very restricted environment. They never occur word initially as do the /n/ and the /m/. They also never occur intervocalically. They are found only in the coda position when followed by another consonant or word boundary (see figure (7), forms b,d, and f), and then only after re-syllabification has had a chance to occur. Since Maximization of Onsets is a highly ranked constraint in this language, codas are constantly forced to be re-syllabified as onsets whenever possible. This means that if a stem final nasal has been resyllabified as an onset after a vowel initial suffix has been added, the pre-stop will not be inserted and the nasal will go unchanged (see forms a,c,e).

The second thing we notice is that these forms always occur after oral vowels, and never after nasal vowels. Once again:

(8)

a. si^{g}ŋdu	meat
b. k^{h}anĩŋdu	round thing
c. wau^{b}mlat^{h}wa	it is red
d. gagãumlat^{h}wa	he is clumsy

Forms *b* and *d*, in figure (8), show that the pre-stop does not occur after nasal vowels. Forms *a* and *c* have oral vowels and so the pre-stop is inserted. Kingston (1974:3) described the environment for these forms in the following way, *"before an ensuing syllable-initial consonant (and after an oral vowel), syllable final .... nasals are realized as sequences of stops and homorganic nasals."*[11]

The consistency with which the pre-stopped nasals and the nasal vowels avoid each other makes it tempting to view the inserted stop as a sort of blocking device to keep oral vowels from becoming nasalized by the following nasal coda. Although I believe this may very well have been the historical source of such forms, this analysis is not possible in the present since we now have many minimal pairs such as the one below which force us to posit an underlying difference in the vowels.

(9)

a. han + lat^{h}*awa*	>	*ha*^{d}*nlat*^{h}*wa*	'it flops'
b. han + áʔwa	>	*hanáʔwa*	'it does not flop'
c. hãn + lat^{h}*awa*	>	*hãnlat*^{h}*wa*	'it is white'
d. hãn + áʔwa	>	*hãnáʔwa*	'it is not white'

(the accent mark indicates a change in tone and the presence of a negative)

The first form in (9) has an oral vowel before the nasal coda and a consonant following it. Therefore the rule applies and we get a pre-stopped nasal coda. The third form has a nasal vowel and therefore the rule does not apply.

Although Kingston's rule works, the focus on the "following consonant" can be a bit misleading. Since pre-stops are also formed word final, (such as *[jaho*^{d}*n]* 'old man') the deciding factor is not one of sequential segments, such as whether the nasal is followed by a consonant, but rather one of structural belonging. It is the syllable structure, and more specifically the rhyme, that is the domain of this rule. If the nasal belongs to the coda of a given syllable (at the post-lexical level) and the nucleus position is filled by an oral vowel, then the pre-stop is formed. The importance of this hierarchical structure will become clearer when we see that the formation of the pre-stop is actually due to a constraint which enforces identicalness within the rhyme.

[11] The words in parenthesis were part of Kingston's analysis, but he did not include them in his final rule. I have added them here for clarity.

3.2 Pre-stopped nasal place features

3.2.1 The interaction between vowels and consonants

As Kingston mentioned above, the pre-stop is always homorganic with the nasal it precedes. But it is not nearly so clear how the nasal segment gets its place features to begin with. Sometimes the nasal cluster appears to borrow its place features from the following consonant while at other times it obviously does not.

(10)

A. NASAL CODA SHARES PLACE WITH FOLLOWING CONSONANT:

tun-ani	*[dunãni]*	the bamboo	N - root
tun-tu	*[du^{d}ndu]*	a bamboo flute	
walek^{h}an-ã-sih-tu	*[walek^{h}anãsiRu]*[12]	a chief's house	N-root
walek^{h}an-tu	*[walek^{h}a^{d}ndu]*	a chief	
jahon-ãni	*[jahonãni]*	the old man	N -root
jahon-tu	*[jaho^{d}ndu]*	an old man	
alain-a-k^{h}atoʔ	*[ala^{i}nak^{h}əɾəʔ]*	I cross over, then	V - root
alain-k^{h}atoʔ	*[alai^{g}ŋk^{h}əɾəʔ]*	he crosses over, then	
litin-aʔwa	*[lidinaʔwa]*	I jump	V -root
litin-k^{h}atoʔ	*[lidi^{g}ŋk^{h}əɾəʔ]*	he jumps, then	
te^{i}n-aʔwa	*[de^{i}naʔwa]*	I close	V - root
te^{i}n-k^{h}atoʔ	*[de^{ig}ŋk^{h}əɾəʔ]*	he closes, then	

B. NASAL CODA DOES NOT SHARE PLACE WITH FOLLOWING CONSONANT

sin-ãni	*[sinãni]*	the meat	N -root
sin-tu	*[si^{g}ŋdu]*	meat	
le^{u}n-ãni	*[le^{u}nãni]*	the tapir	N - root
le^{u}n-tu	*[leu^{b}mdu]*	a tapir	
he^{i}n-ãni	*[he^{i}nãni*	the buriti fruit	N - root
he^{i}n-tu	*[he^{ig}ŋdu]*	a buriti fruit	
lan-áʔsiʔ	*[lanáʔsiʔ]*	not being full	V - root
lan-k^{h}atoʔ	*[la^{d}nk^{h}əɾəʔ]*	to be full (of water)	

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[12] When the /h/ and /t/ are adjacent, they coalesce to form a voiceless, aspirated alveolar flap, which I am encoding here as an [R].

aun-aʔwa	*[aunaʔwa]*	I err	V - root
aun-k^{h}atoʔ	*[au^{b}mk^{h}ərəʔ]*	he errs, then	
sun-aʔwa	*[sunaʔwa]*	I hit	V-root
sun-k^{h}atoʔ	*[su^{d}nk^{h}ərəʔ]*	he hits, then	
t^{h}on-áʔsiʔ	*[t^{h}onáʔsiʔ]*	not growing	V - root
t^{h}on-k^{h}atoʔ	*[t^{h}o^{d}nk^{h}ərəʔ]*	it grows, then	
taun-ãni	*[da^{u}nãni]*	the tail	N - root
taun-tu	*[dau^{b}mdu]*	a tail	
wain-sa̲-tu	*[wai^{g}ŋsa̲ru]*	medicine	N - root
eu-nna-k^{h}atoʔ	*[eu^{b}mnak^{h}ərəʔ]*[13]	you see, then	V - root

It isn't until we take note of the vowels that we see any sort of pattern at all. Here are the same examples as above, but resorted according to the vowels which precede the nasal.

(11)

sin-tu	*[si^{g}ŋdu]*	meat	N -root
litin-k^{h}atoʔ	*[lidi^{g}ŋk^{h}ərəʔ]*	he jumps, then	V -root
te^{i}n-k^{h}atoʔ	*[de^{ig}ŋk^{h}ərəʔ]*	he closes, then	V - root
he^{i}n-tu	*[he^{ig}ŋdu]*	a burití fruit	N - root
wa^{i}nsa̲-tu	*[wa^{ig}ŋsa̲ru]*	medicine	N - root
ala^{i}n-k^{h}atoʔ	*[ala^{ig}ŋk^{h}ərəʔ]*	he crosses over, then	V - root
a^{u}n-k^{h}atoʔ	*[a^{ub}m k^{h}ərəʔ]*	he errs	V - root
ta^{u}n-tu	*[da^{ub}mdu]*	a tail	N - root
le^{u}n-tu	*[le^{ub}mdu]*	a tapir	N - root
e^u-nna-k^{h}atoʔ	*[e^{ub}mnak^{h}ərəʔ]*	you see, then	V - root
lan-k^{h}atoʔ	*[la^{d}n k^{h}ərəʔ]*	full (of water)	V - root
walek^{h}an-tu	*[walek^{h}a^{d}ndu]*	a chief	N-root
tun-tu	*[du^{d}ndu]*	a bamboo flute	N - root
sun-k^{h}atoʔ	*[su^{d}n k^{h}ərəʔ]*	he hits, then	V-root
t^{h}on-k^{h}atoʔ	*[t^{h}o^{d}n k^{h}ərəʔ]*	it grows, then	V - root
jahon-tu	*[jaho^{d}ndu]*	an old man	N -root

[13] Notice this last form does not have a nasal coda in the root morpheme. The initial /n/ from the person affix /nna/ is resyllabified as the coda of the first syllable since the language does not allow for duplicate stops to occur in the onset of a syllable: eu.nna.k^{h}a.to? > eun.na.k^{h}ato? > eu^{b}mnak^{h}ərəʔ.

We immediately notice that the high front vowels or diphthongs, /i, ai, ei/, are all followed by a velar or dorsal coda. The diphthongs /au, eu, iu/ are followed by a labial coda. And the nasals that follow the vowels /a,o,u/ are always coronal.[14] The consistency with which the vowels condition the place of articulation of the following nasal is striking. Kingston (1976) noticed this aspect of the language as well. In the related language of Southern Nambiquara, Kroeker (1963:3) also cites evidence of vowels influencing the place features of nasal codas. But what has continued to remain a mystery in Mamaindé up to this point is why certain vowels should influence the nasal in certain ways. For example, why does the /i/ consistently cause the pre-stop to become velar in [si^{g}ŋ], whereas the /u/ is followed by an alveolar pre-stop in [du^{d}n], and the diphthong /a^{u}/ is followed by a labial pre-stop in [au^{b}m]? Are these cases of feature spreading or dissimilation?

3.2.2 Dissimilation not an option

At first glance, the above data could tempt us to posit some sort of dissimilation process within the rhyme. Back high vowels seem to give us front nasal codas, while front high vowels produce back nasal codas. But if we look at the articulators involved, a dissimilation strategy is not possible. First of all, dissimilation of the feature [back] would not force /a^{u}n/ to change to [a^{ub}m], since the nasal is already [-back]. Secondly, while /sin/ > [si^{g}ŋ] obviously undergoes a change in the place of the articulator, the /a^{u}n/ > [a^{ub}m] process is not a case of changing the place of a particular articulator, but a change in the articulator itself. These differences cannot be explained in a dissimilation approach.

Similarly, since there are two major [-back] points of articulation, Labial and Coronal, how do we know which [-back] or [front] point of articulation would be chosen as the opposite of [+back] or [Dorsal]? For instance, for a form such as /sun/, dissimilation of the [back] feature could never choose between outputs such as [su^{d}n] or [su^{b}m] since their codas are both [-back].

Granted, the case of /in/ > [i^{g}ŋ] does seem to be a possible candidate for dissimilation. But to posit a dissimilation process for the [i^{g}ŋ] forms and some different process for the [au^{b}m] type forms would be ignoring the obvious fact that these two cases are just different examples of the same thing – they are part of a larger phonological process by which Mamaindé vowels influence the place of articulation of coda consonants. Any analysis which can account for all of the forms by means of a single rule or constraint

[14] The absence of the /e/ vowel in this paradigm is due to the fact that the pure /e/ is never encountered before a nasal coda.

instead of two would be preferred. And that can only be done by rejecting a dissimilation approach.

It becomes clear, then, that in Mamaindé, a dissimilation process along the front/back continuum is not an option. We will need to find another reason for the change of place features in the nasal coda.

4. UNIVERSAL MOTIVATION: THE IRC CONSTRAINT

In this section I discuss what universal principles might be motivating the formation of the Mamaindé pre-stopped nasal as well as causing the unusual change of place features in the nasal coda.

When we look at the domain for both the pre-stopped nasal formation and the vowel place feature spreading processes, we begin to realize that these two phenomenon are related. They both result in identicalness within the domain of the rhyme. The nucleus and the coda of the Mamaindé syllable end up sharing features for place and for nasality. But we will later see that when the coda consonant is syllabified as an onset in intervocalic environments, neither of these processes occurs. It appears that the nucleus can only affect the features of a consonant which is in the coda, or more to the point, within the rhyme. I will posit, then, that these processes are motivated by a high ranking family of constraints which refers to this domain of syllable structure. At present, I have not found much in the way of accepted universal constraints pertaining to the features of the rhyme, so I propose the following informal constraint:

(12)

IDENTICALRHYME CONSTRAINT: (IRC)

Rhyme segments share identical features

This could also be re-stated as a negative constraint:

(13)

CONTRASTIVERHYME: (CR)

Rhymes do not bear contrastive features

Although I am not aware of either of these in the optimality literature, the latter follows the pattern of a constraint already proposed by Pulleyblank (1997:81), where ContrastiveCoda meant that "a coda does not bear contrastive features". What is needed in this case is simply an expansion of that domain to include the nucleus.

I prefer, however, to use the positive label, IdenticalRhyme constraint, simply because in most languages there is not such an obvious connection between the nucleus and the coda and the features within them. Using the positive term makes clearer what is intended. It also enables us to understand that the sharing of any features within the rhyme would satisfy this constraint even when there might also be some contrastive features present as well. In the sections that follow, I will propose two IdenticalRhyme constraints. The first one, IdenticalRhyme[nasal] will enforce identical values of nasality within the rhyme. The second, IdenticalRhyme[place], will push for identical place features within the rhyme.

Appealing to syllable structure as a basic motivation for these processes within Mamaindé is strengthened by the fact that this is a quantity sensitive language (see Eberhard 1995:chapter 2) where prominence (stress) is already given to syllables with branching rhymes.

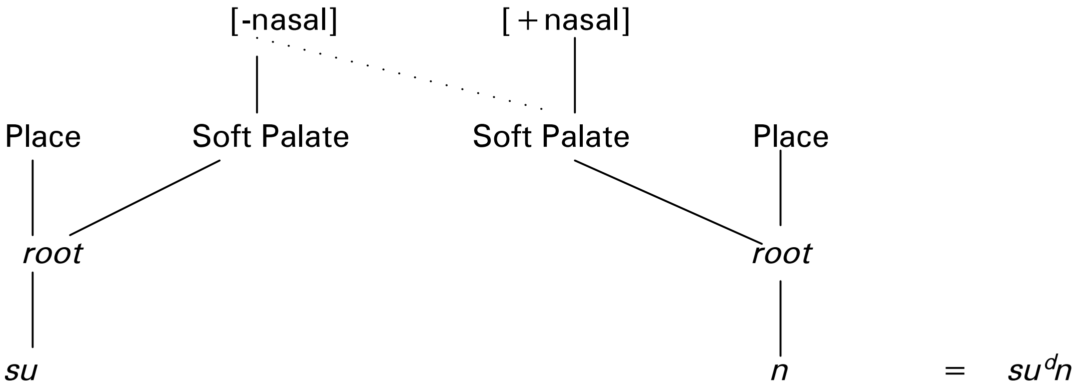
5. PRE-STOPPED NASAL FORMATION AND THE IRC

First we will tackle the question of pre-stop formation. As we saw in section 3.1, Mamaindé nucleus and coda positions must agree in their nasal or oral articulations. I believe this is because the Identical Rhyme Constraint is highly ranked with respect to the features oral/nasal. In autosegmental terms, this could be viewed as a simple oral or nasal spreading process[15]. More specifically, I am proposing a feature geometry which includes a Soft Palate Node linked directly to the root node, similar to the Soft Palate node outlined in Halle's Revised Articulator Theory (Halle 2000:389). For Mamaindé however, the terminal features of this Soft Palate node must be binary, [+nasal] and [-nasal], since both are underlying notions in this language. The fact that the nucleus and the coda always agree in nasal/oral articulation can then be accounted for by the spreading of the terminal features of the Soft Palate node from the nucleus to the coda. Whenever this spreading results in the sharing of the [-nasal] feature throughout the rhyme, the

[15] I use the term 'oral spreading' throughout this paper as another way of saying '[-nasal] spreading'.

surface representation is an oral vowel followed by a pre-stopped nasal coda which retains its original link to [+nasal] (as in /su^{d}n/ 'hit' below)[16].

(14) THE SPREADING OF THE [-NASAL] FEATURE



The spreading of the [-nasal] feature is therefore ultimately responsible for the formation of all the pre-stopped nasals in Mamaindé. And as is the case in most analyses, the spreading of [-nasal] is not a new idea. A similar approach has already been suggested by Anderson (1974:272-74) for certain Macro-Ge languages such as Maxakali, Kaingang, and Apinaye. Although using binary features for nasality is admittedly an unfortunate result of this analysis, I believe the language specific facts outlined in section 3.1 can only be accounted for by such an approach.[17]

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[16] The mirror image of this spreading could also occur - for example, the sharing of [+nasal] throughout the rhyme (as in /k^{h}ãn/ 'hard'). However, since both the vowel and the coda in /k^{h}ãn/ are underlyingly nasal to begin with, it would be impossible to determine whether the sharing of a [+nasal] feature in these cases is due to the OCP or to the IRC.

[17] Piggot, on the other hand (1992), claims that [-nasal] spreading is not necessary. He analyzes nasal systems with both simple nasals and prenasalized segments as having no nasal consonants at all, but simply [-cont] segments unspecified for nasality. In the context of nasal vowels, they take on the nasal quality of the adjacent vowel. In prenasalized segments, their nasality is only a phenomenon of the articulatory apparatus. But in Mamaindé his analysis will not work, for it is quite clear that the nasal quality of the nasal consonants in this language cannot be derived from the nasality of any adjacent nasal vowel, since many of them occur in non-nasal contexts (/nakananitu/ 'his brother'). If the nasal quality of an intervocalic nasal must be treated as underlying (/ suna'si's/) 'without hitting'), then the nasal quality of that very same segment in a different context must also be considered as underlying (/sun-latwa/ 'he hits',) These nasal codas are therefore underlying nasal consonants which become less nasal when they occur in specific environments. When they are intervocalic, they are realized as simple nasals, and when followed by a consonant they are realized as contour pre-stopped nasals. (See also Kenstowicz 1994:492).

I will posit a single constraint, the Identical Rhyme[nasal] constraint, or IRC[nas], to refer to this tendency to enforce oral/nasal agreement within the rhyme. *(I use the abbreviation [nas] here and in several other constraints throughout the remainder of this paper as an inclusive term for both of the terminal features under the Soft Palate node, i.e., the binary ±nasal features, both oral and nasal)*

(15)

IRC[NAS]
Elements within the rhyme share the same terminal features for ±nasal.

It is the IRC[nas], then, that motivates this part of the phonology. Any nasal coda following an oral vowel shares the [-nasal]of the nucleus in order to satisfy the IRC[nas] constraint, while at the same time keeping its original association to its [+nasal] feature. The result is a single contour nasal segment (such as /^{d}n/), whose two parts share all features except nasality.

As the definition of the constraint specifies, we must consider the IRC[nas] constraint to be satisfied whenever the nucleus and the coda both share the same feature of oral/nasal articulation, regardless of whether the nasal is also doubly linked to an opposite value of that feature. Although this position does not result in complete identicalness, it does recognize the sharing of a single ±nasal feature within the rhyme.

Added to this is the **FaithV[nas]** constraint, ensuring that it is the vowel that remains faithful to the input, for the nasality of the nasal never spreads to the vowel, but instead, it is the oral nature of the vowel which spreads to the nasal.

(16)

FAITHV[NAS]
Vowels are faithful in regards to their ±nasal features.

The above constraint assumes total faithfulness, or in other words, that the vowel in the output will maintain any links present to orality/nasality in the input, and the vowel in the input will contain all links to orality/nasality present in the output. So when it comes to vowels, no links to nasality can be deleted or added.

A further constraint is also necessary to ensure that the nasal coda maintains its attachment to the nasal feature.

(17)

MAXC[NASAL]
A consonant's link to any ±nasal feature in the input is retained in the output.

Since this is only a Max constraint and not a total faithfulness constraint, it allows for addition but not deletion. Therefore, it will be considered satisfied as long as the coda's original link to [±nasal] remains intact. This is regardless of whether or not the output has also become doubly linked to an opposite feature of nasality, as is the case for the nasal coda in /su^{d}n/ (see figure (14) above).

The last constraint dealing with the nasal/oral features is IdentOralC. This constraint ensures that oral codas will not acquire any new links in regards to the ±nasal features.

(18)

IDENTORALC
An oral consonant's link to any ±nasal feature in the output will be present in the input.

This last constraint is necessary for the few forms where nasal vowels are followed by oral codas, such as in the form /nũtdu/ -> [nũtdu], 'lizard'. Notice that the IRC[nas] does not apply and the coda does not become pre-nasalized or linked to nasality in any way – it remains oral. This is because IdentOralC is ranked higher than IRC[nas]. By adding IdentOralC to the previous set of constraints, we complete the description of a system where the nasal codas following oral vowels will become contour oral/nasal segments (pre-stopped nasals), but oral codas following nasal vowels will never become nasal/oral segments (pre-nasalized stops).

Since my purpose is to focus primarily on the nasal codas, the IdentOralC constraint outlined above will not need to be included in any of the tableaus in this paper. However, its presence will be assumed.

The tableau for the form /sin/ below shows the interaction of the above set of constraints (except for IdentOralC) and how they enable the optimum candidate to be selected. We will concentrate here solely on the issue of nasal/oral features, leaving the more complex changes in place features to be handled later.

(19)

PARTIAL TABLEAU FOR: /sin/ "meat" + /tu/ "indef. article"

[-nas] [+nas] **sin + tu**	**FaithV[nas]**	**MaxC[nas]**	**IRC[nas]**
sindu			*!
siddu		*!	
⇒si^{d}ndu			
sĩndu	*!		
siĩndu	*!		

(The final output form is [si^{g}ŋdu]. However, this includes constraints on place features which we are not discussing at the moment.)

Notice it makes no difference at this stage how we rank these three constraints. The outcome is always the same. Now we will try a tableau with a nasal vowel.

(20)

PARTIAL TABLEAU FOR: /hãn/ "white, complete" + /k^{h}atoʔ/ "connective"

[+nas] **hãnk^{h}atoʔ**	**FaithV[nas]**	**MaxC[nas]**	**IRC[nas]**
hank^{h}atoʔ	*!		*
ha^{d}nk^{h}atoʔ	*!		
⇒hãnk^{h}atoʔ			
hãdk^{h}atoʔ		*!	*
hã^{d}nk^{h}atoʔ			*!

Notice that the form [hã^{d}n] would have been just as worthy a candidate if we considered the IRC as being satisfied with two separate instances of the nasal feature, one in the nucleus and one in the coda. However, the IRC demands that the oral/nasal feature must be *shared*, not simply identical. This means that there cannot be any opposite value for that feature intervening between the two segments. This explains why the pre-stop is not allowed when the vowel is nasal.

What if the nasal is followed by a vowel instead of a consonant? The data in figure (7) showed us that in such cases the pre-stop does not occur. To handle this, we must include a constraint on syllabification – the MaxOnset constraint below.

(21)

MAXONSET
Intervocalic consonants are syllabified as onsets.

MaxOnset ensures that the force of the IRC will only be felt in situations where the coda cannot be syllabified as an onset in the output. Intervocalic codas, on the other hand, are subject to this syllabification constraint and become disassociated from the rhyme, making them invisible to the IRC. The tableau below shows one of these intervocalic nasals.

(22)

TABLEAU FOR: /sun/ 'hit' + /a/ '1st pers. subject' + /kʰatoʔ/ 'connective'

[-nas] [+nas] **sun+a+kʰa.toʔ**	**MaxOnset**	**FaithV[nas]**	**MaxC[nas]**	**IRC[nas]**
⇒**su.na.kʰa.toʔ**				
su.da.kʰa.toʔ			*!	
suᵈn.a.kʰa.toʔ	*!			
sun.a.kʰa.toʔ	*!			*
sũn.a.ka.toʔ		*!		

(Among other things, the final form [su:nakʰərəʔ] lengthens the vowel of the root as a result of the stress rule.)

In constructions such as the one above, the language chooses an output form that satisfies MaxOnset while at the same time avoiding IRC altogether. Ranking is still not an issue.

6. PLACE FEATURES AND THE IRC

6.1 Vowel Place feature models

We have seen how an oral nucleus affects the nasal feature of the coda. Now we will address the question raised in section 3.2.1, namely, how the nucleus can affect the coda's place features. In 3.2.2, we established that dissimilation is not the answer. In the following sections, I will show that instead of dissimilation, it is actually assimilation that is motivating this part of Mamaindé phonology, at times spreading a [+hi] feature from the /i/ vowel to the consonant to create a velar coda, and at other times spreading a [+round] feature from the /u/ to the consonant to create a labial coda.

But in order for any analysis of the data to be successful, we must first adopt a feature model which can allow for the type of interactions between vowel features and consonant features evident in this language, namely the correspondence between [+round] vowels and Labial consonants, and between [+hi] vowels and Dorsal consonants.

We will take a very brief look at three models of feature theory, the UFT (Clements), RAT (Halle), and a modified version of RVPT (Ní Chiosáin and Padgett). Our attention will be focused on how well these theories can handle the above correspondences between vowels and consonants in the Mamaindé language.

6.1.1 Unified Feature Theory (UFT)

We will begin by looking at Clement's Unified Feature Theory (UFT) (Clements 1989, 1991, Clements and Hume, 1995). Clement's proposes a system with 4 monovalent articulatory features; Dorsal, Coronal, Labial, and Pharyngeal. The strong point of this model is that the features are intended to define equally well the Place of both consonants and vowels.

When we consider the Mamaindé nasal codas which are realized as labials, the UFT model can account for the data quite intuitively.

(23)

a^{u}n-lat^{h}a-wa	>	*[a^{ub}mlat^{h}wa]*	he missed	V - root
ta^{u}n-tu	>	*[da^{ub}mdu]*	a tail	N - root

le^{u}n-tu	>	*[le^{ub}mdu]*	a tapir	N - root
eu-nna-k^{h}atoʔ	>	*[e^{ub}mnak^{h}ərəʔ]*	you see, then	V – root

The labial feature of the /u/ spreads to the coda and creates the appropriate labial coda segment. This correspondence between Labial consonants and the [round] feature in vowels has been noted by many linguists, since it is based on phonetic/articulatory grounds. Kenstowicz points out similar correspondences between vowel and consonant labial features in Tulu and Proto-Bantu (Kenstowicz 1994:462) supporting the idea that "[round] is the vocalic expression of labiality in consonants".

We find, however, that the Unified Feature Theory cannot account so easily for the changes in the coda following the Mamaindé /i/.

(24)

sin-tu	*[si^{g}ŋdu]*	meat	N -root
litin-lat^{h}a-wa	*[lidi^{g}ŋlat^{h}wa]*	he jumps	V -root
te^{i}n-k^{h}atoʔ	*[de^{ig}ŋk^{h}ərəʔ]*	close, then	V - root
he^{i}n-tu	*[he^{ig}ŋdu]*	a burití fruit	N - root
wa^{i}nsa̲-tu	*[wa^{ig}ŋsa̲řu]*	medicine	N - root
ala^{i}n-k^{h}atoʔ	*[ala^{ig}ŋk^{h}ərəʔ]*	cross over, then	V - root

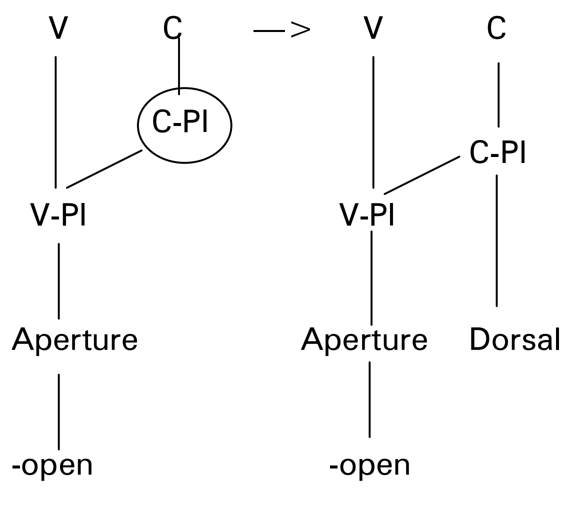
In the above data, we have coda consonants being influenced by the Coronal vowel /i/. The typical expectation would be that Coronal high vowels wouild influence codas by fronting velar consonants, producing palatal or alveo-palatal segments. Such palatalization processes are common in many languages, including Russian, Slavic, German, and Hungarian (Kenstowics 1994:464). But in Mamaindé, instead of palatalization of velars after high front vowels, we get velarization of coronals after the /i/.

While palatalization is quite common, this velarization of coronals after high front vowels is more difficult to find in the literature. However, it has been attested to in other languages besides Mamaindé. In Cologne German, for example, there is a diachronic process by which Middle High German simplex dentals have become Cologne German velars when preceded by Middle High German long high vowels (Scheer, 2001:314-317). Pirahã, a Brazilian language unrelated to Mamaindé, replaces the sequence /hi/ with the velar /k/ (Everett,) For more examples of this phenomenon in other languages, such as the Langsu languages of Yunnan and Burma, the Sinitic languages, some languages of the Western Lakes Plain of Irian Jaya, Berber, and the Antwerp dialect of Dutch, the reader is reffered to a summary posted on Dec. 17, 2002 at http://LinguistList.org/issues/13/13-3330.html.

If we are limited to the unified set of Dorsal and Coronal features for vowels and consonants, it would be difficult to posit any type of assimilation rule for the velarization process shown in (21). And any effort to conform the articulator model (i.e. Dorsal and Coronal) to the Mamaindé data by positing repair rules (where Coronal > Dorsal in specific environments) would simply be hiding the fact that this is a phonology system where the articulator involved is really not the crucial issue. In Mamaindé, we will see in the following pages that it is the height and roundness of the segment, not the articulator, which is most relevant.

An appeal to height is theoretically possible in the UFT model by way of the Aperture node, which includes several levels of openness. However, the Aperture node is dominated by the Vocalic node and thus is normally considered to apply to vowels and not consonants (see discussion in Halle 2000:406). Although the Aperture node is not usually used in spreading processes between vowels and consonants, the Unified Feature Theory does allow for the idea of "promotion", where the V-Place feature of a consonant's secondary articulation takes the place of the primary C-Place feature. This is argued for in consonants which have lost their primary place feature (see Kenstowicz 1994:466). This same logic could be used (Clements, personal comm. 2002) to spread the height features from the Aperture node of a vowel (presumably through the V-Place node) to the C-place of a following consonant which is unspecified for Place. However, how the consonant's place features would finally be filled in is unclear. It is possible that a repair strategy such as the one below might be invoked (the circle indicates a featureless node).

(25) THE UFT APPROACH



The end result would be a consonant whose primary C-Place is filled in by the articulator feature which most corresponds to the height of the vowel. In Mamaindé, that is the Dorsal feature. Assuming that the coronal feature is the unspecified place feature for consonants in Mamaindé, a sequence such as /in/ would then correctly surface as [iŋ] (this is an oversimplification of the output form [i^{g}ŋ]).

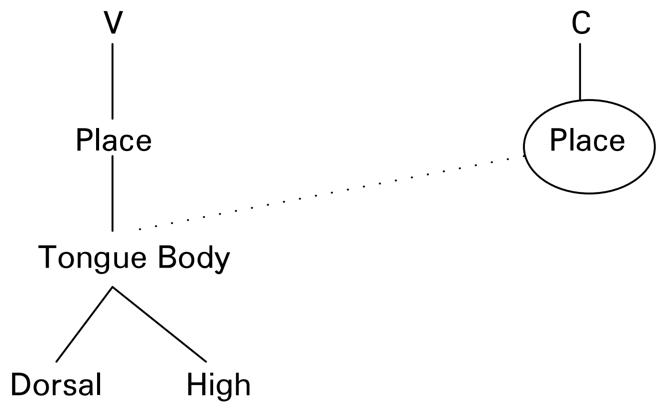
The above discussion has shown that UFT can eventually account for both the case of the Mamaindé /u/ and the /i/. However, it struggles to propose a unified analysis. In the first instance, it spreads an articulator feature (labial) from the V-place node of the vowel to the coda consonant, and in the second instance it spreads a height feature (-open) from the Aperture node of the vowel to the coda. In the case of Labial spreading, no repair strategies are necessary - the consonant gets its articulator feature directly from the vowel, while in the case of the spreading of the aperture node, a repair strategy must be invoked for the coda to receive its articulator feature. I believe that such unrelated processes for dealing with /u/ and /i/ hide the fact that both of these cases are examples of a single phenomenon in Mamaindé – the sharing of place features throughout the rhyme.

Another drawback of this analysis is that the promotion strategy seems better designed to spread articulator type features (labial, dorsal, etc.) from the V-place to the C-place node than height or aperture features. The height of the consonants in this model is intended to be encoded under a stricture node instead of the aperture node. It is not clear how the model would handle a consonant with an aperture node and no stricture node.

6.1.2 Revised Articulator Theory (RAT)

One attempt to incorporate [high] back into feature theory is the Revised ArticulatorTheory (RAT) proposed by Halle, Vaux, and Wolfe (2000). This model calls for a return to some of the more traditional SPE features (Chomsky and Halle, 1968). It also retains the use of the articulator nodes and features, such as Dorsal and Coronal. The feature [high] is available only under the Dorsal node. The actual place features of the vowels are not clearly specified by the authors, but personal communication (Halle 2002) confirms that the author views all vowels as Dorsals, following the lead of Sievers, a German phonetician. This view of vowels allows for an extremely simple analysis of the Mamaindé /i/. By sharing the Tongue Body node of the /i/ with the coda, the result is a high, Dorsal consonant.

(26) THE RAT APPROACH



Thus the Mamaindé data, which requires some way of linking high with Dorsal, adds empirical support for the feature hierarchy proposed by the RAT model. However, since this model considers *all* vowels to be Dorsals, it is not clear how it would distinguish those vowels which cause velarization from those which do not. That difficulty will eventually cause us to adopt another approach in this paper. The RAT model, however, makes some interesting predictions about vowel/consonant features which are reflected in some of the phonological processes at work in the Mamaindé rhyme. Others may eventually be able to use this model to overcome some of the difficulties involved and provide a more convincing analysis of the Mamaindé data than I have been able to accomplish here.

6.1.3 Modified Redundant Vowel-Place Theory (RVPT)

Other theories notwithstanding, I believe what is needed for the Mamaindé data is a return to some of the place features found in the more traditional SPE model, particularly the notions of [high] and [round], without tying these to the articulator features. These SPE features should preferably be linked to the same node and applicable to both vowels and consonants. Ní Chiosáin and Padgett (1993) proposed a feature geometry model, the Redundant Vowel-Place Theory, which meets these requirements. This model employs the articulator features for consonants under C-Place, but SPE features for vowels under V-place. The major innovation of this theory is that all consonants are specified with V-place features as well as C-place features. Even pure consonants without secondary articulations are represented as having a V-place node which is specified by inherent, redundant vowel features that correspond to the consonant's C-place feature. These correspondences are spelled out in equivalency relations.

The equivalency relations posited are the following:

(27) RVPT EQUIVALENCY RELATIONS[18]

[labial] and [round],
[coronal] and [-back]/[+high],
[dorsal] and [+back]/[+high],
[pharyngeal] and [+low]/[+back].

The end result is a model that allows for SPE features that are grouped under a single V-place node to be easily shared by both vowels and consonants.

The above relations already account for the correspondence between [labial] and [round]. The link between the Mamaindé /i/ and the Dorsal feature is a bit more problematic, but can be readily predicted by RVPT, if we take into account the redundancies in the Mamaindé vowel system. We will soon see (in section 6.3) that the Mamaindé vowel features can be reduced to [±high] and [±round] alone. The features [back] and [low] are not contrastive in this language and are never appealed to in any of the vowel feature spreading processes. With that in mind, we can take the features [back] and [low] out of the equivalency relations. And since it is the coronal coda that is always affected by the vowel, we will also posit coronal as the underspecified place feature of Mamaindé consonants. By taking out coronal as well, we are left with the following equivalency relations.

(28) REVISED EQUIVALENCY RELATIONS FOR MAMAINDÉ:

[labial] and [round]
[dorsal] and [high]

These correspondences are exactly what the Mamaindé phonology requires. Therefore, throughout the remainder of this paper I will assume an RVPT feature model, modified slightly to fit the Mamaindé data. (borrowed and modified from Ní Chiosáin and Padgett 1993:4)

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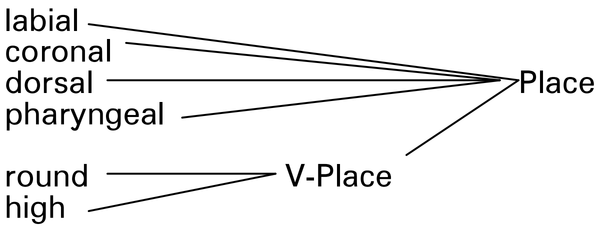
[18] The biggest limitation of RVPT is that it must rely on equivalency relations in order to fill in place features of the coda. But unlike the repair strategy required by UFT, it does this in a consistent way each time, regardless of whether the vowel is the /u/ or the /i/.

(29) RVPT FEATURE MODEL

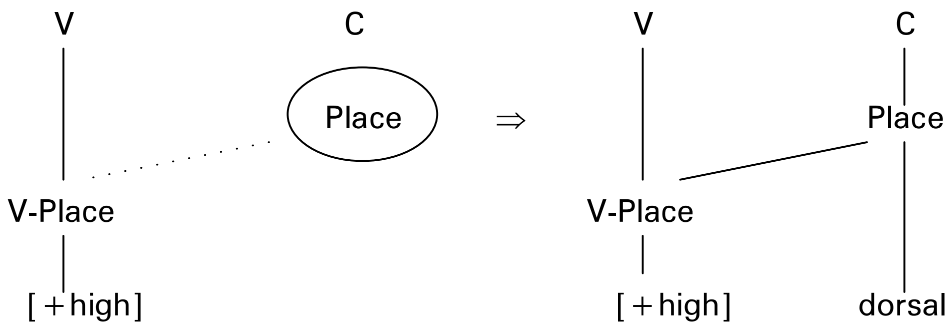


Besides making the features [high] and [round] available in both vocalic and consonantal contexts, this model separates the features [hi] and [round] from the articulator features, something which RAT is unable to do. This model also keeps the notions of height and roundness together under one V-place node, allowing them to be accessed by a single spreading process, something which is difficult to accomplish in UFT.

An example of how RVPT actually handles the Mamaindé data is shown below. Here we have a representation of the velarization of a coronal coda, one of the most difficult processes in Mamaindé to account for. The [+high] feature is spread from the vowel to the coda through the V-place node. The revised equivalency relations posited in (28) are applied to the output and a dorsal coda results.

(30) MAMAINDÉ PLACE FEATURE SPREADING USING AN RVPT APPROACH

(these insights will be presented in OT terms in section 6.4)



One drawback to the RVPT approach, however, should be mentioned. It does require a fair amount of theoretical power, in the form of equivalency relations, for the analysis to succeed. However, in the absence of a simpler solution, and since the equivalency relations stated above actually seem to capture the generalizations found in this language, I will assume the RVPT feature model for the remainder of this paper.

The entire discussion in the section above serves to highlight one of the more crucial points of this paper; namely, that some of the current models used to depict vowel and consonant features are not totally adequate for dealing with cases like Mamaindé where vowels and consonants interact in interesting ways across the Coronal/Dorsal divide. I trust that future advances in phonology will continue to address this issue of vowel/consonant features, taking into account data from lesser know languages such as Mamaindé.

6.2 The Need for Underspecification

Another look at the data reminds us that [high] and [round] are the only features which spread from the vowel to the coda. Other vowel features, such as [back] and [low] are never involved in the spreading process. In fact, the feature [back] is never appealed to in any of the numerous phonological constraints found in this language. This indicates that the [back] feature may not be necessary in this language at all. By reducing the number of vowel features available, we might have some way to explain the relationship between vowel and coda place features in Mamaindé.[19]

Generally it is felt that the underspecification of input representations is incompatible with the output orientation of OT. Recent research has allowed for underspecification only in very specific situations, such as output underspecification which emerges as a property of the grammar (Ito), and the underspecification of alternate surface forms which are predictable (Inkelas). In this paper, I will appeal to the underspecification of vowels simply because the phonology of this language does not make use of the feature [back] and also because adopting this view allows us to capture generalizations about the way vowels influence the place features of consonants which would not be possible without underspecification.

First of all, the IRC Place would be difficult to satisfy without underspecification since the features that are shared throughout the rhyme

[19] No matter which of the three feature models we adopt, some underspecification will be necessary. An UFT approach to the Mamaindé data would require the underspecification of the Coronal feature of the /i/ vowel, while both RAT and RVPT require the underspecification of [back].

do not constitute a complete feature class or node. In each case some vowel features are shared while others are not. Without appealing to underspecification, we would be forced to break up the IRCPlace into numerous separate constraints – one dealing with each possible vowel feature (i.e. IRCHigh, IRCLow, IRCBack, IRCRound, etc.) which would then have to be ranked appropriately. Such an individualistic approach would fail to recognize that each of the cases of feature sharing result from a single motivation, and are therefore best viewed as being part of a single spreading process of the V-Place node, instead of the spreading of individual features. Underspecification reduces the vowel features available to the phonology and allows us to posit a single spreading of the V-Place node.

Secondly, and more crucially, as we shall see in Sec. 6.7, without underspecification it would be impossible to differentiate the simple /u/ (which doesn't participate in spreading the [round] feature – as in the form [du^{d}ndu]) from the /u/ of the diphthong (which **does** spread the feature [round] – as in the form [a^{ub}mlat^{h}wa]). Although the behaviour of the /u/ seems to suggest a vowel/glide distinction, this is not true of the /i/. Notice that both the simple /i/ of [si^{g}ŋ] and the diphthong /i/ of [ha^{ig}ŋ] participate in spreading the feature /high/ to the coda. A difference between vowels and glides is clearly not the issue here. Since the language doesn't treat these semivowel segments as glides, we have to have another way to distinguish the simple /u/ forms from their diphthong counterparts. We will see that by further underspecification of diphthongs, particularly the VPlace2 node, this distinction is possible. Without underspecification, this distinction is lost.

6.3 Underspecification of Vowel features

A look at the data in (3.2) shows that the nasal assimilation to the vowel completely ignores the feature [back]. Take for example the forms /sin/ and /daun/. Although the /i/ in / sin/ is a front vowel, we get a pre-stop that is back, or velar; [si^{g}ŋ], 'meat'. And whereas the /au/ in /daun/, 'tail', contains a back vowel, the pre-stop is fronted or labialized, [dau^{b}m]. Finally, in the case of the central vowel /a/, a nasal coda following the /a/ will have a coronal point of articulation [yada^{d}ndu], 'deer'. Thus, we will claim that the backness (or frontedness) of any given vowel is not distinctive in Mamaindé. Goldsmith also does a similar thing by eliminating backness from his vowel feature inventory (1990:302), only adding it at the end of the phonology as a redundancy rule. But in Mamaindé, the data shows that this feature is completely ignored, suggesting that phonologically, at least, it is simply not there.

In the end, Goldsmith described a 5 vowel system that can be characterized by only two criteria: the roundness and the height of the vowel.[20] It will soon become apparent that these two criteria are exactly what Mamaindé phonology requires as well, although we will also need to retain the feature Low in order to be able to distinguish between /a/ and / e/. We have now arrived at a minimal specification for the Mamaindé vowels.

(31)

MAMAINDÉ VOWEL SYSTEM USING 3 FEATURES:

	Round	**Hi**	**Low**
a	-	-	+
e	-	-	-
i	-	+	-
o	+	-	+
u	+	+	-

(The feature [Low], while necessary to differentiate /a/ from /e/, does not take part in the feature spreading process. Therefore, unless otherwise necessary, I will not refer to the feature [Low] in the remainder of this paper.)

6.4 The IRC [place] constraint

We now consider the actual constraints which will be necessary to handle this phenomenon of place feature spreading within the Mamaindé rhyme. As we saw in section 3.2, the Mamaindé nasal coda consistently shares the place features of the preceding nucleus. And in section 4, I introduced a family of constraints, the IRC constraints, to deal with identicalness within the

[20] Goldsmith also made use of privative features - where only one value of a given feature is marked. I am not proposing privative features for Mamaindé.

rhyme. Here I will propose another constraint in the IRC family, the **Identical Rhyme[place]** constraint, to describe this tendency to share place features throughout the rhyme. It will be reffered to in our notation as the IRC[place]. This constraint is at the heart of this portion of the phonology.

(32)

IRC[PLACE]
Elements within the rhyme share identical V-place feature nodes.

The IRC[place], then, is responsible for all the changes in place features of the nasal codas listed in 3.2. For example, the coronal nasal in the form */sin/* becomes [high] following a [high] vowel, *[si^{g}ŋ]*, due to this constraint on rhyme place features.

Notice that these changes in the place of articulation of codas are not due to the presence of adjacent consonants when syllables are juxtaposed, as is often the case in other languages, but rather, to the presence of certain features within the rhyme of the syllable itself. This shows how important syllable structure, and particularly the concept of the rhyme, is to Mamaindé phonology. These constructs are also appealed to in other areas of the phonology, such as in constraints dealing with stress (Eberhard 1995), and tone (Eberhard, forthcoming).

Two faithfulness constraints are necessary for IRC[place] to have the desired output. **FaithV[place]** is needed to maintain the place features of the vowel, while **FaithC[place]** must be ranked lower than either IRC[place] or FaithV[place]:

FAITHV[PLACE], IRC[PLACE] >> FAITHC[PLACE].

This ranking forces the coda to change its place features instead of the vowel. Notice that this ranking visually demonstrates that in Mamaindé, vowels dominate consonants in terms of faithfulness.

Below is a tableau for the form /sin/, "meat", showing how the correct ranking of these constraints eliminates candidates which violate either FaithV or IRCPlace. The optimal candidate is one which violates neither of these, and spreads the vowel place features (+hi, -rnd) to the coda, creating a velar nasal.

(33)

PARTIAL TABLEAU FOR: /sin/ "meat" + /tu/ "indefinite article"

[+hi], [-rnd] \ / sin + tu	FaithV [place]	IRC [place]	FaithC [place]
sindu		*!	
⇒ siŋdu			*
simdu		*!	*
sendu	*!		

(In the previous table, I have not included the actual output form, [si^{g}ŋdu], as one of the possible candidates since that involves constraints on nasality which we are not considering at the moment. What we are looking for here is simply a correct ranking of the constraints which deal with Place. A fuller tableau will be discussed later where both [place] and [nasal] constraints are included.)

If FaithC[place] were ranked higher than IRC[place], the incorrect form /sin/ would have been chosen. And if it were ranked higher than FaithV[place], [sendu] would have been the optimum candidate.

It should be noted that this set of constraints also predicts the correct output for forms with oral codas, such as the ones below:

(34)

FORMS WITH NON-NASAL CODAS

a. /lit/ + /aʔ/ + /wa/ ` = [liɾaʔwa] 'I am leaving'
b. /lit/ + /ta̠ʔ/ = [likta̠ʔ] 'to leave and...'

c. /we^{i}s / + /aʔ/ + /wa/ = [we^{i}sãʔwa] 'I am making'
d. /we^{i}s / + /ta̠ʔ/ = [we^{i}kta̠ʔ] 'to make and...'

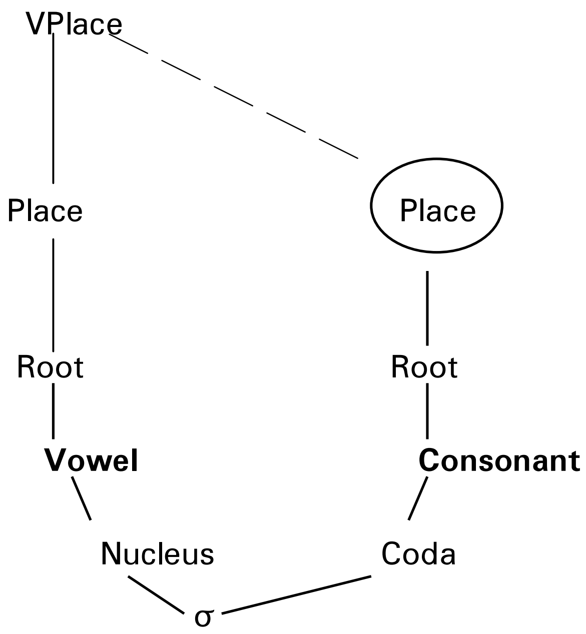
Notice that in 18 (b) and (d) above, the high vowel spreads its [+hi] place feature to the oral coda. Forms (a & c), where a syllabification constraint changes a coda into an onset, are not affected. These examples show that identicalness within the rhyme, or the IRC[place] constraint, is a widespread force in this language, applying to oral as well as nasal codas.

There is one type of coda, however, that is not affected by the IRC. These are the non-alveolar codas. To handle this we will need to split the FaithC[place] into two constraints, one dealing with alveolars and one with non-alveolars.[21] These two faithfulness constraints will be spelled out further in section 8.1, when we consider data with non-alveolar inputs. But since the bulk of this paper focuses on the alveolar nasal coda, such detail will not be necessary in the majority of our tableaus and FaithC[place] will be referred to as a single constraint throughout.

For a visual representation of the effects of IRC[place], we could construct an autosegmental rule such as the one below:

(35)

THE VOWEL PLACE SPREADING RULE (VPS)



(In an autosegmental analysis, alveolars would be unspecified for place since they are the only codas subject to change. The circle refers to these unspecified consonants. The nasal coda is alveolar and would thus be considered underspecified and one of the obvious targets for the above rule.)

Although the autosegmental rule above is a faithful representation of the spreading process involved, I believe this particular aspect of the language is best captured by appealing to cross-linguistic constraints instead of language specific rules. Regardless of the theory used, however, the main point in this

[21] This could also be handled by considering the coronal place feature the unmarked and therefore unspecified place feature for consonants.

discussion is that the data shows us a language where the nucleus is affecting the place feature of the coda. While place feature spreading in many languages seems to occur mostly between vowels or between consonants, here we see a language where place spreading occurs across the vowel/consonant divide, and where the vowel is considered the more dominant player in this drama. It remains to be seen if this vowel dominance in vowel/consonant relations is unique to Mamaindé, or whether this has been attested to in other languages as well. One thing is certain, it is one of the more interesting parts of Mamaindé phonology.

6.5 The low vowels

As we mentioned earlier, the case of the low vowels {o,a} not participating in the place spreading process poses a problem. Notice the forms below where the vowels do not spread any of their place features to the coda:

(36)

UF	SF	Gloss
t^hon + k^hatoʔ >	t^ho^{d}nk^{h}ərəʔ	= "grow" + "then"
jatan + tu >	jada^{d}ndu	="deer" + "indefinite article"

The coda remains coronal. These forms force us to posit another constraint. For lack of a better name, I will refer to this as:

(37)

*LOWV[PLACE]SPREAD
Low vowels do not share place features with codas.

This constraint prohibits a low vowel[22] from spreading its place features to a coda consonant. Or, to put it another way, when a syllable nucleus is low, the coda must remain faithful in terms of place. Although seemingly adhoc on the surface, this alludes to the fact that there is something about high vowels that can affect consonants in a way that low vowels cannot. I believe this has a phonetic basis - it is their closer proximity to the articulation of consonants that makes high vowels capable of spreading their features to those

[22] I use the feature "low" loosely in this paper, as a shorthand to specify the vowels who have no instance of closed aperture at the aperture node.

consonants.[23] Kenstowicz (1994:42) makes mention of the ability of front high vowels to influence the place of articulation of consonants. Similarly, it is only the high vowels that can be viewed as glides, taking on a consonantal nature when occuring in non-nuclear positions within the syllable. Low vowels, it seems, have no such affinity with consonants.

This constraint must be crucially ranked above IRC[place]:

FAITHV[PLACE]; *LOV[PL]SPREAD >> IRC[PLACE] >> FAITHC[PLACE]

Note the necessity of this newly added constraint in the following tableau. If it were not included, or if it had been lower ranked than IRCplace, the candidate with the labial coda, [thom], would be chosen. As it is, this constraint does not allow the low vowel to spread its [+rnd] feature to the coda.

(38)

PARTIAL TABLEAU FOR: /t^hon/, "grow"

[-hi] [+rnd] ＼ ／ **t^hon**	**FaithV [place]**	***LoV[pl]spread**	**IRC[place]**	**FaithC[place]**
⇒ **thon**			*	
thoŋ			*	*!
thom		*!		*
tha^um	*!			*
thun	*!		*	

(This table also does not include the final output form, /tho^dn/, because we are not dealing with constraints on nasality here. The chosen output, /thon/, however, displays the correct place features for the coda.)

Notice the correct candidate [t^hon] above was selected based on the presence of the low ranked FaithC[place] constraint. The FaithC[place] is necessary only in those cases where the IRC[place] is not able to select a winning candidate. This situation comes up whenever we have a low vowel followed by a nasal coda. In these cases the underlying /n/ maintains its place features.

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[23] Although I believe it to have phonetic reality, this constraint must still be viewed here as a proposal based on language specific data, and not a proven cross-linguistic constraint. It would of course be interesting to see if this type of constraint has been attested to in any other language.

Here we can also see the specific ranking of FaithV[place]. If FaithV[place] were ranked lower in respect to IRCplace, /tha^{u}m/ would have been selected. But ranking it lower than *LoV[pl]spread makes no difference. So we now have a basis for the ranking above, where FaithV[place] is put on equal grounds with *LoV[pl]spread but ranked higher than IRCplace.

6.6 The simple /u/

The other vowel which does not participate in this feature spreading process is the simple /u/. Neither its [+rnd] feature nor its [+hi] feature is spread to the coda. Instead, the following nasal always remains alveolar.

(39)

[du^{d}ndu] - *flute*
[su^{d}nk^{h}aʔa] - *hitting stick*

The reason for this lies in the manner in which the IRC constraint is satisfied in Mamaindé. The IRCplace is considered satisfied only when the nucleus and coda share the same VPlace node. Just the spreading of a single place feature from the nucleus to the coda does not fulfill this requirement. If spreading occurs, it must involve the entire VPlace node. And here, in the case of the /u/, the VPlace node has two features, [+high] and [+round]. Now the only other segment in the Mamaindé phonetic inventory which could possibly combine these two features is the /w/. However, a strong coda licensing restriction in Mamaindé (Eberhard 1995:15) prohibits any [+continuant] segment from appearing in the coda. Coda licensing[24], then, effectively keeps the /u/ from spreading its Vplace node to the nasal. This coda licensing restriction can be encoded in a constraint as follows:

(40)

CODA[-CONT]
Codas are [-continuant]

Since this constraint is allowed to block the effects of the IRC[place] constraint, we know it is ranked higher:

CODA[-CONT] > IRC[PLACE]

[24] For a comprehensive treatment of coda licensing, see Goldsmith (1990).

In Tableau 6 we see the effects of this constraint on the form /tun/ "flute".

(41)

PARTIAL TABLEAU FOR: /tun/, "flute"

[+rnd] [+hi] **tun**	**FaithV [place]**	**Coda [-cont]**	***LoV[pl] Spread**	**IRC place**	**Faith Cplace**
⇒ **dun**				*	
duŋ				*	*!
dum				*	*!
din	*!			*	
duw		*!			*

(The form /tun/ becomes /dun/ because voiceless consonants are voiced in the onset of stressed syllables and between voiced segments)

Notice that the form [dum] would have been chosen if the IRC allowed for spreading of only the [+rnd] feature. But the IRC demands a sharing at the Vplace node level, not at the feature level. The /m/ is not [+rnd] AND [+hi] so /dum/ violates the IRC. And the only segment which is [+rnd] and [+hi], the /w/, is rejected by the Coda[-cont] constraint.

6.7 The case of diphthongs

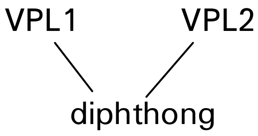
While the simple /u/ is restricted from spreading the [+rnd] feature to the coda, the /u/ of the diphthong is clearly permitted to do so. Some examples of this sharing of [round] when the diphthong is present:

(42)

[da^{ub}*mdu]* - *'tail'*
[gade^{ub}*mdat*^{h}*ã]* - *'life'*

What is the difference between the simple /u/ and the /u/ of the diphthong? It appears that Mamaindé views the second vowel articulation in a diphthong as different from that of the primary vowel articulation. This could be used as an argument to consider these as glides. But in the final analysis, diphthongs actually will allow for a simpler set of constraints.[25] We will treat the two nodes of a dipthong as VPL1 (primary vowel articulation) and VPL2 (secondary vowel articulation).

(43) DIPTHONG STRUCTURE



Thus [a^i, e^i, a^u, e^u, i^u] are considered to be single vowel segments with two place nodes. The first place node can be filled in with any of the 5 vowels, and these must be specified with enough features in order to differentiate between them. The second place node, however, will only be filled in by a much more limited set – the high semi-vowels /i/ or /u/. In this position, then, we would only need to designate a single feature to each of these two vowels in order to distinguish between them. And that is apparently what occurs in the Place 2 node - for in this position, only the [+high] feature ever spreads from the /i/, and only the [+round] feature ever spreads from the /u/. The [+high] feature of the /u/ is not needed here. We will assume then that the [+high] of the /i/ and the [+round] of the /u/ are the only distinctive features necessary in the VPlace 2 node.

(44) VPLACE2 NODE FEATURES:

i > +high
u > +round

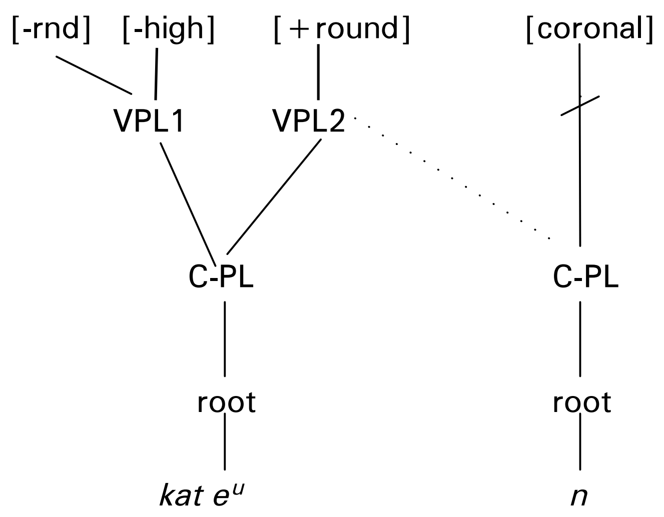
---

[25] Opting for glides is very tempting here. In one sense it would make the distinction between the simple u and the u of the diphthong more obvious, thus becoming /u/ and /w/. That would be a benefit of using glides. It is also tempting to think we can forget the whole notion of identicalness within the rhyme and simply use the identical coda constraint to show how the glide affects the following consonant within the coda. However, the case of the simple /i/ spreading the [+hi] feature to the coda in a very consistent manner forces us back to the domain of the rhyme. Anything less will not deal with the data. So while it is possible to use glides instead of diphthongs in Mamaindé, we are basically just simplifying the nucleus in order to add complexity to the coda. The analysis of place spreading to the coda, however, is not simplified. We must still eventually deal with the issue of how the nucleus affects the coda. Therefore, if we use glides, this place spreading to the coda would require 2 constraints, one for identicalness within the coda and another for identicalness within the rhyme. By keeping the diphthong approach, we will only need one identicalness constraint, making it more obvious that this phenomenon of coda feature changing is a single process.

Below is an example of Mamaindé diphthong structure and the subsequent spreading of the vowel place feature using an autosegmental model.

(45)

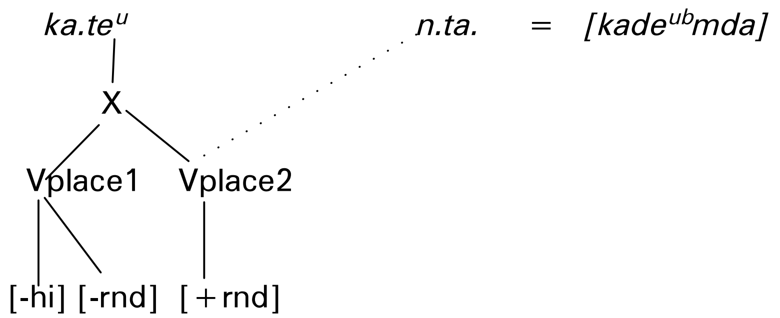
AUTOSEGMENTAL MODEL OF THE FORM:
/kate^{u}nta/ +/t^{h}ã/ > [kade^{ub}mdat^{h}ã] - "alive+nominalizer =life"



As we can see above, the spreading of this [+round] feature from the VPL2 node would not violate the IRC constraint as it did in the case of the simple /u/, since here the two segments are sharing a Place node, not just the feature itself.

Diphthongs also show that the push towards similarity of place features within the rhyme does not always result in total identicalness. Take the form /kate^{u}nta/ > [ka.de^{ub}m.da.] "it is alive". Here, as in all diphthongs in Mamaindé, the single nucleus position is linked to both a Vplace1 and a Vplace 2 node.

(46)



The Vplace 2 node of the diphthong then spreads its place feature, [+rnd], to the nasal coda, creating a labial nasal. But the place1 node of the diphthong does not become [+rnd]. This is because FaithV[place] is ranked higher than the IRC[place] in this language. Apparently vowel faithfulness is more important in Mamaindé than whether or not total identicalness within the rhyme is achieved. But even when total identicalness is not possible (such as in forms with diphthongs), the effects of the IRC[place] are still felt on the coda and seem to be perfectly acceptable in Mamaindé. That is why we must consider the IRC[place] to be satisfied as long as the nucleus and coda are sharing a single place node, regardless of whether the nucleus or coda happens to be linked to another place node as well.

We will now consider how the above constraints will handle input which includes a diphthong. Here is a tableau for the input /ta^{u}n/, 'tail', which has a final output form of [da^{ub}m].

(47)

PARTIAL TABLEAU FOR: /ta^{u}n/ = "tail"

[+rnd] **|** **ta^{u}n**	**FaithVplace**	**IRC place**	**Faith Cplace**
da^{u}n		*!	
da^{u}ŋ		*!	*
⇒ **da^{u}m**			*
du:m	*!		

The above tableau shows that the [+rnd] feature is not restricted from spreading when the vowel is a diphthong.

Our constraints on place features are also able to choose the correct coda when the vowel is nasal. This is shown in the following tableau.

(48)

PARTIAL TABLEAU FOR: /ã^{u}n/ > [ã^{u}m] "leave":

[+rnd] [+hi] ã^{u}n	FaithV [place]	IRC [place]	FaithC [place]
ã^{u}n		*!	
ã^{u}ŋ		*!	*
⇒ã^{u}m			*
ũ:m	*!		*

Finally, just as in the case of pre-stop formation, we need to add the MaxOnset constraint to our tableaus to account for those forms where the nasal coda is followed by a vowel.

(49)

PARTIAL TABLEAU FOR: /sin/ "meat" + /ani/ "definite article"

[+hi] sin + ani	MaxOnset	FaithV [place]	IRC [place]	FaithC [place]
⇒si.na.ni				
siŋ.an.i	*!			*
sim.an.i	*!		*	*
sin.an.i	*!			
se.na.ni		*!		

The high ranking of MaxOnset ensures that intervocalic nasals are never affected by the IRC, either in terms of nasality, or in terms of place features. For this reason, we will not need to consider intervocalic codas, nor the MaxOnset constraint, in any of the remaining tableaus in this paper.

7. COMBINING PLACE AND NASAL CONSTRAINTS

Now we will combine the constraints on nasality, which were described in section 4, with the constraints on place features which we have just seen. When we consider all of these together, we come up with the following constraint ranking:

MAXONSET, FAITHV[PL], FAITHV[NAS],
CODA[-CONT],*LOV[PL]SPREAD, MAXC[NAS]
>>IRC[NAS], IRC[PLACE]
>> >FAITHC[PLACE].

The last tableau below combines all of these constraints (except for MaxOnset which is not relevant here), showing how they interact. It also shows us that FaithC[nas] and FaithV[nas] must be ranked higher than IRC[place]. Otherwise, [du] or [dũ] would have been the optimum candidates. (Note that FaithV[nas] and FaithV[place] have been conflated into a single faithfulness constraint in the first column.)

(50)

TABLEAU FOR THE FORM: /tun/ "flute"

[+rnd] [+hi] tun	**FaithV [nas]; [Pl]**	**Coda [-cont]**	***LoV [pl]spread**	**MaxC [nas]**	**IRC [nasal]**	**IRC [place]**	**FaithC [place]**
dun					*!	*	
⇒du^{d}n						*	
dũn	*!					*	
du^{g}ŋ						*	*!
duŋ					*!	*	*
du^{b}m						*	*!
dup				*!		*	*
duw		*!		*			*
dum					*!	*	*
du				*!			*
dũ	*!			*			*

For more tableaus combining all these constraints, see the Appendix.

8. OTHER CODAS

8.1 Non-coronal Codas

Finally, we must be able to account for the fact that it is only the coronal codas which undergo this change of place features. Non-coronal codas never experience this spreading. Notice that the codas below maintain their place features.

(51)

/wiʔ/	>	*[wiʔ]*	'slow'
/hiktu/	>	*[hiktu]*	'hand'
/juktu/	>	*[juktu]*	'foot'
/waʔna/	>	*[waʔna]*	'to lie'

If IRC[place] were enforced, the form /wiʔ/ would become /wik/. But this does not happen – the coda remains a glottal. Mamaindé seems concerned with satisfying the IRC[place] only when coronal codas are involved. This suggests there is a faithfulness constraint restricting non-coronals from participating in the feature changing process[26]. We are therefore required to split our FaithC[place] constraint into two; **FaithC[coronal]place** which governs coronals and **FaithC[non-coronal]place** which restricts non-coronals.

(52)

FAITHC[CORONAL]
Coronal consonants are faithful in their place features

(53)

FAITHC[NON-CORONAL]
Non-coronal consonants are faithful in their place features

In (53), non-coronal is not intended to represent a feature. This last constraint is simply a conflation of FaithC[dorsal] and FaithC[labial] into a single

[26] Underspecifying the coronal place feature would also be an option. But I am opting for using constraints here instead in order to keep the underspecification necessary in my analysis to a minimum.

constraint. Since the coronals seem to be the unmarked consonants, this latter constraint must also be ranked before the first:

FAITHC[NON-CORONAL] > IRC[PLACE] > FAITHC[CORONAL]

This constraint ranking effectively prohibits any non-coronal consonant from changing its place features. Notice that FaithC[non-cor]place must be ranked higher than IRC[place] or FaithC[cor]place. If this were not the case, the incorrect form /wik/ would have been the chosen candidate in the tableau below.

(54)

TABLEAU FOR THE FORM: /wiʔ/, "slow"

[+hi] wiʔ	FaithV [nas]; [Pl]	Coda [-cont]	*LoV [Pl]Spr	MaxC [nas]	FaithC [non-cor]	IRC [nas]	IRC [Pl]	FaithC [cor]
wik					*!			
⇒wiʔ							*	
wĩk	*!					*		
wĩʔ	*!				*	*	*	
wiŋ				*!	*			

8.2 Epenthetic Codas

One more type of coda must be mentioned – the epenthetic coda. In Mamaindé, a coda is inserted in an open, primary stressed syllable when it is followed by an aspirated consonant[27]. This is stated in the following constraint:

[27] A number of exceptions to this constraint exist. It is not yet known whether this constraint must be limited to a specific stratum of the phonology or whether it needs to be altered in some other manner to account for the violating forms. Regardless of how the epenthetic coda constraint eventually must be encoded, the consonants that are inserted always abide by the feature constraints we have already proposed for the Mamaindé coda.

(55)

SYLLABLECODA
Stressed syllables prior to aspirated consonants have oral stops in their codas.

These epenthetic codas take their place features from the preceding vowel in the same way other codas do. This means that the same constraints we proposed for the nasal coda will correctly predict the place of the epenthetic codas as well, adding more support to our analysis.[28] Below are a few examples of epenthetic codas. Notice that their output forms abide by the constraints we have already seen.

(56)

/ja̲^{u}/	+	/t^{h}ã/	>	[ja̲^{u}pt^{h}ã]	stay + nom. = the staying
/e^{u}/	+	/t^{h}ã/	>	[e^{u}pt^{h}ã]	see + nom. = the seeing
/ʔa̲^{i}/	+	/t^{h}ã/	>	[ʔa̲^{i}kt^{h}ã]	go + nom. = the journey
/tu/	+	/thã/	>	[dutt^{h}ã]	get + nom. = the getting

9. VIOLATIONS OF THE IRC

9.1 Consonant Clusters

There are a few forms which violate the IRC. Some forms show place spreading within a consonant cluster instead of from the nucleus to the coda. These exceptions to the IRC are the result of a constraint which is often highly ranked in other languages - the Identical Cluster Constraint. Although operative in Mamaindé phonology, it has a very restricted domain. Examples of this are shown in the forms below. Here the coda assimilates to the following consonant, and not to the preceding vowel.

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[28] Of course another constraint would have to be added to encode the epenthetic process, and our FaithC constraints will have to be redefined to allow for consonants in the output which are not in the input.

(57) EXAMPLES OF CONSONANT CLUSTER PLACE SPREADING:

stem		suffix		surface form	gloss
mãnkalo	+	*tu*	>	*mãŋgaloru*	- ‘heat - flat thing = clothes’
onka	+	*k^{h}atoʔ*	>	*o^{g}ŋgakhərəʔ*	- ‘to work, to do’
anka	+	*k^{h}atoʔ*	>	*a^{g}ŋgakhərəʔ*	- ‘to be precious’
k^{h}unki	+	*tu*	>	*khu^{g}ŋgiru*	- 'cotton (from cotton plant)'

Since these stems[29] contain vowels which do not participate in feature spreading, we would expect these nasal codas to remain alveolar. However, their velar nature suggests that the Identical Cluster Constraint is at work.

(58)

IDENTICAL CLUSTER CONSTRAINT[PLACE] - (ICC[PLACE])
A sequence of consonants must share place features

But in Mamaindé, this sharing of Place in consonant clusters is limited to the domain of the stem or compound stem. It does not occur elsewhere in the affixation process. Since the locus of most consonant clusters is at the morpheme boundary and not within the stem, these forms are quite rare.[30] In Mamaindé, this stem domain corresponds to (and gives support to) the first stratum of the phonology in a lexical approach (Eberhard 1995:64). The problem we have in Optimality theory is how to specify morphological cycles in terms of constraints. Can we specify that the ICC constraint is only operative in the domain of the stem? Or must we say, as Russell argues (Russell, 1997:131), that the input of these forms is actually not the UR form

[29] All of these "stems" actually consist of a root plus a suffix. However, each of these forms has become so commonplace that the suffix has become fused to the root, creating a single compound stem that is no longer considered as having two parts. This is the case of the form /mãngalo/ 'clothes' which is most certainly a combination of /mãn/ - 'heat' (1st stratum stem), and /galo/ 'flat thing', which is usually a 3rd stratum noun classifier. But in this case, as well as in the other "stems" in our example, it appears that this particular suffix and stem are combined with such frequency that the two morphemes are fused together, creating a new 1st stratum stem.

[30] There are no morphemes which follow the root in the first stratum of the phonology. These forms only occur when a second or third stratum morpheme coalesces to a particular root and forms a new first stratum compound root. The only morphemes which seem to be productive in this coalescing process are the following second and third stratum morphemes /ki/ ‘derivative of’, /ka/ ‘for the benefit of’, and /kalo/ ‘flat thing’. This explains why the only examples of the ICC have involved the dorsal feature.

but another surface form? Whatever the outcome of this theoretical dilemna, we must somehow specify that the pressure for consonant clusters to share place features is only felt in the domain of the Mamaindé stem. For that reason I will modify the above constraint to make it consistent with the data:

(59)

ICC[PLACE] STEM
A sequence of consonants within the stem share place features

This constraint must then be ranked higher than IRC[place] in order to block the effects of the IRC:

ICC[PLACE] STEM > IRC[PLACE]

The root form */kʰun/* 'cotton' shows us how crucial domain is here. When followed by the 1st stratum morpheme */ki/* 'derivative of', a compound stem is formed and the ICC[place]STEM constraint affects the form.

(60)

kʰunki + tu > *kʰuᵍŋgiɾu* - *'cotton from the cotton plant'*

However, when */kʰun/* is followed by any morpheme outside the 1st stratum, such as */kʰat/* 'stick', the ICC has no effect.

(61)

kʰun + kʰat + tu > *kʰuᵈnkʰattu* - *'cotton plant'*

(For further discussion of strata division in Mamaindé, see Eberhard 1995: chapter 8).

9.2 Long vowels

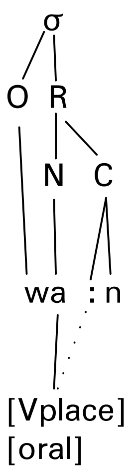
One other construction which appears to violate IRC is the morpheme /:n/ "again". This morpheme, when added to a verb stem with an open syllable, lengthens the vowel and adds a nasal coda.

(62) FORM WITH A LENGTHENED VOWEL

/wa/ + /:n/ + /k^h*atoʔ/ > [wa:n*k^h*ərəʔ]*
come + again + then > come again, then

But in this case, the nasal coda does not obey either of the IRC constraints. It remains faithful in both nasality and place. Although appearing to be a violation of the IRC, there is a possible solution. The syllable template we constructed in section 1.2 allows for extra vowel length in the coda. And Eberhard (1995) shows that this vowel length position in the coda is normally filled when open stressed syllables undergo vowel lengthening and are then considered heavy. Now it appears that Mamaindé uses this same syllable template position to associate the extra length of the vowel in the form [wa:nk^hařoʔ] to the coda and not the nucleus, giving us a structure like this:

(63) VOWEL LENGTH AND THE SYLLABLE TEMPLATE



The demands of the IRC are then met satisfactorily since it only requires a segment in the nucleus and a segment in the coda to share identical feature nodes. This has been accomplished by considering the extra length on the vowel as a coda segment.

9.3 The Final Constraint Ranking

A complete ranking of all the constraints proposed in this paper, all of which have to do with the rhyme, would look like this:

MAXONSET, ICC[PLACE]STEM; FAITHV[PL], FAITHV[NAS],
CODA[-CONT], *LOV[PL]SPREAD, MAXC[NAS], FAITHC[NON-COR.]
>>IRC[NAS], IRC[PLACE]
>> >FAITHC[COR.]

10. CONCLUSION

In this paper we have attempted to uncover some answers to two major difficulties raised by the Mamaindé coda: the unexplained nature of pre-stopped nasal formation and the unique changes in place features which it undergoes. By appealing to Optimality constraints, we have been able to successfully account for both of these phenomenon. However, in the process numerous issues have arisen that are not easily handled by current theory.

First, we see a language where binary features for nasality appear to be necessary. Secondly, we have shown that this is a language that requires a return to the vowel place features [high] and [round], as opposed to the more common Dorsal and Labial, in order to adequately account for the data. This in turn calls for a rethinking of how vowel and consonant features interact. Thirdly, it has been shown that in this language, underspecification appears to be necessary, something which practitioners of OT have had mixed views on. Fourthly, the ranking of FaithV over FaithC, combined with other constraints in the phonology, gives us a language where the vowels dominate the articulation of coda consonants. It would be interesting to determine the prevalence/uniqueness of this type of vowel dominance in other languages. Lastly, we have proposed a new family of constraints, the Identical Rhyme constraints, and have shown evidence that it is the quest for identicalness within the rhyme that motivates this segment of Mamaindé phonology. The IRC[place] governs which place features will appear in the coda, while the IRC[nasal] enforces a similarity on oral/nasal articulation throughout the rhyme.

Support for the IRC is limited, however, in that at present it is based on evidence from a single language. Further research into the interaction between vowels and consonants in other languages will verify whether or not the IRC family of constraints can stand up to wider scrutiny.

APPENDIX

Below I offer a few more tableaus combining all of the constraints (except for MaxOnset) which deal with the nasal and place features of the Mamaindé coda. Note once again that FaithV[nas] and FaithV[place] have been conflated into a single Faith constraint in the first column.

(64)

full tableau for the form /sin/ "meat":

[+hi] [-rnd] s i n	FaithV [nas] [place]	Coda [-cont]	*LoV [pl]spread	MaxC [nas]	IRC [nasa]	IRC [place]	FaithC [place]
sin					*!	*	
si^{d}n						*!	
sĩn	*!					*	
⇒si^{g}ŋ							*
siŋ					*!		*
si^{b}m						*!	*
sik				*!			*
siw		*!		*!		*	*
si				*!			*

Below are several tableaus of forms with diphthongs:

(65)

for the form /ta^{u}n/ "tail":

[+rnd] ta^{u}n	FaithV [nas]; [pl]	Coda [-cont]	*LoV [pl]spread	MaxC [nas]	IRC [nas]	IRC [place]	FaithC [place]
da^{u}n					*!	*	
da^{ud}n						*!	
dã^{u}n	*!					*	
da^{ug}ŋ						*!	*
da^{u}ŋ					*!	*	*
⇒da^{ub}m							*
da^{u}w		*!		*			*
da^{u}p				*!			*
da^{u}				*!			*

(66)

for the form /he^{i}n/ "wash":

[+hi] | he^{i}n	FaithV [nas] [place]	Coda [-cont]	*LoV [pl]spread	MaxC [nas]	IRC [nas]	IRC [place]	FaithC [place]
he^{i}n					*!	*	
he^{id}n						*!	
hẽ^{i}n	*!					*	
⇒he^{ig}ŋ							*
he^{i}ŋ					*!		*
he^{ib}m						*!	*
he^{i}w		*!		*			*
he^{i}k				*!			*
he^{i}				*!			*

Finally, some tableaus with low vowels:

(67)

for the form /lan/ "full of water":

[-hi] | lan	FaithV [nas] [place]	Coda [-cont]	*LoV [pl]spread	MaxC [nas]	IRC [nasal]	IRC [place]	FaithC [place]
lan					*!		
⇒la^{d}n							
lãn	*!						
la^{g}ŋ						*!	*
laŋ					*!	*	*
la^{b}m						*!	*
law		*!		*		*	*
lat				*!			
la				*!			*

(68)

for the form /t^hon/ "grow":

[-hi] [+rnd] t^hon	FaithV [nas] [place]	Coda [-cont]	*LoV [pl]spread	MaxC [nas]	IRC [nas]	IRC [place]	FaithC [place]
t^hon					*!	*	
⇒t^ho^dn						*	
t^hõn	*!					*	
t^ho^gŋ						*	*!
t^hoŋ					*!	*	*
t^ho^bm			*!				*
t^how		*!	*	*		*	*
t^hot				*!		*	
t^ho				*!			*

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