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Trigger Conditions and Nasal Harmony in Terena¹

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0. Introduction

The nasal harmony system of Terena, an Arawakan language of southern Mato Grosso, Brazil, raises significant questions for the treatment of opacity and transparency in phonological theory. As described by Bendor-Samuel (1960), Terena marks the category of 1st-person by progressive nasalization. For forms such as *ayo* 'his brother', each segment is nasalized to produce *ãyô* 'my brother'. Of particular interest, however, is the phonologically janus behavior of obstruents, which pattern systematically both as *targets* for and *blockers* of harmony. Thus, *owoku* 'his house' becomes *ôwô^hgu* 'my house'. Here, nasal spread is blocked by *k*, yet *k* itself surfaces as the prenasalized ^h*g*. The behavior of nasal stops is also of interest. Unlike obstruents, nasal stops are transparent to harmony: they do not alternate, and they do not arrest [+nasal] spread, as in *emo?u* 'his word' → *êmô^h?û* 'my word'. An analysis of the Terena data must thus address these two issues: 1) the dual behavior of obstruents, and 2) the transparency of nasal consonants.

I argue that the data are best accounted for within the context of a theory of feature cooccurrence constraints (cf. Archangeli and Pulleyblank 1989, in press). In §1, I present the relevant facts, and in §2 I provide my analysis, showing that nasalization is subject to a single constraint: *IF [+NASAL], THEN NOT [-SONORANT] (NAS/SON)*. I compare the Terena data with nasalization in Orejón (Pulleyblank 1989), and, crucially, I show that NAS/SON must hold only of triggers for harmony in Terena. This approach then allows for a simple treatment of the transparency of nasal stops in terms of the MORPHEME PLANE HYPOTHESIS (McCarthy 1981, Cole 1987). In §3 I argue against the viability of attributing the behavior of obstruents to the NO CROSSING CONSTRAINT (Goldsmith 1976, Clements 1981, Clements and Sezer 1982, Sagey 1986, Hammond 1988, Rice and Avery 1990, etc.). And in §4 I present my conclusions.

1. The Data

Bendor-Samuel (1960) provides the following phonemic inventory for Terena.² As can be seen, voicing is not distinctive for obstruents, and the language lacks underlying prenasalized consonants and nasalized vowels.³

(1)	stops	p	t	k	?	
	fricatives		s	ʃ	h	hy
	laterals			l,r		
	nasals	m	n			
	glides			y	w	
	vowels	i, e, a, o, u				

The process of 1st-person nasalization is exemplified in (2):

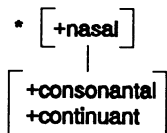
(2)	a. ayo	'his brother'	āyō	'my brother'
	b. arine	'sickness'	ārinē	'my sickness'
	c. unae	'boss'	ūnāē	'my boss'
	d. emo?u	'his word'	ēmō?ū	'my word'
	e. owoku	'his house'	ōwō ^o gu	'my house'
	f. iwu?išo	'he rides'	īwū?ī ^o žo	'I ride'
	g. ituke	'poss. pro.'	ī ^o duke	'1st p. poss. pro'
	h. nokone	'need'	nō ^o gone	'I need'
	i. taki	'arm'	^o daki	'my arm'
	j. tuti	'head'	^o duti	'my head'
	k. paho	'mouth'	^m baho	'my mouth'
	l. piho	'he went'	^m biho	'I went'
	m. ahya?ašo	'he desires'	ā ^o ža?ašo	'I desire'
	n. ha?a	'father'	^o za?a	'my father'
	o. hyišoe	'dress'	^o žišoe	'my dress'

The forms in (a-d) are three ways relevant. First, vowels, liquids, and glides are all seen to be targets for nasalization and also permit the further propagation of the process. Secondly, (b-d) show the transparency of nasal stops, i.e., that these sounds do not block nasalization. And thirdly, (d) shows the transparency of the glottal stop as well. In (e-h) we see that nasalization proceeds from left to right until it reaches an obstruent. As seen in *ōwō^ogu*, the obstruent surfaces as prenasalized and the process is arrested. Interestingly, the forms in (i-l) all begin with an obstruent, showing that harmony cannot skip segments; that is, if the first segment of a word is an obstruent, it is prenasalized and further spread of [+nasal] is halted. Finally, (m-o) show that the laryngeal continuants, *h* and *hy*, pattern with obstruents in that they become prenasalized and arrest nasalization. In the case of *h*, prenasalization involves the concomitant acquisition of a coronal point of articulation.⁴

2. Nasalization and Feature Cooccurrence

In recent years, researchers have looked to feature cooccurrence constraints as a means of deriving opacity (cf. Archangeli and Pulleyblank 1989, in press; Cohn 1989, 1990; Pulleyblank 1989). Usually, such constraints function as filters, i.e., as generalizations which govern the well-formedness of phonological representations. Cohn (1989, 1990), for example, invokes the constraint in (3) for Sundanese:

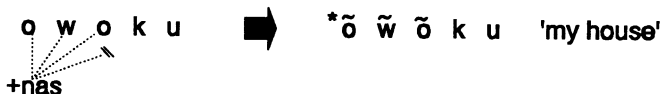
(3)



This constraint prohibits the combination of [+nasal], [+continuant] and [+consonantal] within a segment. For Cohn, this explains the opacity of liquids, whose [+continuant] specification disqualifies them as targets for [+nasal] spread. The claim here is that the puzzling behavior of obstruents in Terena is also best viewed in terms of feature cooccurrence constraints. Specifically, I will assume that harmony results from the application of a rule linking and spreading a floating [+nasal] 1st-person marker. And I will argue that a single NAS/SON constraint holds of this rule:⁵ *IF [+NASAL], THEN NOT [-SONORANT]* (after Archangeli and Pulleyblank in press).

Interestingly, however, conceiving of constraints as filters which hold *globally* for a given language gives rise to an apparent paradox for Terena. Consider, for example, the incorrect derivation of **ōwōku* 'my house':

(4)



If NAS/SON holds globally, [+nasal] should be prevented from docking to obstruents such as *k*. Of course, this cannot be the case, since the correct output is *ōwō^ggu*, a form in which [+nasal] docks to *k*, deriving the prenasalized ^g*g*.

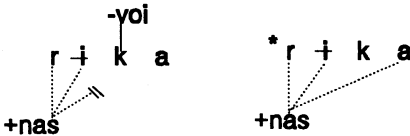
Nevertheless, global constraints do appear to be crucial for the characterization of languages such as the Tucanoan language Orejón (cf. Arnaiz 1988, Pulleyblank 1989). Here, I review Pulleyblank's analysis, in which [+nasal] is claimed to be lexically specified for particular morphemes, as in (5):

- | | | | | | |
|-----|----|-------------|---|--------|------------|
| (5) | a) | [+N] b+te? | → | mĩte? | 'mosquito' |
| | b) | [+N] ?bori- | → | ?mõnĩ- | 'come' |
| | c) | [+N] ?daki- | → | ?nāki- | 'chew' |
| | d) | [+N] r+ka- | → | n+ka- | 'stop' |
| | e) | [+N] yakoa? | → | nākoa? | 'eye' |
| | f) | [+N] gara? | → | ŋānā | 'fly' |
| | g) | [+N] take? | → | tāke? | 'monkey' |
| | h) | [+N] kosa? | → | kōsa? | 'ant' |
| | i) | [+N] sebe? | → | sēmē? | 'wild pig' |

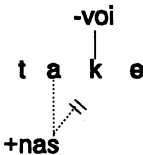
For Pulleyblank, the distribution of nasality is determined by a rule that links and spreads floating [+nasal] from left to right. This rule is subject to a

NAS/VOI constraint of the form: *IF [+NASAL], THEN [+VOICE]; IF [+NASAL], THEN NOT [-VOICE]*. Focussing on the form in (a), we see that NAS/VOI prohibits the association of [+nasal] to the voiceless consonant *t*, resulting in the surface form *míte?* 'mosquito'. The opacity of *t* results from two factors. First, NAS/VOI rules it out as a target for nasalization. Secondly, Pulleyblank assumes that spreading is strictly local, i.e. from segment to segment. Initial, voiceless consonants would appear to constitute counter-examples to the ban against non-local spread, as seen in (g-h). Here, Pulleyblank argues, the prohibition is not violated, since [+nasal] is unassociated at UR. That is, for non-local spread to occur, [+nasal] must already be associated. Iterative association, and not non-local spread, is thus responsible for the skipping of initial voiceless segments. Derivations are provided in (6):

(6) a) [+N] r t̥ k a ➡ n t̃ k a 'stop'



b) [+N] t a k e ➡ t̃ a k e 'monkey'



Crucially, a global use of constraints does characterize the distribution of floating [+nasal] in Orejón. How, then, are we to reconcile the Orejón facts with those of Terena, in which such a use of NAS/SON makes incorrect predictions? Following the work of Archangeli and Pulleyblank (1989, in press), I argue that the solution lies in relativizing the role of constraints in the grammar.

Consider for a moment the following differences between the two languages: 1) Orejón permits the skipping of initial consonants, while Terena prohibits such skipping; and 2) Orejón does not allow [+nasal] to dock to opaque segments, while Terena does, resulting in prenasalization. My claim is that these differences follow directly from role played by feature cooccurrence constraints in each language. In Orejón, NAS/VOI governs all representations, so the combination of [+nasal] and [-voice] is universally proscribed. In Terena, NAS/SON obtains *only* as a constraint on the application of the rule spreading [+nasal]. This is expressed via the statement of NAS/SON as a *trigger condition*

in the rule in (7):⁶

(7)

a) +NASAL LINK/SPREAD:

X
⋮
+nas

Type: LINK/SPREAD
Direction: LEFT TO RIGHT
Iteration: YES
Trigger Condition: NAS/SON

IF [+NAS] then NOT [-SON]

This rule accounts both for the initial association and the subsequent spreading of [+nasal] by iteratively inserting association lines between [+nasal] and target segments from left to right.⁷ Of relevance here is that NAS/SON defines the set of possible triggers for the rule, but that it does not obtain of representations in general. This now provides an explanation for why Terena prohibits the skipping of initial segments. Specifically, since NAS/SON holds only of triggers, the rule linking and spreading [+nasal] applies to all segments. But if an initial segment is [-sonorant], [+nasal] association results in a violation of the NAS/SON constraint. As a trigger constraint, NAS/SON thus blocks any subsequent spread of [+nasal]. In essence, NAS/SON in Terena creates a fly-paper effect: [+nasal] can spread onto any segment, but it cannot continue to spread once it has combined with [-sonorant].

The effect of NAS/SON is seen in the derivation of *owuko* → *ōwū^ogo* 'my house' in (8). Note that under this approach, opacity and prenasalization are derived in one step: [+nasal] docks iteratively across the string up to *k*, while NAS/SON serves to prevent further spread.⁸

(8)



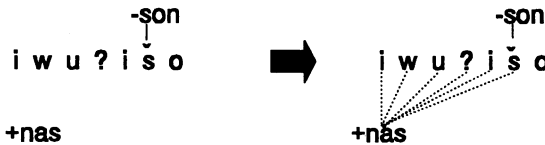
The transparency of nasal consonants can be shown to follow straightforwardly from the Morpheme Plane Hypothesis (McCarthy 1981, Cole 1987). By hypothesis, morphemic [+nasal] resides on and spreads from its own plane. This circumvents the potential problem of opacity effects resulting from the crossing the [+nasal] association lines of underlying nasal consonants. An example is provided in (9), where I assume that plane conflation automatically triggers the fusion of [+nasal] association lines:

(9)



As for the glottal stop, I follow Bendor-Samuel (1960) in assuming that, like all segments, it undergoes nasalization. That is, nothing prevents the lowering of the velum during the articulation of glottal stop, but the lack of airflow results in a case of phonological nasalization with no phonetic effect. I claim that the absence of a [-sonorant] specification accounts for its transparency:

(10)



2.1 Residual questions

Invoking NAS/SON as a trigger condition in Terena provides a maximally simple account for why obstruents are both targets for and blockers of the process. However, two interesting questions emerge. First, this analysis does not treat prenasalized segments as [+nasal]-[-nasal] contours (cf. Sagey 1986). That is, there is no explicit explanation for why the cooccurrence of [-sonorant] and [+nasal] might not equally result in post-nasalization. Similarly, there is no direct relation between the directionality of spreading and the creation of prenasalized segments.

Interestingly, recent work by Steriade (forthcoming_{a,b,c}) on the representation of closure and release provides important insights into these questions in a framework compatible with the approach to feature cooccurrence taken here. Steriade argues that prenasalization is best represented by a theory of feature geometry that explicitly encodes both the closure phase and the release phase of plosives via the use of aperture nodes. Thus, a stop is represented as a sequence consisting of a closure phase (A_0), followed by a release phase (A_{max}). Vowels and approximants, in contrast, are simply characterized as A_{max} segments. Importantly, Steriade's geometry can be incorporated directly into my analysis by assuming that the prenasalization of [-sonorant] sounds involves the spreading of [+nasal] onto their closure (A_0) phase,⁹ while the failure of continued spread derives from the NAS/SON trigger constraint discussed above. In short, this produces representations with nasal closure and oral release, i.e., prenasalized segments.

What is important to note is that Steriade's geometry does not obviate the need for a NAS/SON constraint in Terena. It is still necessary to account for why

nasalization is blocked by obstruents. That is, given that we know that the process is iterative, we must still account for why the harmony does not continue to spread [+nasal] onto the release phase of obstruents, deriving full nasals. In fact, such would have to be the explanation for the full nasalization of underlying voiced stops in the Orejón data above. Thus, while Steriade's model neatly encodes the relationship between the representation of prenasalization and captures its derivation via rightward spreading, NAS/SON is still needed to account for why iteration fails after [+nasal] docks to obstruents.

A second, related issue pertains to the assumption that both the prenasalization of obstruents and the iterative nasalization of vowels and approximants are the result of a single, iterative harmony rule. Alternatively, as Donca Steriade (p.c.) has suggested, one might argue that there are two rules: 1) an iterative harmony rule that is blocked by obstruents, and 2) a later, non-iterative rule that accounts for prenasalization. Under this approach, there would be no need to invoke NAS/SON as a constraint on triggers, since prenasalization would be the result of a separate process.

Clearly, the tacit assumption of such an approach is that two rules are, in some sense, less costly than relativizing the use of feature cooccurrence constraints. Note, however, that Archangeli and Pulleyblank (1989, in press) provide numerous examples in which feature cooccurrence constraints must hold of specific rules within a language and not of representations in general. One such example is their discussion of Lango (Archangeli and Pulleyblank in press). Lango contains a number of rules of [ATR] harmony, one of which involves the left to right spread of [-ATR]. Interestingly, this rule must be restricted to spreading [-ATR] *from* [+back] vowels only, even though the distribution of [-ATR] itself is not restricted to [+back] vowels. This is precisely how NAS/SON functions in Terena insofar as it delimits the set of possible triggers for spread.¹⁰ Given the independent motivation for trigger constraints, then, it is not clear that their use in Terena is any more costly than a multiple rule analysis.

In fact, a two rule analysis itself is not altogether straightforward. Such an analysis would actually require three rules. First, since word-initial obstruents block harmony, the rule associating [+nasal] would have to be non-iterative; i.e. it could not skip initial segments as in Orejón. Secondly, unbounded harmony would require an iterative rule that is blocked by obstruents. And finally, prenasalization would require a non-iterative rule spreading [+nasal] from a nasalized vowel to a following obstruent. The situation is, in fact, even more complicated, since we must also countenance the prenasalization of word-initial obstruents. That is, this approach would also require that floating [+nasal] persist in the derivation after failing to associate word-initial obstruents. Under my analysis, both the general pattern of harmony and the opacity of obstruents receive a maximally simple account in terms of a single rule, subject to a single constraint.

3. Line Crossing

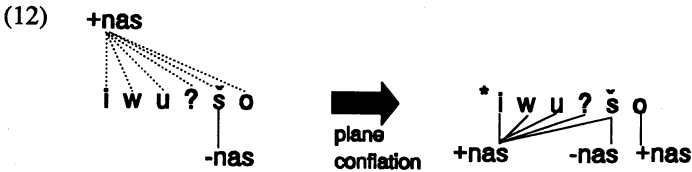
The standard treatment of opacity within autosegmental theory involves the No Crossing Constraint or NCC (Goldsmith 1976, Clements and Sezer 1982, Sagey 1986, Hammond 1988, Rice and Avery 1990, etc.). For Terena, this would require that opaque segments be specified for [-nasal], as in (11):¹¹



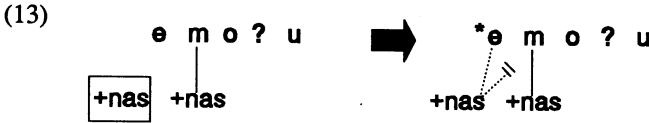
This analysis has two ostensible benefits. First, the prohibition against crossed association lines blocks [+nasal] from spreading across obstruents. Secondly, prenasalized segments are represented as [+nasal]-[-nasal] contours (Sagey 1986). I argue, however, that this use of [-nasal] turns out to be highly problematic for both contrastive and radical approaches to underspecification, and leads to unnecessary complexity in the treatment nasal consonants.¹²

First, consider the cost of a crossing constraint solution in the context of contrastive underspecification (Steriade 1987). Arguably, the feature [+/-nasal] is not contrastive for obstruents in Terena, given that there are no underlying [+nasal]/[-nasal] contrasts in this class. And even if we stipulate that [+/-nasal] is contrastive for non-continuants, it is clearly not contrastive for fricatives, which pattern with stops with respect to harmony, as in *iwu?šo* → *iwū?ʒo* 'I ride'. Yet an NCC based analysis requires the specification of non-contrastive [-nasal] for segments such as *ʒ* solely to provide a barrier for [+nasal] spread.

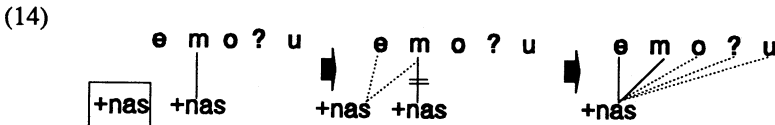
Moreover, the NCC leads to serious problems for the treatment of nasal stops, which are transparent to harmony. The paradox is that invoking the Morpheme Plane Hypothesis would mean the loss of the NCC account for the opacity of [-nasal] segments. This is shown in the derivation of the incorrect *iwu?šo* → **iwū?ʒo* 'I ride' in (12):



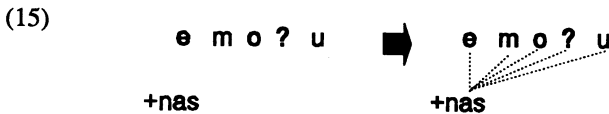
The opacity of obstruents requires that harmony follow plane conflation. But now the problem is that nasal consonants are incorrectly predicted to be opaque:



If plane conflation precedes harmony, the derivation of the correct *emo?u* → *ēmō?ū* 'my word' leads to ad hoc stipulation. In particular, the rule spreading [+nasal] must be feature changing, just in case it targets a [+nasal] (but not a [-nasal]) segment, as in (14):



One might respond by adopting a radical approach to underspecification (Kiparsky 1982, Archangeli 1984, 1988), simply underspecifying nasal consonants for [+nasal]. As Bendor-Samuel notes, nasal consonants themselves do not trigger the nasalization of adjacent vowels. One might thus argue that their transparency arises from their lack of a [+nasal] association line, and that they would only be specified for [+nasal] by a redundancy rule after harmony has applied (i.e. at the output of the phonology). A possible derivation for *ēmō?ū* 'my word' is given in (15):



Note, however, that this is a conceptually peculiar result. First, it is inconsistent with a basic premise of Radical Underspecification in that it requires the violation of the REDUNDANCY RULE ORDERING CONSTRAINT (Archangeli 1984). That is, harmony must refer to [+nasal] prior to default [+nasal] insertion. Moreover, obstruents must be specified for [-nasal], despite the fact that [+/-nasal] is non-contrastive for these sounds. And nasal consonants, the most obvious candidates for an underlying [+nasal] specification, are left unspecified for [+nasal] in order to account for their transparency to harmony.

The fundamental problem derives, I argue, from the assumption that opacity must result from the crossing of association lines. For Terena, this position forces ad hoc revisions in both contrastive and radical approaches to underspecification, running into particular difficulties in the treatment of nasal consonants.

4. Conclusions

The behavior of obstruents in nasal harmony in Terena is particularly interesting in that these segments exhibit two apparently contradictory properties. On the one hand, they are opaque; that is, they block harmony. On the other, they are targets for harmony. Attempting to analyze the data in terms of the No Crossing Constraint leads to a series of problems for the specification of underlying features, and, especially, for the treatment of the transparency of nasal stops. A far simpler analysis involves the interaction of nasalization with a single, feature cooccurrence constraint: IF [+NASAL] THEN NOT [-SONORANT]. Building on the work of Archangeli and Pulleyblank (in press), I have argued in particular that the phonologically janus nature of obstruents is a consequence of the fact that this constraint holds of triggers, but not of targets, for the [+nasal] link/spread rule in (7) above.

Importantly, this approach views opacity as a consequence of the interaction of representations and rules within phonological theory. That is, opacity is not a trivial by-product of representations themselves, but rather, a manifestation of the interplay between representations and relations.¹³ A surprising benefit of this analysis is that besides accounting for the Terena data itself, it calls attention to the similarities between what appear to be quite distinct processes of nasalization in Terena and Orejón, respectively. In particular, the different surface patterns of nasalization can be traced to the role played by feature cooccurrence constraints in the grammar of each language. In Terena, NAS/SON holds exclusively of triggers; in Orejón, NAS/VOI holds of all representations.

Notes

1. I would like to thank Diana Archangeli and Sung-Hoon Hong for much discussion in the development of the ideas presented here. Thanks also to the members of the U. of Arizona Phonology Reading Group, to whom an earlier version of this material was presented, and to Donca Steriade for helpful input regarding the structural representation of prenasalization. All errors are my own. This research was funded in part by an NSF-FAW grant #BNS9023323 to Diana Archangeli.
2. I have included /ʔ/ in the inventory. Though Bendor-Samuel does not include this sound in his chart, he treats it as a segment in his discussion of the data, and it is not clear whether or not its distribution is predictable.
3. Poser (1980) points out that there are a small number of exceptions found either in Portuguese borrowings such as *sēⁿdu* 'one hundred' or in a few native words such as *ēē* 'yes' and *mēū* 'world'.
4. Poser (1980) points out that the phonetic realization of these two sounds is unclear, given the existence of conflicting descriptions. Here, I will treat these

sounds as [-sonorant] and will not address the issue of how *h* acquires a coronal point of articulation, as this question is orthogonal to the focus of this paper.

5. This constraint might equally be stated in terms of the feature [-voice], instead of [-sonorant]. I have chosen [-sonorant] because voicing is not distinctive for obstruents, but this particular choice is not crucial to the analysis.

6. The formalization of this rule is based on the parametric rule model of Archangeli and Pulleyblank (in press).

7. This rule must also only apply in the case of 1st-person marking. Nasal consonants themselves do not induce nasalization.

8. See Mugane (1993) for a [+nasal]-[-sonorant] treatment of prenasalization in Kikuyu. Note also that I represent [-sonorant] here as an autosegment, and not as a feature of the root (cf. McCarthy 1988), for graphic clarity only. Nothing in the analysis hinges on this choice.

9. Of course, in the case of the prenasalization of fricatives, which Steriade characterizes as containing a single phase of fricated release (A_f), prenasalization must also involve the concomitant projection of A_0 , resulting in an A_0A_f structure. For Steriade, all prenasalization requires that a segment be internally complex; i.e., that it have both a closure and release phase.

10. What is particularly interesting about Terena, however, is that iterativity and NAS/SON combine to produce the fly-paper effect described above. In contrast, Archangeli and Pulleyblank's (in press) use of -ATR/BACK in Lango constrains triggers for non-iterative processes.

11. See Piggott (1989) for a particularly complex attempt to accommodate the Terena facts within an NCC based approach.

12. See also Steriade (forthcoming_{a,b,c}) for arguments for the privacy of the feature [nasal]. Clearly, if Steriade is correct, a crossing constraint solution becomes impossible.

13. See Archangeli and Pulleyblank (in press) for discussion of this issue.

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