Morphophonological Properties of Moro Causatives

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1. Introduction

In this paper we describe and analyze the morphophonological properties of the causative construction in Moro, a Kordofanian language spoken in the Nuba Mountains of Sudan. We identify several phonological processes associated with the causative and demonstrate how these processes relate to the causative morpheme's position within the *derived stem*, a constituent familiar from Bantu languages (Downing 2000). Both Kordofanian and Bantu languages belong to the larger Niger-Congo phylum.

The causative suffix is /-i/, added after the root. An illustration of its properties are shown in (1) with a sample verb root *naṭ* 'taste'. The imperfective and perfective are composed of the 3rd singular subject marker which encodes noun class (singular /k-/ in this case), a main clause/finite marker /a-/, and a final aspect/mood vowel, /-a/ or /-o/ respectively. The causative suffix is /-i/ added after the root, and it triggers several phonological changes, as seen in (1b):

(1)

		Imperfective	*Perfective*	*Imperative*	
a.	basic	k-a-náṭ-á	k-a-naṭ-ó	náṭ-ó	'taste'
b.	causative	k-ʌ-nʌ́tʃ-iə	k-ʌ-nʌtʃ-í	nʌ́tʃ-í	'cause to taste'

The first observation is that the aspect/mood vowel /-o/ has been replaced by the causative vowel /-i/ in the perfective and imperative and has apparently fused with the aspect vowel /-a/ in the imperfective. Second, the addition of the causative has triggered vowel harmony - the /a/ of both the clause marker and the root has raised to [ʌ] in the causative forms. Third, the dental stop at the end of the root has palatalized. Fourth, the H-H tone pattern (H on root, H on suffix) in the imperfective has changed to H-L in the causative imperfective, but in the perfective and imperative causative, the tone pattern is the same as the non-causative form. We mark high tone only throughout the paper.

This paper will be structured as follows: section 2 illustrates the application of vowel harmony, while section 3 explores the resolution of vowel hiatus. Section 4 addresses the issue of palatalization of dental stops by the causative and other markers, and section 5 illustrates the distinct tone pattern of the causative in combination with both lexical tone and melodic tone. Each of these properties is due to the position of the causative within the derived stem; furthermore, both vowel harmony and palatalization are shared by other 'extension' affixes which also belong to the derived stem.

All data are from the Thetogovela Moro dialect, which differs in various ways from the Thengorban (Umm Dorein) dialect described in Black & Black (1971).

2. Vowel harmony

A key phonological process triggered by the causative affix is vowel harmony. Vowel harmony is not unique to the causative affix, but is also triggered bi-directionally by vowels in the root and other extension affixes (Gibbard 2006). The Moro vowel system consists of /i e a ʌ o u ə/. The lower vowels /e a o/ are raised to [i ʌ u], respectively. [1] In (2a) and (2b) roots contain non-high vowels, [a] and [e], respectively. In (2c) and (2d), however, roots contain the high vowels [ʌ] and [i], respectively, which trigger raising of the affixes. [2]

(2)   a.   é-g-a-**vað**-ó   b.   é-g-a-**veð**-ó
              1SG-CL-RTC-shave-PFV[3]   1SG-CL-RTC-knock-PFV
              'I shaved'   'I knocked'

         c.   í-g-ʌ-**sʌð**-ú   d.   í-g-ʌ-**við**-ú
              1SG-CL-RTC-defecate-PFV   1SG-CL-RTC-vomit-PFV
              'I defecated'   'I vomited'

As vowel harmony affects both the 1st singular prefix and the final aspect vowel, it can be described as bi-directional.

In addition, /ə/ in some roots triggers vowel raising (3b), but not in others (3a):

(3)   a.   é-g-a-wəɾ-ó   b.   í-g-ʌ-dəɾ-ú
              1SG-CL-RTC-dig-PFV   1SG-CL-RTC-stop-PFV
              'I dug'   'I stopped, stood'

This indicates that schwa is specified as a high or non-high vowel. We do not explore the theoretical implications of this here, but note that other researchers (Hyman 1988, Buckley 1994, Compton & Dresher 2008) have invoked some form of prespecification of features to account for vowels that appear identical on the surface but that trigger different phonological processes.

Extension markers also trigger vowel raising. The causative (4b), benefactive applicative (4c), and passive/reflexive (4d) all trigger vowel harmony. Note that although the applicative and passive markers contain [ə], this vowel can trigger height harmony, as in the verb in (3b), so we assume they are marked by a high feature.

(4)   a.   é-g-a-kad̠-ó   b.   í-g-ʌ-kʌd̠-**í**
              1SG-CL-RTC-plant-PFV   1SG-CL-RTC-plant-CAUS.PFV
              'I planted'   'I made s.o. plant'

         c.   í-g-ʌ-kʌd̠-**ət̠**-ú   d.   ŋ-ʌ-kʌd̠-**ən**-ú
              1SG-CL-RTC-plant-APPL-PFV   CL.SM-RTC-plant-PASS-PFV
              'I planted for s.o.'   'it (corn) was planted'

The only verbal affixes that trigger vowel harmony are extension affixes. [4] Other affixes undergo vowel harmony. Extension affixes, including the causative, occur within the derived stem, a constituent

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[1] The vowel /ʌ/ is a mid vowel, but patterns with the high vowels in the vowel harmony system, suggesting a scalar height analysis rather than one that relies on [+/-high]. We do not have the space to explore this here.

[2] AP= ANTI-PASSIVE/DISTRIBUTIVE/RECIPROCAL; ASP = ASPECT/MOOD; APPL = BENEFACTIVE APPLICATIVE; CAUS = CAUSATIVE; CL = NOUN CLASS; COMP = COMPLEMENTIZER; DIST = DISTRIBUTIVE; IMPV = IMPERFECTIVE; INST = INSTRUMENTAL; ITER = ITERATIVE; LOC = LOCATIVE; LOC.APPL = LOCATIVE/MALFACTIVE APPLICATIVE; OM = OBJECT MARKER; PASS = PASSIVE/REFLEXIVE; PFV = PERFECTIVE; PROG = PROGRESSIVE; RTC=ROOT CLAUSE; SM = SUBJECT MARKER.

[3] The prefix g- is glossed a class marker. It occurs in non 3rd person forms, and is probably cognate with the human singular class marker g-/k-.

delimited on the right by the aspect/mood vowel and on the left by the object marker or progressive marker. An illustration of the entire Moro verb structure is given in (5):

(5)   *Moro verb structure*
COMP-SM-TENSE-CLASS-CLAUSE-OM/PROG-**[**ITER-<u>ROOT</u>-AP-LOC.APPL**-CAUS-**APPL-PASS**]**-ASP-OM-**INST-LOC
                                                                derived stem

Downing (2000) identifies the derived stem in Kinande (Bantu) as consisting of the root and extension affixes. In Moro, there is an iterative reduplicative prefix that we also consider part of the derived stem. Vowel harmony is delimited on the right by the aspect/mood vowel (abbreviated ASP), which normally marks the inflectional stem boundary in Bantu. Preservation and extension of the high feature of the dominant high vowels /i u ʌ ə/ in the derived stem drives vowel harmony in Moro.

3. Vowel hiatus and realization of the causative vowel

Extension affixes follow the root and precede the final aspect/mood vowel. The only exception to this pattern is the causative. As shown in (6), the causative vowel /-i/ is present, but the final aspect/mood vowel (-ó or -ú) is not realized:

(6)   'pinch'   'plant'
                       perfective   *imperative*   *perfective*   *imperative*
       plain   k-a-kəw-ó   kə́w-ó   k-a-kaḏ-ó   káḏ-ó
       anti-passive   k-a-kəv-**əð**-ó   kə́v-**ə́ð**-ó   -----   -----
       causative   k-ʌ-kəv-**í**   kə́v-**í**   k-ʌ-kʌḏ-**í**   kʌ́ḏ-**í**
       passive/reflexive k-ʌ-kəv-**ən**-ú kə́v-**ə́n**-ú   k-ʌ-kʌḏ-**ən**-ú   kʌ́ḏ-**ə́n**-ú
       applicative   k-ʌ-kəv-**əṯ**-ú   kə́v-**ə́ṯ**-ú   k-ʌ-kʌḏ-**əṯ**-ú   kʌ́ḏ-**ə́ṯ**-ú
       loc. applicative ------   -----   k-a-kaḏ-**aṯ**-ó   káḏ-**áṯ**-ó

If the causative appears with another extension marker following it, the final aspect/mood vowel *is* realized. This is illustrated in (7b), where the passive/reflexive follows the causative. Note that the [ə] of the passive/reflexive marker in (7b) is dropped after the causative vowel.

(7)   a.   k-ʌ-við-ú   b.   k-ʌ-við-**i-n**-ú
             CL.SM-RTC-vomit-PFV   CL.SM-RTC-vomit-**CAUS-REFL**-PFV
             'he vomited'   'he made himself vomit'

The other extension markers have a –(V)C shape, but the causative marker is a single vowel whose juxtaposition with the final aspect vowel would create a V-V hiatus sequence: /-i-ú/. Instead of expected [kʌkəviú], however, the actual form is [kʌkəví]. The causative marker triggers vowel raising, and has apparently resolved vowel hiatus through deletion of the aspect/mood vowel.

In the causative imperfective construction, however, vowel hiatus is resolved in favor of [iə]. This vowel is often the raised realization of a final /-a/ as shown for the basic imperfective verb in (8b), so [iə] may indicate the juxtaposition of the causative vowel with a raised /-a/: /i-a/ → i-iə → [iə].

(8)   *imperfective*   *causative imperf*
       a.   k-a-kád-á   k-ʌ-kʌ́d-**iə**   'plant'
       b.   k-ʌ-kíð-iə   k-ʌ-kíð-**iə**   'open'
       c.   k-udə́n-ʌ   k-udə́n-**iə**   'fart'

Nevertheless, in sentential contexts and across other morpheme boundaries word-internally, vowel hiatus in verbs is resolved via deletion of the first vowel (henceforth 'V1 deletion') regardless of the quality of the vowels, rather than deletion of the second, as seen in the causative. The sequence /i-u/ or /i-ʌ/, also found with the causative-aspect vowel sequence, are resolved in these cases by V1 deletion (9e,f). Note that the subordinate verb in (9d-f) is composed of 3sg subject marker áŋɔ́- and a final suffix –e (ʌ́ŋɔ́- and -i by vowel harmony). The verb root *w:að* 'find' has no locative marker –aṭ in (9e-f).

(9) Sentential contexts Verb + Noun: V1 deletion

a.	k-a-w:aðaṭ-ó evəla	[ó-e] → [é]		[kaw:aðaṭ évəla]	'he found the wild cat'
b.	k-a-w:aðaṭ-ó ugi	[ó-u]	[ú]	[kaw:aðaṭ úgi]	'he found the tree'
c.	k-uɔ́ndiṭ-ú evəla	[ú-e]	[é]	[kuɔ́ndiṭ évəla]	'he listened to the wild cat'
d.	áŋɔ́-w:aðaṭ-e ugi	[e-u]	[u]	[áŋɔ́w:aðaṭ ugi]	'(that) he finds the tree'
e.	ʌ́ŋɔ́-w:ʌð-i ugi	[i-u]	[u]	[ʌ́ŋɔ́w:ʌð ugi]	'(that) he makes find the tree'
f.	ʌ́ŋɔ́-w:ʌð-i ʌṭúli	[i-ʌ]	[ʌ]	[ʌ́ŋɔ́w:ʌð ʌṭúli]	'(that) he makes find the spear'

With respect to verb morphology, vowel hiatus arises between the clause marker and a vowel-initial root (10a-f), and between an object marker prefix and the root (10g-h). Once again, the first vowel is deleted, even if this eliminates a segmental morpheme. This means that preservation of a single segment morpheme cannot be the explanation for why the causative vowel is retained.

(10) Clause marker or object marker + root: V1 deletion (assuming application of vowel harmony)

a.	k-a-erl-ó	/a-e/	[e]	[kerló]	'he walked'
b.	k-ʌ-ilið-ú	/ʌ-i/	[i]	[kiliðú]	'he bought'
c.	k-é-aɾ-ó	/é-a/	[á]	[káɾó]	'…who cried'
d.	k-é-ogəṭ-ó	/é-o/	[ó]	[kógəṭó]	'…who jumped'
e.	k-í-ʌnṭ-ú	/í-ʌ/	[ʌ́]	[kʌ́nṭ ú]	'…who entered'
f.	k-í-udən-ú	/í-u/	[ú]	[kúdənú]	'…who farted'
g.	k-ʌ-ɲí-ʌwuṭ-ú	/í-ʌ/	[ʌ]	[kʌ́ɲʌwuṭú]	'he dropped me'
h.	k-ʌ-ŋʌ́-ilið-iṭ-ú	/ʌ́-i/	[i]	[kʌ́ŋiliðiṭú]	'he bought for you'

Given these data, we would have predicted the resolution of the causative-aspect/mood vowel sequence in /k-ʌ-kəv-i-ú/ to be [kʌkəvú], with V1 deletion, and not the attested [kʌkəví].

In contrast to the V1 deletion pattern observed in verbs, in nominal morphology there are multiple resolutions for vowel hiatus, including V1 deletion, glide formation, and fusion, depending on the quality of the vowels. The locative affix –ánó triggers glide formation if the first vowel is peripheral /i e u o/ (11a-d), and V1 deletion if it is central /ə ʌ a/ (11e-g).

(11) Noun + locative suffix: V1 deletion or glide formation

a.	ðugi-ánó	/i-á /	[já]	[ðugjánó]	'inside the plank'
b.	ome-ánó	/i-á /	[já]	[omjánó]	'inside the fish'
c.	umu-ánó	/u-á/	[wá]	[umwánó]	'inside the Arab (derog.)'
d.	ŋombogó-ánó	/o-á/	[wá]	[ŋombogwánó]	'inside the calf'
e.	utrə-ánó	/ə-á/	[á]	[utránó]	'inside the pig'
f.	ʌwíɾʌ-ánó	/ʌ-á/	[á]	[ʌwíránó]	'inside the (type of) tree'
g.	aŋorá-ánó	/á-á	[á]	[aŋoránó]	'inside the elephant'

The demonstrative suffix -íC:i (C = noun class concord consonant) shows reduction to [ə] with peripheral vowels (12a-d) or vowel fusion with central vowels (12e-f).

(12)   Noun + demonstrative suffix: reduction to [ə] or vowel fusion
    a.   ðugi-íð:i   /i-í/   [ɔ́]   [ðugɔ́ð:i]   'this plank'
    b.   ome-ík:i   /e-í/   [ɔ́]   [omɔ́k:i]   'this fish'
    c.   ʌðu-ís:i   /u-í/   [ɔ́]   [ʌðɔ́s:i]   'this breast'
    d.   ŋombogó-íŋ:i   /ó-í/   [ɔ́]   [ŋombogɔ́ŋ:i]   'this calf'
    e.   ðuw:ʌ-íð:i   /ʌ-í/   [ʌ́]   [ðuwʌ́ð:i]   'this smoke'
    f.   ðapa-íð:i   /a-í/   [ʌ́]   [ðapʌ́ð:i]   'this friend'

It is hard to tell which vowel has been deleted in (12a-d), since all peripheral vowels may reduce to [ə] (Gibbard et al 2009). When V1 is central, however, vowel fusion appears to take place, producing a central, but raised [ʌ].

The vowel hiatus patterns observed between causative and the aspect/mood vowel do not pattern like vowel hiatus resolution in the rest of the verb stem or in sentential contexts, where V1 deletion consistently occurs. It is also not the case that suffixes behave differently than prefixes, as vowel hiatus between the aspect vowel and an object suffix also results in V1 deletion: /k-a-vəleð-ó-álánda/ → [kavəleðálánda] 'he pulled us (excl.)'. The causative pattern is more similar to vowel hiatus resolution in nouns in that features of the first vowel are preserved, resulting either in loss of the second or fusion between the two. The explanation we offer for the causative is that segments and features belonging to the inner derived stem (i.e. root, causative) are more faithfully preserved than those outside the derived stem, entailing a different co-phonology for the derived stem.

4. Palatalization of Dental Stops

In this section, we show that palatalization of dental stops preceding a high vowel /i/ or /ə/ occurs in a derived environment within the derived stem in Moro. Moro contrasts two palatal affricates /tʃ/ and /dʒ/, ex. katʃoŋá 'he is hungry' vs. kadʒomó 'he moved', two alveolar stops, and two dental stops, ex. toáðó 'rub!', doátó 'speak!' vs. ḏoáṯó 'send!'. Dental stops /ṯ ḏ/ are palatalized to [tʃ dʒ] by extension suffixes with high vowels: the causative, passive, and the benefactive applicative suffixes, as shown in (13) (-ən and -əṯ are realized as [in] and [iṯ] after palatals):[5]

(13)

	Perfective	Causative perf.	Passive perf.	Applicative perf.
'lick'	k-a-təŋaṯ-ó	k-ʌ-təŋʌtʃ-í	kʌ-təŋʌtʃ-in-ú	k-ʌ-təŋʌdʒ-iṯ-ú
'prepare soil'	k-a-raṯ-ó	k-ʌ-rʌtʃ-í	k-ʌ-rʌtʃ-in-ú	k-ʌ-rʌdʒ-iṯ-ú
'sew'	k-a-waṯ-ó	k-ʌ-wʌtʃ-í	k-ʌ-wʌtʃ-in-ú	k-ʌ-wʌdʒ-iṯ-ú
'repair'	k-a-dogaṯ-ó	k-ʌ-dugʌtʃ-í	k-ʌ-dugʌtʃ-in-ú	k-ʌ-dugʌdʒ-iṯ-ú
'take care of'	k-a-rəmʷəṯ-ó	k-ʌ-rəmʷətʃ-í	k-ʌ-rəmʷətʃ-in-ú	k-ʌ-rəmʷədʒ-iṯ-ú
'find'	k-a-w:aðaṯ-ó	k-ʌ-w:ʌðʌtʃ-í	k-ʌ-w:ʌðʌtʃ-in-ú	k-ʌ-w:ʌðʌdʒ-iṯ-ú
'watch'	k-a-wəndaṯ-ó	k-ʌ-wəndʌtʃ-í	k-ʌ-wəndʌtʃ-in-ú	k-ʌ-wəndʌdʒ-iṯ-ú
'jump'	k-ogəṯ-ó	k-ugətʃ-í	----	k-ugədʒ-iṯ-ú
'throw'	k-ʌwuṯ-ú	k-ʌwutʃ-í	k-ʌwutʃ-in-ú	k-ʌwudʒ-iṯ-ú
'enter'	k-ənṯ-ú	k-əntʃ-í	k-əntʃ-in-ú	k-əndʒ-iṯ-ú
'dance'	k-a-rəṯ-ó	k-ʌ-rətʃ-í	---	k-ʌ-rədʒ-iṯ-ú
'close'	k-a-land-ó	k-ʌ-lʌndʒ-í	k-ʌ-lʌndʒ-in-ú	k-ʌ-lʌndʒ-iṯ-ú
'send'	k-a-ḏoaṯ-ó	k-ʌ-ḏuʌtʃ-í	k-ʌ-ḏuʌtʃ-in-ú	k-ʌ-ḏuʌdʒ-iṯ-ú

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[5] Since /i/ frequently reduces to [ə] in Moro, we hypothesize that the vowel of the passive and benefactive suffixes may have been /i/, which would explain the palatalization effect. Even if it is lexically /ə/ now, it has preserved the ability to palatalize, just like its ability to trigger height harmony, perhaps due to preservation of a feature [-back].

These data also demonstrate a voice dissimilation effect in the benefactive applicative, whereby the voiceless palatal affricate becomes voiced before the voiceless consonant of the applicative.[6]

There are a few verbs where palatalization does not take place with the causative:

(14)   Exceptions with no palatalization

	Perfective	*Causative perf.*	*Passive perf.*	*Applicative perf.*
'drink'	kʌ-t̪-ú	kʌ-**t̪**-í	kʌ-**t̪**-ən-ú	kʌ-**t̪**-ət̪-ú
'cough'	kʌ-tund̪-ú	kʌ-tun**d̪**-í	-----	kʌ-tun**d̪**-ət̪-ú
'plant'	ka-kad̪-ó	kʌ-kʌ**d̪**-í	kʌ-kʌ**d̪**-ən-ú	kʌ-kʌ**d̪**-ət̪-ú

It is unclear why these particular forms do not palatalize. They are the only three exceptions to this pattern so far attested in the language.

Palatalization is only found with dental stops; alveolar stops consistently do not palatalize in the contexts where dentals do, namely with extension suffixes:

(15)   Alveolar stops: no palatalization

	Perfective	*Causative perf.*	*Passive perf.*	*Applicative perf.*
'speak'	ka-doat-ó	kʌ-duʌ**t**-í	kʌ-duʌ**t**-ən-ú	kʌ-duʌ**t**-ət̪-ú
'burn'	ka-wəd-ó	kʌ-wə**d**-í	kʌ-wə**d**-ən-ú	kʌ-wə**d**-ət̪-ú
'catch'	k-ʌnd-ú	k-ʌn**d**-í	k-ʌn**d**-ən-ú	k-ʌn**d**-ət̪-ú

The combinations [t̪i], [d̪i], [t̪ə], [d̪ə] are so far unattested within verb roots (the palatal sequences [t͡ʃi] or [d͡ʒi] are likewise unattested), but they do occur in noun roots, and no palatalization is found within noun roots. From this we conclude that palatalization is a derived environment effect (Kiparsky 1982, Rubach 1984, Lubowicz 2001), even if this cannot be confirmed for verb roots.

(16)   ð ʌ́r̪t̪i̪   'anus'   umər̪t̪in   'co-wife'
        it̪əlí   'year'   id̪əvíní   'shoe'

The proximal subordinate suffix –i (a raised version of /-e/) does not palatalize a preceding dental stop, whether that stop is root-final, or is in the applicative affix (17c).

(17)   *Perfective*   *Subordinate*
     a. k-ənt̪-ú   ... ʌ́ŋ-ə́nt̪-i   'enter'
     b. k-ʌwut̪-ú   ... ʌ́ŋ-ʌwút̪-i   'throw'
     c. kʌ-kʌd̪-ət̪-ú   ... ʌ́ŋə́-kʌ́d̪-ə́t̪-i   'plant for'

In contrast, the passive suffix, which follows the applicative within the derived stem, can trigger palatalization of the applicative: k-ʌnd-it͡ʃ-in-ú 'it was caught for'.

The consecutive imperfective complementizer prefix t̪́ occurs word-initially and is also never palatalized, even when followed by the 1ˢᵗ person subject prefix i-:

(18)   a.   t̪́-í-við-ú   'and I vomited'
        b.   t̪́-í-t̪und̪-ú   'and I coughed'

In summary, palatalization of dental stops only occurs within the derived stem as a derived environment effect triggered by the causative, passive and benefactive suffixes. Affixes outside the derived stem do not trigger palatalization. This is modeled in (19) showing the root and position of the

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[6] Voice dissimilation is active in other environments in Moro as well (Jenks & Rose 2011).

different affixes with high vowels or dental stops within the Moro verb structure. Palatalization is indicated by arrows. The derived stem is marked by brackets:[7]

(19)   COMP-SM-TENSE-CLASS-CLAUSE-OM-PROG-[ITER-<u>ROOT</u>-AP-LOC.APPL-**CAUS**-APPL-PASS]-ASP

         t̪-   i-   [ənt̪   ←̶-i ←-ət̪ ←ən] -i

                                       ↓   ↓

                                   [t͡ʃ]   [t͡ʃ]

The derived stem exhibits a different phonological system than the rest of the verb stem. A co-phonology requiring palatalization is uniquely associated with the derived stem.

5. Tone

Moro verb stems fall into two distinct classes according to aspect/mood: those in which lexical high tone appears on the root and those that have specific melodic or inflectional tone patterns. In this section, we show that the causative imposes its own particular tone pattern, H-L, and how that tone pattern interacts with lexical tone and melodic tone. We assume a H/Ø tone contrast (Jenks & Rose 2011, to appear), although we use the label L to indicate lack of high tone.

5.1. Lexical or default tone

Some verb forms, such as subordinate verb stems and the basic (proximal) imperfective, have high tone within the root, but how high tone is distributed depends on syllable structure and lexical properties of the root (Jenks & Rose 2011, to appear). This is referred to as lexical or default tone, since it is mostly predictable. The basic pattern consists of high tone on the first syllable of the root with binary tone spreading to the right (20a,b). With CVCVC roots, H tone spreads onto the second vowel of the root, and with CVC roots, it spreads onto the following suffix vowel, in these cases the aspect/mood vowel. It is a lexical property of certain roots whether extension to this final vowel is permitted or not (20b). If the first syllable is closed by a coda, as in (20c,d), high tone does not extend to a second syllable. Finally, a consonant-only root has no high tone (20e).

(20)		*Root shape*	*Tone of Root-Aspect*	*Imperfective*	
	a.	CÝCÝC	HH-L	k-a-dógát̪-a	'fix'
	b.	CÝC	H-H	k-a-ð́əw-á	'poke'
				k-a-nát̪-á	'taste'
			H-L	k-a-váð-a	'shave'
				k-a-sát̪-a	'chew'
	c.	CÝC.CVC	HL-L	k-a-mʷándəð-eə	'ask'
				k-a-ẃəndat̪-a	'see'
	d.	CÝC.C	H-L	k-a-wárð-a	'write'
				k-a-lánd̪-a	'close'
	e.	C	L-L	k-a-s:-a	'eat'

Vowel initial roots restrict high tone from appearing on the first vowel of the root (21a,b). This means that VC roots as in (21b) have no high tone. However, if the initial vowel appears in a closed (heavy) syllable, high tone can appear on the first syllable, but, like the forms in (20c,d), does not spread rightwards (21c,d).

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[7] Another possible analysis is to treat palatalization as a derived environment effect triggered only by underlying high vowels, not high vowels derived by vowel raising. The affixes in (17) and (18) are raised variants of /e/.

(21)

		Root shape	Tone of Root-Aspect	Imperfective	
	a.	VCV́C	LH-L	k-ogə́t-a	'jump'
				k-abátʃ-a	'lift'
	b.	VC	L-L	k-al-a	'slice'
				k-oað-a	'mill, grind'
	c.	V́C.CVC	HL-L	k-óndə̱t-a	'dry'
	d.	V́C.C	H-L	k-ʌ́nd-iə	'catch'
				k-áf:-a	'build, shoot'

5.2. Causative tone

Causative imperfectives exhibit very similar tone patterns to non-causatives. In the following examples, the tone patterns are identical:

(22)

		Root shape	Tone of Root-Aspect	Imperfective	Causative imperfective	
	a.	CV́CV́C	HH-L	k-a-dógá̱t-a	k-ʌ-dúgʌ́tʃ-iə	'fix'
				k-a-vɘ́léð-a	k-ʌ-vɘ́líð-iə	'pull'
	b.	CV́C	H-L	k-a-váð-a	k-ʌ-vʌ́ð-iə	'shave'
				k-a-sá̱t-a	k-ʌ-sʌ́tʃ-iə	'chew'
	c.	CV́CCV́C	HL-L	k-a-mʷándəð-eə	k-ʌ-mʷʌ́ndəð-iə	'ask'
				k-a-wɘ́nda̱t-a	k-ʌ-wɘ́ndʌtʃ-iə	'see'
	d.	CV́CC	H-L	k-a-wárð-a	k-ʌ-wʌ́rð-iə	'write'
				k-a-láṉd-a	k-ʌ-lʌ́ndʒ-iə	'close'
	e.	VCV́C	LH-L	k-ogɘ̱́t-a	k-ugɘ́tʃ-iə	'jump'
				k-abátʃ-a	k-ʌbʌ́tʃ-iə	'lift'
	f.	V́CCVC	HL-L	k-árnəð-eə	k-ʌ́rnəð-iə	'divide'

Nevertheless, there are key differences observed with two other types of verb roots. First, CVC roots with a H-H tone pattern in the imperfective are H-L in the causative imperfective (23a), neutralizing the tone distinction between H-H and H-L CVC roots (compare causatives of 23a and 22b). Second, verb roots that lack a high tone altogether in the imperfective, either because there is no root vowel (23b) or because the root is VC (23c), are specified with H tone in the causative. In the former, the H tone is realized on the preceding main clause vowel, and in the latter, it is realized on the root vowel.

(23)

		Root shape	Tone	Imperfective	Tone	Causative imperfective	
	a.	CV́C	H-H	k-a-ðɘ́w-á	H-L	k-ʌ-ðɘ́w-iə	'poke'
				k-a-lág-á		k-ʌ-lʌ́g-iə	'weed'
	b.	C	L-L	k-a-s:-a	H-L	k-ʌ́-s:-iə	'eat'
	c.	VC	L-L	k-al-a	H-L	k-ʌ́l-iə	'slice'
				k-oað-a		k-uʌ́ð-iə	'mill, grind'

The pervasive tone pattern for causative forms is therefore a H tone on the root (or on the preceding vowel if there is no root vowel), and L tone on the causative imperfective vowel. Apart from this restriction, the other aspects of lexical tone are still present, such as binary H-tone spreading (but within the root), and a sensitivity to syllable structure.

The imposition of the H-L tone pattern is specific to the causative affix. The other extension affixes are high or low toned depending on the root to which they attach. These affixes allow H tone

spreading onto them with both H-H and H-L roots, but are otherwise low. This contrasts with the causative affix, which is always L. The imperfective verb forms with extension affixes are in (24):

(24)		'pinch' (H-H)	'peck' (H-L)	'fix' (HH-L)
		k-a-kə́v-á	k-a-tóg-a	k-a-dógát̪-a
	passive/reflexive	k-ʌ-kə́v-ə́n-iə	k-ʌ-túg-ə́n-iə	k-ʌ-dúgʌ́ʧ-iə
	applicative	k-ʌ-kə́v-ə́t̪-iə	k-ʌ-túg-t̪-iə[8]	k-ʌ-dúgʌ́ʤ-it̪-iə
	applicative-passive	k-ʌ-kə́v-ə́ʧ-in-iə	k-ʌ-túg-ə́ʧ-in-iə	k-ʌ-dúgʌ́ʧ-in-iə

In these forms we observe binary spreading of H tone on to the first extension affix following the CVC root, for both H-H and H-L roots. Each affix has L tone otherwise. This illustrates that the low tone on the aspect/mood suffix in H-L verbs (20b) is a non-finality position effect, which disappears when other affixes are present. These data can be analyzed as the extension affixes and the aspect/mood affix lacking underlying high tone. In contrast, the causative affix blocks high tone spreading. We do not believe this is necessarily evidence for a L autosegment; in Moro, tone patterns restrict H tone to appear only in particular constituents or positions within the verb stem – on certain syllables, on the root, within the derived stem, or on affixes outside the derived stem.

5.3. Melodic tone

Some aspect/mood affixes introduce 'melodic' tone patterns that are specific to those inflectional categories, and override the lexical tone observed in the imperfective. The term 'melodic' tone is borrowed from the Bantu literature where it is references tense-aspect-mood inflectional categories that are characterized by the assignment of H tone in the stem (e.g. Clements 1984, Odden 1987, 1996, Bickmore 1997). In Moro, the perfective imposes a L-H tone pattern, the proximal imperative a H-H pattern, and the distal imperative a L-L pattern. These forms are seen in (25). The imperfective, with lexical tone, is shown in contrast. The distinct tone patterns of the different verb roots in the imperfective (e.g. H-H, L-L, LH-L) disappear with melodic tone, which has uniform tone regardless of the type of root.

(25)		(H-H)	(L-L)	(LH-L)
		'weed'	'slice'	'jump'
	imperfective	k-a-lág-á	k-al-a	k-ogə́t̪-a
	perfective (L-H)	k-a-lag-ó	k-al-ó	k-ogət̪-ó
	proximal imperative (H-H)	lág-ó	ál-ó	ógə́t̪-ó
	distal imperative (L-L)	lag-a	al-a	ogə́t̪-a

As seen in the proximal imperative, the H-H tone pattern overrides lexical/default tone and H tone if found across the verb form. These tone patterns also override the causative H-L tone pattern, as shown in (26):

(26)	*Causative*	'weed'	'slice'	'jump'
	imperfective (H-L)	k-ʌ-lʌ́g-iə	k-ʌ́l-iə	k-ugə́tʃ-iə
	perfective (L-H)	k-ʌ-lʌg-í	k-ʌl-í	k-ugət̪ʃ-í
	proximal imperative (H-H)	lʌ́g-í	k-ʌ́l-í	úgə́t̪ʃ-í
	distal imperative (L-L)	lʌg-iə	k-ʌl-iə	ugət̪ʃ-iə

In conclusion, lexical/default tone is partially replaced by the causative tone pattern, whereas melodic tone patterns completely replace both lexical and causative tone patterns.

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[8] The applicative [ə] is not realized in this form, but the closed syllable [túg] preceding prevents tone spreading.
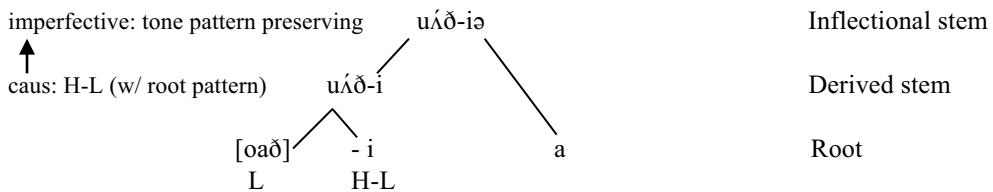
5.4. Analysis of tone patterns

To account for the different tone patterns, we propose that each affix imposes a distinct tonal pattern in accordance with morphological level (Orgun 1996, Inkelas 1998, 2009 Anttila 2002, 2009, Inkelas and Zoll 2005, 2007).

Patterns of tone associated with the root are varied. There is i) binary H tone spreading with C-initial roots, ii) a lexical distinction between CVC roots with/without H tone spreading, iii) no H tone spreading out of heavy syllables and iv) no H tone on initial vowel unless it is a heavy syllable. There are also lexical exceptions to some of these patterns. A complete analysis is found in Jenks & Rose (2011).

At the level of the derived stem, however, distinctions arise between the causative and the other extension affixes, in that the causative H-L pattern overrides i) H tone spreading onto the following affix and ii) a ban on H tone with C: and VC verbs. However, it preserves certain elements of root tone, such as binary H tone spreading with C-initial roots, no H tone spreading out of heavy syllables, and no H tone on initial vowels of longer roots, unless it is a heavy syllable. This is in contrast to the other extension markers such as the passive and benefactive applicative, which have no specific tone pattern and inherit the tone patterns of either the root or the causative. Aspect/mood categories associated with lexical tone are marked by final suffixes that have no specific tone pattern and inherit the tone pattern of the root or the causative. This is shown below in (27):
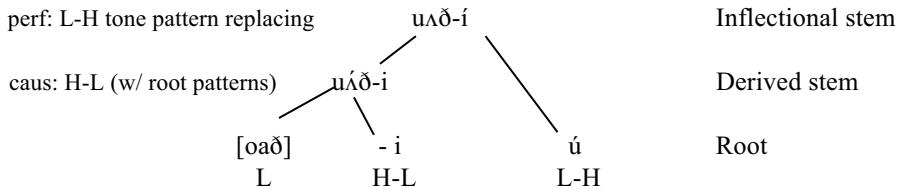
(27)   *Proximal imperfective causative:*

imperfective: tone pattern preserving   uʌ́ð-iə   Inflectional stem

↑

caus: H-L (w/ root pattern)   uʌ́ð-í   Derived stem

          [oað]   - i   a   Root
           L   H-L

We see in this form that the root *oað*, meaning 'to mill' has no H tone on the verb form at the root level. When the causative affix is added in the derived stem, its H-L tone pattern is imposed. The imperfective aspect is added at the inflectional stem level and contributes no specific tone pattern; therefore this form inherits or preserves the tone pattern of the causative and is also realized as H-L.

Tone at the melodic level is associated with aspect/mood categories marked by a suffix that introduce distinct tone patterns applied to the inflectional stem. These tone patterns override root and causative tone. The perfective form imposes a L-H tone pattern whereas the imperative forms impose a L-L or H-H pattern (proximal or distal, respectively). We maintain that the melodic tone patterns are imposed over the derived stem for two main reasons. First, the distal imperative suffix –a has the same form as the imperfective -a, but they have different tone patterns on the derived stem. Two, the final –ó is shared by the perfective, proximal imperative, and another verb form, the consecutive proximal imperfective. All three verb forms have different tone patterns on the root. The perfective root is low toned, whereas the other two are high-toned. Crucially, the consecutive proximal imperfective (28c) has lexical high tone (note the distinction between 'pull' (HH) and 'run' (HL) due to the initial closed syllable in 'run') and exhibits downstep between the final H on the root and the H on the suffix, whereas there is no downstep with the imperative (28b), suggesting a difference in representation between a single H tone spread across the word for the imperative and two juxtaposed H tones for the consecutive proximal imperfective.

(28)		'pull'	'run'
a.	perfective	k-a-vəleð-ó	k-a-lal:əŋ-ó
b.	proximal imperative	və́léð-ó	lál:ə́ŋ-ó
c.	consecutive proximal imperfective	t̪-áŋ-↓və́léð-↓ó	t̪-áŋ-↓lál:əŋ-ó

The association of melodic tone is sketched in (29) for the perfective causative *k-uʌð-í* 'caused to mill' which imposes a melodic L-H tone pattern on to the verb:

(29)   *perfective causative:*

perf: L-H tone pattern replacing	uʌð-í	Inflectional stem
caus: H-L (w/ root patterns)	uʌ́ð-i	Derived stem
	[oað] - i ú	Root
	L H-L L-H	

Again in this form, there is no H tone on the root, but H-L at the derived stem level. However the perfective aspect replaces the causative tone pattern at the inflectional level with its own L-H tone pattern. The tone pattern of the causative affects the tone of the derived stem, but can then be subsequently overridden by tones introduced by affixes added at later levels.

6. Conclusion

The causative suffix in Moro is –i, an extension suffix which is part of the derived stem. The causative affix triggers several phonological processes: vowel harmony, resistance to deletion in vowel hiatus resolution, palatalization of dental stops and the imposition of a partially-replacive tone pattern. These are analyzed as phonological properties associated with the derived stem, requiring a distinct co-phonology for the derived stem. While vowel harmony and palatalization are properties shared with other extension affixes in the derived stem, vowel hiatus resolution and tone pattern are unique to the causative suffix. The former is due to its –V (as opposed to –VC) shape, but the tone pattern is lexically specific to the causative.

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