THE INTERACTION BETWEEN INFIXATION
AND REDUPLICATION IN CHAMORRO[*]

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1.   Introduction

On the basis of Chamorro, an Austronesian language spoken in the Mariana Islands, I provide an argument for an old idea in the study of morphophonology: modeling opacity via serially ordered derivations. The evidence comes from the interaction between infixation and reduplication in Chamorro. I demonstrate that this interaction in the language is opaque (in the sense of Kiparsky 1971, 1976, et seq.) and that it can be understood within a derivational/serial framework where the output of reduplication serves as the input to infixation. The analysis is implemented in Distributed Morphology (Halle and Marantz 1993, 1994, et seq.). Two assumptions, commonly held within this framework but expressible in other frameworks as well, prove essential in the description and analysis of infixation and reduplication in Chamorro: that the association of morphosyntactic terminals with phonological material (i.e. Vocabulary Insertion) proceeds root-outwards and that at least some morphosyntactic terminals delimit cycles for the application of phonological rules that they may trigger. These results do not necessitate a rule-based framework rules and are, in fact, compatible with constraint-based frameworks as long as they adopt multiple derivational stages, such as Stratal Optimality Theory (Kiparsky 2000, 2003, Rubach 2000) and Optimal Interleaving (Wolf 2008). Finally, the analysis presented here relies on a particular conception of aspects of Chamorro clause structure and, in particular, the order in which inflectional material is syntactically composed with a verbal root. Thus, to the extent that the analysis is successful, it provides morphophonological support for structural assumptions about the extended verbal projection that happen, for independent reasons, to be difficult to motivate syntactically in Chamorro.

Section 2 of this paper introduces the phenomenon of infixation as instantiated in Chamorro, including its interaction with a particular vowel fronting alternation, while section 3 outlines the relevant properties of reduplication in Chamorro. Section 4 describes how this type of reduplication interacts with infixation and an analysis of the interaction is offered in section 5. The analysis is followed by a brief note on the difficulties that this interaction, in particular, and opaque interactions, in general, present to non-serial frameworks.

2.   Infixation

2.1.   The infixes *-um-* and *-in-*

There are two infixes in Chamorro, *-um-* and *-in-*, each of which can be the exponent of a number of distinct morphosyntactic elements (Topping and Dunga 1973:170ff.):[1]

(1)   Grammatical functions of *-um-*
   a. singular or dual subject agreement for intransitive predicates in the realis mood (Chung 2014, ch. 2; cf. Topping and Dunga 1973:185,225 on *-um-* as a "verbalizer")
   b. singular or dual subject agreement for intransitive predicates in the infinitive and invariant marking for transitive predicates in the infinitive (Topping and Dunga 1973:185, Chung 1998:64)
   c. subject *wh*-agreement (Cooreman 1987, Chung 1998:201; cf. Topping and Dunga 1973:184 on -um- as an "actor focus infix")

(2)   Grammatical functions of *-in-*
   a. passive with transitive predicates (Chung 1998:37)
   b. object *wh*-agreement with transitive predicates in a nominalization of the predicate (Chung 1998:240; cf. Topping and Dunga 1973:187 in *-in-* as a "goal focus infix")
   c. nominalizer (Topping and Dunga 1973:170,187)

These infixes surface just before the nucleus of the left-most syllable of the stem they combine with. This behavior is observed both when the stem begins with an onsetless syllable and when it begins with a consonant or a consonant cluster (Topping and Dunga 1973:170; Halle 2001:160ff.; Klein 2005:973ff.; Chung 2014, ch. 28):[2]

(3) a.   Infixation of *-um-*

Predicate		*-um-* infixation
kɒti	'cry'	k**um**ɒti
peska	'fish'	p**um**eska
dɒŋkulu	'big'	d**um**ɒŋkulu
metgut	'strong'	m**um**etgut
liʔiʔ	'see'	l**um**iʔiʔ
hɒtsa	'lift'	h**um**ɒtsa
tristi	'sad'	tr**um**isti
adzao	'borrow'	**um**adzao

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[1] Another infix, -Vl- (where "V" stands for "vowel"), which is unproductive and which I am not concerned with, is found in some onomatopoeic words (Chung 2014, ch. 28): e.g., *palaspas* 'splash' (from *paspas* 'splash').

[2] In these examples, the infixes are bolded. Since the low vowels, /a/ and /ɒ/, are distinguished under primary stress but merge otherwise (to /a/), and since affixation may trigger stress shift, there might be differences in the pronunciation of the root in affixed and unaffixed forms of the same word (Topping and Dunga 1973, Chung 2014).

b. Infixation of *-in-*

Predicate		*-in-* infixation
patmɒda	'slap'	p**in**atmɒda
bisita	'visit'	b**in**isita
tattidzi	'follow	t**in**attidzi
liʔiʔ	'see'	l**in**iʔiʔ
hassu	'think'	h**in**assu
istotba	'disturb'	**in**istotba
hɒlla	'pull'	h**in**alla
sɒngan	'say'	s**in**angan

2.2. A previous analysis

Topping and Dunga (1973) analyze *-um-* and *-in-* in Chamorro as underlying prefixes—an analysis that presupposes multiple derivational stages and cyclic rule application. Their empirical argument is based on word forms like *fantsinemmaʔ* 'forbidden things' and it goes as follows. Suppose that this word is formed via the successive merger of the root *tsommaʔ* 'forbid' with the nominalizing infix *-in-*, and of the resulting unit with the plural marker *fan-*.[3] Now, like many Austronesian languages (e.g. see Zuraw 2010), Chamorro has a nasal substitution rule triggered by the prefixes *man-* and *fan-*: when the /n/ of these prefixes is immediately followed by a voiceless consonant, the /n/ assimilates to that consonant in place of articulation, while the consonant itself is deleted (Topping and Dunga 1973:48ff.; Chung 2014, ch. 29)—e.g. *mamɒliʔ* 'priests' from *man-+pɒliʔ* and *maɲeʔlu* 'siblings' from *man-+tseʔlu*. Topping and Dunga (1973) observe that nasal substitution does not apply in *fantsinemmaʔ*; if it did, the plural form of the nominalization would instead be **faɲinemmaʔ*. The suggested explanation is that *-in-* is initially composed with the root as a prefix and that this blocks the application of nasal substitution once *fan-* is added. It is then only after *fan-* has been added to the stem that *-in-* reaches its surface position, as an infix to *tsommaʔ*. On the surface, the environment for nasal substitution is present, but the rule no longer has a chance to apply due to the following rule ordering:[4]

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[3] The change of vowel quality from /o/ in the root to /e/ in the derived word is due to the umlaut alternation (see also the two bottommost rows of (3b)), triggered by the nominalizing infix *-in-* and discussed in section 2.3.

[4] Topping and Dunga (1973) actually suggest not only that Chamorro -VC- infixes are underlying prefixes but also that they are CV- prefixes which undergo metathesis. The latter claim, however, is orthogonal to the question of underlying prefixhood. Note, in addition, that Halle (2001) argues for the underlying CV- nature of these infixes by observing that the /n/ of the infix *-in-* (see steps 3 and 4 in the main text) does not undergo nasal substitution (p. 162). Based on this fact, he concludes that the infix must be represented as *-ni-* at this stage of the derivation. However, this conclusion is unwarranted, as nasal substitution in Chamorro is only triggered by *man-* and *fan-* and no other affixes (see Klein 2005 for a similar point, as well as additional arguments against Halle's (2001) approach).

(4)   Derivation of *fantsinemmaʔ* (Topping and Dunga 1973)
  a. Combine the nominalizer *in-* with the stem *tsommaʔ*
        intsommaʔ
  b. Apply any phonological rules triggered by *in-* (umlaut)
        intsemmaʔ
  c. Combine the plural marker *fan-* with the stem *intsemmaʔ*
        fanintsemmaʔ
  d. Apply any phonological rules triggered by *fan-* (nasal substitution)
        fanintsemmaʔ
      (nasal substitution does not apply here because the triggering context is not present)
  e. Apply the infixation rule
        fantsinemmaʔ

However, the failure of nasal substitution to apply in the case described here can receive an alternative explanation and, thus, does not, on its own, provide unequivocal evidence for the underlying prefixhood idea and the need for multiple derivational stages and cyclic rule application. Specifically, Topping and Dunga (1973) themselves suggest (p. 173) that nasal substitution in general applies only if man- and fan- are combined with morphologically simplex stems: "The regular morphophonemic changes caused by man- will be observed except where another type of affixation, e.g., reduplication has already taken place, as in the case of the derived nouns" (Topping and Dunga 1973:235). In this connection, Klein (2005) further notes that nasal substitution fails to apply at the prefix-prefix boundary in other Austronesian languages as well (e.g. Indonesian). Given this much, nasal substation is, in fact, not expected in the case described above because fan- is combined with a morphologically complex stem. Yet, the failure of nasal substitution to apply here is consistent with the analysis of infixation offered in the present paper, which is in many ways a direct descendant of Topping and Dunga's (1973)—see footnote 12 in section 5.

2.3.   Umlaut

Before discussing the interaction between infixation and reduplication, a special property of the infix *-in-* must be described. The infix *-in-* is one of a small set of morphemes in Chamorro that cause the vowel of the immediately following syllable to be realized as a front vowel, while its height is preserved: in the context of any one of these morphemes, /u/ is realized as /i/, /o/ as /e/, and /ɒ/ as /a/ (Topping and Dunga 1973, Topping 1980, Chung 1983, 2014, Crosswhite 1996, Klein 2000, Kaplan 2011). The effects of this vowel fronting process can be seen in the two bottommost rows of (3b) and in the examples in (5).[5] These changes in vowel quality do not spread

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[5] The other triggers of this vowel fronting process are the proclitic definite article *i*, the proclitic oblique case marker *ni*, the proclitic local-case marker *gi*, the proclitic subject agreement forms *in* (1.EXCLUSIVE.DUAL or 1.EXCLUSIVE.PLURAL) and *en* (2.DUAL or 2.PLURAL; phonemically /in/), the stress-attracting prefix *mi-* 'full of', the directional prefix *san-*, and the prefix *faʔ-* 'make (into)'. When the trigger for vowel fronting is not the infix *-in-*, the process is sensitive to stress in that it only affects the following vowel if it bears primary stress. However, when vowel

further rightward and do not reapply upon subsequent affixation (see Kaplan 2008 on the (non-)iterative status of this process in Chamorro). This phenomenon has been likened both to the German morphophonemic alternation umlaut and to vowel harmony (Safford 1903:294, Conant 1911, von Preissig 1918:6, Topping and Dunga 1973, Topping 1980, Chung 1983, Klein 2000, Kaplan 2011).[6]

(5)   Chamorro umlaut triggered by *-in-*

Base		Trigger+base
'kɒnnuʔ	'eat'	k**i'n**annuʔ
'poʔlu	'put'	p**i'n**eʔlu
'tugiʔ	'write'	t**i'n**igiʔ
'dulalak	'chase'	d**i'n**ilalak
tu'tuhun	'begin'	t**in**i'tuhun
tu'lajka	'change'	t**in**i'lajka
'goddi	'knot'	g**i'n**eddi
'tsommaʔ	'forbid'	ts**i'n**emmaʔ

   Chamorro umlaut might not be entirely morphologically conditioned but phonologically conditioned at least to some extent as well (see Klein 2000 for an overview and discussion). In particular, the fact that most triggering morphemes contain a front vowel suggests that the language might have had a more general phonological process that assimilated a vowel to any front vowel in the immediately preceding syllable (Costenoble 1940). Synchronically, however, Chamorro umlaut is not a general or completely regular alternation because, for example, its application can depend on properties of both the triggering morpheme and the affected base (see Chung 2014, ch. 29 for discussion of this point; cf. Zuraw 2010 on lexical exceptionality in the context of nasal substitution in Tagalog).

3.   Reduplication

Predicates in Chamorro can be associated with one of two aspects: progressive or neutral. The neutral aspect is not signaled by any overt morphophonology while the progressive aspect is signaled by reduplication (Topping and Dunga 1973:191,259). Specifically, the primarily stressed vowel of the predicate and any immediately preceding consonants are doubled. As the following examples demonstrate, the resulting open (C)V syllable bears the primary stress and immediately precedes the original syllable, which bears secondary stress.[7]

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fronting is triggered by the infix *-in-*, it affects the vowel of the immediately following syllable, regardless of whether it is stressed or not. See Chung 1983 and Klein 2000 for details.

[6] A stressed syllable is preceded by '.

[7] Syllables that bear primary stress are preceded by ' and the duplicated (C)V sequences are underlined. Since vowel quality in Chamorro depends on syllabification and stress, the roots in related word forms may differ (see for example the reduplicated forms of *kɒti* and *pɒtgun* in (6)). See also footnote 2.

(6) Chamorro reduplication in the progressive aspect

Predicate		Progressive
'soddaʔ	'find'	'sosoddaʔ
'kɒti	'cry'	'kɒkati
hu'gɒndu	'play'	hu'gɒgandu
kima'son	'burn'	kima'soson
ma'potgiʔ	'pregnant'	ma'popotgiʔ
'pɒtgun	'child'	'pɒpatgun
'dɒŋkulu	'big'	'dɒdangkulu

Various approaches to the analysis of Chamorro progressive reduplication have been taken.[8] According to what might be called the traditional view (Topping and Dunga 1973, Topping 1980, Broselow and McCarthy 1983), the (C)V reduplicant is inserted just before the original stressed syllable of the base with concomitant shift of primary stress to the reduplicant. In particular, Broselow and McCarthy 1983 (p. 55ff.) analyze Chamorro progressive reduplication as partial reduplication of the stressed syllable, which involves phonological prefixation of the (C)V reduplicant to that syllable. Stress shift to the reduplicant in this case follows from the assumption that the prefixed (C)V reduplicant is a stress-attracting prefix—an otherwise not uncommon occurrence in Chamorro. An alternative, suggested by Yu 2007 (p. 125) and Inkelas 2008 (p. 386), views Chamorro progressive reduplication as an instance of infixation of the (C)V of the stressed syllable after the stressed vowel of the base (see also Clothier-Goldschmidt 2014). In this case, the reduplicant (C)V immediately follows the original stressed syllable, and no stress shift needs to be posited.

4.   The interaction between infixation and reduplication

The interaction between infixation and reduplication is such that the generalization about where the infixes *-um-* and *-in-* appear must make reference to the output of reduplication while the generalization about what gets reduplicated must not make reference to the output of infixation. This finding leads to an understanding of word building which involves multiple derivational stages and cyclic rule application whereby reduplication applies at an earlier stage than infixation. This section describes the interaction in detail, while section 5 spells out an analysis couched within a serial/derivational model of word building.

Infixation and reduplication can cooccur within the same word. In this connection, Topping and Dunga 1973:172,191 observe that infixation applies to *sɒga* 'stay' to produce *sumɒga*, as in (7). Now, if this is the base to which progressive reduplication applies, one would expect the hypothetical form ⟨*sumɒmaga*⟩ to be well-formed. However, it is not; the acceptable progressive

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[8] I am not concerned here with another type of reduplication found in Chamorro, which is an instance of derivational morphology and which doubles the final CV of the stem, regardless of the position of stress (Topping and Dunga 1973:183, Klein 1997, Inkelas 2008:387).

form is instead _sumᵖsaga_. The attested surface form is predicted if, instead, infixation applies to a representation at which the result of reduplication is already present.

(7)   The interaction between -_um_- infixation and reduplication

Predicate		Infix	Reduplication	Infix+reduplication	
ʼsɒŋga	'stay'	su'mɒŋga	ʼsɒsaga	su'mɒsaga	*sumɒmaga
ʼtɒŋgis	'cry'	tu'mɒtangis	tɒtangis	tu'mɒtangis	*tumɒmangis
ʼkɒti	'cry'	ku'mɒti	ʼkɒkati	ku'mɒkati	*kumɒmati
ʼhɒnao	'go'	hu'mɒnao	ʼhɒhanao	hu'mɒhanao	*humɒhanao

Topping and Dunga (1973) discuss -_um_- in this connection but the two infixes, -_um_- and -_in_-, exhibit identical behavior in this respect. For example, infixation of -_in_- into _pulan_ 'watch over' produces _pinilan_. Here, the affixation of -_in_- triggers umlaut of the vowel that immediately follows -_in_- and, as a result, /u/ is fronted to /i/. If this were the base to which progressive reduplication applies, one would expect the upshot to be the form ⟨_pininilan_⟩ but this form is not well-formed. Instead, the acceptable progressive form is _pinipilan_. The following table contains additional examples of similar nature:

(8)   The interaction between -_in_- infixation and reduplication

Predicate		Infix+umlaut	Reduplication	Infix+umlaut+reduplication	
ʼpulan	'watch over'	pi'nilan	ʼpupulan	pi'nipilan	*pininilan
ʼkonniʔ	'take'	ki'nenniʔ	ʼkokonniʔ	ki'nekenniʔ	*kinenenniʔ
ʼsoŋgi	'set on fire'	si'neŋgi	ʼsosoŋgi	si'neseŋgi	*sineneŋgi
ʼtsuliʔ	'bring'	tsi'niliʔ	ʼtsutsuliʔ	tsi'nitsiliʔ	*tsininiliʔ

As revealed by these examples, when infixation and reduplication cooccur within a single word, the infixes -_um_- and -_in_- still appear before the stressed vowel of the reduplicant but no part of the infix is doubled (Chung 2014, ch. 29). In particular, while reduplication doubles the primarily stressed vowel of the base, it fails to result in the doubling of the preceding consonant (the /m/ of the infix -_um_- or the /n/ of -_in_-). The following section offers an analysis of this interaction within a serial/derivational model.

5.   Reduplication precedes infixation

The present analysis of the interaction between reduplication and infixation is couched within Distributed Morphology (Halle and Marantz 1993, 1994, Embick 2010, Bobaljik 2012). The crucial assumption that it relies on is that of _cyclicity_: the association of morphosyntactic terminals with phonological material (i.e. Vocabulary Insertion) proceeds root-outwards (Bobaljik 2000, Adger et al. 2003, Embick 2010), and (at least some) morphosyntactic terminals define cycles that govern the application of (phonological) rules.

Consider first a form like *sumɲsaga* in (7), in which *-um-* is the exponent of singular/dual subject agreement in the realis mood, while reduplication is the expression of progressive aspect. I assume that the former is an Agr head in the syntax while the latter is an Asp head in the syntax, and that they are syntactically combined with the verb *sɲga* as illustrated in (9a).[9]

(9) Derivation of *sumɲsaga*
   a. Output of syntax
       [Agr [Asp [V]]]

First, the exponent of V (the verbal root) is inserted and parsed into a Prosodic Word, which is subject syllabification and stress assignment (Chung 1983, Kiparsky 1986):

   b. Vocabulary Insertion of V
       [Agr [Asp ['saga]]]

Then, the progressive Asp head must be spelled out, triggering reduplication. Approaches to reduplication within the present framework of assumptions usually follow the tradition of treating reduplication as a form of affixation (see, e.g. Marantz 1982). Specifically, within Distributed Morphology, at least two implementations of this idea exist (cf. Marantz 1982, McCarthy and Prince 1995, Haugen 2008). One possibility is that, while the reduplicative affix is actually spelled out by a phonologically null Vocabulary Item, it triggers a Readjustment Rule (a type of morphologically triggered phonological rule) that results in reduplication. Another possibility is to spell out the reduplicative affix by the insertion of a Vocabulary Item RED, which acquires its actual phonological content from its context (cf. Marantz's (1982) "skeletal morphemes"). For concreteness, I assume the latter option here: (i) the progressive Asp head is spelled out by RED; (ii) RED copies the vowel and the onset of the primarily stressed syllable of the Prosodic Word that it belongs to; (iii) RED is phonologically affixed to the left of the primarily stressed syllable. The newly formed Prosodic Word is resyllabified and stress is reassigned. At this point, red attracts the primary stress, since it is a stress attracting affix (see section 3).[10]

   c. Vocabulary Insertion of Asp
       [Agr [RED ['saga]]]
   d. Reduplication
       [Agr [sa ['saga]]
   e. Phonological affixation of RED
       [Agr ['sasaga]]

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[9] As discussed in section 2.1, the infixes *-um-* and *-in-* can each be associated with distinct grammatical functions and, thus, be the exponent of distinct terminals. Thus, the question arises of whether *-um-* and *-in-* are farther away from the root than the progressive Asp head in all their grammatical functions. That this is indeed the case is, in fact, quite plausible for all the grammatical functions of both infixes, with the possible exception of (2c) in which *-in-* functions as a derivational, nominalizing morpheme. For discussion of the predictions that the present analysis potentially makes with respect to the *-in-* nominalizer, see section 7

[10] This is, essentially, an implementation of the approach to Chamorro reduplication found in Topping and Dunga 1973, Topping 1980, Broselow and McCarthy 1983.

Finally, the exponent of Agr, *um*, is inserted. Due to the particular requirements imposed on the distribution of this exponent (either lexically or as the result of general phonological principles active in Chamorro), *um* appears to the immediate right of the initial consonant (cluster) of the stem. This results in the Prosodic Word observed on the surface:

    f. Vocabulary Insertion of Agr
        [-um ['sasaga]]
    g. Phonological affixation of *-um*
        [su'masaga]

The derivation of *kinekenniʔ*, which involves infixation of *-in-* and concomitant umlaut, proceeds in exactly the same way up to the steps responsible for reduplication, shown below. In this form, *-in-* is the exponent of passive voice, while reduplication is again the expression of progressive aspect. I assume that the former is a Voice head in the syntax while the latter is an Asp head in the syntax, and that they are syntactically combined with the verb *konniʔ* as illustrated in (10a). Once reduplication has applied, the exponent of Voice, *in*, is inserted. Due to the requirements imposed on the placement of this exponent, *in* appears in the familiar stem-medial position. It is this infixation step that applies to the output of reduplication:

(10)   Derivation of *kinekenniʔ*
    a. Output of syntax
        [Voice [Asp [V]]]
    b. Vocabulary Insertion of V
        [Voice [Asp ['konniʔ]]]
    c. Vocabulary Insertion of Asp
        [Voice [red ['konniʔ]]]
    d. Reduplication
        [Voice [ko ['konniʔ]]]
    e. Phonological affixation of RED
        [Voice ['kokonniʔ]]
    f. Vocabulary Insertion of Voice
        [-in ['kokonniʔ]]
    g. Phonological affixation of *-in*
        [ki'nokonniʔ]

The passive voice morpheme triggers umlaut of the immediately following vowel, which in this case happens to be the nucleus of the reduplicant. As the surface form indicates, however, umlaut affects not just the vowel of the reduplicant but also the corresponding vowel in the base:

    h. Umlaut
        [ki'nekenniʔ]

This is then a base-reduplicant "identity effect" whereby a regular phonological alternation applies in an environment where it is not conditioned with the apparent result of maximizing the similarity between the base and the reduplicant—in other words, umlaut "overapplies". In this connection, it should be noted that overapplication of umlaut is only observed in the context of reduplication and does not normally spread to the right (see section 2.3). Such identity effects have traditionally been viewed as a strong argument in favor of Base-Reduplicant Correspondence Theory (McCarthy and Prince 1993, 1995, 1999). Different implementations are possible, however, as long as they ensure base-reduplicant identity (see, in addition, Wilbur 1973, Marantz 1982, Benua 1997, Steriade 1988, Raimy 2000, Frampton 2009, among others).

What is crucial in these derivations is that the steps responsible for infixation (f, g) have access to the output of the steps responsible for reduplication (c, d, e).[11] The Distributed Morphology model adopted here captures this state of affairs by incorporating the assumption that certain phonological operations (supplying red with phonological content, phonological affixation, umlaut) apply in cycles defined by the Vocabulary Insertion of the terminals that triggers them. The order of the cycles is, in turn, given by the order of Vocabulary Insertion, which is itself determined by the relative syntactic positions of the relevant terminals. This model is consistent with the common assumption that only some heads define cycles (Embick 2010) and also with any order (or lack of order) of Vocabulary Insertion within a given cycle (Deal and Wolf 2016).[12]

6.   A note on non-serial frameworks

The interactions between infixation and umlaut and between reduplication and umlaut yield surface-true generalizations and do not require reference to intermediate derivational stages. As a result, they can, in principle, be accounted for in a non-derivational/parallel model such as Classical (Parallel) Optimality Theory. The opaque interaction between infixation and reduplication, however, may not be entirely expected under certain kinds of non-derivational/parallel frameworks that eschew (multiple) intermediate derivational stages.

Consider the former two interactions first. The infixation~umlaut interaction (section 2.3) yields the generalization (i) below, which holds of output forms both in the presence and absence of reduplication in (see (5) and (8)). The emergence of this pattern could be treated as the result of the interaction between independent constraints that govern umlaut and the linearization of infixes in Chamorro (e.g. Klein 2000, 2005). Likewise, the umlaut~reduplication interaction (section 4) yields the generalization (ii) below, which also holds of the output forms in (8). As already discussed, this overapplication of umlaut can be seen as the result of pressures towards base-reduplicant identity (McCarthy and Prince 1995; see also Klein 1997).

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[11] However, the order of (f) and (g) with respect to one another and the order of (c), (d), and (e) with respect to another is not crucial. The steps in each of these two sets can apply in an order different from the one given above or they can apply simultaneously (e.g. it should be possible to obtain the results of the steps within each set in a constrained-based system). Umlaut is, likewise, not crucially ordered with respect to the steps responsible for infixation.

[12] As far as the failure of nasal substitution in forms like *fantsinemma?* (discussed in section 2.2) is concerned, the present analysis must resort to the alternative explanation offered in section 2.2: nasal substitution in the context of the prefixes *man-* and *fan-* applies only if these prefixes are combined with morphologically simplex stems.

(i)	The infix *-in-* appears on the surface immediately before the left-most vowel of the stem to which it is attached; the vowel of the immediately following syllable is realized as a front vowel of the same height.
(ii)	The vowel in the base and the vowel in the reduplicant have the same quality, so that if one of them is realized as a front vowel due to the presence of an umlaut trigger, the other one is also realized as a front vowel.

In contrast, consider the opaque interaction between infixation and reduplication (section 4). Recall that, in general, the following two generalization hold of reduplication in Chamorro:

(iii)	Reduplication doubles the nucleus and the onset of the primarily stressed syllable of the base.
(iv)	The reduplicant and the original syllable in the base are each contiguous and adjacent to one another: e.g., *sosoddaʔ* (from *soddaʔ*) and *hugɒgandu* (from *hugɒndu*)—see section 3 for details and more examples.

When reduplication and infixation cooccur as in (7) and (8), however, these generalizations about the behavior of reduplication are not surface-true: e.g. _tum**ɒ**tangis_ (from *tɒngis*) and _**sin**eseŋgi_ (from *soŋgi*). In this case, a kind of opacity arises, whereby the surface forms are expected to have undergone reduplication according to (iii) and (iv), and appear as *_tum**ɒ**mangis_ and *_**sin**eneŋgi_. But they do not. Reduplication is expected to double not just the primarily stressed vowel of the base but also the preceding consonant (in this case, the /m/ of the infix *-um-* or the /n/ of the infix *-in-*), contrary to fact.[13]

Within a non-serial framework, it might be tempting to attempt to account for the fact that reduplication in Chamorro does not copy any part of the infixes by excluding affixes in general or infixes in particular from the base of reduplication (e.g. along the lines of Shaw 2005). In general, however, affixal material can readily be copied by reduplication in Chamorro, as examples involving stressed prefixes demonstrate. For instance, the word *a'tsatsamatsoʔtsuʔ* 'work together (said of two people)' is composed of the root *matsoʔtsuʔ* 'work' and the prefix *a'tsa-*. Progressive reduplication in this case doubles the primarily stressed syllable, which happens to be part of the stress attracting prefix *a'tsa-* (see also Topping et al. 1975, p. xxv).

As McCarthy (2007) points out (p. 108), among many others, cases of opacity which involve non-surface-true generalizations (as opposed to non-surface-apparent generalizations in the sense of McCarthy and Prince 1999) may "supply the best (arguably, the only) evidence for language-particular rule ordering." Such rule ordering can, in turn, be readily implemented in rule-based derivational/serial frameworks. The challenge then is to account for robust instances of opacity, such as the interaction between infixation and reduplication in Chamorro, within frameworks that impose more severe restrictions on the number and kinds of levels of representation. While there may not be consensus about the appropriate approach within such frameworks, there certainly is no shortage of promising ideas: see for example Goldsmith 1993 on

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[13] On the phenomenon of phonological opacity, see Kiparsky 1971, 1976 and much subsequent work; for overviews of opacity and relevant related issues (including counterfeeding relations and under-application opacity), see McCarthy 2007 and Baković 2011.

Harmonic Phonology, Lakoff 1993 on Cognitive Phonology, Wilson 2000 on targeted constraints, McCarthy 2002, 2003a on comparative markedness, McCarthy and Prince 1999; McCarthy 2003b on sympathy, Bye 2001 on virtual phonology, among others (see McCarthy 2007 for an overview).

7.   Conclusion

The opaque interaction between infixation and reduplication in Chamorro was understood here within Distributed Morphology model which allows the output of reduplication to serve as the input to infixation. The crucial assumptions that the analysis relies on are the following:

(i)   the association of morphosyntactic terminals with phonological material (i.e. Vocabulary Insertion) proceeds root-outwards;

(ii)   (at least some) morphosyntactic terminals define cycles that govern the application of (phonological) rules;

(iii)   the relation between a reduplicant and the base of reduplication is such that it ensures (partial) base-reduplicant identity;

(iv)   the progressive Asp head in Chamorro is closer to the root than the heads expressed by the infixes *-um-* and *-in-* (at least in the cases discussed here).

Assumptions (i) and (ii) are two of the central ways in which cyclicity is manifested within Distributed Morphology, but equivalent results can also be achieved in constraint- based frameworks that allow serial derivations (e.g. Kiparsky 2000, Wolf 2008). Assumption (iii) is motivated for Chamorro by the observed overapplication of umlaut in the context of reduplication (Wilbur 1973 and much subsequent work). Finally, independent evidence for the language-specific assumption (iv) and, in particular, for the assumed structures in (9) and (9) is scarce in Chamorro. To the extent that the analysis presented here is successful, the morphophonological behaviors of infixation and reduplication described here can be taken as support for these structures.

　　　In this connection, the analysis makes the prediction that, if, in contrast to (iv), the head expressed by an infix is, in fact, closer to the root than the reduplicative progressive Asp head, reduplication should, in principle, be able to double parts of the infix. That's because in this case the output of infixation will serve as the input to reduplication, due to the relative syntactic prominence of the relevant morphemes. The most promising testing ground for this prediction seems to me to involve the derivational uses of the infix *-in-*, which presumably will be closer to the root than the reduplicative progressive Asp head, which is inflectional.

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