Quantity and moras: an amicable separation

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1. Introduction[1].

In recent phonological theory, the mora is assumed to play a dual role. First, moras represent weight. A syllable node dominating one mora is light (1a), while a syllable dominating two moras is heavy (1b).

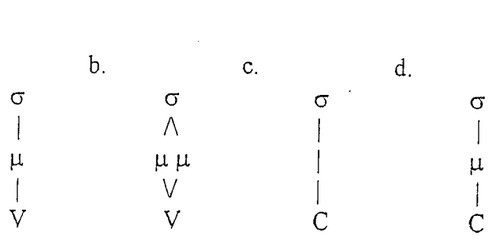
(1)

a. b.

Moras also represent quantity: Following Hayes (1989), a vowel dominated by one mora is short (2a), a vowel dominated by two moras is long (2b), a consonant dominated by no moras (unless assigned by rule) is short (2c), and a consonant dominated by one mora is long (2d).

(2)

a. b. c. d.



The assumption underlying the quantity distinctions in (2) is presented in (3). I will call this assumption The Quantity Assumption:

(3) **The Quantity Assumption.**
A contrast in the number of moras dominating a segment is realized as a contrast in length.

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[1] Special thanks to David Perlmutter and Kathleen Hubbard, who worked with me closely on this paper; to Aurelien, Herisoa, and Noro, informants; to the members of the 1993 field methods class at UC San Diego, the source of much of the data in this paper: Kathleen Ahrens, Donald Dodero, Susanne Kemmer, William Leshner, Tung-You Lin, Sui-Sang Mok, Masuhiro Nomura, Karin Pizer, and Martha Senturia; to Ed Keenan, who re-energized my interest in Malagasy and provided me with an online dictionary, without which this paper would not have been possible; and to Matt Pearson. Thanks also to David Askins, Matthew Chen, Steve Demeter, John Pierce, Maria Polinsky, Charles Randriamasimanana, Tom Shannon, Joan Stiles, Moira Yip, and of course, Jenée Wagner.

In this paper, I reject this assumption and show that there is no principled reason to make it. Using new data from original field research, I show that Malagasy, the language of Madagascar, has contrasts in the number of moras dominating vowels, but no length contrasts. First, in section 2, I demonstrate on the basis of stress and diphthongs that Malagasy has bimoraic feet, with stress falling on the syllable dominating the penultimate mora. Then, in section 3, I reanalyze Malagasy roots, and explain various vowel and consonant alternations in suffixed versus unsuffixed forms. In section 4, I show the existence of syllables dominating both derived, bimoraic vowels and epenthetic, nonmoraic vowels, and in section 5, I reject the Quantity Assumption based on the fact that the vowels in these syllables are all realized with identical length.

2. Phonological system.

Section 2.1 presents the vowels and consonants of Malagasy. Section 2.2 contains a discussion of Malagasy phonotactics, including whether Malagasy has prenasalized segments. The prosodic structure of Malagasy, including the processes of morafication, syllablification, and footing are presented in 2.3.

2.1. Vowels and Consonants.

Traditionally, Malagasy is analyzed as having a four-vowel system, *i*, *u*, *e*, and *a*, and two diphthongs, *ai*, and *au*. In addition, the vowel *o* occurs in (primarily French) loan words (Parker 1883; Arakin 1963; Rambelosoa 1975; Fedorov 1988; Dziwirek 1989; Pearson 1994). There are no long vowels in Malagasy.

The consonants of Malagasy are as follows:

(4)

	Bilabial	Labio-Dental	Dental	Retroflex	Velar	Glottal
Stops	p,b		t,d		k,g	
Fricatives		f,v	s,z			h
Affricates			ts, dz	t^r, d^r		
Nasals	m		n			
Laterals			l			
Trills			r			

There are no geminates in Malagasy.

2.2. Phonotactics.

All Malagasy words end in vowels. The only consonant sequences in Malagasy consist of a nasal followed by a homorganic stop or affricate (which I shall abbreviate as NC):

(5)

lainga[2]	a lie	misondrotra	to be elevated
ngoly	numb from cold	njola	cross-eyed
tambato	a stonemason	vintsy	a small kingfisher

There are two possible analyses of NC in Malagasy, as nasal–stop sequences, or as single prenasalized segments. Assuming that these elements are clusters, then the phonotactics are stated as follows:

(6)

Syllable template: CVN.
N must be homorganic to a following C.
An onset C must become a stop or affricate when preceded by N.
No Codas are allowed word-finally.
The maximal onset is one segment.
Exception: Some NC clusters are allowed word-initially.

The alternative and traditional analysis of NC is that these are prenasalized single segments (Rajaobelina 1987). Under this analysis, the phonotactics are stated as follows:

(7) Syllable template: CV.

In the absence of phonetic data bearing on this issue, I will assume that these NCs are prenasalized segments, because of the simpler phonotactic restrictions necessary under this assumption. I will show later that syllabification is simpler under this assumption as well.

2.3. Prosodic Structure in Malagasy

I discuss in this section the prosodic structure of Malagasy words. In section 2.3.1, I present morafication and syllabification algorithms, and in 2.3.2, I present and argue for the Bimoraic Foot Hypothesis.

2.3.1. Morafication and Syllabification.

Following Hyman (1984), McCarthy and Prince (1986), Hayes (1989), and Zec (1994), moras are taken as the lowest level of the prosodic hierarchy:

(8) **Prosodic Hierarchy**:
Phonological Phrase>>Phonological Word>>Foot>>Syllable (σ)>>Mora (μ)

[2] Throughout this paper, I will use the Malagasy orthography when presenting data. Except for the following cases, the written language is straightforward: /u/ is written *o*, /dz/ is written *j*, and word-final /i/ is written *y*.

Zec (1994) claims that "it is a universal property of languages to have sets of moraic and syllabic segments; the memberships of these sets are determined on a language-specific basis." That is, all languages have moras. Furthermore, according to Zec, these sets universally include the "sonorous end" of the sonority scale. Since by definition, vowels are at the sonorous end of the sonority scale, it follows that all languages have moras dominating vowels (what varies, according to Zec, is what segments in addition to vowels may be dominated by moras). In Malagasy, the most sonorant segments are vowels. By default, therefore, vowels must be dominated by moras. Furthermore, since there are no codas in Malagasy, and since it is widely claimed that onset consonants are universally non-moraic (Hayes 1989), I claim that only vowels are dominated by moras. Thus, I claim that the morafication algorithm in Malagasy is as stated in (9):

(9) **Morafication Algorithm**:
A vowel projects a mora.

Zec (1994) claims that in all languages, the set of syllabic segments is a subset of the set of moraic segments. In Malagasy, therefore, since only vowels are moraic, it follows from Zec's claim that only vowels are syllabic. Therefore, I posit the following syllabification algorithm:

(10) **Syllabification Algorithm**:
A mora projects a syllable and becomes a nucleus; all non-moraic segments are syllabified as onsets.

Itô (1986) interprets syllabification as template matching. In her terms, the Syllabification Algorithm in (10) can be restated as (11):

(11) **Syllabification Algorithm**:
Match segmental material to the following template:

σ
/\
CV

The Morafication Algorithm creates moras dominating vowels, and the Syllabification Algorithm creates CV syllables dominating moraic structure: a moraic segment becomes a nucleus, and a non-moraic segment becomes an onset.

2.3.2. Stress and Feet.

In this section, I present two alternative analyses of stress in Malagasy. In section 2.3.2.1, I present stress as a rule, and in 2.3.2.2, I argue against this statement of stress in favor of the Bimoraic Foot.

2.3.2.1. Stress.

Most words in Malagasy have primary stress on the penultimate syllable:

(12)

mandéha	to go
miándry	to wait, watch
mihány	to sun-dry
misótro	to drink
mamángy	to visit
mahíta	to see
miása	to work
mitóndra	to carry, bring
mijínja	to reap, cut down
mijéry	to look at
lámbo	a wild boar
làndiházo	cotton
àtidóha	the brain
bàraráta	a small bamboo that grows in or near water

However, word final diphthongs are always stressed:

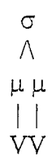
(13)

manáo	to do
indráy	sometimes
bemiráy	patched together from many different pieces
hatrizáy	since the time that
mandráy	to take

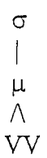
Two possible representations of diphthongs are presented in (14):

(14)

a.



b.



If Malagasy diphthongs are represented as in (14b), then diphthongs and monophthongs have the same number of moras (one). There is no explanation under this analysis for the generalization that diphthongs in final position are always stressed, while monophthongs are not. However, if as Pearson (1994) assumes, the correct representation of diphthongs is as in (14a),

then the generalization that final diphthongs and penultimate monophthongs are stressed, is explained by the Stress Rule in (15):

(15) **Stress Rule**:
Stress the penultimate mora.

The Stress Rule predicts that diphthongs in penultimate position are stressed on the second mora. However, diphthongs in penultimate position are always stressed on the peak, or the first mora:

(16)

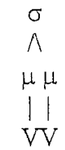
báiko	a foreign word; a command
akáiky	near
áina	life; breath
báinga	a clod of earth turned over

As diphthongs are represented as in (18), with only one syllable node, the Stress Rule in (15) is revised to account for the data in (16):

(17) **Stress Rule**:
Stress the syllable containing the penultimate mora.

Recall the proposed structure of diphthongs (14a), repeated here as (18):

(18)



The structure in (18) violates the Syllabification algorithm in (11), given again as (19), because two moras are incorporated into one syllable.

(19) **Syllabification Algorithm**:
Match segmental material to the following template:

To account for the existence of diphthongs in Malagasy, an exception to the Syllabification algorithm must be posited:

(20) **Diphthongization**:
When the sequences *ao* and *ai* occur tautomorphemically, then only one syllable node is projected[3].

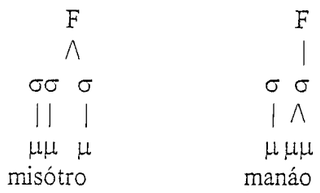
2.3.2.2. Bimoraic Foot Hypothesis.

In this section, I present an alternative analysis of Malagasy stress, which I call the Bimoraic Foot Hypothesis:

(21) **Bimoraic Foot Hypothesis**:
Stress is construed by parsing the word into feet (Hayes 1995).
Feet consist of two moras, and are built from right to left.

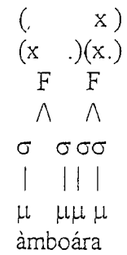
(22) presents an example of the bimoraic foot:

(22)



The Bimoraic Foot Hypothesis (21) is preferred to the Stress Rule in (17) for two reasons. First, stress is not a stipulation, as in the Stress Rule (17), rather, it follows from three established universal principles that underlie metrical stress theory: foot binarity (McCarthy and Prince 1986), the Iambic/Trochaic Law (Hayes 1995, following Bolton 1894 and others), and directionality of foot parsing (Hayes 1995). Furthermore, with the addition of End Rule Right (Prince 1983; Hayes 1995), the Bimoraic Foot Hypothesis predicts secondary stress, which in Malagasy falls on even-numbered syllables counting backwards from the primary stress (Pearson 1994), whereas the Stress Rule (17) does not (a further stipulation regarding secondary stress must be made):

(23) **End Rule Right**:



[3] According to Senturia (1995), (20) is predictable from the fact that the two diphthongs *ao* and *ai* constitute the only two instances of maximally falling sonority of all possible vowel sequences in Malagasy. However, the fact that these sequences constitute hiatus when a morpheme boundary intervenes must still be stipulated.

In short, End Rule Right marks one stressed element in every word as recieving primary stress. All other stressed elements receive secondary stress. For further discussion of End Rule Right and word-layer metrical structure, I refer the reader to Hayes (1995).

An augmentation of the Bimoraic Foot Hypothesis also accounts for stress on forms with penultimate diphthongs (13), repeated here as (24):

(24)

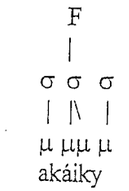
báiko	a foreign word; a command
akáiky	near
áina	life; breath
báinga	a clod of earth turned over

To account for the data in (24), Syllable Integrity is posited:

(25) **Syllable Integrity**:
Two moras within a single syllable are dominated by the same foot.

Hayes (1995:58,121-123,138) argues extensively for Syllable Integrity as a universal principle of metrical theory, and for the sake of space, I do not give these arguments here. Given the universal metrical principle of Syllable Integrity, then, the proper representation of a form containing a penultimate diphthong is in (26):

(26)



Building feet from right to left, the final two moras (dominating the final vowel and the second half of the diphthong *ai*) are prevented by Syllable Integrity from being parsed as a single foot. As a result, the two moras of the diphthong *ai* are footed together, and stress falls on the peak of the diphthong. It follows from Syllable Integrity (and the ban on degenerate feet, discussed below), that stress is placed correctly on the first element of diphthongs when occurring in penultimate position[4].

[4] Given the notion of the foot:

> One of the seminal ideas in metrical stress theory is this: the best way to express stress rules might not actually be the most direct one, that is, to place stress on a particular syllable. The alternative is to state the possible structures for metrical constituents and construe stress placement as the parsing of a word into such constituents. These contituents, the minimal bracketed units of metrical theory, are called **feet**. (Hayes 1995:40)

it follows that syllables which are not incorporated into feet, such as the final syllable in (26), are not stressed. In other words, foot structure determines stress, so no foot, no stress.

A final element of the Bimoraic Foot Hypothesis in Malagasy is an absolute ban on degenerate feet, or feet dominating a single mora. Hayes (1995) proposes the following account of possible prohibitions on degenerate feet:

(27) **Prohibition on Degenerate Feet**
Foot parsing may form degenerate feet under the following conditions:
a. **Strong Prohibition**: degenerate feet are absolutely disallowed.
b. **Weak Prohibition**: degenerate feet are allowed only in strong position.
c. **Non-prohibition**: degenerate feet are freely allowed. (Hayes 1995:87)

Hayes states that an absolute ban on degenerate feet (27a) makes the prediction that "there can be no degenerate-sized [content] words" (Hayes 1995:88), whereas under (27b) and (27c), degenerate-sized content words are allowed. That is, if the minimal word in Malagasy is at least two moras, or one full foot, then Malagasy absolutely disallows degenerate feet (27a). This is indeed the case in Malagasy: in Hollanger's English-Malagasy dictionary (Hollanger 1973), containing over 7,000 Malagasy words, there are fewer than 10 exceptions[5] to the generalization that all content words are minimally bimoraic. Therefore, degenerate feet are absolutely disallowed in Malagasy (Strong Prohibition). Recalling the representation in (26), shown again in (28), no degenerate feet are built over the initial or final mora, because of Strong Prohibition:

(28)

In summary, (29) presents all the universal principles and language-specific parameters of the Bimoraic Foot Hypothesis in Malagasy:

(29)

Metric Principle	Parameter value in Malagasy	Evidence
Foot unit	Mora	bimoraic diphthongs stressed word-finally, otherwise penultimate stress
Parsing directionality	Right to Left	CV(CVCV), not (CVCV)CV[6]
End Rule	Right	Primary word stress falls on the final stressed mora.
Iambic/Trochaic Law	Trochaic	Stress on leftmost vowel in foot
Syllable Integrity	---	Universal; see (Hayes 1995) for discussion
Degenerate Foot Ban	Strong Prohibition	Minimal Word is bimoraic

[5] Several of these exceptions can be shown to derive from underlyingly bimoraic roots, so their lexical forms, then, would not be exceptions.
[6] Instances of antepenultimate stress are discussed in section 3.2.

I have argued in this section that the Stress Rule (17) is dispreferred to the Bimoraic Foot Hypothesis, as the Stress Rule stipulates stress placement, while the Bimoraic Foot Hypothesis predicts stress based on established universal principles and parameters of metrical stress theory.

3. Malagasy roots.

In previous analyses of Malagasy, roots are assumed to be identical in form to the surface forms of nouns, adjectives, or active verbs forms (minus any prefixation), thus adhering to the surface constraint that all words must end in a vowel (Parker 1883; Auber 1957; Arakin 1963; Hollanger 1973; Rambelosoa 1975; Fedorov 1988; Dziwirek 1989; Pearson 1994). In this section, I show that surface forms often differ significantly from the roots from which they are derived. In section 3.1, I argue that an apparent gap in the distribution in the second vowel of Malagasy roots is explained by a reanalysis of the underlying representation of these roots. In section 3.2, I show that instances of antepenultimate stress derive from roots that end in consonants, and furthermore, by positing epenthesis following some of these root-final consonants, and deletion of others, I show that antepenultimate stress is not a counterexample to the Bimoraic Foot Hypothesis.

3.1. *e~i*.

It is a curious artifact of all previous analyses of Malagasy roots that the vowel e is never posited as the second vowel in the root (most roots are bimoraic), while any vowel can occur as the first vowel in the root:

(30)

1. Unsuffixed form	2. Suffixed form[7]	3. Gloss	4. Root (Hollanger 1973)	5. Proposed Root
a.				
miróky	ìrokíana	speak a dialect	roky	---
misángy	ìsangíana	fool around, tease	sangy	---
màhafály	ahàfalíana	make happy	faly	---
mandídy	àndidíana	cut; command	didy	---
mandíhy	àndihízana	dance	dihy	dihiz[8]
mànonófy	ànofisana	to dream	nofy	nofis
midínika[9]	idiníhana	examine together	dinika	dinih

[7] Besides clitics, there are only two suffixes in Malagasy. *-ana/-ina*, which has several functions, including relative verb (shown here) formation, and nominalization, and *-a*, imperative, which will be discussed in section 4.2.
[8] Roots that end in consonants will be discussed in section 3.2.
[9] Forms with antepenultimate stress will be discussed in section 3.2.

(30)

1. Unsuffixed form	2. Suffixed form[10]	3. Gloss	4. Root (Hollanger 1973)	5. Proposed Root
b.				
báby	babéna[11]	carrying on the back	baby	babe
màhafáty	ahàfatésana	kill	faty	fates
mànalémy	leména	soften, weaken	lemy	leme
mandrésy	reséna	defeat, conquer	resy	rese
manòrisóry	sorìsoréna	vex, chagrin	sory	sore
mamból y	voléna	to plant	boly	bole
manétry	ànetréna	to humble, demote	etry	etre
mifétsy	fetséna	trick, get the best of	fetsy	fetse
mirènirény	ìrenirenéna	wander about	renireny	rene
manósika	ànoséhana	shove	tosika	toseh
mamónjy	àmonjéna	help, save	vonjy	vonje

In (30a), *i*[12] is word-final in unsuffixed forms, and is unchanged before the morpheme *-ana* in suffixed forms. In (30b), word-final *i* alternates with *e* in suffixed forms. The traditional analysis is that the *i* is basic in both (30a) and (30b), based on the fact that this is what surfaces in unaffixed forms. Hence, there must be a rule changing *i* to *e* in suffixed forms under this analysis. The root under the traditional analysis is given in column 4 of (30).

The traditional analysis has a number of failings. First, it is unpredictable when *e* will surface in the affixed form. Second, this analysis does not explain why *e* never occurs as the second vowel in a root. Third, the traditional analysis does not explain why, in the affixed form, if the second root vowel is *e*, then the first root vowel is never *i*.

I propose that *e* is basic in the *i~e* alternation, and that there is a rule changing *e* to *i* in unsuffixed forms. The proposed roots are in column 5 of (30). This analysis suffers none of the failings of the traditional analysis of Malagasy roots. First, the presence of *e* and *i* in suffixed forms is straightforwardly predictable as they are present in the underlying representation. The *i* alternate of *e* in unsuffixed forms is determined by rule. Second, there is no accidental gap whereby the vowel *e* never occurs as the second vowel of a root. Third, a new generalization is apparent: whenever the second vowel of a root is *e*, the first is never *i*, and whenever *i* is the second vowel, the first is never *e*. This is explained by a rule of vowel harmony.

(31) **Vowel features**:

[i]: [-bk, +hi]
[e]: [-bk, -hi]
[u]: [+bk, +hi]
[a]: [+bk, -hi]

[10] Besides clitics, there are only two suffixes in Malagasy. *-ana/-ina*, which has several functions, including relative verb (shown here) formation, and nominalization, and *-a*, imperative, which will be discussed in section 4.2.
[11] The *-na~-ana* alternation will be discussed in section 4.1.
[12] Recall that in Malagasy orthography, *i* is written *y* word-finally.

If the features of the four vowels are as in (31), then the vowel harmony rule can be stated as in (32):

(32) **Vowel harmony**:
Within a root, if both V_1 and V_2 are [-bk], then V_1 and V_2 must agree for the feature [hi].

I have shown in this section that there is a rule of Vowel Harmony in Malagasy (32), which explains the pattern of *i~e* alternations in Malagasy verb forms: Vowel Harmony explains why *e* never occurs as the second vowel in an unsuffixed form, and explains why, in the affixed form, if the second vowel in an affixed form is *e*, then the first vowel is never *i*.

3.2. Weak final syllables

Many words which end in *-na*, *-ka*, or *-tra* appear to have stress on the antepenultimate mora (instead of the syllable dominating the penultimate mora, as predicted by the Binary Foot Analysis). I will call these endings Weak Final Syllables:

(33)

Active Verb	Gloss
a.	
manándrana	to try
míndrana	to borrow
mitándrina	to take care of
mangátaka	to ask for
manáraka	to follow
miánatra	to study
mihínana	to eat
mitsángana	to stand
misáotra	to thank
maháritra	to bear, endure
manándratra	to promote, lift up
mahàfináritra	to please
tápaka	cut
lávitra	far
vólana	month
b.	
korána	pleasant conversation
lalóna	a tree with hard reddish wood
saláka	a loincloth
màhavátra	to support
màhazátra	to make accustomed to
mamátra	to measure in a container
mamétra	to set limits
vàtravátra	a downpour of rain

A previous analysis of the data in (33), from Pearson (1994), is presented in section 3.2.1. I argue for an alternative analysis in section 3.2.2.

3.2.1. The Stem-Formative Analysis

One possible analysis is to stipulate that Weak Final Syllables are extrametrical. However, this does not account for the data in (33b), that is, some instances of Weak Final Syllables would have to be marked as extrametrical in the lexicon, while others would not be marked as extrametrical. Another alternative analysis is in Pearson (1994). This analysis, which I will call the Stem-Formative Analysis, proposes that Weak Final Syllables are morphemes, what are called "stem-formatives," claiming that they delete in compounding, reduplication, and before clitics:

(34)

tápaka "cut" + **vólana** "month" → **tàpabólana** "fortnight"
lávitra "far" → **làvidávitra** "rather far"
mipétraka "sit" → **mipètrapétraka** "sit for a while"
zánaka "child," **zánako** "my child," **zànatsíka** "our (incl.) child"
fántatra "know (pass.)," **fántatro** "known-by-me," **fàntatraréo**[13] "known-by-you (pl.)."
(Pearson 1994; p.7)

The Stem-Formative Analysis requires that stress assignment precede the affixation of these "stem formatives:"

(35)

a. Stress Assignment	b. Stem-Formative affixation
míndra	míndrana

The Stem-Formative account of the forms in (33b) is that these forms underlyingly end in *-na*, *-tra*, or *-ka*. However, the Stem-Formative analysis provides no explanation of why some words take these "stem formatives" while others do not. For example, the analysis of *volana*

[13] Clitics larger than one mora seem to "pull" main stress onto themselves. The foot structure of this form (analogous to that given in Pearson 1994) is as follows:

```
  F     F
  ∧     ∧
σ σ   σ σσ
|  |  |  ||
μ μ   μ μμ
fàntatr+aréo
```

In other words, clitics which are equal to or larger than the minimal word (two moras) have foot structure. The entire structure is then suffixed, resulting, in the above case, in a word-medial unfooted syllable, and secondary stress "preserved" on the initial syllable. Clitics smaller than the minimal word do not have foot structure.

("month"), from (33a), is *vola+na*, where *vola* is taken as the root. But there is another word, *vola*, which means "silver." The Stem-Formative analysis does not explain why the root meaning "month" takes the stem-formative morpheme, while the root meaning "silver" does not. There are a number of such pairs, some of which are shown in (36):

(36)

Surface form	**Gloss**
$hála_1$	hate
$hála_2$	spider
hálatra	steal, rob
láva	long
lávaka	pit, hole
váva	mouth
vávaka	prayer
váta	box
vátana	body, torso

The Stem-Formative analysis must stipulate in the lexicon which roots take the "stem formative," and which do not.

There is still another shortcoming of the Stem-Formative Analysis. To account for the fact that all (non-clitic) suffixes except "stem formatives" affect stress, the Stem-Formative analysis must stipulate that "stem-formatives" attach to the root after stress assignment (35), while other suffixes attach before stress assignment. Under my analysis, presented in the following section, all suffixes affect stress, and no such varying of the ordering of stress assignment and suffixation is necessary.

3.2.2. Root-final consonants.

My analysis of the data in (33) follows from my reanalysis of roots. (37) presents a variety of unsuffixed and suffixed forms, and proposed roots.

(37)

Active verb (unsuffixed)	Relative verb (suffixed)[14]	Proposed Root	Gloss
a. **V-final roots**			
m+i+sótro	i+sotró+ana	sotro	to drink
m+a+mángy	a+mangí+ana	mangi	to visit
m+i+tadídy	i+tadidí+ana	tadidi	to remember
m+a+híta	a+hitá+(a)na	hita	to see
m+i+ásа	i+asá+(a)na	asa	to work
m+i+tóndra	i+tondrá+(a)na	tondra	to carry, bring
m+i+jínja	i+jinjá+(a)na	jinja	to reap, cut down
m+i+jéry	i+jeré+(a)na	jere	to look at
b.**-z, -v, -s, -n final roots**			
m+an+áo	an+áov+ana	taov	to do
m+i+háhy	i+haház+ana	hahaz, hahiz[14]	to be out in the sun to dry
m+i+ándry	i+andrás+ana	andras	to wait, watch
m+an+dráy	an+dráis+ana	rais	to take
m+i+tády	i+tadiáv+ana	tadiav	look for
m+aha+fáty	aha+fatés+ana	fates	to kill
m+an+déha	an+dehán+ana	lehan	to go
m+i+vídy	i+vidián+ana	vidian	to buy
c. **-m, -f, -r, -h, -t, -n final roots**			
m+an+ándrana	an+andrám+ana	andram	to try
m+(i)+índrana	(i)+indrám+ana	indram	to borrow
m+i+tándrina	i+tandrém+ana	tandrem	to take care of
m+an+gátaka	an+gatáh+ana	hatah	to ask for
m+an+áraka	an+aráh+ana	arah	to follow
m+i+ánatra	i+anár+ana	anar	to study
m+i+hínana	i+hinán+ana	hinan	to eat
m+i+tsángana	i+tsangán+ana	tsangan	to stand
m+i+sáotra	i+sáor+ana	saor	to thank
m+an+ándratra	an+andrát+ana	andrat	to promote, lift up
m+aha+fináritra	aha+finarét+ana	finaret	to please
m+an+áhaka	an+aháf+ana	ahaf	to scatter
m+an+áloka	an+alóf+ana	alof	to cast a shadow on
m+i+lélaka	i+leláf+ana	lelaf	to lick

[14] Antepenultimate stress in these suffixed forms will be discussed in 4.1.

The meanings of the affixes in (37) are as follows:

(38)

m-	present tense prefix
i-, an-	active verb prefix
a-	passive verb prefix
aha-	causative/potential verb prefix
-ana	relative suffix

Note the consonant alternations between the unsuffixed and suffixed forms. In (37b) and (37c) above, there are consonants which appear in the suffixed forms which do not appear, or are different, in the unsuffixed forms. Here is a summary of the alternations:

(39) **Consonant Gradation**:

Active verb variant	Relative verb variant
a. ∅ ~ C alternations	
∅	-z, -v, -s, -n[15]
b. C ~ C alternations	
-n	-n, -m
-k	-h, -f, -k
-tr	-r, -t, -f

There are two possible analyses of these consonant alternations. They could be part of the suffix. Under this analysis, the standard analysis of roots in traditional grammars and dictionaries of Malagasy (Hollanger 1973), all suffixes have numerous allomorphs (*-zana, -nana, -fana; -za, -na, -fa*, etc.), and every root ends in a vowel. This analysis suffers from two failings: first, it is impossible to predict which allomorph surfaces with which root, and second, there is no explanation why a given root selects suffix allomorphs beginning with the same consonant, no matter what the particular suffix is. Under this analysis, each root has to be lexically marked as to which allomorph it takes.

I propose that the roots in (37b) and (37c) end in consonants. The posited roots under this analysis are presented in the "Proposed Root" column of (37). There is no massive allomorphy of the suffixes under this analysis, and no lexical marking of what root takes what allomorph.

3.2.2.1. Root-final Consonants and Syllabification.

Recall the Syllabification Algorithm in (11), repeated here as (40):

(40) **Syllabification Algorithm**:
Match segmental material to the following template: CV.

[15] If the root ends in -V*as*, -V*av*, -V*az*, then the a also deletes with the following consonant.

Root-final consonants constitute a problem for the Syllabification Algorithm in unsuffixed forms, since they can neither be syllabified as nuclei nor onsets:

(41) **Output of Syllabification Algorithm**:

```
  σ   σ   σ
  |   |   |
  μ   μ   μ
m a n a l o f
```

According to Kenstowicz (1994), citing the work of Itô (1986):

(42)

> ...all phonological segments must be prosodically licensed. There are two ways to achieve prosodic licensing: association to the syllable template or declaration as extrasyllabic at the edge of the relevant prosodic domain. Material that is not prosodically licensed is deleted by Stray Erasure. (Kenstowicz 1994:285)

Recall (39): some root-final consonants undergo gradation and surface as onsets preceding the vowel *a* (39b), and some do not surface at all (39a). Since root-final consonants never create exceptions to the syllable template CV, I assume that extrasyllabicity is not allowed in Malagasy. In other words, all segmental structure *must* be syllabified or deleted. A method of syllabifying root-final consonants in unsuffixed forms is to epenthesize a following vowel. This vowel becomes a nucleus, and the root-final consonant becomes the onset:

(43)

a. Output of morafication

```
  μ μμ
manalof
```

b. Syllabification[16]

```
  σ   σ   σ   σ
  |   |   |   |
  μ   μ   μ   μ
m a n a l o k a
```

As noted above, some root-final consonants do not undergo Consonant Gradation and do not surface with a following epenthetic vowel (39a). These consonants are not syllabified, and undergo Stray Erasure during the syllabification process, following Itô (1986; 1989):

[16] (43b) shows the output of Consonant Gradation (in this case, *f* → *k*). I do so for clarity: I am not making a claim regarding the ordering of Consonant Gradation with respect to processes of syllabification, morafication, etc.

(44)

a. Output of morafication

```
  μμ μμ
mahafates
```

b. Syllabification

```
  σ   σ   σ   σ
  |   |   |   |
  μ   μ   μ   μ
m a h a f a t y
```

After syllabification, of course, footing occurs. The vigilant reader will have noticed that footing the structure in (43b) results in incorrect surface stress. This and other occurences of antepenultimate stress are discussed in the next section.

3.2.2.2. Root-Final Consonants and Footing.

Recall (44b), the output of syllabification, presented here as (45a). Footing follows syllabification, presented here as (45b):

(45) a. Output of Syllabification Algorithm

```
  σ   σ   σ   σ
  |   |   |   |
  μ   μ   μ   μ
m a n a l o k a
```

b. Footing

```
    F       F
   / \     / \
  σ   σ   σ   σ
  |   |   |   |
  μ   μ   μ   μ
m a n a l o k a
```

By properly building bimoraic feet from right to left on the structure in (45a), (45b) predicts stress incorrectly: *mànalóka*, instead of the proper *manáloka*. The analysis in (45), which I call the Omnipotent Morafication analysis, assumes that Morafication (9) occurs whenever a vowel is present. In other words, all vowels project moras, whether present in the lexicon or epenthetic. Another alternative is that morafication only occurs once, prior to syllabification (perhaps in the lexicon itself). Under this analysis, which I call the Nonmoraic Epenthesis Analysis, epenthetic vowels do not project a mora, because epenthesis occurs after morafication. A sample derivation under the Nonmoraic Epenthesis Analysis is presented in (46):

(46)

a. Morafication

```
  μ μμ
manalof
```

b. Syllabification

```
  σ   σ   σ   σ
  |   |   |   |
  μ   μ   μ   |
m a n a l o k a
```

c. Footing

```
      F
     / \
  σ   σ   σ   σ
  |   |   |   |
  μ   μ   μ   |
m a n a l o k a
```

(46c) predicts stress correctly: *manáloka*; thus the Nonmoraic Epenthesis Analysis is preferred.

3.2.2.3. Nonmoraic Epenthesis and Weak Layering.

Nonmoraic epenthetic vowels are not often posited in phonological analyses, most likely because the representation of nonmoraic epenthetic vowels violates the Strict Layer Hypothesis (Selkirk 1984):

(47) **Strict Layer Hypothesis**.
A prosodic category at level *i* of the prosodic hierarchy must immediately dominate at least one instance of the prosodic category *i*-1.

The constituents of the prosodic hierarchy relevant for the present discussion are the syllable and the mora. The Strict Layer Hypothesis mandates that every syllable dominate at least one mora. Thus, Omnipotent Morification is generally assumed: Omnipotent Morification provides a mora wherever one is needed, avoiding violations of strict layering.

More recently, Itô and Mester (1992) argue that the Phonological Word may immediately dominate a syllable, bypassing the foot. This is termed the Weak Layer Hypothesis[17]. In Piggott (1995), as in the present paper, arguments for nonmoraic epenthetic vowels are presented. Regarding Weak and Strict Layering, he states:

(48)

> Recently, Itô and Mester (1992) argue that prosodic organization must allow a syllable to be licensed directly by the word bypassing the foot, the Weak Layering hypothesis. By extension, it should be possible for a vowel to be licensed directly by a syllable bypassing the mora, onset consonants are, of course, directly licensed by the syllable.
>
> The adoption of a theory with Weak Layering removes any principled objections to the phonological well-formedness of [nonmoraic epenthetic vowels]. (Piggott 1995:323).

Following Itô and Mester (1992), Piggott (1995), and Hayes (1995), I adopt a theory of Weak Layering, for two purposes: first, to allow a ban on degenerate feet (the Phonological Word is therefore able to immediately dominate the syllable, bypassing the foot); and second, to allow nonmoraic epenthetic vowels (the syllable is able to directly dominate the vowel, bypassing the mora). By allowing nonmoraic epenthetic vowels, the adoption of Weak Layering also allows the confinement of Morafication to the lexicon (or at least prior to syllabification).

4. Heavy Syllables in Malagasy.

In this section, I present two instances of derived heavy syllables in Malagasy, and present Compensatory Weight and Quantity Assumption analyses. In 4.1, I discuss derived heavy syllables in penultimate position, and in 4.2, I discuss derived heavy syllables in final position.

[17] Note that Hayes (1995) assumes weak layering in allowing bans on degenerate feet.

4.1. Aberrant Penultimate Stress.

In this section, I show the existence of derived bimoraic syllables in Malagasy, in an analysis I call the Multiple Weight Analysis.

(49)

1. Active verb (unsuffixed)	**2. Relative verb (suffixed)**	**3. Proposed Root**	**4. Gloss**
a.			
misótro	ìsotróana	sotro	to drink
mamángy	àmangíana	mangi	to visit
mìtadídy	itàdidíana	tadidi	to remember
b.			
mahíta	àhitána	hita	to see
miásа	ìasána	asa	to work
mitóndra	ìtondrána	tondra	to carry, bring
mijínja	ìjinjána	jinja	to reap, cut down
c.			
mijéry	ijeréna	jere	to look at
mambóly	àmboléna	vole	to plant
maméfy	àmeféna	fefe	to fence in
miáiky	iàikéna	aike	to give in; to confess

Notice that in (49a), the suffixed forms all have antepenultimate stress. I claim that the final *-a* in these forms is epenthetic and nonmoraic, and that the actual form of the suffix is *-an* (the derivation of forms with these suffixes is parallel to forms with Weak Final Syllables). Therefore, the forms in (49b) and (49c) are apparent counterexamples to the Bimoraic Foot Hypothesis, as it appears that vowel dominating the final mora is stressed. I will call this phenomenon Aberrant Penultimate Stress. Note that in (49b), the final vowel of the root and the first vowel of the suffix are identical. I propose that because Malagasy has no length distinction, a sequence of two identical vowels fuse:

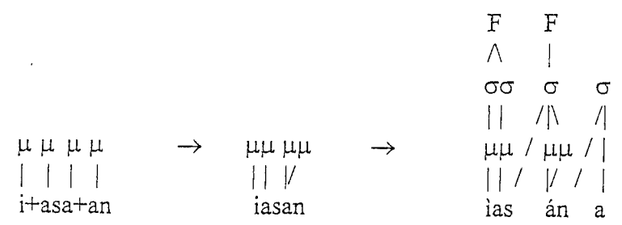
(50) **Vowel Fusion**:

$V_iV_i \rightarrow V_i$

Vowel fusion results in a syllable dominating a bimoraic vowel:

(51) **Multiple Weight Analysis.**

a. Morafication b. Vowel Fusion c. Syllabification & Footing



In (51), Morafication occurs first, in the lexicon (51a). Then morphological concatenation occurs, suffixing *an*, and prefixing *i*, to the root *asa*. This results in a disallowed sequence: two identical vowels in hiatus. Vowel Fusion occurs (51b), deleting one of the offending vowels. The mora that the deleted vowel had previously projected does *not* delete, and attaches to the remaining vowel, creating a bimoraic vowel. Then, syllabification (including epenthesis, in order to syllabify the final *n*) and footing occur, yielding the correct result: *ìasána*.

I claim that the penultimate stress in the examples in (49b) is derived identically as in (51), however, the constraint that forces the bimoraic *e*[18] is stated in (52):

[18] Pearson (1994) postulates that all instances of *e*, underlying and derived, are bimoraic. However, this analysis is untenable given the following reduplication data:

Root	Unreduplicated Form	Reduplicated Form	Gloss (unreduplicated)
a. **bisyllabic reduplication**			
avo	ávo	àvoávo	high
faly	fály	fàlifály	happy
hiaz	mahía	mahìahía	thin
zava	mazáva	mazàvazáva	bright
ratsy	rátsy	ràtsirátsy	bad
vony	vóny	vònivóny	brown/yellow
hendre	héndry	hèndrihéndry	well behaved
helo	màlahélo	màlahèlohélo	sad
tere	téry	tèritéry	narrow
tezer	tézitra	tèzatézitra	angry
kely	kély	kèlikély	small
b. **monosyllabic reduplication**:			
may	mamáy	màmaimáy	hot
vao	váo	vaováo	new
traoh	tráoka	traotráoka	windpipe; bluster, threats
tsaika	tsáika	tsaitsáika	walking on tiptoe
paih	paika	paipáika	a stroke, blow

The reduplicant is a bimoraic foot. Note that *e* patterns with other monomoraic vowels rather than with bimoraic diphthongs. That is, the reduplicated form of *kély* is *kèlikély*, not **kekély*.

(52) **Disallowed Vowel Sequences**[19]:

**ei*[20]; **ea*

Restriction: These constraints only apply to tautomorphemic sequences.

An alternative to the Multiple Weight Analysis of aberrant penultimate stress is motivated by the Quantity Assumption (3), repeated here as (53):

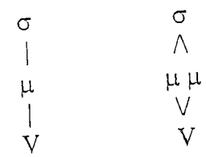
(53) **The Quantity Assumption.**
A contrast in the number of moras dominating a segment is realized as a contrast in length.

Since the vowel in the bimoraic syllable in (51) is not realized as long, a traditional analysis based on the Quantity Assumption deletes one of the moras dominating the vowel. The reasoning is as follows: since there is no length contrast in Malagasy, then by the Quantity Assumption there cannot be a contrast in the number of moras dominating vowels.

Recall (2a) and (2b), restated here as (54):

(54)

a. b.



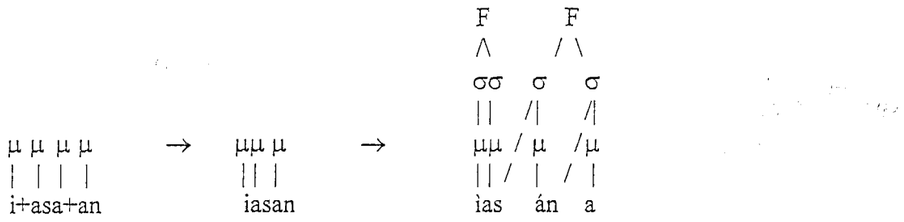
(54) presents the standard interpretation of the Quantity Assumption with respect to vowels: long vowels are bimoraic and short vowels are monomoraic, with no other possibilities. The standard interpretation further assumes that in the absence of a length contrast, all vowels are represented as (54a), or as short vowels. This includes epenthetic vowels (which in languages with length contrasts also surface as short). In other words, the standard interpretation of the quantity assumption assumes Omnipotent Morafication: whenever a vowel is inserted, a single mora accompanies, resulting in a short vowel. A Quantity Assumption Analysis of aberrant antepenultimate stress, which assumes Omnipotent Morafication[21] as well, is given in (55):

[19] Senturia (personal communication) has indicated that a possible motivation for a ban on these sequences is that they are not "far enough apart" in sonority to be viable sequences. However, *eo* is attested, as well as *ae* and *ia*, but these latter two only occur when the first vowel is a verbal prefix *i-* or *a-*, and thus the existence of heteromophemic *ie* and *ae* sequences is ascribed to morpheme integrity.

[20] Since *-in* and *-an* are unpredictable allophones of the same morpheme, it is impossible to determine which of these allophones is actually underlyingly present in (49c).

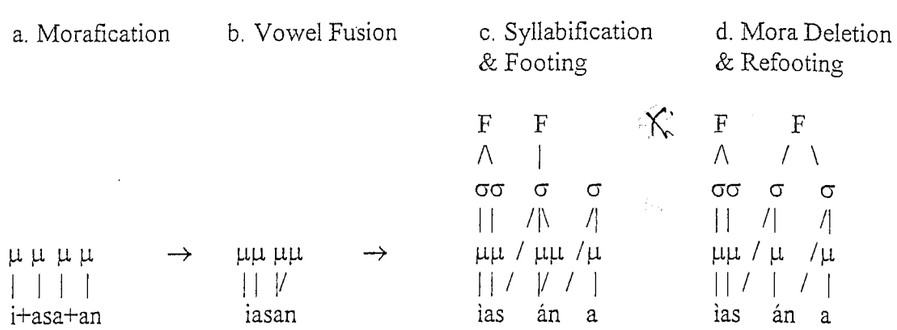
[21] Arguments against Omnipotent Morafication were given in section 3.2.2.2.

(55) **Early Mora Deletion Variant of Quantity Assumption Analysis.**



Morification (55a) is identical to (51a). Vowel Fusion results in mora deletion (55b), because the vowel does not surface as long. This step has no language-internal motivation; the only reason for mora deletion is the Quantity Assumption. Under this analysis, stress again is correctly predicted, just as in the Multiple Weight Analysis. In (55), mora deletion is assumed to occur before syllabification and footing, hence the name "Early Mora Deletion". A plausible alternative to this is that mora deletion is a late step, following syllabification and footing. This alternative, which I will call the Late Mora Deletion Variant, is presented in (56).

(56) **Late Mora Deletion Variant of Quantity Assumption Analysis.**

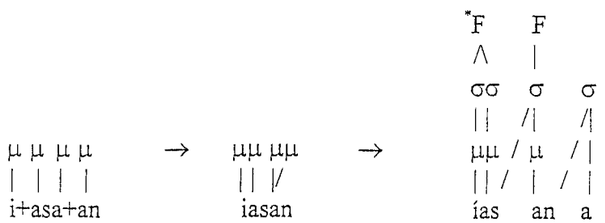


In (56), Mora Deletion occurs after syllabification and footing. In an intermediate step following mora deletion but before refooting (after (56c) but before (56d); not shown), the final foot dominates the penultimate syllable, which now dominates only one mora. This constitutes a degenerate foot, and is an impermissible structure because of the ban on degenerate feet (27). An extra refooting step is forced, whereby the final syllable is incorporated into the final foot, creating a well-formed structure. The Late Mora Deletion Variant, like the previous variant of the Quantity Assumption analysis, results in the correct structure, but is dispreferred to the previous variant because the Late Mora Deletion Variant results in an ill-formed structure (a degenerate foot) which must be fixed by a final refooting process.

Two more variants of a Quantity Assumption analysis are conceivable: parallel analyses to the Early and Late Mora Deletion variants (55) and (56), but which do not assume Omnipresent

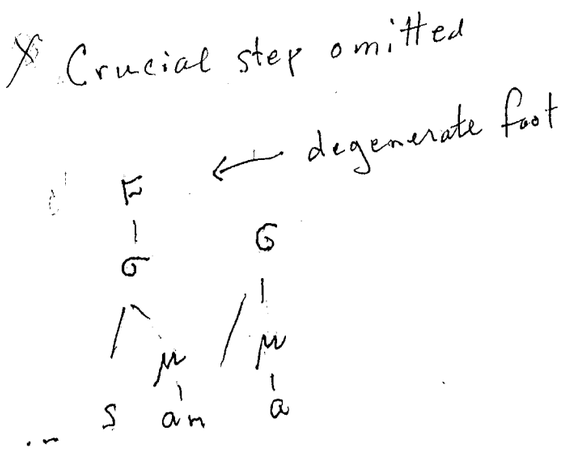
Morification: that is, analyses in which nonmoraic epenthetic vowels are allowed. However, in both these variants, the incorrect structure results:

(57) **Quantity Assumption Analysis; no Omnipresent Morification:**



(57) shows the Late Mora Deletion Variant, though in the Early Mora Deletion Variant, the result is the same: a degenerate foot is created (which is ill-formed). Since no mora dominates the final vowel, no footing or refooting which would allow correct stress assignment, is possible. Therefore, Omnipotent Morification must be assumed in a viable Quantity Assumption analysis of aberrant penultimate stress. However, as I show in section 3.2.2.2, Omnipotent Morification must be abandoned to allow a proper analysis of antepenultimate stress in words with Weak Final Syllables. That is, the only account which can properly predict *all* cases of antepenultimate *and* penultimate stress is one which allows three degrees of syllable weight: syllables dominating nonmoraic epenthetic vowels, as well as light and heavy syllables: the Multiple Weight Analysis. An analysis under the Quantity Assumption must disallow nonmoraic vowels to account for cases antepenultimate stress, but must allow nonmoraic vowels to account for aberrant penultimate stress.

Further evidence against a Quantity Assumption analysis is presented in section 4.2, where instances of final stress are discussed.



4.2. Final Stress.

Another apparent counterexample to the Bimoraic Foot Hypothesis is in some imperative forms, where an apparent stress shift occurs in those verbs with roots ending in *a* or *e*. The imperative data is presented in (58):

(58)

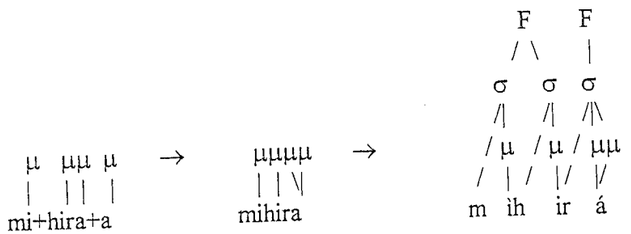
Root	Active	Imperative	Gloss
a. Roots in *-i* and *-o*; no fusion			
voly	mambóly	màmbolía	to plant
valy	mamály	màmalía	to answer
azo	maházo	màhazóa	understand
haino	miháino	mihàinóa	sleep
b. Consonant-final roots			
fates	máty	matésa	die
dihiz	mandíhy	màndihíza	dance
voar	mànambóatra	manàmboára	arrange, prepare
c. Roots in *-a* and *-e*; fusion and deletion, respectively			
hira	mihíra	mìhirá	sing
asa	miásа	mìasá	to work
fefe	maméfy	màmefé	enclose
jere	mijéry	mìjeré	look at

The data in (58a) and (58b) are explained as suffixation of the imperative morpheme *-a*, either to a vowel-final (58a) or consonant-final root (58b). Under a Multiple Weight analysis, the forms in (58c) are analyzed as follows: The imperative suffix *-a* fuses with the preceding vowel (in the case of final *-a+a*), or deletes (in the case of **ea*)[22]. As in (51), only the vowel deletes, while the mora remains, which is incorporated into the preceding syllable, forming a derived bimoraic heavy syllable:

[22] Recall the ban on the sequences **ea* and **ei* (52).

(59) **Multiple Weight Analysis (Final stress on imperatives).**

a. Morafication b. Vowel Fusion c. Syllabification & Footing

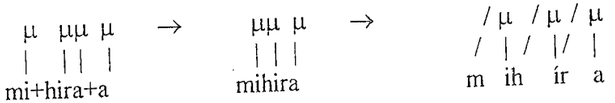


Stress is correctly predicted under the Multiple Weight Analysis, because a heavy final syllable is allowed.

A analysis of this data based on the Quantity Assumption is presented in (60):

(60) **Early Mora Deletion Variant of Quantity Assumption Analysis of Final Stress.**

a. Morafication b. Vowel Fusion c. Syllabification & Footing

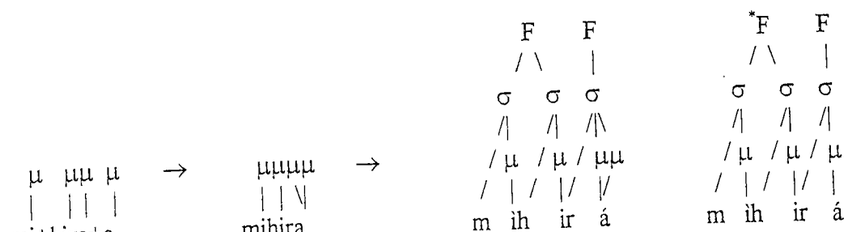


The structure in (60c) predicts that stress on the surface form is *mihíra*; while the actual form is *mìhirá*.

For comparison, the Late Mora Deletion Variant is presented in (61):

(61) **Late Mora Deletion Variant of Quantity Assumption Analysis of Final Stress.**

a. Morafication b. Vowel Fusion c. Syllabification & Footing d. Late Mora Deletion



The Late Mora Deletion Variant results in a degenerate foot, which can not be resolved in such a way as to correctly predict final stress. Therefore, no version of a Quantity Assumption analysis can account for final stress in Malagasy. Therefore, the Multiple Weight Analysis is preferred.

5. Conclusion

Recall the Quantity Assumption:

(62) **The Quantity Assumption.**
A contrast in the number of moras dominating a segment is realized as a contrast in length.

I have argued that in Malagasy, a language with no length contrast, there exist syllables which dominate nonmoraic epenthetic vowels, monomoraic vowels, and derived bimoraic vowels. That is, there is a three-way weight distinction among Malagasy syllables, but no length distinction among Malagasy vowels. I have shown that various analyses which presume the Quantity Assumption can not account for all realizations of Malagasy stress: antepenultimate, penultimate, and final.

In Malagasy, all epenthetic vowels and only epenthetic vowels are nonmoraic, and furthermore, all derived vowels and only derived vowels are bimoraic[23]. This is predictable from the independently posited notions in (63):

(63) a. Morafication algorithm: A vowel projects a mora.
b. Reanalysis of roots: some have final consonants.
c. NoCoda.
d. Syllabification: The inability to syllabify root-final consonants forces epenthesis in some instances, Stray Erasure in others (unpredictably).
e. Vowel Fusion
f. **ea*, **ei*; to resolve this, the second vowel deletes, but the associated mora does not.

Crucially, none of the processes (63b-f) which follow morafication add or delete a mora. That is, morification is the only source of moras in Malagasy, and all moras created by morafication are preserved, whether dominating the vowel that projected them or otherwise. When a vowel is epenthesized (63d), no new mora is introduced, hence, the existence of nonmoraic vowels. When a vowel is fused (63e) or deleted (63f), the mora remains and is incorporated by the preceding vowel, hence, the existence of bimoraic vowels. Thus, the three-way syllable weight contrast is predictable from the independently motivated elements in (63). All syllables surface with vowels of a single length in their nuclei, directly the contradicting the

[23] Caveat: I have not determined if instances of identical vowel fusion to the left of the main stress affect secondary stress. Even if it does not, this does not refute the statement that "all derived vowels and only derived vowels are bimoraic," as there are attested languages in which heavy syllables only affect primary stress.

Quantity Assumption. I therefore claim that the Quantity Assumption is not a universal law, rather, that the phonetic interpretation of contrasts in mora count is a language-specific function[24].

This claim makes several predictions about the content of universal grammar versus the content of the grammars of individual languages. Under the Quantity Assumption, there exist universal rules which map syllable weight to phonetic duration. In absence of the Quantity Assumption, there are language-specific phonetic rules that derive phonetic duration from weight. Malagasy represents the case where the grammar does *not* contain any such rule.

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[24] Note that this claim is consistent with the observed fact that languages vary in relative mean duration of long versus short segments (Hubbard 1994).

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UCLA OCCASIONAL PAPERS
IN LINGUISTICS
NUMBER 17

The Structure of Malagasy

VOLUME I

edited by

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University of California, Los Angeles
1996