The Nzema Verbal Phrase: An Optimality Theoretic Account[1]

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Abstract

An optimality-theoretic (OT) approach to the phonology of the verbal phrase in Nzema, a Niger-Congo language, is presented. The analysis accounts for ATR harmony spreading from roots to prefixes, nasal homorganicity in nasal-obstruent clusters, and the opacity found in assimilation in nasal-obstruent clusters. ATR is assumed to be specified in the input on certain vowels in certain roots and then spread leftward onto verbal prefixes. A combination of constraints on association line linking and delinking and an alignment constraint to account for spreading provides a relatively straightforward account of the ATR harmony. The case of nasal homorganicity in nasal-obstruent clusters is also relatively straightforward from an OT perspective. A pair of faithfulness constraints ranked with respect to a constraint requiring place features to be shared by the components of a cluster are sufficient to account for most of the data. An additional positional faithfulness constraint on onsets is required to account for homorganicity in nasal-nasal clusters. Finally, individual faithfulness constraints and a conjoined faithfulness constraint are among those used to account for the assimilation of obstruents to nasals in voicing (in the case of voiceless obstruents) and in nasality (in the case of voiced obstruents).

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Introduction

Optimality Theory (OT) has proved useful in accounting for such phonological phenomena as nasal consonant homorganicity and vowel harmony in a variety of languages of the world. Opacity effects have proved to be a challenge for traditional Optimality Theoretic approaches, but the analysis of the Nzema verbal phrase below suggests that local conjunction is one viable solution for dealing with some forms of opacity within the OT framework. The present paper provides an OT analysis of the formation of the verbal phrase in Nzema, which includes such phenomena as vowel harmony, nasal consonant homorganicity, and consonant assimilation.

Like many West African languages, Nzema, a Niger-Congo language spoken in Ivory Coast and Ghana, exhibits a vowel system in which advanced tongue root (ATR) is a contrastive feature. The Nzema vowel inventory contains five pairs of vowels differing only in ATR, for a total of ten vowels, as shown in (1). In general, only a single value of the feature ATR is present in a single lexical item in Nzema. That is, the vowels of affixes (both prefixes and suffixes) tend to harmonize to the ATR value of the root.

(1) The Nzema vowel system[2]

+ATR	***-ATR***
i	ɪ
e	ɛ
æ[3]	a
o	ɔ
u	ʊ

In verbal phrase formation, we find the effects of vowel harmony both on pronominal prefixes and on affixes marking tense and aspect. The [+ATR] and [-ATR] counterparts of the subject pronouns in Nzema are shown in (2).

(2) Subject pronoun prefixes in Nzema

	+ATR	***-ATR***
I	mi-	mɪ-
You Sg.	e-	ɛ-
He/She	o-	ɔ-
We	je-	jɛ-
You Pl.	be-	bɛ-
They	be-	bɛ-

[2] The [+ATR] counterpart of the low back vowel /a/ is somewhat controversial in related languages, but a phonetic analysis of low back vowels in [+ATR] and [-ATR] environments in Nzema revealed systematic phonetic differences between [+ATR] and [-ATR] low back vowels (Clopper and Trennepohl, 2000)

[3] The symbol [æ] is used here to indicate the [+ATR] counterpart of [a], and not a low front vowel.

The effects of ATR harmony are also found on the prefix marking the progressive in Nzema, *lɛ-*. This tense marker is realized as *le-* when affixed to a root containing an initial [ATR] vowel.

The present analysis focuses on data from two tenses in Nzema, the present and progressive, in both affirmative and negative constructions. The basic formation of these four verbal phrases is shown in (3). The affirmative present is formed by prefixing the ATR-appropriate personal pronoun to the root. The affirmative progressive is formed by prefixing the ATR-appropriate personal pronoun and the ATR-appropriate progressive marker *lɛ-* to the root. The negative tenses are formed by inserting the negative marker, a homorganic nasal consonant, before the root. In both the present and the progressive, the root-initial obstruent assimilates to the inserted nasal in either voicing or nasality. Specifically, root-initial voiceless obstruents become voiced following the negative marker and root-initial voiced obstruents become nasals following the negative marker.

(3) Verbal phrase formation in Nzema, where P indicates a personal pronoun, N indicates a homorganic nasal consonant marking negation, and *lɛ* is the progressive marker.

Tense	***Affirmative***	***Negative***
present	P + root	P + N + root
progressive	P + lɛ + root	P + lɛ + N + root

Data showing the formation of Nzema verbal phrases are shown in (4).

(4) The Nzema verbal phrase

a. Affirmative Present

i.	/mɪ+si/	[misi]	'I dance'
ii.	/ɛ+si/	[esi]	'you dance (sg)'
iii.	/ɔ+si/	[osi]	'he dances'
iv.	/jɛ+si/	[jesi]	'we dance'
v.	/bɛ+si/	[besi]	'you dance (pl)'
vi.	/bɛ+si/	[besi]	'they dance'
vii.	/mɪ+kɔ/	[mɪkɔ]	'I go'
viii.	/ɛ+kɔ/	[ɛkɔ]	'you go (sg)'
ix.	/ɔ+kɔ/	[ɔkɔ]	'he goes'
x.	/jɛ+kɔ/	[jɛkɔ]	'we go'
xi.	/bɛ+kɔ/	[bɛkɔ]	'you go (pl)'
xii.	/bɛ+kɔ/	[bɛkɔ]	'they go'

b. Affirmative Progressive

i.	/ɔ+lɛ+tia/	[oletia]	'he is walking'
ii.	/ɔ+lɛ+ŋu/	[olewu]	'he is seeing'
iii.	/ɔ+lɛ+nea/	[olenea]	'he is looking'
iv.	/ɔ+lɛ+tie/	[oletie]	'he is listening'
v.	/ɔ+lɛ+biza/	[olebiza]	'he is asking'
vi.	/ɔ+lɛ+di/	[oledi]	'he is eating'
vii.	/ɔ+lɛ+kɔ/	[ɔlɛkɔ]	'he is going'
viii.	/ɔ+lɛ+tɪ/	[ɔlɛtɪ]	'he is hearing'
ix.	/ɔ+lɛ+sɪlɪ/	[ɔlɛsɪlɪ]	'he is laughing'
x.	/ɔ+lɛ+tʃɪ/	[ɔlɛtʃɪ]	'he is catching'
xi.	/ɔ+lɛ+kɛlɛ/	[ɔlɛkɛlɛ]	'he is writing'
xii.	/ɔ+lɛ+fʊ/	[ɔlɛfʊ]	'he is climbing'

c. Negative Present

i.	/ɔ+n+tia/	[ondia]	'he does not walk'
ii.	/ɔ+n+ŋu/	[oŋŋu]	'he does not see'
iii.	/ɔ+n+nea/	[onnea]	'he does not look'
iv.	/ɔ+n+tie/	[ondie]	'he does not listen'
v.	/ɔ+n+si/	[onzi]	'he does not dance'
vi.	/ɔ+n+biza/	[ommiza]	'he does not ask'
vii.	/ɔ+n+di/	[onni]	'he does not eat'
viii.	/ɔ+n+kɔ/	[ɔŋgɔ]	'he does not go'
ix.	/ɔ+n+tɪ/	[ɔndɪ]	'he does not hear'
x.	/ɔ+n+sɪlɪ/	[ɔnzɪlɪ]	'he does not laugh'
xi.	/ɔ+n+tʃɪ/	[ɔndʒɪ]	'he does not catch'
xii.	/ɔ+n+fʊ/	[ɔɱvʊ]	'he does not climb'

d. Negative Progressive

i.	/mɪ+lɛ+n+si/	[milenzi]	'I am not dancing'
ii.	/ɛ+lɛ+n+si/	[elenzi]	'you are not dancing (sg)'
iii.	/ɔ+lɛ+n+si/	[olenzi]	'he is not dancing'
iv.	/jɛ+lɛ+n+si/	[jelenzi]	'we are not dancing'
v.	/bɛ+lɛ+n+si/	[belenzi]	'you are not dancing (pl)'
vi.	/bɛ+lɛ+n+si/	[belenzi]	'they are not dancing'
vii.	/mɪ+lɛ+n+fʊ/	[mɪlɛɱvʊ]	'I am not climbing'
viii.	/ɛ+lɛ+n+fʊ/	[ɛlɛɱvʊ]	'you are not climbing (sg)'
ix.	/ɔ+lɛ+n+fʊ/	[ɔlɛɱvʊ]	'he is not climbing'

x.	/jɛ+lɛ+n+fʊ/	[jɛlɛɱvʊ]	'we are not climbing'
xi.	/bɛ+lɛ+n+fʊ/	[bɛlɛɱvʊ]	'you are not climbing (pl)'
xii.	/bɛ+lɛ+n+fʊ/	[bɛlɛɱvʊ]	'they are not climbing'

OT Analysis of ATR Harmony

In the OT framework it is relatively straightforward to account for the ATR vowel harmony found in the data in (4). Given that prefixes harmonize to the ATR value of the root-initial vowel and that roots are contrastive with respect to ATR, it is assumed that roots can carry specification for [ATR], but that affixes can not. In addition, some roots do contain mixed ATR values, such as *biza* 'to ask.' In these cases, spreading of ATR occurs outward from the edge-most vowels of the root. Due to the possibility of mixed ATR roots, it must be assumed that [ATR] is lexically specified on certain vowels of a given root and then spreads outward to affixes. While ATR harmony does spread to both prefixes and suffixes in Nzema, the process of ATR spreading is more complex with suffixes than with prefixes. The data presented here only contain prefixes, so the analysis below will only account for leftward spreading. Finally, it is assumed that [ATR] is a privative feature and that all prefixes are underlyingly unmarked for [ATR].

Following Pulleyblank, Jiang-King, Leitch, and Ola's (1995) analysis of Degema, I propose the constraints shown in (5) below to account for Nzema ATR harmony. The DepIO[ATR] constraint in (5a) ensures that [ATR] is not inserted on roots or affixes when it is not present in the input. The AlignATR-L constraint in (5b) accounts for the leftward spread of [ATR] onto the verbal prefixes by requiring the left edge of the [ATR] span to align with the left edge of the grammatical word. In order to ensure that lexically specified values of [ATR] are realized, the Max-Link constraint in (5c) is necessary. In the case of Nzema, this means that the ATR feature must be realized on the vowels of the root for which ATR is specified in the input. That is, deletion of association lines is prohibited.

(5)

a. DepIO[ATR] => insertion of [ATR] is disallowed

b. Align[ATR, L; GrWD, L] => align the left edge of the featural span of ATR with the left edge of the grammatical word

c. Max-Link => deletion of association lines is disallowed

d. Dep-Link => insertion of association lines is disallowed

e. NoGapping => associating a single feature with non-adjacent target segments is disallowed

The Dep-Link constraint in (5d), taken from Akinlabi's (1994) analysis of Kanembu, prohibits linking features to segments that are not linked in the input. That is, it prohibits inserting association lines. Violations for both Max-Link and Dep-Link are incurred for each deletion or insertion of an association line, respectively. In the case of the affirmative progressive where two morphemes are prefixed to the verbal root, the constraint in (5e) is necessary to ensure that both of the prefixes harmonize with the root with respect to ATR by prohibiting a feature from being associated with non-adjacent segments.

As in any OT analysis, some of the constraints listed in (5) are violable in Nzema. Given that ATR spreading occurs, we know that the Dep-Link constraint is a low-ranking constraint. Specifically, it must be dominated by Max-Link, as shown in the tableau in (6). In all of the following tableaux, solid lines are used to indicate an underlying association between the feature [ATR] and a vowel, while dotted lines are used to indicate an inserted association.

(6) Nzema 'he dances' /ɔ-si/ -- [osi]

/ɔ-si/	Max-Link	Dep-Link
☞ a. [ATR] osi		*
b. [ATR] ɔsi	*!	

This tableau shows that Max-Link >> Dep-Link, because if the constraints were reversed, the candidate in (6b) would be incorrectly chosen as the winning candidate.

Dep-Link must also be ranked below AlignATR-L, as shown in the tableau in (7). Again, if the constraints were reversed, such that Dep-Link >> AlignATR-L, the candidate in (7b) would incorrectly be chosen as the winning candidate.

(7) Nzema 'he dances' /ɔ-si/ -- [osi]

/ɔ-si/	AlignATR-L	Dep-Link
☞ a. [ATR] osi		*
b. [ATR] ɔsi	*!	

We cannot rank DepIO[ATR] with respect to Dep-Link because a violation of DepIO[ATR] always also results in a violation of Dep-Link. However, following Pulleyblank et al. (1995), it will be assumed that DepIO[ATR] is a high-ranking constraint. It will also be assumed that NoGapping is an undominated constraint as association lines are not permitted to skip vowels in Nzema. The Max-Link and AlignATR-L constraints also can not be ranked with respect to one another. The ranking of these constraints is shown in (8).

(8) DepIO[ATR], NoGapping, Max-Link, AlignATR-L >> Dep-Link

Tableaux showing the application of this constraint ranking are shown in (9) through (12). The first of these tableaux demonstrates the case of an [ATR] root in the affirmative present. The most faithful candidate in (9c) fatally violates the AlignATR-L constraint. The candidate in (9b) with no [ATR] vowels in the output fatally violates the Max-Link constraint. The candidate in (9d), where [ATR] is realized only on the prefix, violates both Max-Link and Dep-Link. The winning candidate is therefore in (9a), despite its violation of Dep-Link through the association of the ATR feature with the vowel in the prefix.

(9) Nzema 'he dances' /ɔ-si/ -- [osi]

/ɔ-si/	DepIO[ATR]	NoGap	Max-Link	AlignATR-L	Dep-Link
☞ a. [ATR] osi					*
b. [ATR] ɔsɪ			*!		
c. [ATR] ɔsi				*!	
d. [ATR] osɪ			*!		*

The tableau in (10) shows the formation of the affirmative present when the root does not contain an [ATR] vowel. The most faithful candidate does not incur any violations of the constraints included, and is therefore the winning candidate over the other candidates which all incur a fatal violation of DepIO[ATR]. Specifically, the candidate in (10a), which contains only [ATR] vowels, incurs a violation of DepIO[ATR] and two violations of Dep-Link (one for each vowel). The candidate in (10c), which contains an [ATR] vowel on the root incurs an AlignATR-L violation and a Dep-Link violation in addition to its DepIO[ATR] violation. The candidate in (10d), which contains an [ATR] vowel only on the prefix also incurs DepIO[ATR] and Dep-Link violations.

(10) Nzema 'he goes' /ɔ-kɔ/ -- [ɔkɔ]

/ɔ-kɔ/	DepIO[ATR]	NoGap	Max-Link	AlignATR-L	Dep-Link
a. [ATR] oko	*!				**
☞ b. ɔkɔ					
c. [ATR] ɔko	*!			*	*
d. [ATR] okɔ	*!				*

The tableaux in (11) and (12) demonstrate similar effects for the affirmative progressive when formed with roots with [ATR] vowels in (11) and without [ATR] vowels in (12). Again, we see that the candidate in (11) which best satisfies the constraints is the one in which all of the vowels to the left of the root are [ATR] vowels, harmonious with the left-most root vowel. The candidate in (12) which best satisfies the constraints is the one which is most faithful to the input, such that none of the output vowels are [ATR] vowels. In both (11) and (12) the NoGapping constraint eliminates candidates in which [ATR] vowels are non-adjacent.

(11) Nzema 'he is listening' /ɔ-lɛ-tie/ -- [oletie]

/ɔ-lɛ-tie/	DepIO[ATR]	NoGap	Max-Link	AlignATR-L	Dep-Link
☞ a. [ATR] oletie					**
b. [ATR] ɔlɛtɪɛ			*!*		
c. [ATR] ɔlɛtie				*!	
d. [ATR] oletɪɛ			*!*		**
e. [ATR] olɛtie		*!			*

(12) Nzema 'he is writing' /ɔ-lɛ-kɛlɛ/ -- [ɔlɛkɛlɛ]

/ɔ-lɛ-kɛlɛ/	DepIO[ATR]	NoGap	Max-Link	AlignATR-L	Dep-Link
a. [ATR] olekele	*!				****
☞ b. ɔlɛkɛlɛ					
c. [ATR] ɔlɛkele	*!			*	**
d. [ATR] olekɛlɛ	*!				**
e. [ATR] olɛkelɛ	*!	*			**

The analysis of ATR harmony presented above accounts for all of the phonologically interesting material in the affirmative verbal phrase data in (4a) and (4b). An account of spreading to suffixes would require additional constraints against skipping vowels when linking the ATR feature, as well as an alignment constraint to extend the domain of [ATR] to the right edge of the word.

OT Analysis of Consonant Homorganicity

We now turn our attention to the negative verbal phrases found in (4c) and (4d). A phonological account of this data must consider both the homorganicity of the negative marker and the root-initial consonant assimilation following this marker.

Pulleyblank (1997) provides a nice summary typology of homorganicity effects in natural languages. In particular, he considers the Niger-Congo language of Yoruba, spoken in Nigeria, that exhibits a pattern of homorganic nasals in nasal-obstruent clusters similar to that found in the Nzema data in (4). The three constraints used by Pulleyblank in his analysis of Yoruba are shown in (13) below. As will be shown, these three constraints are also adequate to account for the Nzema case of nasal-obstruent cluster homorganicity.

(13)

a. Identical Cluster Constraint [Place] (ICC[Place]) => components of a cluster must share place features

b. IdentIO[Place]Obstruent => input and output obstruent correspondents must have identical values of the place feature

c. IdentIO[Place]Nasal => input and output nasal correspondents must have identical values of the place feature

In this analysis, the negative morpheme in Nzema will be treated as an underlying /n/, given the general unmarkedness of coronals in languages of the world. It would also be possible to posit that the negative morpheme is a nasal consonant that is unmarked for [place] features, and such an assumption would not significantly change the analysis beyond the formulation of the constraints.

A brief discussion of Nzema syllable structure is appropriate at this point in the analysis. Typically only open syllables are permitted in Nzema, suggesting that *Coda is a high-ranking constraint. However, nasal consonants are found in coda position, as shown in the verbal data, as well as in monomorphemic forms and nominal plurals. An alternative account of Nzema syllable structure is that only open syllables are permitted and that the apparent coda nasals are actually syllabic nasals (cf. Berry, 1955). This distinction is not crucial to the present analysis, however, and it is assumed that only nasal consonants are permitted in coda position. For the moment, we will ignore the alternations of the root-initial obstruents and assume that the [ATR] value of the vowels is taken care of independently of the consonant alternations, through the constraint hierarchy discussed in the previous section.

Given that the negative morpheme appears in the output forms as a homorganic nasal, we can conclude that ICC[Place] is a high-ranking constraint that is satisfied at the cost of violating IdentIO[Place]Nasal. It can be assumed that MaxIO and DepIO are also high ranking constraints, given that ICC[Place] is not satisfied by deletion or epenthesis. That ICC[Place] must outrank IdentIO[Place]Nasal is shown in the tableau in (14). If the constraints were ranked in the opposite order, the candidate in (14b) would be incorrectly selected as the winning candidate.

(14) Nzema 'he does not ask' /ɔ-n-biza/ -- [ommiza]

/ɔ-n-biza/	ICC[Place]	IdentIO[Pl]Nasal
☞ a. ommiza		*
b. onbiza	*!	

IdentIO[Place]Nasal must also be ranked below IdentIO[Place]Obstruent, as shown by the tableau in (15). If the constraints were reversed, the candidate in (15b), in which the root-initial obstruent assimilates to the place of the negative nasal marker, would be incorrectly selected as the winner.

(15) Nzema 'he does not ask' /ɔ-n-biza/ -- [ommiza]

/ɔ-n-biza/	IdentIO[Pl]Obs	IdentIO[Pl]Nasal
☞ a. ommiza		*
b. ondiza	*!	

IdentIO[Place]Obstruent and ICC[Place] cannot be ranked with respect to one another, which leads to the ranking shown in (16) of the three constraints from (13). Tableaux showing the application of this constraint ranking are shown in (17) and (18).

(16) ICC[Place], IdentIO[Place]Obstruent >> IdentIO[Place]Nasal

The tableau in (17) shows that when the root-initial obstruent is coronal, the most faithful candidate with respect to nasal place in (17a) is the winner because it does not violate any of the constraints. The candidates in (17b) and (17c) both contain fatal violations of ICC[Place]. In (17b), the nasal consonant has a different place feature in the output than the input. In (17c), the obstruent has a different place feature in the output than in the input. The constraint ranking in (16) successfully maintains place identity for both components of the cluster when ICC[Place] is not violated.

(17) Nzema 'he does not listen' /ɔ-n-tie/ -- [ondie]

/ɔ-n-tie/	ICC[Place]	IdentIO[Pl]Obs	IdentIO[Pl]Nasal
☞ a. ondie			
b. omdie	*!		*
c. onbie	*!	*	

By contrast, when the root-initial obstruent is not coronal, the nasal consonant assimilates to the place of articulation of the obstruent, as shown by the winning candidates in the tableau in (18). The most faithful candidate (18a) has a fatal violation of ICC[Place]. While candidates (18b), (18c), and (18d) all satisfy ICC[Place], candidates (18b) and (18c) are preferred over candidate (18d) because they also satisfy IdentIO[Place]Obstruent at the expense of IdentIO[Place]Nasal. The selection of the true winning candidate in (18c) over (18b) will be discussed in the next section on consonant alternations.

(18) Nzema 'he does not ask' /ɔ-n-biza/ -- [ommiza]

/ɔ-n-biza/	ICC[Place]	IdentIO[Pl]Obs	IdentIO[Pl]Nasal
a. onbiza	*!		
☞ b. ombiza			*
☞ c. ommiza			*
d. ondiza		*!	

These three constraints account for the homorganicity in the nasal-obstruent clusters in the Nzema verbal phrase. However, the data also include nasal-nasal clusters in which the negative morpheme assimilates to the place of articulation of the root-initial nasal consonant. In order to account for this uni-directional assimilation, a positional faithfulness constraint must be added to the constraints above. Lombardi (1999) argues that the onset is a privileged position in phonology. In her discussion of Yiddish cluster voicing assimilation, she suggests including a position-specific faithfulness constraint in addition to the position-neutral faithfulness constraint. The position-specific constraint required for this analysis is shown in (19).

(19) IdentIO[Pl]Onset => input and output correspondents in syllable onsets must have identical values of the place feature

It is not possible to provide a ranking argument for this new constraint with respect to the others, but as Kager (1999) points out in his discussion of positional faithfulness, it is typically assumed that position-specific constraints outrank their corresponding position-neutral constraints. Therefore, IdentIO[Pl]Onset will be assumed to outrank IdentIO[Pl]Nasal and IdentIO[Pl]Obs, providing the ranking of all four relevant constraints as in (20). The tableau in (21) shows the application of these four constraints to a negative verbal phrase containing a root with an initial nasal consonant.

(20) ICC[Place], IdentIO[Pl]Onset >> IdentIO[Pl]Obs >> IdentIO[Pl]Nasal

(21) Nzema ‘ he does not see’ /ɔ-n-ŋu/ -- [oŋŋu]

/ɔ-n-ŋu/	ICC[Place]	IdentIO[Pl] Onset	IdentIO[Pl] Obs	IdentIO[Pl] Nasal
a. onŋu	*!			
b. onnu		*!		*
☞ c. oŋŋu				*

The most faithful candidate (21a) contains a fatal violation of ICC[Place]. The candidates in (21b) and (21c) satisfy ICC[Place], but the candidate in (21c) is the winning candidate because the coda /n/ assimilates to the onset /ŋ/, thereby satisfying IdentIO[Pl]Onset. This constraint is violated by the assimilation of the onset /ŋ/ to the coda /n/ in candidate (21b).

OT Account of Root-Initial Consonant Alternations

Now that the homorganicity of the negative morpheme has been accounted for, we can turn our attention to the alternations found in the root-initial obstruents in the environment of the negative morpheme. This phenomenon can be explained in derivational terms as a classic case of counterfeeding. That is, voiceless obstruents are voiced following a nasal and voiced obstruents are nasalized following a nasal, resulting in an apparent underapplication of the nasalization process. Kager (1999) refers to this type of opacity as a chain shift, as schematized in (22).

(22) A => B and B => C, but *A => C

The relevant constraints for accounting for this data are shown in (23). The constraints in (23a) and (23b) require input-output faithfulness of the features [nasal] and [voice], respectively. The constraints in (23d) and (23e) prohibit geminates of obstruents and nasals, respectively. The constraint in (23f) is similar to the constraint presented in (13a), in that it requires both components of a consonant cluster to share a feature; in this case, the nasal feature must be shared. Finally, the constraint in (23c) is a high-ranking constraint motivating the root-initial obstruent assimilation, used by Kager (1999) in his discussion of post-nasal voicing in Quechua. It will be assumed that MaxIO and DepIO are also highly ranked, so that *NC̥ violations are not satisfied by either insertion of a vowel or deletion of a consonant. It is assumed that ATR harmony and nasal homorganicity are achieved through the independent ranking of the constraints presented in the previous two sections.

(23)

a. IdentIO[Nasal] => input and output correspondents must have the same value of the feature [nasal]

b. IdentIO[Voice] => input and output correspondents must have the same value of the feature [voice]

c. *NC̥ => nasal plus voiceless obstruent clusters are disallowed

d. *GemObs => obstruent geminates are disallowed

e. *GemNasal => nasal geminates are disallowed

f. ICC[Nasal] => components of a cluster must share nasal features

The realization of voiceless obstruents as voiced following a nasal can be accounted for by the crucial ranking of *NC̥ over IdentIO[Voice], as shown in the tableau in (24). If the constraints were reversed, the faithful candidate (24b) would be incorrectly selected as the winning candidate.

(24) Nzema 'he does not walk' /ɔ-n-tia/ -- [ondia]

/ɔ-n-tia/	*NC̥	IdentIO[Voice]
☞ a. ondia		*
b. ontia	*!	

The realization of voiced obstruents as nasals implies three additional crucial constraint rankings. In the tableau in (25), ICC[Nasal] is shown to outrank IdentIO[Nasal]. The more faithful candidate (25b) incurs a fatal violation of ICC[Nasal]. The tableau in (26) shows that *GemObs >> *GemNas. Nasal gemination is preferred to obstruent gemination. Finally, ICC[Nasal] outranks *GemNas as shown in the tableau in (27). ICC[Nasal] is satisfied through nasal gemination.

(25) Nzema 'he does not eat' /ɔ-n-di/ -- [onni]

/ɔ-n-di/	ICC[Nasal]	IdentIO[Nasal]
☞ a. onni		*
b. ondi	*!	

(26) Nzema 'he does not eat' /ɔ-n-di/ -- [onni]

/ɔ-n-di/	*GemObs	*GemNas
☞ a. onni		*
b. oddi	*!	

(27) Nzema 'he does not eat' /ɔ-n-di/ -- [onni]

/ɔ-n-di/	ICC[Nasal]	*GemNas
☞ a. onni		*
b. ondi	*!	

Taken together, the constraint rankings in (28) emerge. However, combining all of the constraints in (23) into a single hierarchy (28d) produces incorrect winning candidates for verbal phrases containing voiceless root-initial obstruents, as shown in the tableau in (29).

(28)

a. $*N\mathring{C}$ >> IdentIO[Voice]

b. ICC[Nasal] >> IdentIO[Nasal], *GemNas

c. *GemObs >> *GemNas

d. $*N\mathring{C}$, *GemObs, ICC[Nasal] >> Ident[Nasal], Ident[Voice], *GemNas

(29) Nzema 'he does not walk' /ɔ-n-tia/ -- [ondia]

/ɔ-n-tia/	$*N\mathring{C}$	*GemObs	ICC[Nas]	Id[Nas]	Id[Vc]	*GemNas
a. ontia	*!		*			
b. ondia			*!		*	
☹ c. onnia				*	*	*
d. oddia		*!		*	*	

The constraints as they have been formulated above produce output forms that are transparent to the process of nasalizing voiced obstruents following nasals. That is, in the tableau in (29), the candidate in (29c) with the geminate nasal is incorrectly selected as the winner (indicated by the ☹) because it satisfies the three constraints which outrank

IdentIO[Nasal]. The actual winning candidate (29b) is eliminated through a fatal violation of ICC[Nasal]. The most faithful candidate in (29a) fatally violates the undominated *NC̥ constraint. The candidate in (29d), containing a geminate /d/, violates the undominated *GemObs constraint.

In order to block the voiceless obstruent from becoming a nasal, either *GemNas or IdentIO[Nasal] must outrank ICC[Nasal]. However, the ranking arguments shown above in the tableaux in (25) and (27) require that ICC[Nasal] outrank IdentIO[Nasal] and *GemNas. We are therefore left with an apparent ranking paradox.

One solution to chain shifts such as that found in the Nzema verbal phrase is local constraint conjunction (Kirchner, 1996; McCarthy, 1999). In local constraint conjunction, two constraints are joined into a single constraint using the AND operator. That is, the simultaneous violation of both constraints is worse than the violation of either of the constraints on its own. While local constraint conjunction is somewhat controversial as an opacity-fix in OT (e.g., Ito & Mester, 1999), it is most acceptable when the conjoined constraints are from the same family (Fukazawa, 2001). In this particular example, the two constraints which must be conjoined are the input-output faithfulness constraints IdentIO[Voice] and IdentIO[Nasal], as shown in (30).

(30) IdentIO[Voice]+IdentIO[Nasal] => input and output correspondents of a single segment must have the same value of the feature [voice] AND the feature [nasal]

The conjoined constraint must outrank the ICC[Nasal] constraint as shown in the tableau in (31) below. If the constraints were ranked in reverse, the candidate with the geminate nasal (31b) would be incorrectly selected as the winning candidate.

(31) Nzema ‘he does not walk’ /ɔ-n-tia/ -- [ondia]

/ɔ-n-tia/	Id[Voice]+Id[Nasal]	ICC[Nasal]
☞ a. ondia		*
b. onnia	*!	

The constraints in (23) and (30) can all be ranked within the same hierarchy as shown in (32). The application of this constraint ranking to negative verbal phrases in Nzema produces the correct output for both forms with voiceless root-initial obstruents and forms with voiced root-initial stops, as shown in the tableaux in (33) and (34), respectively.

(32) *NC̥, *GemObs, Id[Vc]+Id[Nas] >> ICC[Nas]
>> Id[Nas], Id[Vc], *GemNas

(33) Nzema ‘he does not walk’ /ɔ-n-tia/ -- [ondia]

/ɔ-n-tia/	*NC̥	*GemObs	Id[Vc]+ Id[Nas]	ICC[Nas]	Id[Nas]	Id[Vc]	*GemNas
a. ontia	*!			*			
☞ b. ondia				*		*	
c. onnia			*!		*	*	*
d. oddia		*!			*	*	

In the tableau in (33), the most faithful candidate (33a) is not the winning candidate because it incurs a violation of the undominated *NC̥ constraint. As in the tableau in (29), candidate (33d) is not the winning candidate because it fatally violates the *GemObs constraint. Candidate (33b) is correctly selected as the winning candidate, given that the candidate in (33c) incurs a fatal violation of the conjoined faithfulness constraint presented in (30). This candidate violates the conjoined constraint because the input /t/ is realized as an /n/ in the output; the single segment is unfaithful in both its voicing and its nasality from input to output.

(34) Nzema ‘he does not ask’ /ɔ-n-biza/ -- [ommiza]

/ɔ-n-biza/	*NC̥	*Gem Obs	Id[Vc]+ Id[Nas]	ICC[Nas]	Id[Nas]	Id[Vc]	*GemNas
a. ompiza	*!			*		*	
b. ombiza				*!			
☞ c. ommiza					*		*
d. obbiza		*!			*		

Nasalization is not blocked, however, in the case of voiced root-initial obstruents. As shown in the tableau in (34), the winning candidate (34c) contains a geminate nasal. This candidate does not violate the conjoined constraint because it only incurs a violation of IdentIO[Nasal] and not IdentIO[Voice]. The candidate with a geminate /b/ in (34d) is eliminated for violating *GemObs. The most faithful candidate (34b) is eliminated for a violation of ICC[Nasal]. Finally, devoicing the root-initial obstruent is prohibited by *NC̥ in (34a).

Conclusions

The OT framework has provided a relatively concise account of the phonology of the Nzema verbal phrases presented here. The solution to vowel harmony involving leftward [ATR] spreading was straightforward and required reference to only four critical constraints. The solution to the homorganicity of nasals in nasal-obstruent clusters was also quite straightforward and only required three constraints. An additional positional faithfulness constraint was required in order to account for the place assimilation of the first nasal to the second in nasal-nasal clusters. However, there is some evidence that onsets are more prominent in speech perception, motivating the claim that onsets might be more privileged in the phonological system (Beckman, 1997).

Finally, the solution to the opacity found in the assimilation of the obstruent to the voice and nasal features of the nasal in nasal-obstruent clusters was the most complex aspect of the analysis presented here. Specifically, it required a local conjunction of two faithfulness constraints in order to account for the chain shift assimilation. While local constraint conjunction is considered to be controversial in the OT literature, the conjunction required in this analysis involved two constraints from the same family, namely feature faithfulness constraints. The conjunction of two similar constraints is less problematic for OT than conjunction of unrelated constraints because it serves to limit how many constraints must be learned and ranked.

The phonology of the Nzema verbal phrase can be accounted for with an OT approach, using some developments such as local constraint conjunction and positional faithfulness, in addition to basic markedness and faithfulness constraints. Further analyses of the Nzema verbal phrase should consider other forms in the verbal paradigm, such as other tenses, aspects, and moods, as well as serial verb construction.

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