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TWO PERSPECTIVES ON MALAGASY REDUPLICATION: DERIVATIONAL AND OT ANALYSES*

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Malagasy is an Austronesian language with a productive reduplication morphology that applies to both roots and affixed stems. In this paper, we focus on the reduplication of a class of verbs in Malagasy. These verbs often appear with an active voice marker "*an-*" that triggers alternation in the root-initial consonants. The reduplication of the "*an*"-verbs is analyzed within two different frameworks. The first analysis is rule-based, and accounts for phonological variants with variable rule ordering. This analysis is then used to construct an alternative account, from the perspective of correspondence theory – a sub-theory of Optimality Theory. The strong derivational characteristics of the Malagasy data leads us to argue that although OT is perhaps a better model for language universals, phonological rule can still be valuable analytic tool for understanding reduplication.

1. INTRODUCTION

Reduplication refers to the phenomena, seen in many languages, that a phonological form has two or more (nearly) identical components. In both derivational phonology (Chomsky and Halle 1968) and Optimality-Theory (Prince and Smolensky 1993), reduplication has attracted much attention partly because it provides a testing ground for a variety of sophisticated formalisms constructed within these two frameworks.

A derivational analysis is characterized by its use of *phonological rules*, whose role is to modify the phonological representation in a certain order. Reduplication is primarily accounted for with a type of "copying" rule. In contrast, OT assumes there is a machinery that provides many possible candidates for a given underlying representation, and that a *constraint hierarchy* determines the optimal candidate as the output. The specific version of OT that has been used to analyze reduplication is termed *Correspondence Theory* by McCarthy and Prince 1995. The key insight of their proposal is to view morphologically complex forms as the result of competing constraints that require different parts of the form to be similar to each other. Within the OT framework, the similarity requirements are formalized as correspondence constraints.

Evidently, OT has become the dominant practice in phonology, partly because it has addressed a number of long-standing problems in the derivational phonology[1]. Thus it may seem that phono-

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[1]See, for example, Archangeli and Langendoen 1997 general discussions.

logical rules have become outdated in theoretical work. However, the task of drawing a linguistic analysis needs to be separated from that of constructing a universal grammar. When a linguist faces a body of data and intends to summarize the significant patterns therein, rules can still be a valuable analytic tool for revealing linguistic generalizations at a pre-theoretic level.

This paper will try to achieve two goals. First, the data was collected from the author's fieldwork and may be of interest to Austronesian specialists as well as formal phonologists. The emphasis is given to the reduplication of a class of verbs in Malagasy. These verbs often appear with an active voice marker "*an*-" that triggers alternation in the root-initial consonants. Many of the "an-" verbs have duplicated forms that are primarily determined by the phonological shapes of the root. In particular, there are three factors that contribute to the outcome of "an-" verb reduplication: 1) stress pattern of the root; 2) the initial consonant of the root; and 3) the final syllable of the root. These factors are correlated, and they must be taken into account together in order to predict the duplicated form. Compared to the previous work (Keenan and Razafimamonjy 1998), the current data contains many more cases of the reduplication of "an-" verbs and documents some phonological variants in reduplication.

Our second goal is to illustrate the strong derivational character of the Malagasy data, and how a rule-based analysis of reduplication can inform the use of correspondence constraints. The OT analysis sketched here shares a number of assumptions with the derivational analysis, such as the shape of the underlying form and the identification of base and reduplicant. These two analyses are followed by a brief discussion about the comparison between the theoretical approaches.

2. Overview of data

Malagasy is a West Austronesian language spoken by about 12 million people. The Malagasy vowel system consists of four vowels: [a], [e], [i], [u] and three diphthongs [ai], [au] and [ui]. The Malagasy consonant inventory is shown in Table 1. Each Malagasy stop or affricate can be preceded by a nasal air flow during its oral closure. This class of complex articulations can be transcribed either as a consonant cluster (i.e. *nasal+consonant*) or as a pre-nasalized segment. Here we follow Keenan and Polinsky 1998 and treat them as prenasalized segments, since there is no phonological evidence suggesting that they are consonant clusters.

The case study presented here is based on the Merina dialect of Malagasy. It has two notable differences from the standard dialect: First, [h] is completely dropped and creates some vowel sequences not in the diphthong inventory. But these vowel sequences do not behave in the same way as true diphthongs and are always treated as belonging to two different syllables. Second, intervocalically, the nasal murmur of pre-nasalized obstruents is rather weak. For example, word-medial b/mb, p/mp, k/nk cannot be easily distinguished from the spectrogram. However, such neutralization effects appear to be phonetic, since they do not create a problem for the phonological analysis discussed in this paper.

Introducing prenasalized segments in the consonant inventory leads to a uniform CV structure for all syllables. To a large extent, the metrical structure in Malagasy is predictable, based on a proper identification of different classes of roots. Most roots have penultimate stress, but roots that end with diphthongs or singleton [e] have ultimate stress[2]. A particular class of words bear an anti-penultimate stress, and they will be discussed in Section 3.1. For a detailed description of stress as well as more details of Malagasy phonology, we refer readers to Erwin 1995 and Albro to appear.

Unlike some other Austronesian languages, Malagasy morphology only has one type of reduplication. When a word has several reduplicated forms, they usually share the same meaning among repetition, intensification, moderation or approximation. The reader can get a rough idea by taking a quick look at the following examples:

(1) latábatra "*table*" latàbatábatra "*kind of a table*"
(2) soméby "*upset*" somèbiséby "*quite upset*"
(3) máty "*dead*" màtimáty "*warm*"
(4) mamángy "*visit (formal)*" mamàngivángy "*visit, (casual)*"
(5) mamádika "*turn over*" mamàdibádika "*keep turning over*"
(6) mamítana "*fish (job)*" mamìtampítana "*fish (for fun)*"
(7) mamíndry "*press*" mamìndrimíndry "*press gently, massage*"

The following representative dataset would be analyzed in both rule-based and OT analyses:

(8) sátroka "*hat*" + fótsy "*white*" sátropótsy / sátroka-fótsy "*white hat*"
(9) lèhibé "*big*" le̍hibèbé "*very big*"
(10) salàma "*health*" salàmaláma "*very fit*"
(11) lávitra "*far away*" làvidávitra "*far, far away*"
(12) latábatra "*table*" latàbatábatra "*little table*"
(13) manáo "*do*" manàonáo / manàotáo "*do repeatedly*"
(14) mamáky "*break*" mamàkivàky "*break intensively*"
(15) manása "*invite*" manàsanása "*invite casually*"
(16) mamádika "*turn over*" mamàdibádika "*roll*"
(17) manófa "*wave*" manòfanófa / manòfaófa / manòfófa "*wave repeatedly*"

[2]However, an exception is noted in Martin 2005 where he observed that a class of loanwords (e.g. *s òkolá* "chocolate") have final stress.

All transcriptions were made in Malagasy orthography. It differs from the international phonetic alphabet in a few symbols:

(18)

Orthography	IPA	Example
i/y	[i]	ivy [ivi]
o	[u]	mofo [mufu]
j	[dz]	rojo [rudzu]
nj	[ndz]	vanja [vandza]
ng	[ŋg]	ngeza [ŋgeza]

3. A RULE-BASED ACCOUNT

We start by outlining a rule-based analysis of the data. Our analysis may be not be the most theoretically-informed kind, but the emphasis is placed on giving an intuitive account, i.e. "making sense" of the data.

3.1. Weak words and the incorporation rule

One of the keys to understanding alternations in Malagasy reduplication is to relate a special class of words to the following morphological process, where the final syllable of the word is deleted. This rather complicated pattern was given the name "incorporation" by Keenan 1998. Below are some examples of incorporation:

(19) fántatra *"known"*+ rakóto *"Rakoto"* ⟶ fántadrakóto / fántatra-rakóto
"known by Rakoto"

(20) sátroka *"hat"*+ fótsy *"white"* ⟶ sátropótsy / sátroka-fótsy *"white hat"*

(21) mánana *"has"*+ zánaka *"chidren"* ⟶ mánanjánaka / mánana-zánaka
"has children"

(22) závatra *"thing"*+ nisého *"happened"* ⟶ závanisého / závatra-nisého
"past event"

In order to describe this process, "incorporation" looks like a more appropriate term than "deletion", because for the consonant in the last syllable, the manner of articulation is retained, but the place of articulation is lost. Notably, all words with anti-penultimate stress can undergo this process, and the final syllable is either [na], [ka] or [tra][3]. Since these syllables undergo (incomplete) deletion, Keenan called them "weak" syllables, and this class of words is called "weak" words. It

[3]In Keenan 1998, the weak words are historically related to Bantu influence.

should be noted that words with anti-penultimate stress are only a proper subset of the weak words, since some bisyllabic words, such as *fóka* and *fétra*, are also weak[4].

Although weak words all have [na]/[ka]/[tra] final syllables, not all words ending with [na]/[ka]/[tra] are weak. This point can be illustrated with the homonyms *saina* "mind" and *saina* "flag", which behave differently in incorporation:

(23)

	Surface form	UR	Behavior in Incorporation
Weak	saina "mind"	/sain/	sain-potsy "white mind"
Non-weak	saina "flag"	/saina/	saina-fotsy "white flag"

The only way of distinguishing this pair of words is to assume a distinction in the underlying representation: while *saina* "flag" has a final vowel specified in the underlying form, *saina* "mind" is consonant-final. This distinction in the underlying form is neutralized by the following epenthesis rule:

(24) Epenthesis: $\phi \longrightarrow a \Big/ C\_\_ \Big]_{word}$

Once such a distinction in underlying form is recognized, incorporation can be formulated as a rule that applies to consonant clusters[5]. The alternations can be seen more clearly by sorting the consonants according to six different manners of articulation, as shown in Table 1.

Based on Table 1, the effect of incorporation can be summarized in two lines:

- All kC or trC clusters are mapped to the segment at column 3 and the same row as C.
- All nC clusters are mapped to the segment at column 2 and the same row as C.

This generalization gives rise to the following rule:

(25) Incorporation:

$$\begin{bmatrix} -continuant \\ \alpha\, nasal \end{bmatrix} \begin{bmatrix} -syllabic \\ \beta\, continuant \\ \gamma\, nasal \\ \mu \end{bmatrix} \longrightarrow \begin{bmatrix} -syllabic \\ -continuant \\ (\alpha \vee \gamma)\, nasal \\ \mu \end{bmatrix}$$

[4]Note: our use of "weak words" includes what Keenan called "Weak"and "Pseudo-weak". The extra "pseudo" is to distinguish bisyllabic weak words from polysyllabic ones.

[5]Since prenasalized stops/affricates are treated as one single segment, we will not consider *nasal+obstruent* sequences as consonant clusters.

	1 nasals	2 prenasalized stops/ fricatives	3 oral non-continuants	4 fricatives	5 liquid	6 flap/trill
labial/labiodental		mp	p	f		
	m	mb	b	v		
dental/alveolar		nt	t			
		nts	ts	s		
	n	nd	d		l	
		ndz	dz	z		
postalveolar		ntr	tr			
		ndr	dr			r
velar/laryngeal		ŋk	k	h		
	ŋ	ŋg	g			

Table 1: Malagasy consonant inventory

The structural description on the left-hand side of (25) includes all consonant clusters discussed above. μ is the feature matrix of the second consonant excluding the feature [continuant]. It can be verified that the above formalization captures all the relevant aspects of incorporation.

Considering the fact that incorporation is optional, we allow the ordering between Epenthesis (24) and Incorporation (25) to be variable[6]. The effect of variable ordering can be seen in Table 2.

/manan/ + /zanak/		
VP-compounding	$\longrightarrow$	/manan-zanak/
Epenthesis	$\longrightarrow$	/manana-zanaka/
Incorporation	$\longrightarrow$	/manana-zanaka/
/manan/ + /zanak/		
VP-compounding	$\longrightarrow$	/manan-zanak/
Incorporation	$\longrightarrow$	/manan-dzanak/
Epenthesis	$\longrightarrow$	/manan-dzanaka/

Table 2: Variable ordering of *Epenthesis* and *Incorporation*

3.2. Primary stress

The stress system of Malagasy has been discussed extensively in Erwin 1995. Because the primary stress determines the domain of copying in reduplication, we introduce a general rule that assigns the primary stress to a word, without working out all the details involved in the rule:

[6] An alternative to variable ordering is to treat Epenthesis as an optional rule. But this option will not be pursued here.

(26) Primary Stress Assignment (Stress): stress ultima if it is a heavy syllable; otherwise, stress the penultima.

Here a heavy syllable is defined as a syllable with a diphthong or [e] as the nuclei, not including the exceptions of loanwords noted in the overview. Since the *Stress* rule only includes two types of stress, in order for anti-penultimate stress to appear on the weak words, *Stress* has to be applied before *Epenthesis*. In a more conventional analysis, one may wish to treat the final [na]/[ka]/[tra] syllables as extra-metrical. But the current strategy simplifies the analysis by avoiding another rule of syncope that triggers incorporation. This point will be further illustrated in the reduplication of weak words.

3.3. Prefixation

For a large number of Malagasy verbs, the root morpheme has a passive meaning (e.g. *váky* "to be broken"). On the other hand, most prefixes that can be applied to verbs are related to voice. For example, the active voice prefix *an-* can be applied to a variety of passive verbs. Phonologically, *an*-prefixation does not cause any change in the primary stress, but triggers alternation in the root-initial consonant since a [nasal]+C consonant cluster may occur as the result of prefixation, as illustrated in Table 3.

an	+	fokatra	famokarana	an	+	haja	manaja
	+	petraka	mametraka		+	kenda	manenda
	+	voly	fambolena		+	takona	fanakonana
	+	valy	mamaly		+	sivana	fanivanana
	+	babo	mamabo		+	tsiratsira	faniratsirana
	+	bata	mambata		+	zaitra	fanjaitra
	+	gina	fanginana		+	lamaka	fandamahana
	+	hataka	mangaraka		+	rahona	fandrahonana

Table 3: Examples of an-prefixation

Compared to *Incorporation*, these patterns are different in two aspects: First, only voiced obstruents can undergo postnasal hardening; voiceless ones simply delete. Second, the nasal prefixation rule also has exceptions (e.g. */babo/mamabo* v.s. */bata/mambata*). The complication will arise as we encounter the reduplication of prefixed forms. For simplicity, we will use *Prefixation* to represent the pattern as illustrated in Table 3.

3.4. The basic copying rule

The basic reduplication pattern is represented by examples (27)–(30):

(27) lèhibé *"big"* ⟶ lèhibèbé *"very big"*
(28) salàma *"healthy"* ⟶ salàmaláma *"very fit"*
(29) latábatra *"table"* ⟶ latàbatábatra *"little table"*
(30) lavitra *"far away"* ⟶ làvidávitra *"far, far away"*

In order to produce these patterns, we use a rule adapted from a similar version in Keenan 1998:

(31) Copy: given an input form $\alpha\acute{\sigma}\beta$, where $\acute{\sigma}$ is the syllable that carries the primary stress, α and β are the adjacent substrings (including ϵ), then the result of applying *Copy* is $\alpha\grave{\sigma}\beta\acute{\sigma}\beta$.

This rule simply stipulates that one find the primary stress of the string, copy everything from the stressed syllable to the right edge, and concatenate the copied string after the original string. Based on the discussion of stress in 3.2, an alternative way is to introduce a prosodic template, such as an iambic foot, and then fill in the template with appropriate segments. Here we use rule (31) because of its simplicity.

Since *Copy* refers to the the primary stress, it must be ordered after *Stress*. Also in order to get the consonant alternation as illustrated by *làvidávitra*, Incorporation has to be applied after Copy. The following derivations illustrate such a rule ordering effect.

(32)

		latabatr	lavitr	haigan	fok
Stress	⟶	latábatr	lávitr	háigan	fók
Copy	⟶	latàbatrtábatr	làvitrlávitr	hàiganháigan	fòkfók
Incorporation	⟶	latàbatábatr	làvidávitr	hàigankáigan	fòpók
Epenthesis	⟶	latàbatábatra	làvidávitra	hàigankáigana	fòpóka

3.5. Hiatus resolution

Another wrinkle in reduplication appears when the base word has the form of VCV with an initial stress. For these words, the unstressed vowel may be reduced, thus resulting in a clash in word stress:

(33) óva ⟶òvaóva / òvóva
ívy ⟶ìviívy / ìvívy

We formulate an optional rule for hiatus resolution:

(34) Hiatus Resolution: $V \longrightarrow \phi / \_\_ \hat{V}$

The domain in which this rule is applied must exclude monomorphemic environments[7] in reduplication, since the hiatus in morphologically simple forms never gets reduced (e.g. *vo.a.va.ry* "tapeworm cyst", *ba.ra.re.o.ka* "bleat").

3.6. The interaction between reduplication and prefixation

As seen in 3.3 and 3.4, prefixation and reduplication triggers alternation in two separate domains: while the *an* prefix induces alternation in the root-initial consonant (Table 3), the root-final weak syllables are the main source of alternation in reduplication. The most sophisticated patterns arise in situations where these two domains overlap with each other. Those patterns fall into two groups.

In the first group, the two copies in the duplicated form share the same initial consonant, as illustrated by the following example:

(35) *táo* "to be done" ⟶*manàonáo* "do repeatedly"

These cases can be analyzed by placing the Prefixation rule before Copy and Incorporation, as illustrated by the following example.

(36)

	/fafy/	/hery/	/sofin/	/halatr/
Stress	fàfy	héry	sófin	hálatr
Prefixation	mamàfy	mangéry	manófin	mangálatr
Copy	mamàfimàfy	mangèringéry	manòfinnófin	mangàlatrngálatr
Incorporation	mamàfimàfy	mangèringéry	manòfinófin	mangàlangálatr
Epenthesis	mamàfimàfy	mangèringéry	manòfinófina	mangàlangálatra

Notice that in the case of *mangàlangálatra*, although a consonant cluster occurs during the derivation, the two copies still share the syllable onset *ng* because Incorporation deletes the *tr* before a nasal.

In the other group of patterns, the two copies do not share the same initial consonant. For example, below is another variant for "do repeatedly":

(37) *táo* "to be done" ⟶*manàotáo* "do repeatedly"

While the nasal onset in the first copy is the result of *an*-prefixation, the underlying *t* appears in the second copy instead. Such an effect can be seen as the consequence of a different rule ordering, which is exemplified below[8]:

[7] Or alternatively, this may be seen as a "cyclic" rule that only applies in derive environments.

[8] Unlike *táo*, these words only have one duplicated form for the active voice.

(38)

	/tsipy/	/voly/	/petrak/	/vadik/
Stress	tsípy	vóly	pétrak	vádik
Copy	tsìpitsípy	vòlivóly	pètrakpétrak	vàdikvádik
Incorporation	tsìpitsípy	vòlivóly	pètrapétrak	vàdibádik
Prefixation	manìpitsípy	mambòlivóly	mamètrakpétrak	mambàdibádik
Epenthesis	manìpitsípy	mambòlivóly	mamètrapétraka	mambàdibádika

Notice in *mambàdibádika*, the onset consonant of the second copy (*b*) is different from both the first copy (*mb*) and the underlying syllable onset (*v*). Although this seems puzzling, a natural explanation presents itself once we recognize *vádika* as a weak form: the syllable onset *b* is a consequence of incorporation (*kv* $\longrightarrow$*b*). The same story also applies to (39), where an underlying *p* needs to be identified root-initially in order to understand the origin of the onset *mp*.

(39) mamítana *"fish (job)"* $\longrightarrow$mamìtampítana *"fish (for fun)"*

As a final note, since there is no systematic difference in either meaning or syntax between the forms in (38) and those in (36), we suspect that the effect of different rule orderings is purely phonological.

3.7. Summary and implications of the rule-based analysis

We have shown a rule-based account of the Malagasy reduplication data. In particular, the variation in the data set can be explained by variable rule ordering and an optional rule:

- Variable rule ordering:
  - $\{$Epenthesis$\} \longleftrightarrow \{$Incorporation$\}$
  - $\{$Copy $\longrightarrow$ Incorporation$\} \longleftrightarrow \{$Prefixation$\}$
- Optional rule: Hiatus Resolution

Table 4 illustrates the analysis proposed so far, where multiple reduplication forms are observed for *ofa*[9], which means "to be waved":

It's worth noting that the analysis presented in this section can be extended to suffixation and infixation as well. For example, (40) illustrates two orderings for suffixation, and (41) for infixation.

[9]This word is usually transcribed as *hofa* in the standard dialect. Because [h] is dropped in our speaker's dialect, we will not add it in our transcription.

	/ofa/		/ofa/		/ofa/
AsgStress	ófa	AsgStress	ófa	AsgStress	ófa
Prefixation	manófa	Copy	òfaófa	Copy	òfaófa
Copy	manòfanófa	Incorporation	òfaófa	Incorporation	òfaófa
Incorporation	manòfanófa	Prefixation	manófaófa	Prefixation	manòfaófa
Epenthesis	manòfanófa	Epenthesis	manòfanófa	Epenthesis	manòfanófa
				-Hiatus	manòfófa

Table 4: 3 different ordering of rules that produce the three reduplicated forms of *ofa*

			/fonitr/			/ijery/
(40)	Suffixation	$\longrightarrow$	fonètana	Reduplication	$\longrightarrow$	ijèrijéry
	Reduplication	$\longrightarrow$	fonètanétana	Suffixation	$\longrightarrow$	ijèrijeréna
			/lano/			/seby/
(41)	Infixation	$\longrightarrow$	lománo	Reduplication	$\longrightarrow$	sèbiséby
	Reduplication	$\longrightarrow$	lomànománo	Infixation	$\longrightarrow$	somèbiséby

4. **Sketch of an Optimality-Theoretic analysis**

An OT analysis of the data presented here is likely to be quite complex. Limited by space, we will only list three problems that need to be addressed by any OT account. The first problem is the copying pattern that is sensitive to primary stress . The second problem is the alternation between the two copies, triggered by the weak syllables. Third, such alternations are made even more complex by the rule over-application effect in *an*-prefixation. Outline of some possible solutions will be included after the discussion of each problem. For simplicity, only part of the constraint ranking will be discussed, and no attempt is made to enumerate all possible candidates.

4.1. Reduplication as suffixation

Within the framework of correspondence theory (McCarthy and Prince 1995), phonological reduplication is seen as a type of affixation. Usually the two copies in a duplicated form are assigned different roles: one is treated as the source of copying and referred to as *Base*; while the other is treated as an affix, which is copied from the base and referred to as *Reduplicant* (henceforth shortened as RED).

As seen in 3.4, our rule-based analysis implicitly treats Malagasy reduplication as a kind of suffixation. The OT analysis sketched here will follow this route. Taking *mandàvidávitra* as an example, the input, base and reduplicant are identified as follows:

(42) $[lavitr]_{Input} \rightarrow ma[ndavi]_{Base}[davitra]_{RED}$

The unusual aspect of this analysis is that neither the base nor the reduplicant is completely faithful to the input, because *lávitra* is a weak word. This problem requires correspondence constraints on the segmental as well as on the featural level.

4.2. Setting up the basic copying pattern

To require that reduplicant serve as a suffix to the base, we need the following constraint from the family of Generalized Alignment constraints (McCarthy and Prince 1993):

(43) Align(Base,Right,RED,Left): the left edge of the reduplicant must be placed at the right edge of the Base.

The following constraints are also motivated by the rule-based analysis, in which copying starts from the primary-stressed syllable and proceeds to the right edge of the base:

(44) IdentStress: RED must contain a stressed syllable corresponding to the Base.

(45) Locality: the copy should be right next to the source string where it is copied from[10].

(46) *STRUC: the output representation should be as short as possible.

(47) MAX-IB(seg): the base should contain all the segments from the input.

(48) MAX-IR(seg): copy as much as possible from the input to RED.

The following table illustrates how these constraints select the desired copying pattern:

(49)

saláma /salama/	IdentStress	Locality	MAX-IB(seg)	*Struc	MAX-IR(seg)
salàmaláma				10	**
*salàmama	*!			8	****
*salásaláma			*!*	10	**
*salàmalá		*!		8	****
*salàmasaláma				12!	

To summarize: *salàmama fails because it doesn't copy stress; *salásaláma fails the base does not maximally preserve the input; *salàmalá does not satisfy Locality; *salàmasaláma copies too much and becomes unfavorable regarding *STRUC.

[10]For example, the following candidates all satisfy *Locality*: manòfanófa, manòfófa, manòfaófa.

4.3. Incorporation of weak words

Three alternations related to the weak words were discussed in the previous section: First, when the weak word forms a compound with a following word, incorporation occurs to reduce the weak syllable from the compound. Second, in isolated forms, a final vowel [a] is inserted word-finally. Third, in reduplication of weak words, the weak syllables are reduced. While the first process is optional, the last two processes are obligatory.

The first optional process can be accounted for with a variable constraint ranking (Zuraw 2000) between the two following constraints:

(50) MAX-IO(C#): word final consonants cannot be deleted from the underlying form.

(51) DEP-IO(V): do not insert vowels.

In addition, the following inviolable constraints are needed to ensure the pattern described in 3.1 does become the optimal output.

(52) CV: consonant clusters are not allowed in any position, and words should not end in consonants.

(53) MAX-IO([-continuant, α nasal]): all underlying [-continuant] and [α nasal] features must be preserved in the output.

(54) and (55) illustrate how a possible constraint ranking among the constraints listed above would regulate incorporation and final epenthesis.

(54)

/satrok/+/fotsy/	CV	MAX-IO([-cnt,nas])	MAX-IO(C#) <> DEP-IO
sátroka fotsy			*
sátro potsy			*
*sátro fotsy		*!	*
*sátrok fotsy	*!		

(55)

/satrok/	CV	MAX-IO([-cnt,nas])	MAX-IO(C#) <> DEP-IO
sátroka			*
*sátro		*!	*
*sátrok	*!		

4.4. Reduplication of weak words

First, we would like to address a simpler case, where the weak syllable deletes in reduplication. Here the crucial rival candidate is the following:

(56) **latàbatratábatra*, as opposed to *latàbatábatra*

Along the line of 4.2, because MAX-IB(seg) dominates *Struc, **latàbatratábatra* does not fail because it copies an extra syllable. Rather, an additional ranking DEP-IO >> MAX-IB is needed to ensure that word-medial *-n, -k, -tr* always delete in reduplication. Such a ranking captures the intuition that epenthesis is never allowed word-medially as a repair strategy for consonant clusters. (57) illustrates this analysis:

(57)

/latabatr/	CV	MAX-IO(C#)	DEP-IO	MAX-IB
latàbatábatra				*
*latàbatrtábatr	*!*			
*latàbatratábatra			*!	

The second case involves the incomplete deletion / incorporation of the word-medial *-n, -k, -tr*. Because there are many theoretically possible ways of resolving consonant clusters, in addition to the constraints used in 4.3, we need at least some other constraint that prevents deletion from occuring to the wrong target. One of such a constraint is formulated as follows:

(58) MAX-BR([CV́): if a stressed syllable is copied from the Base, do not delete its onset from RED.

We take the reduplication of /*lavitr*/ as an example to demonstrate how the constraint proposed above would replicate the result of the rule-based analysis in 3.4.

(59)

/lavitr/	CV	MAX-IO([-cnt, nas])	MAX-BR([CV́)	MAX-IO(C#)	DEP-IO	MAX-IB
làvidávitra						*
*làvitrlávitr	*!*					
*làvitralávitra					*!	
*làvilávitra		*!				*
*làvitrávitra			*!			

4.5. Over-application of nasal assimilation

The example *manàonáo* in 3.6 provides an example of rule over-application: the same consonant from nasal assimilation appears in both the base and the reduplicant. In contrast, nasal assimilation only applies to the first copy in *manàotáo,* not the second one. From the perspective of Correspondence Theory, such a variation can be seen as a tension between faithfulness requirements between input, base and the reduplicant. This type of idea can be formalized in terms of correspondence constraints, such as (60) and (61):

(60) Ident-IR: every feature in the reduplicant should be the same as its correspondent in the underlying form.

(61) Ident-BR: every feature in the reduplicant should be the same as its correspondent in the base.

For example, one way of entertaining both *manàotáo* and *manàonáo* is to allow Ident-IR to stand in variable ranking with Ident-BR, as illustrated in (62) and (63):

(62) Ident-IR >> Ident-BR

mamáky /vaky/	PU(prefix)	Ident-IR	Ident-BR	*Struc	MAX-IR
mamàkiváky			*	10	**
* mamàkimáky		*!		10	**
* mamàkimamáky		*!		12	
* mavàkiváky	*!			10	**

(63) Ident-BR >> Ident-IR

manása /sasa/	PU(prefix)	Ident-BR	Ident-IR	*Struc	MAX-IR
* manàsanása			*	10	**
* manàsasása		*!		10	**
* manàsamanása			*	12!	

In the above tables, *PU(prefix)* represents a paradigm uniformity constraint. It excludes forms such as **mavàkiváky*, which does not conform to the nasal assimilation observed in another member of the paradigm *mamáky*. Although we did not spell out the details, it suffices to acknowledge that its role is to ensure that nasal assimilation occur in the base.

This discussion concludes the sketch of the OT analysis. Since the variable ranking analysis can be easily extended to the optional hiatus resolution, we will end here.

5. DISCUSSION

As a formalism that maps underlying representations to surface ones, a notable advantage of OT is that it solves the "conspiracy problem"(Kisseberth 1970). Simply speaking, the conspiracy problem reflects the situation that many rules seem to achieve the same "goal", but such a goal never appears in the formal analysis as a valid generalization. In the Malagasy case, the issue appears to be the case of consonant clusters. As the analysis in this paper implies, incorporation, vowel epenthesis and the root-initial alternation in reduplication are all related to the obvious generalization that Malagasy has a uniform CV syllable structure, but this observation cannot be stated in the rules. In comparison, the OT constraint *CV* achieves this goal.

However, OT also faces some unresolved issues. Many problems that require extensions of the basic OT formalism are still being investigated with the goal of resolving "derivational residue"

(Hermans and van Oostendorp 2000). One such problem has been identified by Steriade 2001 as the "too-many-solutions" problem: how can the grammar choose among the many possible "repair" strategies? Consonant alternations related to Malagasy weak words present such a case: why are consonant clusters resolved in the particular fashion of (25), instead of epenthesis or simple deletion? In 4.4, we have used a constraint *MAX-BR([CV́)*. Does this constraint have some perceptual motivation? What are the consequences of introducing such a constraint with respect to factorial typology? Although we did not analyze the nasal assimilation patterns listed in Table 3, they are likely to raise similar concerns[11]. These types of questions have been studied in recent research in phonology, and it will be interesting to observe how they provide a more satisfying account of the Malagasy data.

We hope to have illustrated that an OT analysis of reduplication can benefit from a more traditional, rule-based one. Since the current incarnation of OT has not let go of the underlying form assumption, such a connection is especially valuable, since it clarifies some basic questions, such as the identification of the base and reduplicant. After all, phonological rule can still be a valuable analytic tool for understanding reduplication.

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[11] For example, in nasal assimilations triggered by the *an*-prefix, root-initial *k* is deleted, as in *kenda* ⟶*manenda*. However, root-initial *h* is not always deleted, as seen in *hataka* ⟶*mangaraka*.

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