

# CLOSURE, RELEASE, AND NASAL CONTOURS

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## 1. INTRODUCTION

### 1.1. Working Assumptions

This article studies the consequences of introducing notions like stop closure and stop release into the phonological analysis of nasality. It is part of a larger project which investigates the hypothesis that segments are represented in the phonology as positions defined in terms of degrees of oral aperture. The current working assumptions of the project are spelled out in this introductory section.

The central idea explored here is that plosives—stops and affricates—are phonologically represented as a sequence of two positions, closure and release. In contrast, continuants—vowels, approximants, and fricatives—are assumed to carry a single position in phonological representations. I refer to these units as aperture positions. As we shall see below, an aperture position is rather similar to the feature-geometric notion of root node; it has the same functions of anchoring segmental features like place of articulation, nasality, and laryngeal features, and of connecting segments to prosodic structures such as syllables and moras.

There are a number of conceivable ways of representing the closure and release phases of a stop. McCawley (1967), Kim-Renaud (1974, 1986), and Selkirk (1982), three of the rare linguists to have pointed out the phonological relevance of these notions, choose to employ a binary feature [ $\pm$ release]. The alternative adopted in this study is based on the hypothesis that the release of a stop is structurally identical to the aperture position carried by an approximant or by a frica-

tive. A stop with plain release is then a sequence of closure plus an approximant. A stop with fricated release, an affricate, is a closure followed by a fricative. The three aperture positions we arrive at in this way—closure, approximant, fricative—are defined below, following Ladefoged (1971:46). The definitions are accompanied by abbreviated designations:  $A_0$ , or zero aperture, stands for closure;  $A_{\max}$ , or maximal aperture, stands for approximant release; and  $A_f$ , or aperture-cum-friction, stands for fricative release.

- (1) Closure ( $A_0$ ): total absence of oral airflow.  
 Fricative ( $A_f$ ): degree of oral aperture sufficient to produce a turbulent airstream.  
 Approximant ( $A_{\max}$ ): maximal degree of oral aperture in consonants.

A further distinction, that between vowels and approximants, can be introduced if we follow Catford (1977:122) in distinguishing between the degree of oral stricture that does not create turbulence and the degree of oral stricture that creates turbulence only when accompanied by a wide glottis, as in voiceless consonants. Catford calls the former type *resonants*, which I broadly construe as vowels; the latter type are the approximants proper.<sup>1</sup> For the purposes of this article, however, the vowel/approximant distinction can be safely ignored.

If plosives are represented as sequences of closure plus some release, whether of the approximant or the fricated variety, we obtain the representations in (2).

- (2) Plain, released stop:  $A_0A_{\max}$   
 Affricate(d stop):  $A_0A_f$   
 Approximant:  $A_{\max}$   
 Fricative:  $A_f$

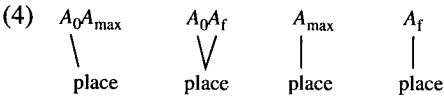
The distinction between released and unreleased stops—the phonological uses of which were first pointed out by McCawley (1967)—can now be simply represented. Unreleased stops are simple closures.

- (3) Unreleased stop:  $A_0$

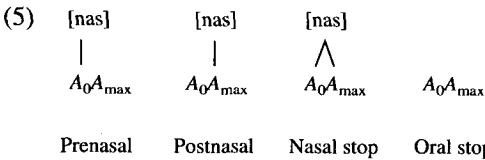
The representations introduced so far are clearly based on idealizations of the phonetic facts. One idealization is the decision to represent the release of a consonantal constriction just in case the constriction is maximal: I am in effect claiming that the phonetic release of the nonmaximal approximant or fricative constrictions is not a fact phonology pays attention to. Similarly, I ignore here the narrowing of the vocal tract forming the transition between a vowel and a consonant, an articulatory phase called *approach* by Laver (1989). Finally, I choose to represent stop releases only when accompanied by audible bursts: as Laver points out, there is a clear sense in which all stops, indeed all constrictions, are necessarily followed by a release, since the articulatory organs always somehow return to their rest position. The notion of stop release used here is the narrow sense of the

term: an audible release, audible either because accompanied by burst or because it is released with audible frication. We will see shortly why these particular idealizations are useful ones. For the moment, the reader need only note that previous phonologists who discovered uses for the closure/release distinction—McCawley, Kim-Renaud, and Selkirk—had in mind the same notion of release.

Let us turn now to the anchoring function of these aperture phases. These are the positions to which individual features or feature groups associate. It is logically necessary to assume that the place of articulation features are associated to the closure phase of a plosive, since they characterize the location of the closure and the active articulator involved in it. It is not necessary to assume that the place features are associated to the release phase unless the release involves significant stricture, as in the case of affricates. From these considerations follow the range of associations between the place component and aperture positions shown in (4).



Nonplace features, in particular nasality and the laryngeal features, can in principle associate to either phase of a plosive. Indeed, we find nasality associated to either the release (in the case of postnasalized stops) or to the closure (in the case of prenasalized ones) or to both (in the case of the unmarked nasal stops). These possibilities are depicted in (5).



Similarly, we find laryngeal features associated either to release, as in the case of postglottalized stops as in Klamath (Barker, 1964), or with the closure, as in the case of the preglottalized stops of South Barbacoan Chibcha (Moore, 1962). A third possibility, that of laryngeal features simultaneously linked to the closure and release of plosives, parallel to the pattern of nasality linked to closure and release in fully nasal stops, is also predicted. The question of possible associations between laryngeal features and aperture positions is discussed in greater detail in Keating (1990) and Steriade (1992).

A general prediction that distinguishes our proposed representation for closure and release from the featural account based on [ $\pm$  release], as well as from the standard practice of relegating such notions to the phonetics, is that, while plosives can give rise to four-way contrasts in the mode of association of nasality or laryngeal features [as seen in (5)], continuants, because they contain a single aperture position, are predicted to contrast only two ways in mode of association: a given

feature value will either associate to their unique *A* position or will fail to associate. I verify here this prediction for the feature [nasal].

Leaving stop releases aside, the representations proposed above correspond quite closely to those we can derive within a standard feature-geometric model (cf. Clements, 1985; Mohanan, 1984; Sagey, 1986) if we assume that the root node, the anchoring element corresponding to our aperture positions, is a bundle of specifications for [continuant] and [sonorant]. This equivalence is depicted below.

- (6)  $A_0$ : root<sub>[-cont]</sub>  
 $A_f$ : root<sub>[+cont, -son]</sub>  
 $A_{max}$ : root<sub>[+cont, +son]</sub>

The proposal to identify some or all stricture features as properties of the root node, rather than as autosegments linked to it, is not new. It appears in Schein and Steriade (1986) and McCarthy (1988) and reflects the view that stricture features lack autosegmental behavior: they fail to give rise to clearly identifiable partial assimilations and dissimilations. The new element in our proposal is the suggestion that released plosives carry not one but two aperture positions (i.e., root nodes) throughout the phonological derivation.

But is it not the case that the release of stops is always a nondistinctive property? Although languages may differ in the positions where they allow stops to be released, no language has a lexical contrast between released and unreleased stops. How does this fundamental observation square with our decision to give a phonological representation to the stop releases? The nondistinctive yet phonologically relevant character of plosive releases is entirely parallel to that of syllables, syllabicity, prosodic structure, and subsegmental architecture. In all these cases, a now standard assumption is that the phonology builds structures based on underlying representations consisting of bundles of features and relations of linear ordering. The issue, then, is not whether a given structure is distinctive or not but whether it is phonologically relevant: I show here that the plosive releases are.<sup>2</sup>

I distinguish, however, two types of predictable releases. First, I assume that, after projection of hierarchical segment structure (including *A* positions), all plosives project a release which, in the unmarked case, is of the approximant variety.

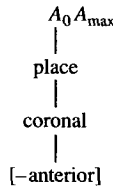
- (7) Universal projection of plosive releases:  $A_0 \rightarrow A_0 A_{max}$

I see no reason to divide phonological derivations into a before-(7) and an after-(7) stage, any more than I see a need for a derivational stage that precedes the projection of syllabic or subsegmental structure. For all intents and purposes, then, plosive releases will always be there, unless overridden by language-specific well-formedness conditions such as one prohibiting releases in the rime.

Second, I assume that the fricative release of affricates is not a distinctive property either. Rather, it represents the surface accompaniment of underlying distinctions in point of articulation, or, less frequently, in aspiration. For example,

individual languages have the option of realizing laminopalatal stops with a significantly delayed release, which results in frication noise: this is the case in English and Tamil, whose laminopalatal plosives are affricated. In contrast, Lardil realizes its corresponding noncontinuant as a plain stop. This choice between affricated and plain release is universally available to only a limited class of features and feature combinations. The differences between the representations of noncontinuant laminopalatals in English and Lardil are shown in (8).

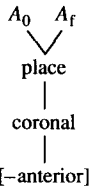
(8) After universal projection of stop releases:



Language-specific projection of  $A_f$ :

English

Lardil



n/a

Output:

English [č]

Lardil [t]

The representation of affricates in (2) is thus a special case of the general pattern of released plosives, where  $A_{\max}$  has become  $A_f$ . The discussion of Postnasal Hardening in Section 2.3 provides evidence for the assumption that the fricative releases of sounds like [č] or [pf] are predictable from their point of articulation features.

Of particular relevance to the subject of this study, nasal contour segments, is my claim that plosive releases are *projected*. This claim has a stronger and a weaker interpretation: the stronger is that plosive releases are universally absent from underlying representations, precisely because their presence can be predicted; the weaker is that they may be present underlyingly, but that projection mechanisms such as (7) will preclude the possibility of lexical contrasts based on the presence versus absence of release. Thus, even if an unreleased stop were to arise underlyingly or in derived representations in positions where releases are allowed, (7) would automatically project its release and thus prevent the contrast with released stops. In many languages (e.g., Gbeya, discussed in Section 3.3.2), oral stops contrast underlyingly with nasals and prenasals: /d/ versus /n/ versus /<sup>n</sup>d/. I claim that the difference between /n/ and /<sup>n</sup>d/ lies exclusively in the oral versus nasal quality of their releases; and this appears to commit me to the view

that the releases are necessarily present underlyingly and, hence, to the weaker interpretation outlined above. I will not attempt to further clarify this issue here, beyond noting that Herbert (1986) has made a largely successful effort to show that prenasals like /<sup>n</sup>d/ are not underlying segments: they arise mostly from nasal–consonant clusters via merger mechanisms discussed below. If Herbert is right, the Gbeya contrast between /n/ and /<sup>n</sup>d/ is underlyingly that between a segment and a cluster. On this assumption, the stronger interpretation of my claims can be maintained.

## 1.2. Outline

The major claims of this article are: released plosives are bipositional segments, and [nasal] is a privative feature. I now clarify the logical connection between these hypotheses.

One generalization that will be established is that only plosives can support nasality contours: only stops or affricates can be part nasal and part oral. This fact follows in part from the difference I postulate between noncontinuants, which have two *A* positions, and continuants, which have only one. The plosives can be partially nasal because each of their *A* positions can be separately characterized as nasal or oral.

But our explanation must contain one other ingredient: we must rule out configurations in which the single *A* position of continuants is linked to both [+nasal] and [–nasal].

(9) \*[-nasal] // [+nasal]



Why this prohibition? A possible reason is that all segmental contours are ill-formed. In support of this view, I note that the only nontonal features that give rise to the well-documented appearance of contours are nasality and continuancy; this is a suspiciously small and seemingly arbitrary set.<sup>3</sup> The continuancy contours, previously used in the analysis of affricates, can be eliminated if we adopt the analysis in (2). The representations in (5) indicate that nasality contours can also be eliminated, provided they are limited to stops. So we can probably uphold the general principle that segmental contours of any kind are disallowed.

(10) \*[αF] [-αF]



However, there is an additional reason, more intimately tied to the nature of nasality, that can also explain the ill-formed nature of (9): the fact that [nasal] is probably a privative feature. No privative feature can create contours. To see this, assume that the constraint in (10) does not hold and consider what happens when [–nasal] values are removed from the representation:

(11)		Oral segment	Nasal segment	Nasal contour segment
a. with [-nas]	[-nas]	[+nas]	[-nas] // [+nas]	
			/ \	
	A	A	A	
b. without [-nas]		[+nas]	[+nas]	
	A	A	A	

Examination of (11) reveals that nasal contours are lost in the translation from an equipollent (11a) to a privative (11b) theory of nasality. The latter can represent partially nasal segments only if they are released plosives and thus contain two *A* positions.

The combination of privative [nasal] and bipositional representations for plosives derives a number of predictions. I enumerate them in the order of which they are verified here. Section 2 examines the predicted absence of pre- (or post-) nasal continuants. It shows that attested segments characterized as prenasal fricatives must instead be analyzed as prenasal affricates: plosives with nasal closure and oral fricated release. Section 3 considers the predicted contrast in the effect nasal assimilation rules have on stops and continuants: local nasalization may affect a stop only partially, in nasalizing just its release ( $A_{max}$ ) or just its closure ( $A_0$ ), but must affect a continuant in its entirety. Section 4 verifies the prediction that plosives can support nasality contours only when they are released: unreleased stops contain only an  $A_0$  which must be either fully oral or fully nasal. I will not argue directly here for the elimination of [-nasal] as a phonological object. But my analyses will show that a large number of phenomena can be adequately treated by relying on a single-valued feature [nasal]. I defer a complete treatment of the privative status of [nasal] to a future study.<sup>4</sup>

## 2. SEGMENT INVENTORIES AND NASAL CONTOURS

### 2.1. Prenasal Fricatives

It is generally known that the segments most commonly displaying nasal contours are the stops. The following statement, from a first version of Anderson's (1976) study of partially nasal segments, is representative:

Nasal contours are usually found only on segments that are non-continuants (stops, affricates, flaps). . . . Vowels, for example, can be distinctively nasal or non-nasal, but apparently nasality contours do not occur on vowels (except perhaps as a mechanical effect): phonologically vowels are always homogeneously nasal or non-nasal. (Anderson, 1975:23)

Anderson does not say that only plosives can display nasal contours: only that the contours are normally found on plosives. Herbert (1986:33), Ladefoged and Maddieson (1986), as well as Maddieson and Ladefoged (this volume) take the

same line in describing partially nasal segments: they acknowledge the existence of prenasalized fricatives while at the same time noting that the prenasal stops are the norm.

### 2.1.1. INVENTORY

Let us first inventory the sounds described as prenasal continuants and consider how widespread they are. According to Rosenthal (1989), only strident fricatives can be prenasalized. Rosenthal seems unaware of the prenasal trills and nonstrident fricatives described by Maddieson and Ladefoged (this volume) and mentioned in Herbert (1986), but the thrust of his generalization is surely correct: the vast majority of prenasal continuants are strident. Listed in (12) are the relevant sounds, with their common orthographic representation, the closest oral consonant in the language, and some relevant references.

(12) Prenasal strident fricatives:

Sound	Closest oral C in the language	Language	Source
<i>nz</i>	<i>ts</i>	Paez	Maddieson (1984)
		Punu	Mikala (1980)
	<i>s</i>	Wantoat	Maddieson (1984)
		Rundi, Ganda, Zande	Herbert (1986)
		Hungu, Nyanja, Lega	Herbert (1986)
		Ngbaka	Thomas (1963)
		Mbum	Hagège (1970)
Rwanda	Coupez (1980)		
<i>ns</i>	<i>s, ts</i>	Rundi, Ganda	Herbert (1986)
		Bamileke, Lega	Herbert (1986)
	<i>ts</i>	Rwanda	Coupez (1980)
<i>nš</i>	<i>š, tš</i>	Rundi	Herbert (1986)
		Rwanda	Coupez (1980)
<i>nž</i>	<i>ž</i>	Rundi	Herbert (1986)
		Rwanda	Coupez (1980)
<i>mv</i>	<i>v</i>	Rundi, Ganda, Zande, Hungu	Herbert (1986)
		Rwanda	Coupez (1980)
	<i>b</i> (labiodental stop)	Mbum	Hagège (1970)
<i>mf</i>	<i>pf</i>	Rwanda	Coupez (1980)
	<i>f</i>	Rundi, Ganda, Bamileke Punu	Herbert (1986) Mikala (1980)



The attested nonstrident prenasal continuants appear to be limited to the sounds listed in (13).

(13) Prenasal nonstrident continuants:

Sound	Closest oral C in the language	Language	Source
<i>nθ</i>	<i>θ</i>	Amahuaca	Osborn (1948)
<i>nr</i>	<i>dr</i>	Fijian	Maddieson (1990)
	<i>r</i>	Malagasy	Herbert (1986)

The prenasal bilabial trills discussed by Maddieson and Ladefoged (this volume) are not included, because they appear to be allophonic variants of prenasal stops and because Maddieson and Ladefoged's discussion leaves no doubt as to the plosive nature of their articulation.

### 2.1.2. GENERALIZATIONS

A theory of nasal contours must provide phonological representations for all the sounds listed above, no matter how infrequent they may be. But it must equally account for the generalizations these sounds fall under. The first of these concerns the basic markedness difference between prenasal plosives and continuants. An indication of this is the fact that among the 17 languages of Maddieson's (1984) survey which possess prenasal segments, only 2 [Paez and Wantoat, listed in (12)] have prenasal continuants. Our theory must address this difference.

(14) Prenasal continuants are significantly less frequent than prenasal plosives.

The second generalization is a weakened version of Rosenthal's generalization: the impressive markedness difference between prenasal strident and nonstrident continuants.

(15) Prenasal strident continuants are significantly more frequent than prenasal nonstrident ones.

It is worth noting that (15) cannot be explained by appeal to the fact that strident fricatives are more frequent than nonstrident ones. We are asking not only why /ns/ is more frequent than /nθ/, but also why /ns/ is vastly more frequent than /nr/. There is no clear markedness difference between /s/ and /r/ that could explain this observation.

In languages that oppose fricatives to homorganic affricates, there is frequent (perhaps invariable) neutralization of the contrast between prenasal affricates and prenasal fricatives. Thus Kinyarwanda (Kimenyi, 1979) contrasts /ts/ with /s/ and /pf/ with /f/, but merges the two classes of obstruents, when they become prenasal, as /nts/ and /mpf/ respectively. In related Rwanda (Coupez, 1980), the neutraliza-

tion goes in the opposite direction: /ts/ and /s/ are both prenasalized as /ns/, while /pf/ and /f/ are prenasalized as /mf/. My survey of the available data has not produced any clear instances of either underlying or derived contrast between prenasal affricates and fricatives. This fact too deserves explanation.

- (16) The contrast between prenasal affricates and fricatives is always neutralized.

Next, we need to ask why prenasal vocoids are not only infrequent but in fact unattested as phonological entities, a point raised earlier by Anderson (1975).

- (17) Prenasal contours are impossible on vowels.

Finally, we note that the less widely attested postnasal contours are only found on stops. There are relatively few instances of postnasal segments, and this makes it more difficult to determine the numerical significance of any gap. But in at least one case (Zing Mumuye, discussed in Section 2.4.1), one and the same language contrasts postnasal plosives with fully nasal continuants. This contrast, and the complete absence of postnasal continuants, must be explained.

- (18) Postnasal contours are possible only on plosives.

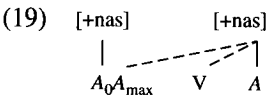
### 2.1.3. PHONETIC REALIZATIONS

*2.1.3.1. Prenasal Fricatives as Prenasal Affricates.* A single observation is at the core of most of the generalizations made above. The attested prenasal fricatives and rhotics are not realized as half-nasal, half-oral continuants. Rather, in the vast majority of cases, the initial phase of these sounds is accompanied by complete oral closure; these are then prenasalized plosives with fricated release, not prenasalized continuants.

Thus Chawner (1938) describes the prenasal /ns/ and /nš/ of Thonga as equivalent to the English clusters /ns/ (of *answer*) and /nš/ (of *handshake*, with *d* omitted), which involve a nasal stop followed by a spirant, not a partially nasal spirant. Hagège (1970) characterizes the prenasal consonants /nz/ and /mv/ of Mbum (Nganha dialect) as “occlusives”, a term he consistently reserves for plosives. Piper (1977:65) describes the surface prenasal phones /mv/ and /nz/ of Suku as noncontinuants, along with the stops and affricates of the language: Piper’s noncontinuants are all and only the sounds involving a period of complete oral closure. This classification is meant as a comment on the phonetic realization of these sounds as it is part of Piper’s “systematisch-phonetisches Inventar” of Suku. On the prenasal /nr/ of Fijian, one can now consult Maddieson’s (1990) careful study, which makes it clear that this is a prenasal stop with oral rhotic release rather than a half-nasal, half-oral /r/. This point is underscored by Maddieson’s use of the trigraph [nr] instead of the ambiguous [nr].

2.1.3.2. *Prenasal Continuants as Fully Nasal.* In a few cases, the sounds transcribed as prenasal continuants are continuants indeed; in these cases, however, the segment is nasalized throughout. Thus the Zande digraphs ⟨nz⟩ and ⟨nv⟩ represent, according to Tucker (1959:35, translated), the fully nasal continuants [ž] and [ṽ] whose nasality spills over into the following vowels: “The nasal character [of ⟨nz⟩, ⟨nv⟩] is very light and is often expressed only as nasalization of the following consonant. This is the case particularly between vowels, which are also nasalized: ⟨unvuru⟩ ‘elder brother’ [ũvũru], ⟨binza⟩ ‘doctor’ [bĩžā].” Note that only a fully nasal segment could have the effect of nasalizing a following vowel.

The overall system of nasal consonants in Zande contains the prenasal plosives /mb/, /nd/ (which has alveopalatal affricated allophones before front vowels), /ŋg/, and /ŋgb/, and the fully nasal continuants /w̃/, /r̃/, /nz/ (= [ž]), and /nv/ (= [ṽ]). The distribution of partial and full nasality in Zande illustrates well my claim that only plosives can be partially nasalized: corresponding to the partially nasal stops and affricates, we get fully nasal continuants. A specific argument establishing the fact that the digraphs ⟨nz⟩ and ⟨nv⟩ stand for fully nasal sounds, both phonetically and phonologically, is provided by Tucker’s observations about Ganda Law effects in Zande. Ganda Law is a nasal assimilation process whereby an underlying sequence NC V N (a prenasal consonant followed by vowel followed by a nasal or prenasal segment) becomes N Ṽ N: for example, /nda-ndai/ becomes [nāndai]. In terms of my theory of A positions and segmental representation, the underlying prenasal is realized as fully nasal because its release has acquired the nasality of the following vowel. Without attempting to carefully formalize Ganda Law, I can diagram its global effect:



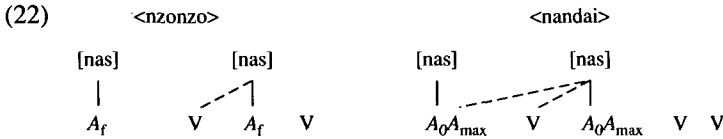
Examples of Ganda Law in Zande appear in (20) (from Tucker, 1959: 36). The process is optional in this language: I provide only the variants where Ganda Law has applied.

- |   |   |
|---|---|
| (20) <i>mbedā</i> ‘to approach’<br><i>ndaā</i> ‘be elastic’ | <i>mēmbedi</i> ‘close’<br><i>nāndai</i> ‘elastic’ |
|---|---|

Tucker observes that the sounds written ⟨nz⟩, ⟨nv⟩ condition Ganda Law—as shown by forms like [ŋženze] ‘nail’ from /N-genze/—but do not appear to undergo it. There are, for instance, no ⟨nz⟩ ~ ⟨n⟩ alternations in the environment of a following nasal. If ⟨nz⟩ represented a partially nasal fricative, we would expect a different, fully nasal, segment in the output of Ganda Law.

- |  |   |                   |
|--|---|-------------------|
| (21) <i>nzonzo</i> ‘well developed’<br><i>nzunzu</i> ‘correctly’ | <i>nvuṛu</i> ‘antelope’<br><i>nvunvu</i> ‘dusk’ | (Tucker, 1959:35) |
|--|---|-------------------|

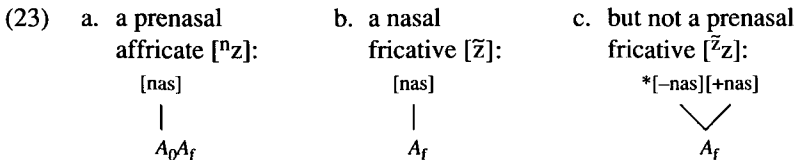
The reason is clear: unlike the prenasal stops, ⟨nz⟩ and ⟨nv⟩ have no oral phase at all. They could be assumed to undergo Ganda Law, but only vacuously, since they are completely nasal in its input. A comparison between ⟨nzonzo⟩ and ⟨nandai⟩ (from /nda-ndai/) illustrates this.



A similar example of apparent prenasalization in a continuant is provided by the ⟨nr⟩ of Mbay (Caprile, 1968:30), a digraph for a completely nasal rhotic. Mbay has a series of prenasal plosives (/mb/, /nd/, /nj/, /ng/) and a series of fully nasal approximants (/ɽ̃/, /w̃/). Although Caprile does not make this point, it appears from his discussion that ⟨nr⟩ belongs to the latter class, that of nasal approximants, since it is realized as  $\tilde{V}\tilde{r}^2$ . Once again, we note that the reduced vowel following ⟨nr⟩ is nasalized; this can only be understood if  $\tilde{r}$  is phonologically fully nasal.<sup>5</sup>

My claim, then, is that digraphs like ⟨mv⟩, ⟨nz⟩, ⟨nr⟩ represent either prenasal affricates (nasal closure plus oral fricated release) or nasalized continuants (a release linked to [nasal]).<sup>6</sup> What they do not represent is a single aperture position containing two values for nasality: ⟨nz⟩ does not represent [ $\tilde{z}$ z].

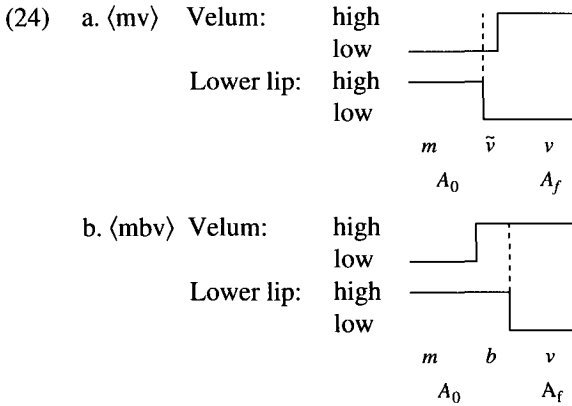
What ⟨nz⟩ digraphs may and may not represent:



For the remainder of this section, I discuss variations and differences in the phonetic implementation of the prenasal affricates transcribed as ⟨nz⟩, ⟨mv⟩.

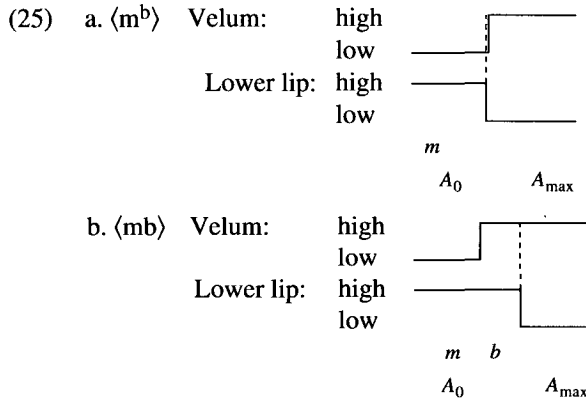
*2.1.3.3. Two Phonetic Types of Prenasal Plosives.* We must now consider the nature of the difference between prenasal sounds transcribed as ⟨mv⟩, ⟨nz⟩ and those transcribed as ⟨mbv⟩, ⟨ndz⟩. I claim that both transcriptions reflect the same phonological reality, the prenasal affricate (23a). How do they differ, then? The answer is that, although they are the same phonologically, they do differ phonetically in terms of the timing of the velum raising relative to the oral release.

The timing characteristics I attribute to the two sounds are diagrammed schematically in (24).



I assume that in the sounds described as prenasal fricatives, the velum raises simultaneously with or after the oral release. The former would yield [mv], the latter—depicted in (24a)—[m̃v]. In the sounds described as prenasal affricates, I assume that the velum raises slightly before the release of the oral constriction, yielding [mbv] (21b).

This analysis of the affricates predicts that these kinds of nonphonemic timing differences between oral release and velum raising should also be available to prenasal stops. I represent them in (25).



Maddieson and Ladefoged (this volume) demonstrate that both timing possibilities are indeed instantiated on stops. The majority of prenasal stops are realized with velum raising preceding the oral release and thus correspond to the [mb] diagrammed in (25b). But there exist also sounds—the Chinese poststopped nasals described by Chan (1987) and a subset of the Acehnese nasal stops (Durie, 1985)—in which nasality covers the entire period of oral closure. Maddieson and

Ladefoged propose an analysis of these consonants that corresponds precisely to the [m<sup>b</sup>] diagrammed in (25a): “It is reasonable to infer . . . that there is a very precise synchronization of the raising of the velum and opening of the oral closure, so that airflow is shunted almost instantaneously from a nasal escape to an oral one, without the overlapping of nasal and oral closures that occurs in a prenasalized stop.”

As with the prenasal affricates, the prenasal [mb] and [m<sup>b</sup>] are never in phonological contrast. This result is insured by the representations we give these sounds. Though phonetically distinct, both types of stop have the same phonological representation: nasal closures followed by oral releases, as in (5a). A phonological distinction between [mb] and [m<sup>b</sup>], were it to exist, could not be represented in the theory I propose. The same holds for the lack of contrast between [mv] and [mbv] noted earlier: both of these are represented as nasal closure followed by oral fricated release and thus cannot be phonologically differentiated.

I have argued that the phonetic distinction between [mv] and [mbv] is a slight timing difference independently observed in the articulation of other prenasal plosives. This strengthens my claim that [mv] and [mbv] represent a single phonological structure. For the remainder of the article I refer to the [mbv]-type affricate as an affricate with partially nasalized closure and to the [mv]-type sound as an affricate with fully nasalized closure.

## 2.2. No Contrast between Prenasal Affricates and Fricatives

I noted in (16) that prenasal fricatives and affricates do not contrast. The immediately preceding discussion makes it clear that “prenasal fricatives” is a misnomer used for affricates with full nasal closure. The reasons the two types cannot contrast have been laid out above. We must consider now more carefully the facts behind the generalization.

A number of languages have been surveyed which possess prenasal segments as well as contrasts between affricates and fricatives. These languages, randomly selected, fall into four categories: (1) languages in which affricates and fricatives preceded by a nasal are realized as affricates with partly nasalized closure (henceforth NTS), (2) languages in which the two classes are realized as affricates with fully nasalized closure (henceforth NS), (3) languages in which prenasal affricates with full and partial nasal closure are in free variation. A number of languages appear to display another possibility: (4) surface contrasts of the form /mf/:/mpf/, /ns/:/nts/. In all clearly documented cases of this kind, such contrasts turn out not to involve minimal pairs, because the sequences in question also differ systematically in the moraic status of the nasal: either N in the NS sequences is moraic whereas N in NTS is not, or the other way around. A careful examination of these four types of case suggests that none of the languages for which we have relevant data display a genuine opposition between the two prenasal types NS and NTS.

I now illustrate each of the possibilities outlined above with data from one language.

2.2.1. VENDA

A language where both N-affricate and N-fricative sequences are realized as NTS (prenasalized affricates with partially nasalized closure) is Venda (Ziervogel, Wentzel, & Makuya, 1972:27–28 and passim).

(26)	Affricates				
	<i>bv</i>	<i>bvuma</i>	'roar'	<i>N-bvuma</i> → <i>mbvumo</i>	'roaring'
	<i>ts</i>	<i>tsumbula</i>	'roll in dust'	<i>N-tsumbulo</i> → <i>ntsumbulo</i> → <i>tsumbulo</i>	'rolling'
	<i>pf</i>	( <i>zwi</i> )- <i>pfene</i>	'baboons'	<i>N-pfene</i> → <i>mpfene</i> → <i>pfene</i>	'baboon'
	<i>tš</i>	( <i>zwi</i> )- <i>tšila</i>	'tails'	<i>N-tšila</i> → <i>ntšila</i> → <i>tšila</i>	'tail'
	Fricatives				
	<i>v</i>	<i>vuledza</i>	'finish'	<i>N-vuledzo</i> → <i>mbvuledzo</i>	'finishing'
	<i>z</i>	<i>ziamedza</i>	'put heavy thing onto some- thing'	<i>N-ziamedzo</i> → <i>ndziamedzo</i>	'placing onto'
	<i>zw</i>	<i>zwima</i>	'hunt'	<i>N-zwimo</i> → <i>ndzwimo</i>	'hunting'
	<i>ž</i>	<i>žuβula</i>	'snatch'	<i>N-žuβulo</i> → <i>ndžuβulo</i>	'snatching'
	<i>s</i>	<i>senga</i>	'hear a case'	<i>N-sengo</i> → <i>ntsengo</i> → <i>tsengo</i>	'court- hearing'
	<i>š</i>	<i>šengela</i>	'suffer'	<i>N-šengelo</i> → <i>ntšengelo</i> → <i>tšengelo</i>	'suffering'
	<i>f</i>	<i>fula</i>	'graze'	<i>N-fulo</i> → <i>mpfulo</i> → <i>pfulo</i>	'pasture'
	<i>x</i>	<i>xisa</i>	'beat at game'	<i>N-xiso</i> → <i>nkiso</i> → <i>khiso</i>	'beating'

The examples above show that after the formation of affricates, the nasality of all voiceless consonants is lost in most contexts. But, in at least one grammatical context, after the first person object concord *N*-prefix, the nasality of voiceless prenasal segments is not lost. In this case, the intermediate forms postulated above (*nts*, *ntš*, *mpf*) surface as such (Ziervogel et al., 1972:51).

(27)	<i>f</i>	<i>farisa</i>	'help'	<i>o N-farisa</i> → <i>o</i>	'he helped me'
				<i>mpfarisa</i>	
	<i>s</i>	<i>sea</i>	'laugh'	<i>u a N-sea</i> → <i>u a</i>	'he laughed at me'
				<i>ntsea</i>	

š	šušedza	'frighten'	yo N-šušedza → yo ntšušedza	'it frightend me'
sw	swuswela	'chase for'	o N-swuswela → o ntswuswela	'he chased some- thing for me'

A large number of the languages surveyed and analyzed by Herbert (1986) follow the pattern described here for Venda: underlying nasal–fricative and nasal–affricate sequences are realized identically as prenasal affricates with partial nasal closure. We mention a few additional examples: Kinyarwanda (Kimenyi, 1979), Bamileke-Ghomala (Nissim, 1981), Lame (Sachnne, 1982), Yaka (van der Eynde, 1968), Lua (Boyeldieu, 1985).<sup>7</sup>

### 2.2.2. RWANDA

A language where N–affricate and N–fricative sequences are realized as affricates with complete nasal closure transcribed as ⟨mf⟩, ⟨ns⟩, ⟨nsh⟩ (for [nš]) is Rwanda (Coupez, 1980). Because moraic and nonmoraic nasals behave identically in Rwanda when forming prenasal clusters, I include in my examples forms of both types.

(28)			Affricates		
	ts	tsirim-	'rub'	n-tsirim-a → nsirima	'I rub'
	tš	tšakir-	'grasp'	n-tšakir-a → nšakira	'I grasp'
	pf	aga-pfizi	'little ox'	i-ny-pfizi → imfizi	'ox'
					(Coupez, 1980: 124)
			Fricatives		
	s	ba-sogot-a	'they could pierce'	ni-n-sogot-a → ninsogota	'if pierce'
		sengo	'master of ceremo- nies'	i-N-sengo → insengo	'royal insignia'
	z	-zu	'house'	ny-zu → nzu	'house'
	f	fate	'prisoner'	i-N-fate → imfate	'prisoners'
		imi-funzo	'papyrus'	i-N-funzo → imfuzo	'papyrus field'
	u	k u-vug utya	'as you say so'	ko N-vuga N-tyo → ko mvuga ntyoo	'as I say so'
					(Coupez 1980: 134–161, passim)

According to Coupez (1980: 124), most Rwanda speakers realize underlying



/ky/, /gy/ sequences as the affricates [ts], [dz]. When prenasalized, these sequences are also realized as [ns], [nz].

- (29) /hek-ye/ → *hetse* 'carry on the back-perfective'  
 /onk-ye/ → *ontse* → *onse* 'suck-perfective'  
 /ang-ye/ → *andze* → *anze* 'refuse-perfective'
- (Coupez, 1980:131)

A minority of Rwanda speakers realize /ky/ as /tšy/ instead of /ts/. But the prenasal counterpart of this /tšy/ is also subject to the same realization as the other prenasal affricates of Rwanda and surfaces as [nšy].

- (30) /-kyah-/ → *tšyah* 'blame'  
 /N-kyah-a/ → *ntšaha* → *nšyaha* 'I blame' (Coupez, 1980:29, 124)

We observe that, whatever their derivational origin, all the prenasal affricates of Rwanda are realized identically: as prenasal affricates with full nasal closure. Here too the contrast between NS and NTS is neutralized.

Languages with patterns of prenasal affricate realization similar to those of Rwanda are: Punu (Mikala, 1980), whose paradigm seems identical in all relevant respects to that of Rwanda; Mbum (Hagège, 1970); Lamba (Doke, 1938); Paez (Maddieson, 1984); and Suku (Piper, 1977).

### 2.2.3. NGAMBAY AND NTOMBA

A third category of languages involves those in which NS and NTS structures are realized in free variation. These include Ngambay (Vandame, 1961) and Ntomba (Mamet, 1955). Both languages possess prenasal affricates—Ngambay /nž/ and Ntomba /nz, nž/—with realizations ranging from full to partial nasal closure. On the /nž/ of Ngambay, Vandame writes (1961:11, author's translation): "/nž/ is pronounced [nž] or [ndž] in free variation." For his part, Mamet refrains from declaring the Ntomba /nz/ and /ndz/ as free variants, but the following statement makes it clear that he was not able to establish a contrast between the two (1955:9, author's translation): "/ž/ and /z/ being, in the native Ntomba-words, always preceded by a nasal, there is also a tendency to pronounce ndž and ndz for nž and nz. We give /nž/ and /nz/ according to what appeared to us to be the closer transcription." The lexicon of Ntomba provided by Mamet contains items recorded in both variants such as /nzombi/ ~ /ndzombi/ 'ability to become invisible'.

The Ntomba and Ngambay prenasal affricates aptly illustrate the point that determining the exact timing of the oral release relative to velum raising is a matter of phonetic realization rather than phonological structure. While some languages may consistently dictate a particular timing relation between the two gestures, others—like Ntomba and Ngambay—may leave the choice between timing possibilities up to the individual speaker. The absence of a strict norm gives rise to the variation observed.

## 2.2.4. SPURIOUS NS/NTS CONTRAST

A number of languages, some of them already mentioned, appear to involve surface contrasts between “prenasal fricatives” NS and prenasal affricates NTS. In most cases, it is possible to show that the contrast is spurious. In a few others, the decisive information is lacking.

Yaka realizes N-fricative sequences as affricates with partial nasal closure NTS but, as van der Eynde (1968:8) notes, this realization rule applies only when the sequence in question does not involve a syllabic nasal: when the nasal is syllabic, the cluster is realized with full nasal closure (NS). (Van der Eynde’s examples are limited to /N-s/ sequences, although the generalization is apparently meant to hold of all clusters containing a syllabic nasal.) There is also an additional difference between the syllabic and nonsyllabic nasal closures: the nonsyllabic nasals are lost when the closure is voiceless, whereas the syllabic nasals are preserved in this case.

- (31) a. Nonsyllabic nasal: class 9 and 10 prefix *N-*
- |          |                       |            |                              |            |
|----------|-----------------------|------------|------------------------------|------------|
| <i>v</i> | <i>(ku-)vuundzuka</i> | ‘be dirty’ | <i>N-vuundzi</i> →           | ‘dirty     |
|          |                       |            | <i>mbvuundzi</i>             | water’     |
| <i>f</i> | <i>fuundzi</i>        | ‘wind’     | <i>N-fuundzi</i> →           | ‘wind’     |
|          |                       |            | <i>mpfundzi</i> →            |            |
|          |                       |            | <i>pfundzi</i>               |            |
| <i>z</i> | <i>(lu-)zala</i>      | ‘nail’     | <i>N-zala</i> →              | ‘nails’    |
|          |                       |            | <i>ndzala</i>                |            |
| <i>s</i> | <i>(lu-)sala</i>      | ‘feather’  | <i>N-sala</i> →              | ‘feathers’ |
|          |                       |            | <i>ntsala</i> → <i>tsala</i> |            |
- b. syllabic nasal: class 1 prefix *N-*
- |          |                  |                |                  |          |
|----------|------------------|----------------|------------------|----------|
| <i>s</i> | <i>-singa</i>    | ‘thread, rope’ | <i>N-singa</i> → | ‘thread’ |
|          |                  |                | <i>nsinga</i>    |          |
|          | <i>(ku-)sala</i> | ‘work’         | <i>N-sadi</i> →  | ‘worker’ |
|          |                  |                | <i>nsadi</i>     |          |

The phonological representations of intermediate /ns/ and /nts/ (→ [ts]) differ exclusively in the moraic or nonmoraic status of the closure.

- (32) a. a prenasal affricate with moraic closure:
- $$\begin{array}{c}
 [\text{nas}] \\
 | \\
 A_0 A_f \\
 \wedge \\
 \mu \quad \sigma
 \end{array}$$
- b. prenasal affricates with nonmoraic closure:
- $$\begin{array}{c}
 [\text{nas}] \\
 | \\
 A_0 A_f \\
 \vee \\
 \sigma
 \end{array}$$

A case similar to that of Yaka is encountered in Kinyarwanda (Kimenyi, 1979: 38). In Kimenyi's terms, in nonverbs a rule deletes the stop portion of a voiceless affricate when a nasal precedes.

- (33) *in-pfura* → *imfura* 'noble'  
*in-tsina* → *insina* 'banana tree'  
*in-tšuro* → *inšuro* 'time'

Before verb stems the rule fails to apply, and this failure yields apparent contrasts between [mpf] and [mf], [nts] and [ns].

- (34) *a-ra-n-pfiira* → *araampfiira* 'he is dying for me'  
*ku-n-tseemb-a* → *kuuntseemba* 'to destroy me'  
*mu-ra-n-tšurika* → *muraantšurika* 'you are putting me upside down'

But there is a telling difference between the two cases: the [mf], [ns], [nš] sequences are never preceded by long vowels, whereas the [mpf], [nts], [ntš] invariably are. Kinyarwanda is one of the Bantu languages in which the creation of prenasal consonants is always accompanied by compensatory lengthening (cf. Clements's (1986) study of the parallel process in Luganda): from the fact that surface NS sequences fail to trigger compensatory lengthening, we deduce that the nasal preserves its mora in these cases. We can maintain then that the phonological contrast between sequences like [mf] and [mpf] in Kinyarwanda hinges on the moraic status of the nasal closure: the nominal *iN-* prefix differs from the verbal *N-* in containing an invariably moraic nasal. The contrast between full and partial nasal closure—[mf] versus [mpf]—is secondary and can be derived from the difference in moraic structure in (32). It need not receive a phonological representation as such.

Finally, Rundi (Meeussen, 1959) also appears to display a contrast between NTS and NS prenasals. Its exact nature remains unclear to me at present. Like Rwanda, Rundi generates an affricate [ts] from underlying /ky/ sequences; like in Rwanda, this [ts] is realized as [ns] when prenasal.

- (35) *gu-shik-ya* → *gushitsa* 'to arrive-causative'  
*u-mu-shik-yi* → *umushitsi* 'he who arrives, visitor'  
*aank-ye* → *aantse* → *aanse* 'he hates'  
*aank-yi* → *aantsi* → *aansi* 'he who hates, enemy'

(Meeussen, 1959: 39–40)

This phenomenon would appear to indicate that the prenasal affricates of Rundi are always realized with full nasal closure. Meeussen's data, however, contains numerous transcripts like [nts], [mpf], [ntš] in addition to [ns], [mf], [nš]. It has been impossible to determine, based on Meeussen's grammar, whether the NTS/

NS contrast correlates, as in Yaka, with a contrast in the moraic character of the nasal, or whether other differences are involved.<sup>8</sup> I leave this problem unresolved.

We have observed in this section that the languages in which a contrast between NS and NTS segments is a priori possible, indeed expected, fail to display it. None of the languages surveyed present clear evidence of such a contrast. On the contrary, the clearly documented pattern is that of neutralization between underlying N–fricative and N–affricate sequences. The directions of neutralization are precisely those predicted by the discussion in Section 2.1.3.3. Neutralization between NS and NTS is the expected outcome if we assume that surface phones like [mf] and [mpf] represent the same phonological reality: a prenasal affricate.

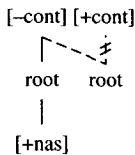
### 2.3. Postnasal Hardening

This section provides a more direct argument that NS segments—affricates with fully nasal closure—are affricates rather than fricatives. We show here that in many Bantu languages the NS segments must be assumed to have undergone a process which turns continuants into plosives when they follow a nasal. If segments transcribed as ⟨ns⟩ are the output of a general stopping rule, it follows that they cannot be represented as in (23c) and that their proper phonological representation is [ʰs] rather than [ʰs̥].

Herbert (1986: 237) discusses the realization of /NS/ sequences as [NTS] under the rubric of postnasal hardening (PNH). According to Herbert, PNH encompasses the realization of /Nv/ as [mbv],<sup>9</sup> of /Nβ/ as [mb], /NI/ as [nd], /Nɣ/ as [ŋg]/, /Ny/ as [nɟ]. I claim that PNH is also involved in the derivation of consonants like [mv], [mf], [nz], [ns], since these are also affricates. Although the exact mechanism involved in PNH is not directly related to the argument of this article, an analysis of this phenomenon is suggested below. My main concern in this section is simply to establish that in languages that have a PNH process, the “prenasal fricatives” like [mv] have also undergone it and have become affricates. Although I maintain Herbert’s terminology, my claim is that PNH does not involve an unspecified increase in oral stricture but rather the invariable transformation of a continuant into a stop: postnasal stopping would be a more appropriate term.

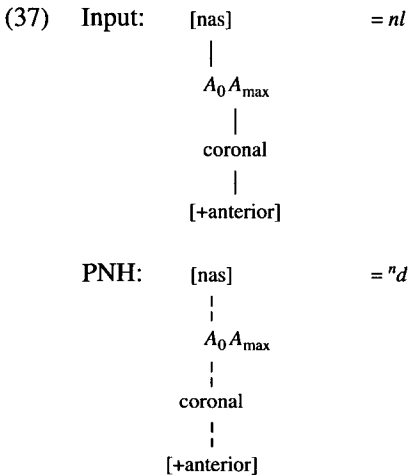
I will not consider here a traditional formulation of PNH, such as the spreading of [–continuant] from the nasal onto a following segment.

#### (36) Postnasal Hardening?



A rule like (36) will fail to explain any of the recurrent characteristics of PNH. The relevant questions are the following. (1) Why is it that only nasal stops spread their [-cont] values and not also oral stops ( $mw \rightarrow mb$  but not  $*tw \rightarrow tb$ )? (2) Why do nasal continuants fail to spread their [+cont] values (why not  $*b\bar{a} \rightarrow \beta\bar{a}$ )? (3) Why is it that spreading goes left to right and never right to left ( $mv \rightarrow mbv$  but  $vn \not\rightarrow *vbm$ )? (4) Why is continuancy spreading always accompanied by place assimilation ( $nv \rightarrow mbv$  but not  $*nv \rightarrow nbv$ )? I believe that these questions will ultimately be answered if we view PNH not as the propagation of [-cont] values but as the merger of two segments into one.

Given the representations proposed here, PNH can be viewed as originating in the encounter of two distinct segments: an unreleased nasal stop and a following continuant. I assume that, in the absence of release, the point of articulation features of the nasal are lost; the input sequence to PNH, then, will contain, a nasal closure lacking a place component. In languages which disallow clusters of distinct consonants, such a sequence can easily be turned into a single consonant by transferring the place of articulation features of the continuant onto the preceding nasal closure. The result is structurally identical to a single underlying stop. In the case of an underlying /N-*l*/ sequence, the transfer of features would take place as shown in (37).



I assume that the laterality of /*l*/ is either phonologically irrelevant (i.e., unspecified) or else eliminated after transfer in order to insure a structure-preserving output.

In eliminating underlying clusters like /*Nl*/, there is an alternative to PNH: that of transferring the nasality of the first consonant to the *A* position of the second. This would result in a fully nasal continuant of the type discussed earlier in con-

nection with Zande [ṽ] and Mbay [ř̄]. The closure position, once vacated of all features, will be eliminated.

(38) [nas] Transfer: /nr/ → [ṽ]

Input sequence: [nas]  
 |  
 A<sub>0</sub>A<sub>max</sub>  
 |  
 coronal  
 |  
 [-anterior]

[nas] transfer: [nas]  
 |  
 A<sub>0</sub>A<sub>max</sub>  
 |  
 coronal  
 |  
 [-anterior]

Surface: [nas]  
 |  
 A<sub>max</sub>  
 |  
 coronal  
 |  
 [-anterior]

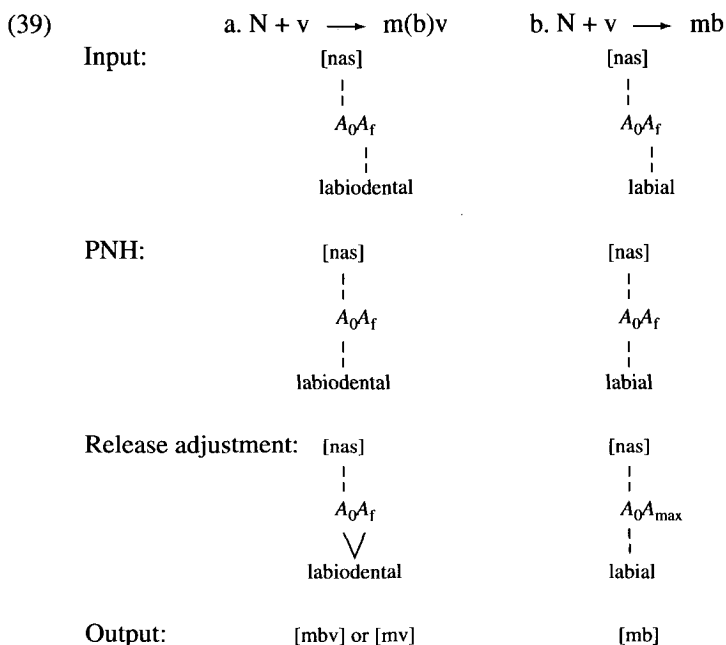
The fact that PNH appears to be more frequent than [nasal] transfer, in particular in the case of fricatives and liquids, can be explained by reference to the articulatory and perceptual difficulties raised by nasalized fricatives and liquids. On this point, see Ohala (1975: 300) and Poser (1981).

The application of PNH [i.e., the process illustrated in (37)] to a nasal–fricative cluster can yield either a prenasal stop or a prenasal affricate. Thus the Bantu languages Kamba, Ndonga, and Kwanyama (Herbert (1986: 157, 185) turn /N–v/ sequences into [mb]. Other Bantu languages (Lega, Ganda, Rundi) turn /N–v/ and /N–f/ into the prenasal affricates [mv] and [mf]. Others still (Kinyarwanda, Bamileke-Ghomala, Venda) realize /N–v/ as [mbv] and /N–f/ as [mpf], the prenasal affricates with partially nasal closure.<sup>10</sup>

The option between [mb] and [m(b)v] as the outcome of /m–v/ undergoing PNH reflects the choice of analyzing the input /v/ somewhat abstractly as a labial fricative (equivalent to [β]) or, more concretely, as a labiodental one. PNH applied

to a labiodental fricative will yield a labiodental plosive (always realized with fricated release as the affricate [bv]). PNH applied to the labial fricative will yield the unmarked labial stop, the bilabial [b].

Derivations of the two PNH options discussed are shown below. After PNH transfers the features of  $A_f$  onto the preceding closure, the resulting stop has its release adjusted: if it is a bilabial stop, its release must be  $A_{max}$ , since bilabials are plain rather than affricated stops. If it is a labiodental, its release must be an  $A_f$  position, linked to the place component. These adjustments in the output structures resulting from PNH are consistent with the hypothesis that the relation between the point of articulation features of a stop and the nature of its release reflects well-formedness conditions rather than rules.



One prediction of this analysis is that languages that, for purposes of PNH, analyze [v] abstractly as a labial fricative, rather than concretely as a labiodental one, will not contrast [v] with [β]. As far as I know, this is true. A different prediction, also upheld, is that the unambiguous [β] (analyzable only as bilabial) will always yield [mb] when subjected to PNH, never [mbv] or [mbβ].

The analysis can be extended to the effect of PNH on coronal continuants. I mention here a couple of cases directly relevant to this discussion. Most /N-y/ sequences yield the prenasal affricate [ɲ]. This can be attributed to the fact that /y/ is analyzable as a palatal or as a palato-alveolar coronal: PNH will thus derive

a palatal or palato-alveolar stop, which is realized, in the relevant languages, with fricated release. As in the case of [m(b)v], the affricated release of [n̥] is the surface reflex of the point of articulation feature of the plosive.

The sequences /N-s/, /N-z/ are turned by PNH into the affricates [n(t)s], [n(d)z]. I simplify the discussion of these cases by assuming that the feature [strident] plays a role in distinguishing the coronal stops /t/, /d/ from the spirants /s/, /z/. The strident coronal fricatives would be turned by PNH into strident plosives, which must be realized with fricated release. This will explain the fact that PNH always creates a prenasal affricate, rather than a stop, in these cases. The relevant derivation is given in (40).

(40) Underlying: 
$$\begin{array}{c} [\text{nas}] \\ | \\ A_0A_f \\ | \\ \text{coronal} \\ | \\ \text{strident} \end{array} = n + z$$

PNH: 
$$\begin{array}{c} [\text{nas}] \\ | \\ A_0A_f \\ | \\ \text{coronal} \\ | \\ \text{strident} \end{array}$$

Release adjustment: 
$$\begin{array}{c} [\text{nas}] \\ | \\ A_0A_f \\ \vee \\ \text{coronal} \\ | \\ \text{strident} \end{array} = {}^n(d)z$$

The distinction between nonstrident stops (*t, d*) and strident fricatives (*s, z*) has the virtue of explaining why the nonstrident fricative [ð] always yields a stop when subjected to PNH? /N-ð/ becomes [nd], never [n(d)z] or [nð].

At the core of my analysis lies the claim that PNH is involved not only in the derivation of sequences like [mbv], [ndz] but also in that of [mv] and [nz]. This is directly tied to the point that [mv] and [nz] are prenasal affricates [as in (23a)] rather than fricatives [as in (23c)]. The claim that PNH is involved in the derivation of [mv] and [nz] can be supported by several arguments.



I consider first a frequent aspect of the PNH paradigm, encountered for instance in Rwanda (Coupez, 1980), Ganda (Herbert, 1986:265), and Ntomba (Mamet, 1955:12). In these languages, as elsewhere in Bantu, PNH is demonstrably involved in turning /NI/ into [nd] and, in the case of Rwanda, /Nr/ into [nd]. Further instances of PNH are involved in the Ntomba alternations between /h/ and /ns/ and in the Rwanda alternations between /h/ and /mp/. I discuss these below. It is clear that all three languages experience some postnasal increase in stricture. On the other hand, nasal-fricative sequences surface as [mv], [mf], [nz], [ns] in all three languages. Are the fricatives excluded from PNH? If so, why? No valid reason for such an exclusion suggests itself. My claim is that fricatives are not exempted from PNH. I analyze [mv], [nz], and so on as affricates, and this allows the assumption that PNH has applied across the board in Ganda, Rwanda, and Ntomba, without regard to the nature of the continuants involved. Had we assumed that sounds like [mv] are continuants, such as [<sup>v</sup>v], PNH would have had to be arbitrarily restricted to apply to nonstridents only.

A distinct argument can be built on the sound changes which turn Ntomba /s/ into /h/ and Rwanda /p/ into /φ/ and then into /h/. The change from /s/ (or /φ/) to /h/ is frequently encountered with fricatives and has been analyzed by Thráinsson (1978) and McCarthy (1988) as the loss of their supralaryngeal features. In Ntomba, the prenasal /ns/ remains unaffected by this rule. The result is widespread alternations.

(41) Prenasalization bleeds the Ntomba change  $s \rightarrow h$ :

<i>Singular</i>	<i>Plural</i>	
<i>lo-haha</i>	<i>n-sahe</i>	'light'
<i>lo-haka</i>	<i>n-saka</i>	'clapping'
<i>lo-hango</i>	<i>n-sango</i>	'news'
<i>heko</i>	<i>n-seko</i>	'tell', 'tales'

The reason prenasal /ns/ fails to become /h/ is that /ns/ is not a fricative, but a plosive. We establish this by noting first that a widespread restriction on debuccalization (McCarthy's apt term for loss of the supralaryngeal component) is precisely that the target segment be a continuant, not a plosive: an  $A_f$ , not  $A_0$ . On the other hand, I know of now cases in which debuccalization is blocked by the presence of nasality in the potential target.<sup>11</sup> My argument, then, is that the only reasonable explanation for the difference between /s/ and /ns/ with respect to debuccalization is the plosive nature of /ns/, the presence of  $A_0$  in its representation, not its prenasal character.<sup>12</sup> This too argues for (23a) as the representation of /ns/.

A third argument establishing the fact that PNH is involved in the derivation of surface NS is provided by a denasalization process attested in several Bantu languages. The Venda and Yaka paradigms considered above showed that nasality is removed from a voiceless  $A_0$ : /mp/, /nt/, /ŋk/ are realized as [p(h)], [t(h)], [k(h)]. In Venda and Yaka the surface prenasal affricates are realized as plosives with

partially nasal closure (NTS): [mbv], [ndz], [ndž]. It therefore comes as no surprise that, upon the loss of [nasal] from voiceless prenasals, the resulting structure will be an affricate TS: /nts/ → [ts], /mpf/ → [pf]. The Venda/Yaka change from prenasal to oral voiceless plosive is outlined in (42).

- (42) [+nas]  
 †  
 A<sub>0</sub>  
 |  
 [- voice]

The rule in (42) will have the effect shown in (43) on the prenasal affricates:

- (43) [+nas]  
 †  
 A<sub>0</sub>A<sub>f</sub> (e.g., Yaka /nts/ → [ts], Venda /mpf/ → [pf])  
 |  
 [- voice]

A clear prediction of my analysis is that the effects of (42) will be the same regardless of whether the surface prenasal affricates of the language in question are realized with a fully or partially nasalized closure. I predict, in other words, that the denasalization in (40) will yield [pf], [ts] even if the language in question realizes prenasal affricates as [mf], [mv], [ns], [nz] rather than as [mpf], [mbv], and so on. Consider now the PNH paradigm of Suku (Piper, 1977:17–34), a language which bears out this prediction.

- (44) Voiced stops:  
*N-gunga* → *ŋgungga* ‘the shaking’  
*N-dinga* → *ndingga* ‘the searching’  
*N-buta* → *mbuta* ‘the testifying’  
 Voiceless stops:  
*N-puba* → *phuba* ‘the flattering’  
*N-toka* → *thoka* ‘the self-warming’  
*N-kata* → *khata* ‘the packing’  
 Voiced continuants:  
*N-lenga* → *ndengga* ‘the going for a walk’  
*muN-zenzi* → *munzenzi* ‘the guest, the stranger’  
*N-zaangi* → *nzaangi* ‘little tree monkey’  
*N-vula* → *mvula* ‘the years’  
*N-vuumbi* → *mvuumbi* ‘spirit of a dead one’  
 Voiceless continuants:  
*N-fuumba* → *pfuumba* ‘corner, nook’  
*N-fueti* → *pfweti* ‘I must’

*N-sad-a* → *tsala*                    'to get married'  
*N-sambuadi* → *tsambwadi*        'seven'

Note first that, in the case of voiced continuants like /l/, the prefixation of N clearly yields prenasalized plosives rather than continuants: /Nl/ becomes /nd/. This is in itself a hint that the nasal prefix N creates a plosive rather than merely nasalizing the first half of a following continuant. Observe further that the sounds [mv] and [nz] are classified by Piper himself as phonetically [–continuant] (1977: 65), surely because their articulation involves complete oral closure.

But the most reliable indication of the fact that these sounds are plosives, not only phonetically but phonologically as well, is the comparison between [mv] and [pf]. It must be assumed that PNH has yielded, from underlying /N-f/, an affricate like the one outlined in (43), for otherwise the [pf] output of denasalization would be incomprehensible: we would expect denasalization of a fricative to yield [f], not [pf]. By parity of reasoning, we must assume that the same has happened with the voiced fricatives: /N-v/ must have undergone PNH too to become an affricate. Therefore the outcome of that process, [mv], is an affricate. We cannot avoid this conclusion by arbitrarily excluding voiced strident continuants from the application of PNH, since we know independently that the phonetic output of underlying /N-v/, [mv], is also an affricate.

The final argument that PNH is involved in the derivation of NS prenasals is typological. Observe that nasals have only two possible effects on a following consonant: they either turn the consonant into a stop (PNH), or they nasalize it in its entirety (nasal transfer). It is never the case that nasals induce a decrease in the degree of stricture of a following consonant: they never turn stops into continuants or fricatives into glides. Having established this, I note that in languages like Rwanda—where PNH is active—prenasal affricates are realized as NS: /n-ts/ → [ns]. To assume that [ns] is phonologically a prenasal continuant [<sup>s</sup>s] would lead to the absurd conclusion that PNH turns affricates into fricatives (/N-ts/ → [<sup>s</sup>s]) but operates in the opposite direction for nonstridents by turning continuants into stops (/N-r/ → [nd]). To avoid this, it must be granted that the Rwanda prenasals like [ns] are not [<sup>s</sup>s] but prenasal affricates, when they originate as /N-ts/ sequences. But, once this step is taken, it must also be granted that the phonetically identical [ns] originating from Rwanda /N-s/ is also an affricate. And there is no reason to assume that what is true of Rwanda [ns] is false for the prenasals of Mbum or Lega or Rundi.

To sum up, then: PNH is the process whereby a closure specified only as nasal and a release position specified with a complementary set of features (place and laryngeal) merge to form a single consonant. The output of PNH combines the features of the two input segments and maintains the basic aspects of the initial sequence of A positions: a closure and a release. The only difference is that the output configuration of features and A positions is that of a single plosive. PNH

results not only in prenasal stops or prenasal affricates with partly nasal closure (NTS) but also in prenasal affricates with a fully nasalized closure (NS).

## 2.4. No Postnasal Continuants

### 2.4.1. THE FACTS

Postnasal contours are attested in a number of African, Amerindian, and Austroasiatic languages, many of which were surveyed by Poser (1979). None of the sources mentioned by Poser, Herbert (1986), Maddieson (1984), or indeed any other source known to me records the existence of postnasal continuants. Digraphs such as ⟨sn⟩, ⟨βm⟩, ⟨γŋ⟩—to the extent they are encountered at all in the literature—refer to clusters of continuants followed by nasal stops rather than to unit prenasal phones.

I briefly consider here one African language, the Zing dialect of Mumuye described by Shimizu (1983), whose inventory of nasals and postnasals suggest strongly that the absence of postnasal contours on continuants is systematic rather than accidental. Shimizu provides the consonant inventory in (45) for Zing Mumuye. The digraphs ⟨ny⟩, ⟨zh⟩, and ⟨sh⟩ stand for palatals or palatoalveolars.

(45)	p,b	t,d		k,g	kp,gb
	m	n	ny	ŋ	(ŋm)
	f,v	s,z	sh,zh		
		l			
		r	y	w	

The postnasalized consonants of Zing Mumuye are given below; the notation is, again, Shimizu's.

(46)	pm,bm	tn,dn		kŋ,gŋ	kpm	gbm
	vm	sn,zn	shn,zhn			
		m	(yn)		wn	

Given the transcriptions, one would expect that both sounds like ⟨tn⟩ and sounds like ⟨sn⟩ should be produced with a considerable lag between the onset of the oral constriction and the lowering of the velum. According to Shimizu's own observations, this lag is indeed observed in the articulation of the stops; but it does not exist for the continuants.

In the pronunciation of postnasalized plosives, after the usual closure phase, the release of the velic closure precedes that of the oral closure. On the other hand, in the postnasalized fricatives roll and approximant, the release of the velic closure immediately follows or is almost simultaneous with the formation of oral stricture. (1983:8)

The postnasal stops described by Shimizu involve the following sequence of articulatory events: oral closure ("the usual closure phase") followed by velum lowering ("the release of velic closure") followed by oral release. It is clear that

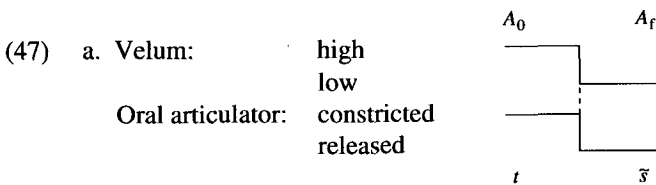
the onset of the nasal gesture follows that of the oral one: this is what makes these stops postnasal.

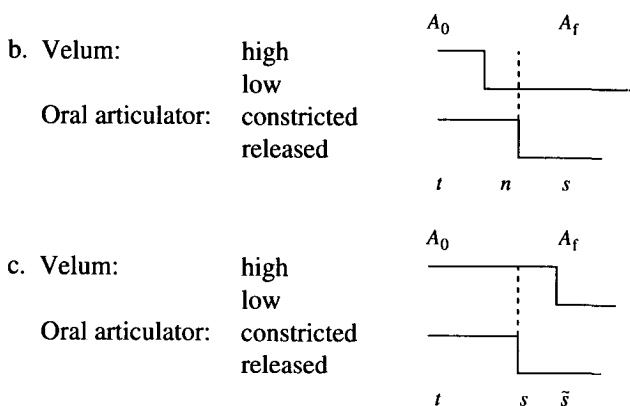
In the articulation of “postnasal” approximants and fricatives, however, the onset of velum lowering is reported as “almost simultaneous with the formation of oral stricture.” Although Shimizu implies that there is sometimes a slight lag between oral closure and velum lowering for continuants, this lag is not reported as being either significant or invariably present. Given this, I see no reason for the phonological representations of ⟨sn⟩, ⟨rn⟩, and the rest to incorporate a distinct oral phase preceding the nasal phase. Shimizu’s description of the continuants is more compatible with phonological representations in which they are fully nasal rather than postnasal.

The Zing Mumuye data are significant because, as indicated by Shimizu, the same historical process generated both the postnasal stops and the nasal fricatives. For our purposes it does not matter whether this process was a vowel syncope (CVNV → CNV) or the nasalization of a vowel with subsequent transfer of nasality (CVN → C $\tilde{V}$  → CNV). What is important is that both the continuants and the postnasal stops originated in a common development. This fact indicates that the absence of postnasal continuants in Zing Mumuye—or elsewhere—is systematic and requires explanation. We must ask why the Zing Mumuye sound change did not yield [tn] and [sn] (i.e., [s $\tilde{s}$ ]), rather than [tn] and [s̃]. More generally, we must ask why [s $\tilde{s}$ ] is unattested elsewhere. Our answer is based on the claim already outlined that nasal contours cannot surface on continuants. Like the prenasal contours, the postnasal ones require two distinct positions, and only plosives can provide them.

### 2.4.2. WHY NO POSTNASAL FRICATIVES?

In preceding sections we have observed that a certain class of prenasal affricates—those with fully nasal closure—lend themselves to transcriptions (⟨mv⟩, ⟨nz⟩) that can be mistakenly thought to represent part-nasal, part-oral continuants. The question to consider now is whether the same illusion of partially nasalized continuants can arise with the postnasal consonants. More specifically, can a postnasal affricate be mistaken for a postnasal fricative? A look at the representations proposed for these sounds in their relation to the articulatory events suggests that this is not possible.





The diagrams in (47) represent the three possible timing variations between oral release and velum lowering in a postnasal affricate. In (47a) the two are simultaneous; in (47b) the onset of the velic gesture precedes the oral release; in (47c) the oral release precedes the velic gesture. What is invariant in all three cases is the presence of an initial oral phase—transcribed as [t]—during the period of oral constriction. No postnasal affricate could conceivably lack this phase. And no sound containing this phase could be mislabeled as a fricative. This, I suggest, is why no postnasal fricatives have been reported in the literature.

## 2.5. The Generalizations Explained

In Section 2.1.2, a number of general statements were proposed about the frequency, distribution, and possible contrasts between various types of nasal contours. We are now in a position to explain these generalizations.

I have observed, in (14), that sounds characterized as prenasal continuants are vastly less frequent than the prenasal plosives. There are two reasons for this. First, the prenasal “continuants” are in fact just one of the two conceivable phonetic realizations of the prenasal affricates. Second, affricates of any sort are a variety of plosive significantly less frequent than the stops. Combined, these two observations predict correctly the very considerable difference in frequency between unmistakable prenasal plosives (the stops, and prenasal affricates with partial nasal closure NTS) and the apparent prenasal “fricatives” (prenasal affricates with full nasal closure NS).

A related question, originally raised by Rosenthal (1989), is the much higher frequency of “prenasal strident continuants” relative to the “prenasal nonstrident continuants” [cf. (15)]. The terms are, once again, misleading, since both sound classes Rosenthal refers to turned out to be affricates. The question raised by (15) should then be rephrased as follows: Why is it that prenasal affricates with strident release (e.g., [nz]) are significantly more frequent than those with nonstrident re-

lease (e.g., [nr])? The answer relevant for our immediate purposes is simple: the vast majority of affricates, oral or not, have strident releases. Sounds like [dr], [tθ], although attested occasionally,<sup>13</sup> are very rare compared to [dž] or [ts]. Prenasal affricates will necessarily share in this generalization.

I also noted, in (16), the absence of contrast between prenasal “fricatives” and affricates. It was shown that this absence of contrast follows from the fact, independently established, that both sound classes have the same phonological representation: a nasal closure followed by an oral fricated release.

I turn now to the generalization in (17), the impossibility of nasal contours on vowels. In terms of the analysis proposed here, the question is not why vowels in particular will not display nasality contours—since I claim that no true continuants do—but rather why phonologists have used the misnomer “prenasal continuant” for sounds like [nz], which end in a fricative phase, and not with sequences like [ni], which end in a vocalic phase. Once the question is phrased like this, the answer is clear: a sequence like [ni] cannot be mistaken for a vowel whose first half is nasal because it is clearly bisegmental. In contrast, a nasal closure followed by fricative release like [nz] can be viewed as monosegmental and is therefore subject to mislabeling.

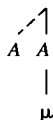
Finally, I noted in (18) that all documented postnasal consonants are plosives. This follows plainly from my hypothesis that nasal contours of any type are possible only on plosives. The reasons why postnasal affricates—in contrast to prenasal ones—cannot be mislabeled as postnasal fricatives were explained above.

### 3. NASALIZATION RULES: EFFECTS ON STOPS VERSUS CONTINUANTS

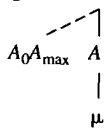
I have considered so far the ways in which segment inventories reflect the fact that only plosives can support nasal contours. I turn now to the effects of this restriction on the application of nasalization rules.

The structural difference I postulate between plosives and continuants allows us to account for rules spreading nasality which derive partially nasalized plosives and, at the same time, fully nasal continuants. An example of this kind is the historical process that generated the postnasal plosives and nasal continuants of Zing Mumuye (cf. Section 2.4.1). The rule formulated below assumes that at some stage in this process the language had nasal vowels. Nasality then spread leftward.

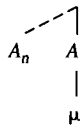
(48) a. The rule: [+nas]; noniterative



b. The rule applied to stops: [nas] =  $t \rightarrow in$



c. The rule applied to continuants ( $A_n$ ): [nas] =  $s \rightarrow \tilde{s}$



I will document in greater detail this contrast between stops and continuants in the output of nasalization rules. Before doing this, however, I should outline more precisely the predictions the analysis makes about the possible effects of rules spreading nasality.

### 3.1. Which Nasalization Rules Will Generate Contours?

Here I consider rules that can in principle associate nasality to any  $A$  position, regardless of its segmental content. Of these, I distinguish iterative from noniterative processes. I predict nasal contours to always arise in the output of noniterative rules, such as (48a): because the rule is allowed a single iteration, it will always nasalize just one of the two  $A$  positions of a stop or affricate. The plosive that has been partially affected in this way will form the nasal contour. In contrast, a single iteration will be sufficient to fully nasalize the continuants. Thus I predict that no language will display a paradigm of nasalization such as the one summarized in (49).

- (49)  $s\tilde{e}ya \rightarrow s\tilde{e}\tilde{y}a$   
 $s\tilde{e}yra \rightarrow s\tilde{e}\tilde{y}ra$   
 $s\tilde{e}ra \rightarrow s\tilde{e}\tilde{r}a$   
 $s\tilde{e}da \rightarrow s\tilde{e}na$   
 $s\tilde{e}ga \rightarrow s\tilde{e}\tilde{n}ga$

What excludes a system like (49) is the fact that the rule involved is clearly noniterative (cf. [s $\tilde{e}\tilde{y}a$ ]), yet it affects both the closure and the release of the oral stops by nasalizing them in their entirety. Thus the presence of strings like [s $\tilde{e}\tilde{y}a$ ] in a language is sufficient to predict that underlying /s $\tilde{e}da$ /, if at all subject to nasalization, will be realized as [s $\tilde{e}^n$ da], not as \*[s $\tilde{e}na$ ].<sup>14</sup>

Iterative rules, on the other hand, should not generate contours: if the rule can spread nasality onto any  $A$  position, and if it can iterate, then both positions of a plosive will necessarily undergo the rule. In this way, an underlying oral stop will become fully nasal. The prediction then is that the iterative rules will treat continuants and stops alike in nasalizing them throughout.



In what follows we consider both data that are clearly consistent with these predictions and data that look problematic at first glance. The overall conclusion will be that the relevant data support my analysis: no iterative rules generate nasality contours, all (relevant) noniterative rules do.

### 3.2. Progressive Noniterative Rules

#### 3.2.1. AUCA

Auca is a genetically unclassified Ecuadorian language, also known as Huarani. Saint and Pike (1962) provide a phonemic analysis for the language. I list in (50) all but the phonemes identified by Saint and Pike as extrasystemic (used only in onomatopoeic or emphatic expressions).

(50)	p	t	k	i	ĩ		
	b	d	ʝ	g	e	ẽ	o ð
	m	n	n	ŋ	æ	æ̃	a ã
	w						

My phonemic table differs from Saint and Pike's only in the status of /j/, a palatal consonant with both glide and plosive allophones. Saint and Pike write it as ⟨y⟩ while taking note of its ambiguous status in the Auca system. I decide to assign it unambiguously to the plosive class, and thus write ⟨j⟩, for reasons that will become clear below. This decision does not affect the analysis.

In their discussion of consonantal variation in Auca, Saint and Pike note that all voiced stops have obligatory prenasal variants when they follow nasal vowels.<sup>15</sup> Voiceless stops also display prenasal variants after nasal vowels; in their case, however, prenasalization is accompanied optionally by voicing. Unlike the stops, the continuant /w/ is completely nasalized after a nasal vowel.

(51)	g:	õõ <sup>g</sup> gae	'I am going to hunt'
	b:	wĩ <sup>m</sup> bika	'he does not drink'
	j:	wĩ <sup>n</sup> jawi ĩ <sup>m</sup> ba	'it is not a toucan'
	p:	awã <sup>m</sup> pa, awã <sup>m</sup> ba	'club'
	t:	ĩ <sup>n</sup> tapa, ĩ <sup>n</sup> dapa	'it was'
	w:	kõwĩ	'always'
		onõwã	'foot'
		tomɛjã wã kaeka	'he does well'

A process of spirantization interacts with nasal spreading. Three of the voiced stops, /d/, /j/, and /g/, are frequently realized as the voiced continuants [ř], [y], and [ɣ]. The spirantized variant of /d/, [ř], is realized as fully nasal when it follows nasal vowels. No spirantized versions of /g/ and /j/ are recorded in the environment of nasal vowels, perhaps because—unlike word-medial /d/—/g/ and /j/ are only optionally subject to spirantization. For this reason, I limit the discussion of

spirantization to /d/, whose continuant allophone is described as a rapid flapped [ř]. The spirantization of /d/ is prevalent in morpheme-internal position and may be obligatory there. The only nonspirantized [d]'s recorded are either utterance- or morpheme-initial. The nasal version of [ř] is a nasalized flap [ň] which, according to Saint and Pike (1962:9), remains distinct from the allophones of the nasal stop /n/.

(52) a. Spirantization of /d/ in oral contexts:

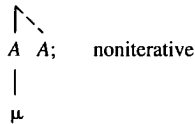
/odo-dia/: [ořo-dia] ~ [ořo-řia] 'it is partly full'  
 /dadonja/: [dařiŋa], [<sup>n</sup>dařiŋa] 'he fishes'

b. Spirantization of /d/ in nasal contexts:

/biwī-dia/: [biwī-<sup>n</sup>dia] ~ [biwī-ňia] 'younger brother (emphatic)'

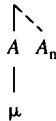
I analyze the Auca nasalization as rightward noniterative spreading of the distinctive nasality of vowels. The noniterative nature of the process, an independently observable fact, is sufficient to derive the contrast between fully nasalized continuants and prenasalized stops.

(53) General Nasalization: [+nas]



I leave the formal details of spirantization vague, in large part because they are irrelevant to the discussion. It is also irrelevant whether the flap [ř] should be analyzed as an  $A_f$  or as an  $A_{max}$ : I write it as  $A_n$ , leaving the identity of n undecided. The only crucial, and uncontroversial, part of the analysis is that the flap is a continuant and thus lacks the original closure position  $A_0$ . From this it follows that the flap will be subject to full rather than incomplete nasalization.

(54) Rule (53) applied to [ř]: [nas]



A further detail noted by Saint and Pike is also explained by my analysis: the derived contrast between the nasal flap [ň] and the underlying nasal [n]. The two are distinct because the latter is still a stop, unaffected by spirantization.

(55) [nas]                      [nas]  
       |                            ^  
        $A_n$                          $A_0 A_{max}$   
  
       [ň]                         [n]

In their brief section on Auca morphophonemics, Saint and Pike (1962:25) note that certain suffixal morphemes and enclitics beginning with a stop substitute the corresponding nasal when affixed to a stem ending in a nasal vowel. In this case the nasalization affects the entire plosive rather than just its closure.

- |      |               |            |                |               |
|------|---------------|------------|----------------|---------------|
| (56) | <i>a-bo</i>   | 'I see'    | <i>ã-mo</i>    | 'I say'       |
|      | <i>a-ka</i>   | 'he sees'  | <i>ã-ŋa</i>    | 'he says'     |
|      | <i>taa-do</i> | 'go trail' | <i>giyã-no</i> | 'small trail' |
|      | <i>ba-ga</i>  | 'is tooth' | <i>waĩ-ŋa</i>  | 'good tooth'  |

This morphologically conditioned nasalization is clearly noniterative, as shown by the final oral vowels in [ãmo] or [waĩŋa]. Why then does it affect the stops in their entirety? Note that the rule differs in two ways from General Nasalization (53): it does not affect continuants at all, and it affects stops in their entirety. This suggests that the process, Suffixal Nasalization, is fed by (53) and consists of spreading nasality from closure to release. There is no principled difficulty in assuming this ordering: the more general rule is perhaps both cyclic and postcyclic, while the lexically restricted one, Suffixal Nasalization, is clearly only cyclic, as indicated by the fact that it applies only in derived environments.

(57) Suffixal nasalization:

[lexically restricted; cyclic; follows the cyclic application of (53)]



The derivation of [ãmo] 'I say' appears below. I indicate only nasality and A positions.

- |      |             |       |                     |                        |
|------|-------------|-------|---------------------|------------------------|
| (58) | Underlying: | [nas] | =                   | $\tilde{a} - b o$      |
|      |             |       |                     |                        |
|      |             |       | A                   | $A_0 A_{max}$          |
|      | Rule (53):  | [nas] | =                   | $\tilde{a} - {}^m b o$ |
|      |             |       | $\swarrow \searrow$ |                        |
|      |             |       | A                   | $A_0 A_{max}$          |
|      | Rule (57):  | [nas] | =                   | $\tilde{a} - m o$      |
|      |             |       | $\swarrow \searrow$ |                        |
|      |             |       | A                   | $A_0 A_{max}$          |

An obvious motivation for rule (57), the lexically restricted nasalization, is the principle of Structure Preservation (Kiparsky, 1985). The lexical applications of rule (53) will belong to the class of rule applications which frequently display structure-preserving effects: the possible outputs of the rule are limited to configurations already present underlyingly. Since Auca has no prenasal stops underlyingly, the prenasals derived by the lexical applications of (53) must be "repaired." The solution is then to take the extra step of nasalizing the release, since this

derives segments present in the underlying inventory. What I have dubbed here Suffixal Nasalization is then identified as the repair strategy chosen to enforce structure preservation.<sup>16</sup> I do not, however, wish to claim that every lexical nasalization rule—or every lexical rule in general—is structure-preserving. Rather, my claim is that a subset of lexical nasalization rules is structure-preserving and that this subset will not be allowed to generate prenasal stops in languages where such segments do not exist underlyingly. Given this possibility, the predictions made at the beginning of this section will have to be adjusted: in languages lacking underlying nasal contours, only noniterative rules exempt from the requirements of structure preservation will create nasal contours on plosives.<sup>17</sup>

### 3.2.2. ZOQUE

Rather similar to the progressive nasalization of Auca are the morphological nasalization processes that mark the first person and second person in Zoque, a language of southern Mexico that has been extensively described by Wonderly (1951). In this case nasality is a prefix which links up to the first consonant of the stem. The result of attachment is a set of prenasal stops and a set of fully nasal approximants. In Zoque, as in many other cases mentioned before, the fricatives and liquids cannot be nasalized. The significant point here is that all Zoque stops differ from all Zoque continuants in the manner in which they are affected by nasalization: stops undergo it only partially by becoming prenasal, whereas continuants are either completely nasalized (the glides) or remain completely oral (fricatives and liquids).

(59) Zoque consonants

p	t	c	č	ty	k
b	d		ǰ	dy	
f	s		š		h
m	n			ŋ	ŋ
	l		r		
w				y	

(after Wonderly, 1951)

In (60), the first column represents the unpossessed form of the noun; the second is the form indicating a first person singular possessor.

(60) Zoque [nasal] attachment:

a. stops:		
<i>pama</i>	<i>mbama</i>	'clothing' <sup>18</sup>
<i>tatah</i>	<i>ndatah</i>	'father'
<i>čoʔngoya</i>	<i>njoʔngoya</i>	'rabbit'
<i>kwarto</i>	<i>ŋgwarto</i>	'room'
<i>plato</i>	<i>mblato</i>	'plate'
<i>tramba</i>	<i>ndramba</i>	'trap'

<i>disko</i>	<i>ndisko</i>	'phonograph record'
<i>gayu</i>	<i>ŋgayu</i>	'rooster'
<i>mok</i>	<i>mok</i>	'corn'
<i>naka</i>	<i>naka</i>	'skin'
b. glides:		
<i>waka</i>	<i>w̄aka</i>	'basket'
<i>yomo</i>	<i>ȳomo</i>	'wife'
<i>huki</i>	<i>h̄uki</i>	'cigarette'
c. other [+cont]:		
<i>faha</i>	<i>faha</i>	'belt'
<i>sapun</i>	<i>sapun</i>	'soap'
<i>lawus</i>	<i>lawus</i>	'nail'
<i>r:anco</i>	<i>r:anco</i>	'ranch'

Wonderly writes ⟨*nwaka*⟩, ⟨*nyomo*⟩, ⟨*nhuki*⟩ for my ⟨*w̄aka*⟩, ⟨*ȳomo*⟩, ⟨*h̄uki*⟩ but indicates elsewhere (p. 107) that his transcriptions do not represent phonetic sequences: "Word initial clusters *ny*, *nw*, *nh* are set up in which *n* is indeterminate as to point of articulation and is actualized as a nasalization of the *y*, *w*, *h*." Wonderly's transcriptions reflect the morphological composition of the cluster (*N* prefix + stem) rather than any sequence of articulatory events.<sup>19</sup>

The second person marker, identified as /*Ny*/ by Wonderly, gives rise to the same patterns as seen in (60). In addition, the initial cluster is palatalized in this case, an effect which Wonderly records by positioning the palatal glide /*y*/ after the stem-initial consonants. No examples are provided for the /*Ny*/ prefix attached to stems beginning with any continuants, but there is no reason to believe that their pattern of nasalization would be different from that of the continuant-initial stems prefixed with first person *N*-.

(61)

Stem	Second person singular	
<i>tih-</i>	<i>ndyihu</i>	'arrive'
<i>dura-</i>	<i>ndyuracahku</i>	'last'
<i>cahk-</i>		
<i>ken-</i>	<i>ŋgyenu</i>	'look'
<i>krus</i>	<i>ŋgrus</i>	'cross'

Since the effects of Zoque nasalization do not extend beyond the initial segment of the stem, we must assume that the rule is not iterative. Indeed, iterativity is hardly the issue here, since this is not a spreading rule at all: nasality simply associates to the first *A* position of the stem. The result of association is, as in Auca, different for plosives and continuants. This is in line with the general predictions outlined above.

Finally, note that the Zoque attachment of nasality to stem-initial segments,

although likely to be a lexical process, is not structure-preserving: prenasal consonants do not exist in Zoque independently of the effects of the first and second person morphemes. That is, in part, why I have refrained from adopting Kiparsky's (1985) stronger claims on Structure Preservation, which predict that all lexical rules will be subject to it.

### 3.3. Regressive Noniterative Rules

I now compare the progressive attachment of nasality in Auca and Zoque with regressive rules of nasal propagation. I expect that consonants will undergo regressive nasalization by becoming fully nasal, if they are continuants, or postnasalized, if they are plosives. An example that fits exactly this description is the Zing Mumuye nasalization process discussed in Section 2.4.

#### 3.3.1. GOKANA

A similar case, though less transparent, is that of nasalization in Gokana (a Benue-Congo language of eastern Nigeria). Gokana nasalization was analyzed by Hyman (1982), who demonstrates that nasality is not an underlying property of any Gokana segment, with the possible exception of /m/. Rather, stem morphemes may be the underlying carriers of a [nasal] autosegment, which associates subject to a number of constraints.

(62) Gokana surface phones:

p	t	ky	k	kp	ʔ	i	ĩ	u	ũ
b	d	gy	g	gb		e		o	
	f	s				ɛ	ẽ	ɔ	õ
	v	z						a	ã
m	ɱ	n	n	ŋ					
	l	r							

(after Hyman, 1982)

Some of these sounds have a restricted distribution within Gokana stems, which can be either disyllabic C(V)VCV, heavy monosyllabic CVC, CVV, or light monosyllabic CV. The second stem consonant must be voiced and is restricted to [b], [g], [m], [n], [ŋ], and the liquids [l] or [r]. The velar nasal [ŋ] does not occur stem-initially. The bilabial stop [b] becomes a spirant [v] in intervocalic position. Similarly, the liquids [l] and [r] appear to be in complementary distribution, with [r] appearing in intervocalic position and [l] elsewhere. The oral voiced continuants [v], [z], [r] ~ [l] occur stem-initially only in oral stems. Hyman provides the following comparison between acceptable and unacceptable stems containing these sounds:

(63) va 'wife'	*uã
li 'root'	*lĩ
zɔ 'pain'	*zõ

<i>zib</i> ‘thief’	<i>*zīm, *zim</i>	
<i>zari</i> ‘buy’	<i>*zāni, *zani, etc.</i>	
<i>zaari</i> ‘scatter’	<i>*zāāni, zaanī, etc.</i>	(Hyman, 1982:116)

In contrast, oral stops—whether voiced or voiceless—and voiceless continuants can occur without restriction at the beginning of both nasal and oral stems.

(64) <i>tɔ</i> ‘house’	<i>tɔ̃</i> ‘ear’	
<i>ba</i> ‘arm, hand’	<i>bā</i> ‘pot’	
<i>si</i> ‘go, visit’	<i>sī</i> ‘face’	(Hyman, 1982:116)

The presence of nasal consonants in the stem imposes certain restrictions on the distribution of oral segments. Hyman states these at first descriptively in the form of constraints (1982:114–115).

- (65) Constraint No. 1: If the  $C_1$  [of the stem] is [+nasal], then all successive segments must also be [+nasal].

<i>nū</i> ‘thing’	<i>*nu</i>
<i>nɔ̃m</i> ‘animal’	<i>*nɔb, *nom, *nɔ̃B</i>
<i>mēnē</i> ‘chief’	<i>*mene, *menē, *mēle, etc.</i>

Constraint No. 2: If the  $C_2$  is [+nasal], then any and all preceding and following vowels must also be [+nasal].

<i>dēm</i> ‘tongue’	<i>*dem</i>
<i>fīnī</i> ‘monkey’	<i>*fini, *finī</i>
<i>kūūnī</i> ‘cooking store’	<i>*kuuni, kūūni, kuunī</i>

Constraint No. 3: If a vowel or vowel sequence is [+nasal], then all successive segments must also be [+nasal].

<i>dēm</i> ‘tongue’	<i>*dēb</i>
<i>fīnī</i> ‘monkey’	<i>*fīli, fīlī, fīni, finī, etc.</i>
<i>kūūnī</i> ‘cooking store’	<i>*kūūli, kūūlī, kuunī, etc.</i>

Hyman’s analysis of these distributional gaps is centered on the assumption that nasality in Gokana stems originates as a morpheme-level [+nasal] autosegment rather than as a feature of individual segments. This implies that the surface nasal consonants and vowels of Gokana are underlyingly oral. The following are the underlying-to-surface correspondences Hyman proposes for the Gokana consonants.<sup>20</sup>

(66) Underlying	In oral stems	In nasal stems
<i>v</i>	<i>v</i>	<i>m̩</i>
<i>L</i>	<i>l ~ r</i>	<i>n</i>
<i>z</i>	<i>z</i>	<i>ɲ</i>

This simplification of the underlying inventory explains why the voiced continuants [v], [r], [l], [z] can occur only in oral stems: in nasal stems, they will become [m̩], [n], and [ɲ]. As for the origin of stem noninitial [m] and [ɲ], these

are assumed to come from underlying /b/ and /g/, a hypothesis which is consistent with the fact that the /b/ and /g/ are allowed in the C<sub>2</sub> position of Gokana stems.

(67) Underlying	Medial in oral stems	Final in oral stems	Medial/final in nasal stems
<i>b</i>	<i>v</i>	<i>b</i>	<i>m</i>
<i>g</i>	<i>g</i>	<i>g</i>	<i>ŋ</i>

Finally, the nasal vowels all have oral counterparts, which makes identification of their underlying sources obvious.

We must consider now the mode in which the morpheme-level [nasal] feature attaches to individual segments within the stem. Hyman deduces from the constraints in (65) that all stem-medial and stem-final consonants can successfully be associated to the floating [nasal]. Recall that the only oral consonants allowed to occupy the C<sub>2</sub> slot are /b/, /g/, /l ~ r/. When nasality associates to these, we obtain, correctly, /m/, /ŋ/, /n/. We can deduce then, following Hyman, that nasality associates from the first stem vowel to the very end of the stem domain, in unbounded (i.e., iterative) fashion.

The stem-initial consonants, which are subject to many fewer restrictions, raise the following problem: nasal stems such as /biom/, /fini/, /tɔ/, /gɔ/ indicate that nasality does not always associate to the stem-initial consonant. In fact, it never seems to affect initial stops like /g/, since its nasal counterpart /ŋ/ is unattested stem-initially. On the other hand, in nasal stems beginning with voiced continuants, association to C<sub>1</sub> must be assumed to be obligatory, for otherwise one cannot understand the constraint which prohibits [z], [l], and [v] at the beginning of nasal stems. To reconcile these facts, Hyman (1982: 126) formulates a rule associating nasality to all stem segments except an initial stop or voiceless consonant.

(68) Nasal Association:

$$\# \left\{ \begin{array}{l} [-\text{cont}] \\ [-\text{voice}] \end{array} \right\} \left[ \begin{array}{c} [+nas] \\ \vdots \\ [+seg]_1^n \end{array} \right] \# \left\{ \begin{array}{l} C \\ \# \end{array} \right\}$$

The exclusion of voiceless segments from Nasal Association is natural enough and holds (vacuously) of all positions in a Gokana word. But that of stops strikes me as puzzling. Stem-internal stops clearly do undergo nasal association to become [m] and [ŋ] in stems like [dem] 'tongue' (from /deb/) and [siŋ] (from /sig/). Why are stem-initial stops different?

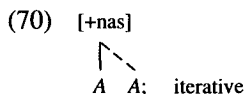
I suggest an answer to this by breaking down Hyman's rule into several distinct steps. I assume that initial association of [nasal] targets a vowel.

(69) [+nas] left-to-right

$$\begin{array}{c} \diagdown \\ A \\ | \\ \mu \end{array}$$

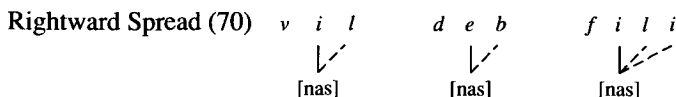
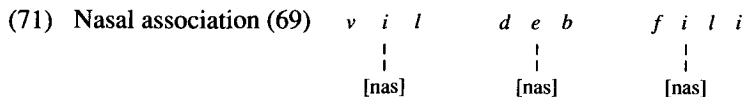


A necessary second step is the unbounded rightward spreading of nasality.



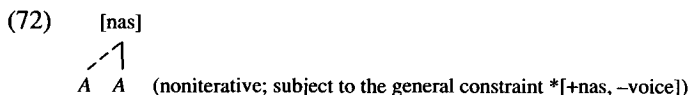
The distinction between (69) and (70) is required even on Hyman's account: word-initial /m/ is the unique underlyingly nasal segment of Gokana, as Hyman demonstrates, and spreading from /m/ must be accomplished by some means distinct from Hyman's rule (68), since the latter is only applicable to floating [nasal]. In addition, Hyman demonstrates that affixal segments are also affected by rightward spreading, a fact which (68) does not appear to incorporate.

Having settled these two aspects of the system, let us consider the derivation of three nasal stems, [m̃in] 'child' (from /vīl/), [d̃em] 'pot' (from /dēb/), and [f̃inī] 'monkey' (from /fīli/).



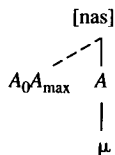
Intermediate output:      ṽin                      d̃em                      f̃inī

The surface forms can be obtained by a noniterative regressive spreading.



This rule will completely nasalize the continuants like /v/, /z/, /l/, deriving [m̃in] from [ṽin], [ñī] from [zī], [ñū] from [lū], and so on. It will also nasalize the releases of all stops, thus effectively deriving postnasal plosives for Gokana.

(73) Rule (72) applied to stops:



The idea that a sequence transcribed as [d̃ā], [b̃ā] may contain a postnasal stop is by no means implausible. The postnasals transcribed as [d<sup>n</sup>], [b<sup>m</sup>]—such as the sounds attested in Mumuye Zing—are only one conceivable phonetic manifesta-

tion of the phonological structure I assign to postnasals: they are transcribed as [d<sup>n</sup>] because their oral release lags behind the velic lowering. I claim that in the Gokana derived postnasal plosives, the two gestures are tightly synchronized: for this reason one will not perceive any nasal stop at all but simply a heavily nasalized release. This is consistent with Hyman's transcriptions of the Gokana [dā], [bā] sequences. Recall that the strategy of assigning several distinct timing relations between nasal and oral gestures to the same phonological structure has proven successful in explaining the distinction between prenasal stops and "post-stopped" nasals as well as that between prenasal affricates and "prenasal fricatives."<sup>21</sup>

To summarize: I suggest that Hyman's rule (68) represents the conflation of three distinct processes (association of floating [nasal], iterative rightward spread, and noniterative leftward spread) and two independent constraints (the filter blocking \*[-voice, +nasal], and the structural distinction between stops and continuants, which affects the outcome of the noniterative leftward spreading rule). I have noted above that Hyman's own analysis requires a distinction between linking and spreading. The rules postulated are free of rule-specific constraints and reduce to combinations of the three basic parameters: association versus spread; direction; iterativity. The point that favors this analysis is the fact that it avoids stipulation of the role of stops in the Gokana system: it explains why stem-internal stops, which undergo the unbounded rightward spread, are completely nasalized, whereas stem-initial stops (affected by the noniterative spread) are only partially affected. Hyman has transcribed the latter as oral stops; I hypothesize that their release is nasal, because this allows a maximally simple statement of Leftward Spread (72). The Gbeya evidence discussed next confirms this hypothesis.

A prediction of the analysis that remains to be investigated is that all phonological processes spreading nasality once, onto a preceding *A* position, will generate postnasal stops. I also predict that processes spreading nasality leftward onto an approximant (as in Mbaise Igbo; cf. Ihionu, 1984) will also apply to stops, generating postnasal stops, since the latter end in an approximant, *A*<sub>max</sub>. These predictions require instrumental work in order to be verified, since mere transcriptions like [dā] are not sufficient to confirm or disconfirm them.<sup>22</sup>

### 3.3.2. GBEYA

Gbeya, a Niger-Congo language, has a system of nasal spreading rules somewhat similar to that of Gokana. The description of these phenomena is due to Samarin (1966). I focus here on the Gbeya equivalent of rule (72) (Leftward Spread), with the aim of strengthening my argument that such rules create postnasalized stops.

(74) Gbeya phonemes:

p	t	k	kp	ʔ	u	ũ	i	ĩ
b	d	g	gb					
mb	nd	ŋg	ŋmgb		e	ē	o	ō
ʔb	ʔd							
ʔm	ʔn				ɛ	ē	ɔ	ō
m	n	ŋ	ŋm					
w	y					a	ã	
v	r							
l								
f	s		h					
v	z							

(after Samarin, 1966)

The Gbeya approximants /w, y, l, r/ are nasalized before a nasal vowel. The stops are not reported as subject to assimilation; but, as Samarin points out, the prenasal stops do not occur at all before nasal vowels. This suggests strongly that the very same process that nasalizes the approximants turns the prenasals into full nasals by spreading nasality onto their release.

(75) a. Nasalized approximants:

<i>ɣĩĩĩĩĩ</i>	‘thin’
<i>ɣōɣ</i>	‘to stretch out’
<i>w̃ōōō</i>	‘many (people)’
<i>řek</i>	‘to be narrow’

Oral approximants:

<i>yele</i>	‘certain basket’
<i>yu</i>	‘to flee’
<i>wolo</i>	‘hole’
<i>rik</i>	‘eye, face’

b. Full nasals:

<i>mā</i>	‘to appear’
<i>řnēŋ</i>	‘to chop off’
<i>ŋmāỹ</i>	‘to split’

Prenasals:

<i>ŋmgbā</i>	‘to interfere’
<i>nduy</i>	‘certain mouse’
<i>mbā</i>	‘to greet’

Since Samarin fails to mention nasal allophones of the fricatives, I assume that only  $A_{max}$  positions are subject to regressive nasalization.

(76) Gbeya Leftward Spread:



Rule (76) will turn underlying /wōōō/ into [w̃ōōō] and underlying /mbā/ into [mā]. In this case, unlike in Gokana, we have some direct evidence that leftward spread onto an approximant is affecting not only the glides and the liquids but also the releases of stops.

As in Gokana, the Gbeya voiced stops are not reported as postnasalized but as simply oral. I suggest here too that transcriptions like [dōō] ‘beer’, [gbē] ‘to be

ripe', [g̃ɔ̃y] 'like this' are fully compatible with the claim implicit in (76) that these voiced stops are postnasal before nasal vowels. These are postnasal stops in which the gesture of velum lowering either is simultaneous with the oral release or follows it slightly. Note that any analysis of Gbeya that fails to recognize this point must split (76) into two distinct processes, one affecting approximants only and the other affecting prenasal stops only.

The overall Gbeya nasalization system presents further similarities to that of Gokana. Samarin's discussion makes it clear that nasalization extends from the initial vowel rightward to the end of the word and leftward to the immediately preceding A position. Clear instances of rightward nasalization are provided in the following examples, whose pronunciation fluctuates between fully oral and fully nasal: [b̃aŋãã] and [baŋgara] 'certain fish', [dula] and [dũẽ] 'tadpole'. As in Gokana, the voiceless segments of Gbeya are unaffected by the spread, leftward or rightward, of nasalization: [yũtũtũ] 'many (such as chicks)'. As in Hyman's analysis of Gokana, the underlying bearer of nasality in Gbeya appears to be the stem morpheme as a whole rather than some individual segment within it: alternate pronunciations like [dũẽ] ~ [dula] differ primarily in the presence or absence of the nasal autosegment. As in Gokana, stem-internal voiced stops are fully nasalized by the rightward propagation of [nasal]. As a result, nasal vowels cannot precede, on the surface, the oral segments /b, d, g, gb/, and stems such as \*[bãba] are impossible. This suggests that Gbeya has the equivalent of Gokana Rightward Spread (70), an iterative rule that delivers full nasals from underlying oral stops.

The only significant differences between the two systems involve their underlying inventories: Gbeya has underlying prenasals as well as nasal consonants, whereas Gokana generally lacks underlying nasal segments. The Gbeya prenasals have provided a further argument that noniterative rules spreading nasality leftward create postnasal stops: the assumption that they do allows a unified analysis of the effect vowel nasality has on initial approximants and prenasals.

### 3.3.3. APINAYÉ

I next consider the patterns derived by a noniterative rule spreading nasality in both directions.

Anderson (1976) has reported on a rule of nasalization found in Apinayé, a language of Brazil. Anderson's analysis is based on work by Callow (1962) that has been unavailable to me. The patterns of nasalization described for Apinayé by Burgess and Ham (1968) appear to come from a distinct, though closely related, dialect. I refer to Callow's dialect as Apinayé C and to Burgess and Ham's as Apinayé B. Both dialects, like many other South American languages (such as Barasano, Cubeo, and Guaraní) contrast a series of voiceless plosives that remain generally oral in all contexts and a series of voiced plosives that are subject to

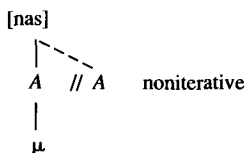
contextual as well as, sometimes, context-free nasalization. The voiced series is sometimes misidentified as underlyingly nasal, as I observe below in the discussion of Barasano. In Apinayé C, the dialect I focus on here, the voiced series is subject to progressive as well as regressive nasalization. I now present the table of allophonic variants of Apinayé C voiced plosives, as provided by Anderson (1976).

(77)

Single stops			Stop clusters		
V	<i>b</i>	V	V	<i>b</i>	<i>d</i> V
$\tilde{V}$	<i>mb</i>	V	$\tilde{V}$	<i>m</i>	<i>d</i> V
V	<i>b<sup>m</sup></i>	$\tilde{V}$	V	<i>b</i>	<i>n</i> $\tilde{V}$
$\tilde{V}$	<i>m</i>	$\tilde{V}$	$\tilde{V}$	<i>m</i>	<i>n</i> $\tilde{V}$

The Apinayé continuants are fully nasalized when contiguous to nasal vowels, as indicated by Burgess and Ham. I assume this holds for Callow's dialect as well, as it appears to be a widespread areal feature. I now consider the effect of nasalization on the stops. Intervocalic stops become postnasal when followed by nasal vowels, prenasal when preceded by nasal vowels, and fully nasal when surrounded by nasal vowels. These effects call for a bidirectional, noniterative spreading rule. My assumption is that this rule is sufficient to account for the effect of vowel nasality on continuants and stops, singly or in clusters.

(78) Bidirectional [nasal] Spread:



The pattern of contextual nasality in stop clusters is more complex. I assume that Apinayé C clusters of plosives are heterosyllabic: there is considerable evidence for syllabifications like *Vb.dV* in the Apinayé B data. The stops of Apinayé B, like those of most languages I know of, are unreleased in utterance-medial codas; I assume the same holds for Apinayé C. Given this, there is a simple explanation for the fact that underlying / $\tilde{V}b.dV$ / surfaces as [ $\tilde{V}m.dV$ ] rather than as [ $\tilde{V}mb.dV$ ]: the first stop lacks a release, and an unreleased prenasal [*mb*] is just a nasal closure [*m<sup>̃</sup>*]. Section 4 provides further evidence for this line of argument.

So far, then, rule (78) proves adequate to handle nasality assimilation in clusters, but two cases (*Vb.n $\tilde{V}$*  and  $\tilde{V}m.n\tilde{V}$ ) continue to look problematic. The explanation for these patterns requires us to reconstruct certain aspects of the phonetic implementation of Apinayé postnasals. The rule in (78) predicts that /*Vb.d $\tilde{V}$* / sequences will surface as [*Vb.dn $\tilde{V}$* ], rather than the attested [*Vb.n $\tilde{V}$* ]; and that / $\tilde{V}b.d\tilde{V}$ / will surface as [ $\tilde{V}m.dn\tilde{V}$ ], and not as [ $\tilde{V}m.n\tilde{V}$ ]. I claim that the phono-

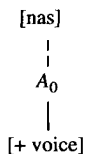
logical representations in terms of *A* positions involve a nasal release only, as in the predicted surface representations [Vb,dn $\tilde{V}$ ], [ $\tilde{V}$ m,dn $\tilde{V}$ ], but that the oral portion of the closure of [dn] is not easily perceptible in a cluster. Recall (from the discussion of Gokana) that there are two ways of realizing a postnasal stop, depending on whether the velum is lowered early or late, that is, before or after the oral release. From Callow's transcriptions [V.bm $\tilde{V}$ ], I deduce that the Apinayé postnasals involve early velum lowering; thus only part of the closure of postnasals is phonetically oral. I note next that, in general, the duration of consonant clusters is less than the sum of the expected durations of the cluster members. This predicts a certain reduction in the duration of each Apinayé stop occurring in clusters, in particular in the duration of the postconsonantal postnasals. It is reasonable to assume that the cluster reduction involves the early, oral, portion of the closure and thus essentially neutralizes the distinction between postnasals and plain nasals by reducing the oral portion of the onset postnasal to the point of making it imperceptible.<sup>23</sup>

Finally, in the case of stop clusters surrounded by nasal vowels, the effect of cluster reduction, as outlined above, would be to turn the predicted phonological sequence of nasal closure, oral closure, and nasal release into a perceived sequence of nasal closure, nasal closure, and nasal release, or a cluster of two fully nasal stops. If this suggestion is adopted, no phonological rule need be postulated beyond (78).

Regardless of the final analysis of nasalization in postconsonantal stops, the overall pattern of Apinayé *C* nasalization confirms in every respect the prediction that noniterative rules, regressive or progressive, will create nasal contours on plosives and only on plosives.

The facts of Apinayé *B*, Burgess and Ham's dialect, differ from those of Apinayé *C* chiefly in the realization of voiced stops before oral vowels. While the Apinayé *C* stops are realized as fully oral in this context, those of Apinayé *B* are prenasal. Thus Apinayé *C* /ba/ corresponds to Apinayé *B* /mba/. Further, the voiced stops of Apinayé *B* occurring before nasal vowels surface as fully nasal rather than postnasal: Apinayé *B* /mã/ corresponds to Apinayé *C* /bmã/. Finally, Apinayé *B* coda stops are always realized as nasals, regardless of whether they follow nasal or oral vowels; thus Apinayé *B* has forms like [om], where we expect Apinayé *C* [ob]. I analyze all three differences as stemming from one low-level rule of Apinayé *B*: this rule nasalizes the closure of a voiced stop.

(79) Closure Nasalization:





netic delay in the onset of nasalization on the consonant. The delay is obviously motivated by the fact that the preceding vowel is *distinctively* oral: had nasalization started “on time,” at the very beginning of the stop closure, the possibility of anticipatory nasalization affecting the preceding vowel would have muddled the contrast between oral and nasal vowels. In any case, nothing in the Kaingang paradigm forces us to conclude either that [–nasal] spreads or that ternary contours of nasality exist.

### 3.3.4. BARASANO AND CUBEO

I now consider two cases of bounded leftward spread which appear more problematic. A non-structure-preserving process nasalizes the continuants /h/, /r/, /w/, /y/ yielding [h̃], [r̃] or [ñ], [w̃], and [ỹ]. The same rule turns the stops /b/, /d/, /g/ into the corresponding nasals [m], [n], [ŋ]. The rule is bounded (since /VN̄V/ sequences maintain the initial oral vowel) and not subject to structure preservation (since it generates nonunderlying nasal approximants). For this reason, its fully nasalizing effect on stops appears problematic: we would expect postnasal stops instead.

The languages displaying this pattern are Cubeo and two dialects of Barasano, all spoken in the Vaupes region of Colombia. I consider first Southern Barasano, an Eastern Tucanoan language described by Smith and Smith (1971). The following is the phoneme inventory.

(82)	p	t	k	u	ũ	i	ĩ
	b	d	g	o	õ	e	ẽ
		s				a	ã
		r					
	w	r	y				

There is allophonic variation between oral and nasal consonants, as determined by a following nasal vowel. All the voiced segments become fully nasal before nasal vowels. The voiceless /p/, /t/, /k/, /s/ remain unchanged. Before oral vowels the approximants are always oral, but the stops vary between “oral with lenis nasal onset” and “oral with non-lenis nasal onset.” Smith and Smith do not elaborate on what this means, but their transcriptions of stops before oral vowels vary between [b], [d], [g] and [ᵐb], [ᵐd], [ᵐg]. I assume that the two variants involve a greater (“nonlenis”) versus lesser (“lenis”) amount of nasalization in the closure. In word-initial position before oral vowels, all voiced stops are consistently transcribed as prenasal [ᵐb], [ᵐd], [ᵐg].

(83)	a.	Before oral V:	Before nasal V̄:
		<i>hoa</i> ‘hair’	<i>h̃ēõre</i> ‘to light’
		<i>kariwa</i> ‘chief’	<i>r̃iã</i> ‘egg’
		<i>riaga</i> ‘river’	<i>w̃ãti</i> ‘demon’



b. Before oral V:		Before nasal $\tilde{V}$ :	
<i>mba</i>	‘uncommitted’	<i>māhāmā</i>	‘go’
<i>waba</i> ~ <i>wamba</i>	‘come’	<i>ŋāmōrōrī</i>	‘ear’
<i>mbedi</i> ~ <i>mbendi</i>	‘brother’	<i>nīse</i>	‘black’
<i>riaga</i> ~ <i>riaŋga</i>	‘river’	<i>romīō</i>	‘woman’
<i>ndiro</i>	‘grasshopper’		

Forms like /*koeamī*/ ‘he washes’, /*hioamī*/ ‘he pours’, /*romīō*/ ‘woman’ indicate that the regressive nasal assimilation is not iterative.<sup>24</sup> Why, then, does it nasalize both the release and the closure positions of voiced stops? As noted, Structure Preservation cannot explain the effect, since the rule’s outcome is clearly non-structure preserving for either approximants or stops.

What seems to me to be the key observation is that the “oral” stops have some degree of nasalization in their closure regardless of context. I do not assume this nasal closure to be distinctive or underlying; however, its mere existence is sufficient to solve the problem at hand. So I postulate a low-level rule of closure nasalization identical to (79) above.

The cumulative effect of nasalizing the stop release—by applying a leftward noniterative [nasal] spread identical to (72)—and nasalizing the closure—by a rule like (79)—will be fully nasal stops. It does not matter whether the amount of nasality introduced by (79) is great or small, since even a partially or weakly nasalized closure followed by a fully nasal release will be easily perceived as a nasal stop. Although this explanation does justice to the entire Southern Barasano paradigm known to me, an alternative analysis is also possible. I present it in the discussion of the other Barasano dialect.

The phonology of Northern Barasano (spoken in areas of Colombia and Brazil) has been studied by Stolte and Stolte (1971). The phoneme inventory differs from that of the Southern branch only in the absence of /s/ and the presence of the high central vowels /*ɥ*/, /*ĩ*/. The approximants /*w*/, /*r*/, /*ɣ*/ are reported as nasalized when “contiguous” to nasal vowels (p. 89), although there is some inconsistency in transcribing the nasal approximants after the nasal vowels. When located before nasal vowels, the approximants are regularly transcribed as nasal. The laryngeal [h] is recorded as oral in all contexts, including when flanked by nasal vowels, but Stolte and Stolte report that nasality propagates from syllable to syllable precisely when the onset consonant is [h], that is, in  $\tilde{V}hV$  contexts. This suggests that [h] is nasal in such cases and perhaps others. The voiced stops are fully nasal before nasal vowels, prenasal after nasal vowels and sometimes in word-initial position, but oral otherwise.

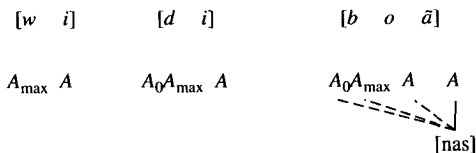
(84) a. Before oral V:		Before nasal $\tilde{V}$ :	
<i>we</i>	‘black paint’	<i>wīāpu</i>	‘to light’
<i>yuka</i>	‘again’	<i>do:ȳā</i>	‘come’
<i>waru</i>	‘ribs’	<i>hūārīhe</i>	‘red’

<i>ihero</i>	‘mouth’	<i>kīha</i> → <i>kīhā</i> ([kīhā]?)	‘they’
		<i>yēhēřike</i>	‘hurting’
b. Before oral V:		Before nasal $\tilde{V}$ :	
<i>botirihe</i> ,	‘white’	<i>widimōā</i>	‘lemon’
<i>mbotirihe</i>			
<i>wuabe</i>	‘cassava’	<i>mōā</i>	‘fly’
<i>amoki</i>	‘chicken’		
<i>ndahe</i> ,	‘toucan’	<i>nīhāwī</i>	‘I was/ we were’
<i>dahe</i>			
<i>widimoa</i>	‘lemon’	<i>mīnō</i>	‘tobacco’
<i>kandi</i>	‘edible part of fruit sp.’	<i>nūā</i>	‘ashes used for pottery’
<i>dakegi</i>	‘child-boy’	<i>itaŋā</i>	‘stone’

It appears that there is an obligatory rule spreading nasality leftward, since all voiced segments are fully nasal before nasal vowels. The rule is probably not unbounded, as indicated by forms like [waimāhā] ‘fish people’, [widimōā] ‘lemon’, although relevant data indicating this are scant. As in Southern Barasano, nasalization is non-structure preserving. And, unlike in Southern Barasano, there is no motivation for postulating a rule that nasalizes the closures of voiced stops, since the prenasal allophones occurring in oral contexts are limited to initial position and considered rare even then. Why is it, then, that this regressive nasalization creates fully nasal rather than postnasal stops?

My suggestion is that the rule, although bounded, is iterative. The domain of the rule is the syllable: regressive nasalization cannot proceed across the boundaries of its original syllable, and this accounts for forms like [widimōā]. But within the syllable, the rule is iterative and may in principle affect any sequence of A positions. This is why both the closure and the release of stops are affected. I illustrate in (85) the iterative, syllable-bounded mode of operation of Northern Barasano nasalization. Syllable boundaries are indicated as bracketings around segments. The effects of nasalization are shown below the bracketed segments, on the corresponding A positions.

(85) *widibōā* → *widimōā*



We note that syllable-bounded iterative assimilations are independently attested (e.g., Clements & Sezer, 1982, on Turkish [back] assimilation within the syllable); so are the nasal assimilations taking place within a given prosodic domain, such as the metrical foot (e.g., Guaraní, in van der Hulst & Smith's, 1982b, analysis). The mode of operation I postulate for Northern Barasano nasalization thus involves the intersection of well-motivated parameters. Although this cannot be verified in Barasano, I predict that a language with this type of nasal assimilation will nasalize all onset clusters in their entirety. The proposal made for the Northern dialect may well be adequate for the Southern one as well.

The few remarks made by Stolte and Stolte on the distribution of nasal and oral segments after nasal vowels appear to indicate that an optional rule exists which propagates nasality rightward in noniterative fashion. This explains why the voiced stops may become prenasal in this context. The effects of this rule on approximants, however, cannot be directly observed, as it is clear that a more general process propagates nasality rightward onto a maximal sequence of approximants. This and other aspects of Barasano phonology are not adequately illustrated in our source.<sup>25</sup>

### 3.4. The Output of Iterative Rules

Iterative rules, when applicable to any sequence of *A* positions, are predicted to affect both the closure and the release of oral stops: this excludes in principle the creation of nasal contours.

I mention first some of the many processes that are consistent with this prediction. Two other Eastern Tucanoan languages, Desano and Tatuyo, display unbounded nasal harmonies that turn the voiced continuants [w], [r], [y] into the corresponding nasals [w̃], [r̃], and [ɲ]. The unbounded character of the rules is illustrated below. The morpheme placed in parentheses cannot—for morphological reasons—be affected by nasalization. A careful discussion of the interaction between the morphology of Tatuyo and nasalization is provided by Gomez-Imbert (1978). The Desano data have been analyzed by Kaye (1971).

(86) Desano:

- a. *doʔobe - a - (by)* → [nōʔōmāby] 'I moved'
- b. *sedā-du* → [sēnānū] 'pineapple'
- c. *by-da* → [m̃yṅā] 'old men'

- (87) Tatuyo:
- a. *ki-bak-ire* → *kĩmākĩrē* 'to his son'
- [nas]
- b. *kiha-dodi-wi* → *kĩhānōnĩwĩ* 'we (excl.) gave'
- [nas]
- c. *ko-dodi-yu-pa-i* → *kononinupii* 'they say he gave to her'
- [nas]

Further examples of unbounded [nasal] spread generating fully nasal segments are the Gokana Rightward Spread discussed above and the nasalization rule of Suku discussed by Piper (1977: 34). The Suku data are interesting because the language allows prenasal stops, yet progressive nasalization turns underlying sequences like /kam-ud-ud/, /san-ad-ad/ into surface [kamūnūn], [sanānān].

At least two languages (Guaraní, as described by Gregores & Saurez, 1967, and Terena, as described by Bendor-Samuel, 1960) display nasal contours in the output of what appear to be iterative rules of nasal assimilation. These systems raise questions, not directly for my claim about the output of unbounded nasalization rules, but rather for the hypothesis that [nasal] is a privative feature: the standard analyses of rules of this sort (reviewed by van der Hulst & Smith, 1982a,b) generate the surface contours by relying on the presence of [-nasal] in the input strings. Although it is possible to show that these phenomena do not in fact require the adoption of oral autosegments, I do not address this issue here.

I now summarize the discussion of this section by displaying in tabular form the predicted results of noniterative nasalization rules, as determined by the mode of operation of the rule and by the segments affected.

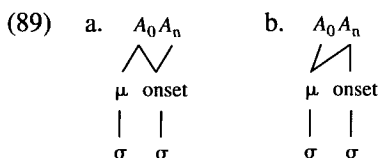
(88)	On continuants	On stops	Examples
		Left to right	
Structure preserving	n/a	Fully nasal	Auca (lexical)
Non-structure preserving	Fully nasal	Prenasal	Auca (postlexical) Zoque Apinayé
		Right to left	
Structure preserving	n/a	Fully nasal	?
Non-structure preserving	Fully nasal	Postnasal	Gokana Zing Mumuye Apinayé Gbeya

#### 4. UNRELEASED STOPS CANNOT SUPPORT NASAL CONTOURS

An unreleased stop is a plain closure:  $A_0$ . The absence of a release position makes such sounds structurally identical to the continuants: they can be fully oral or fully nasal, but not partially nasal. This property of unreleased stops was important in my analysis of Apinayé. Here I present a more systematic look at the predictions derived from this idea.

Two types of data are considered. One is the realization of prenasal stops when geminated. The other is the realization of non-geminate nasal contour consonants in positions where the absence of release can be independently ascertained.

My analysis of geminate stops is based on Hayes's (1991) demonstration that the invariant property of geminates is their moraic status, rather than the presence of multiple association. Given their bipositional structure, geminate plosives can in principle surface as either a moraic closure with nonmoraic release, as in (89a), or as a moraic closure followed by a moraic release, as in (89b). In fact, there is considerable reason to believe that only (89a) is attested.



In support of (89a) as the unique representation of geminate stops is the fact that geminate affricates are always reported as containing a long stop portion with a release comparable in duration to that of non-geminate affricates. Had (89b) been an option, we would expect geminate affricates with long releases. A distinct consideration favoring (89a) is the fact that many languages possessing geminates do not allow released stops in their codas: indeed most languages, with or without geminates, disallow released stops in all but word-final rimes. Only the structure in (89a) permits this generalization to be maintained. In contrast, (89b), which contains a moraic release, is incompatible with any general constraint against stop releases in the rime. We would expect (89b) to be exploited, if at all, only in one of the extremely rare languages in which word-internal as well as word-final coda consonants surface as released.

In the remainder of this study I consider only (89a). The choice of this structure as the representation of geminate stops has immediate consequences for the analysis of nasal contours. I explore these below.

The data I present in this section show that in every single case where prenasals are placed in positions that disallow release, the underlying nasal contour surfaces as nasal. This is a central piece of evidence for my analysis of unreleased stops. It also provides an argument against the existence of [-nasal]. If the input structure had consisted of a [+nasal] closure followed by a [-nasal] release, we would not

expect that the loss of the release position would necessarily entail the loss of the [-nasal] autosegment. Features left floating can reassociate. If [-nasal] exists, we could not exclude in principle mappings such as those in (90).

- (90) a.  $\begin{array}{ccc} [+nas] & [-nas] & \longrightarrow & [+nas] & [-nas] \\ | & | & & \swarrow & \\ A_0 & A_{max} & & A_0 & (=^n d) \end{array}$
- b.  $\begin{array}{ccc} [+nas] & [-nas] & \longrightarrow & [+nas] & [-nas] \\ | & | & & \cancel{\swarrow} & \\ A_0 & A_{max} & & A_0 & (= d) \end{array}$

Yet it appears that [nd] never surfaces as [(<sup>n</sup>)d] when unreleased. A principled explanation for this is the nonexistence of [-nasal]. The release of prenasals is oral simply because it lacks an association to [nasal]. Once the release position is lost, nothing remains in the representation to perpetuate the underlying oral string.

#### 4.1. The Sinhala Unreleased Stops

Feinstein (1979) has analyzed the prenasal stops of Sinhala (an Indic language of Sri Lanka) as onset clusters consisting of homorganic nasal and oral stops. I follow his presentation of the Sinhala syllable structure in relation to prenasalization.

One relevant phenomenon is the word-final neutralization to which nasal and prenasal stops are subject.

(91) Sinhala inanimate nouns:

Singular definite	Plural		
<i>gamə</i>	<i>gaŋ</i>	'village'	
<i>kanə</i>	<i>kaŋ</i>	'ear'	
<i>bimə</i>	<i>biŋ</i>	'ground'	
<i>li<sup>n</sup>də</i>	<i>liŋ</i>	'well'	
<i>a<sup>m</sup>bə</i>	<i>aŋ</i>	'mango'	(Feinstein, 1979:247)

Feinstein identifies the final /ə/ as the marker of definiteness in singular nouns. The plurals are then the bare stems. The neutralization observed in the plurals of (91) is attributed to the effect of a cluster simplification rule (whereby the second of two coda consonants is lost) followed by a general neutralization in point of articulation affecting all coda nasals. The effect of the two rules is shown in (92).

- (92) Underlying            *li<sup>n</sup>d*    *gam*    *li<sup>n</sup>d-ə*  
 C → ∅/ C\_\_]<sub>σ</sub>        *lin*    n/a    n/a  
 [+nas] → ŋ/ \_\_]<sub>σ</sub>    *liŋ*    *gaŋ*    n/a

I propose a slightly different scenario. Sinhala stops are unreleased in syllable-final position. Lacking release, a prenasal stop—nasal  $A_0$  plus oral  $A_{max}$ —necessarily turns into a nasal closure. The lack of release can also be thought to

condition the loss of place features: following Trigo's (1988) proposals, I interpret Sinhalese [ŋ], in contexts other than before a homorganic stop, as a placeless glide. The loss of place distinctions is a normal process affecting unreleased nasals.

This interpretation of the data has the advantage of explaining why, in Feinstein's terms, it is precisely the second C in a syllable-final cluster that is lost: this second C is in fact the release, the part of stops typically disallowed in coda position. Feinstein notes (1979: 246) that, in general, prenasal stops do not occur in coda position. Surely this cannot be attributed to the cluster simplification rule  $C \rightarrow \emptyset / C\_ ]_s$ , since many languages lack such rules. Rather, the reason is that, whether or not they allow coda clusters, languages disallow released stops in coda position.<sup>26</sup>

Sinhala creates geminate consonants in certain morphological contexts. The exact derivational origin of the geminates is not important here. A possible analysis of the phenomenon is proposed by Feinstein; examples appear in (93).

(93)	<i>puttu</i>	'son-pl.'	<i>putaa</i>	'son-sg.'
	<i>gonnu</i>	'bull-pl.'	<i>gonaa</i>	'bull-sg.'
	<i>weddu</i>	'doctor-pl.'	<i>wedaa</i>	'doctor-sg.'
	<i>pottə</i>	'core-sg.def.'	<i>potu</i>	'core-pl.'
	<i>ginnə</i>	'fire-sg.def.'	<i>gini</i>	'fire'
	<i>reddə</i>	'cloth-sg.def.'	<i>redi</i>	'cloth'

When the input is a prenasal consonant, gemination yields a heterosyllabic nasal-stop sequence. In the examples in (94), the plural is the bare stem, while the singular forms involve the application of the gemination rule.<sup>27</sup>

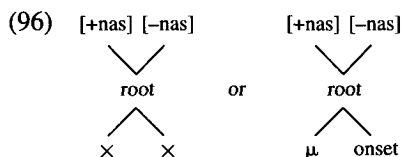
(94)		Singular	
	Plural	definite	
	<i>ka<sup>n</sup>du</i>	<i>kandə</i>	'hill'
	<i>ho<sup>m</sup>bu</i>	<i>hombə</i>	'chin'
	<i>hæ<sup>n</sup>di</i>	<i>hændə</i>	'spoon'
	<i>ko<sup>n</sup>du</i>	<i>kondə</i>	'backbone'

The reported nature of the contrast between Sinhala geminate and non-geminate prenasals is as predicted by the claim that geminate stops differ from non-geminates in possessing a moraic closure. A geminate prenasal will therefore have a correspondingly lengthened nasal  $A_0$ .

(95)		
	[nd] in [kan.də]	[ <sup>n</sup> d] in [ka. <sup>n</sup> du]

Maddieson and Ladefoged (this volume) provide some additional data on the nature of the difference between the geminate and simplex prenasals of Sinhala. Their interpretation is that even on a purely phonetic basis, the contrast in Sinhala appears more appropriately described as a contrast of single versus geminate nasals followed by stops, that is [mb, nd] versus [mmb, nnd], and so on. This is reflected directly in the structures in (95): the lengthened phonetic duration of the nasal portion reflects the moraic nature of the closure. From examining the spectrograms provided by Maddieson and Ladefoged, it also appears that, for their examples, the release portions are durationally identical for geminate and non-geminate prenasals. This too points to (95)—and hence to (89a)—as the correct structure.

It should be noted that in a framework such as Sagey's (1986), where prenasal segments are analyzed as root nodes linked to the sequence [+nas][−nas], geminate prenasals raise questions about the nature of the mapping between phonological and phonetic structure. The difficulty is independent of the choice between a moraic and a nonmoraic notation, as can be seen by inspecting the structures shown in (96).



One conceivable phonetic realization of the structures in (96) is that both the coda and the onset segment will surface with nasal contours; this would yield the never-attested surface strings [n<sup>h</sup>d<sup>h</sup>d]. Another possible interpretation of (96) is that the combined duration of the coda + onset sequence will be evenly divided into a nasal and an oral half. A third possibility is that the relative duration of the nasal and oral portions will vary unpredictably, among different languages or different speakers.

None of these interpretations is consistent with the facts recorded by Feinstein or with the additional instrumental data provided by Maddieson and Ladefoged: the nasal stretch alone is lengthened, in just the same way that the noncontinuant half alone surfaces lengthened in a geminate affricate. There is no plausible principle of phonetic interpretation that will take as input either structure in (96) and deliver the desired temporal relations between the nasal and oral portions of geminate prenasals.<sup>28</sup>

## 4.2. Coda Nasal Contours Elsewhere

A look at other languages suggests that the properties of Sinhala prenasals hold cross-linguistically. The prediction that prenasal plosives can surface as such



only in positions where stop releases are independently allowed receives further confirmation.

Samarin (1966) reports that Gbeya prenasals are permitted prevocally but disallowed as codas, a position where other stops, oral as well as nasal, are attested. Before clitics beginning with oral vowels, a stem-final nasal alternates with a prenasal stop.

(97)	<i>tom</i>	'to send'	<i>tomb-aa</i>	'send him'
	<i>bom</i>	'to be blind'	<i>bomb-a</i>	'became blind'
	<i>kam</i>	'food'	<i>kamb-aa</i>	'the food'
	<i>?doŋ</i>	'back'	<i>?doŋg-aa</i>	'the back'

A possible analysis of these alternations is that the stems in question end in underlying prenasals. These survive in contexts where they can be syllabified as onsets, that is, where a release is permitted, but lose their oral portion where the release is disallowed. An alternative analysis is that surface [tom] corresponds to underlying /tom/, rather than /tomb/, and that the prenasal in [tombaa] is created by resyllabification. Before resyllabification, /tom/ ends in an unreleased stop, the only *A* position licensed in Gbeya codas. Once the stop is moved to a position where a release is allowed, the stop release is automatically projected. In this case, the oral quality of the release is simply the result of the fact that no Gbeya rule provides for the surface spreading of nasality from closure to release. The data provided by Samarin are not sufficient to choose between these two scenarios, but both support the general lines of my analysis.<sup>29</sup>

In Lua, a language of Chad analyzed by Boyeldieu (1985), the prenasal plosives /mb/, /nd/, /nj/ and /ŋg/ are attested in initial, intervocalic, and medial postconsonantal position; that is, in all positions where a consonant would be syllabified as onset and where stops would be able to maintain a release. The prenasals are absent in word-medial preconsonantal and in word-final position; that is, in contexts where a consonant would be syllabified as a coda. Boyeldieu mentions repeatedly that both nasal and oral stops of Lua are unreleased in the very same contexts where prenasals are disallowed, namely, in the coda (1985:75, 76, 80, 84). Significantly, the affricates of Lua, /č/ and /ʃ/, are also generally disallowed in coda position, presumably because, in the absence of the distinctive fricative release, the difference between unreleased palatoalveolars and unreleased alveolars is hard to perceive.<sup>30</sup>

The prenasals of Mbum (Hagège, 1970), Fe'efe's Bamileke (Kamga, 1944), Ghomala Bamileke (Nissim, 1981), Ngambay (Vandame, 1961), and Lamé (Sachnine, 1982) are subject to identical phonotactic restrictions. In all these languages, plain oral and nasal stops are allowed in coda position, along with other consonants, but prenasals and affricates are disallowed; both facts can be explained as stemming from the absence of release in coda stops.

In general, I have not encountered any language that displays nasal contour

segments in positions where a stop is necessarily unreleased: that is, in preconsonantal codas. The postnasal coda segments of languages like Land Dayak (Scott, 1964) and Wolof (Poser, 1979) are attested only word-finally, a position where stops are demonstrably released.

## 5. CONCLUSIONS

### 5.1. A Remark on Contours

Phonologists study contour segments as a class because they represent a paradox. On the one hand, they are tautosyllabic onset sequences even in languages where no other onset clusters are allowed. On the other hand, they are phonetic sequences of distinct gestures, each of which can be identified with a separate segment: /<sup>n</sup>d/ contains something that looks like /n/ and something that looks like /d/. If we claim that /<sup>n</sup>d/ is a cluster, then in languages like Sinhala where complex onsets are generally disallowed we must explain why this particular cluster, to the exclusion of others, is a possible onset; and we must tailor our theory of sonority sequencing to the explanation, a rather daunting task. If we claim that /<sup>n</sup>d/ is a single segment, we must explain why one segment may encompass this particular sequence of articulatory gestures—lowering and then raising the velum—rather than any other conceivable gestural sequences. Are /kt/, /km/, /rp/, /str/, /ws/ also conceivably analyzed as single segments? If not, why not?

The paradox I describe has been recognized since Anderson (1975, 1976) demonstrated that nasal contour consonants must contain in their phonological representations a nasal and an oral substring. As Anderson shows, one cannot claim that the phonological distinction between /<sup>n</sup>d/, /d<sup>n</sup>/, /d/, and /n/ involves any features other than [nasal]: [sonorant], [continuant], or [delayed release] will not adequately characterize the contrast between nasal, oral, and nasal contour segments. The solution advocated by Anderson, and adopted in all subsequent work, was to admit that sounds like /<sup>n</sup>d/ contain a sequence of distinct specifications for [nasal]. This recognition, however, leads directly, as Anderson himself noted, to the questions raised above: Which configurations of distinct feature values define a segmental boundary and which do not? What principles will regulate the distinction between intrasegmental and cross-segmental gesture sequences?

My study has not so far addressed these questions. Up to now I have concentrated on making one empirical point: that the distinctive occurrence of nasal contours is tied to the presence of a closure and a release. This central observation now suggests some remarks about the distinction between single segments, with or without contours, and segment sequences.

Nasal contour consonants belong to a larger class of phones whose status as

single segments is ambiguous. The other well-known members of that class are the affricates, also standardly analyzed as involving a phonological contour.<sup>31</sup> We may add to these the laterally released stops as well as the pre- or postspirated and pre- or postglottalized stops. All these phones involve phonetic sequences of distinct gestures, each of which corresponds, in a standard feature inventory, to a distinct feature value: [–lateral] and [+lateral], [–spread glottis] and [+spread glottis], and so on. All these sounds have the distributional characteristics of the nasal contours: they are allowed to occur in positions where a language otherwise tolerates only single segments. The question then is how to distinguish these sounds from the unambiguous clusters: what makes them single segments despite the presence of contours.

I suggest that there are two factors distinguishing clusters from single segments. One is that true single segments contain either a single *A* position or a sequence of *A* positions that could be attributed to the mechanisms of release projection discussed earlier [cf. (7, 8)]. A released plosive such as /<sup>n</sup>d/ or /d<sup>n</sup>/, although containing both a closure and a release, can be traced back to a single basic *A*<sub>0</sub> in this way. That is, in part, what allows this sequence to be identified as a single segment. In contrast, strings like [lt], [pt], [sp], [ws] contain sequences of *A* positions that could not have been projected from a single segment. As a result, they will always be viewed as unambiguous clusters<sup>32</sup> and will function phonologically as such.

A second necessary condition for viewing a sequence of articulatory gestures as a single segment is feature compatibility: phones analyzable as single segments must be bundles of nonconflicting feature specifications. Two feature values are nonconflicting, or compatible, if the corresponding articulations can be simultaneous. Thus /<sup>n</sup>d/ contains one [nasal] value, one place component, and one laryngeal feature. The three gestures corresponding to these features can be realized simultaneously and, in the case of /<sup>n</sup>d/, also happen to be. They are not simultaneous in /d<sup>n</sup>/—since [nasal] is realized on the release in this case—but the combined set of features realized on closure and release are still compatible with each other: they could be simultaneously articulated. A more complex example, the prenasal /<sup>n</sup>mgb/, is also amenable to this analysis, since its place component contains, as shown by Sagey (1986), two compatible and largely simultaneous active articulators, labial and dorsal.

According to the analysis proposed in (2), affricates are also bundles of compatible features: on the surface, they differ from simple stops not in their feature composition but in the nature of their release. Underlyingly, they differ from the corresponding stops in point of articulation or laryngeal features. I anticipate that an analysis of laterally released stops will reveal them to be identical in structure to other affricates. Their distinguishing feature is [lateral]. This feature is realized, necessarily, only on release; but this fact does not require us to represent the closure as [–lateral]. Thus there is no more reason to analyze a laterally released /tl/

as a sequence of incompatible values [–lateral][+lateral] than to analyze the affricate /č/ as the sequence [–continuant][+continuant].

Stops involving the laryngeal features of aspiration and glottalization also tend to be realized with some surface lag between the oral gestures and the laryngeal ones: typically the laryngeal gesture is realized on release. But, although such sounds are phonetic sequences of temporally ordered articulations, they satisfy the criteria for single segmenthood because they too represent one bundle of compatible features: one place component, one or no nasal specification, one laryngeal feature. Finally, two distinct laryngeal specifications can be analyzed as belonging to a single segment if they are compatible, but not otherwise: thus a voiceless closure followed by an aspirated release can correspond to the nonconflicting bundle of features [–voice, +spread] and thus can be analyzed as representing a single segment, a voiceless aspirated stop. But an aspirated closure followed by a glottalized release cannot be so analyzed, because [+spread] and [+constricted] are incompatible specifications. They could not be articulated simultaneously. Such articulatory sequences represent a sequences of distinct segments: a (pre-)aspirated stop followed by /ʔ/. Some empirical motivation for this aspect of my proposal is presented in Steriade (1992).

The condition that temporally ordered articulations must be compatible or nonconflicting in order to be attributed to a single segment can be developed as the motivation for the ban against “true” segmental contours in (10). It was mentioned earlier that there is little or no reason to assume that configurations such as (10) exist in the phonology. Perhaps the reason they do not is that single *A* positions are necessarily analyzed as single segments: as such they cannot contain pairs of incompatible feature values [αF] and [–αF]. Further work on the nature of the mapping between articulatory gestures and phonological representations is needed in order to develop this idea.

In a nutshell, my solution to the paradox posed by contour segments is this. An articulatory sequence represents one segment if (1) it is analyzable as a basic single *A* position and (2) if its featural components represent actually or potentially simultaneous articulations. Note that this solution does not commit us to the view that prenasal consonants—or any other contour segments—which emerge as single surface segments according to our criteria are underlyingly single segments. I accept Herbert’s (1986) argument that a majority of prenasal contours arise from underlying sequences of distinct segments: a nasal and a following consonant. But I am interested in explaining why this particular class of underlying sequences is treated as single segments once they become prenasal plosives. My criteria for defining single surface segments do not deal with derivational history: rather they are proposed as ways of mapping articulations onto surface phonological structures.

The theory of gesture-to-segment mapping sketched here relies critically on the claim that nasal contour segments do not contain a [–nasal] value, in addition to

their [+nasal] specifications; for if they did, they could not represent a bundle of compatible features. To the extent, then, that this represents a satisfying resolution of the paradox of contour segments, it reinforces my belief that [nasal] is privative and it supports the theory of aperture positions I have presented.

## 5.2. A Comparison with the Standard Theory

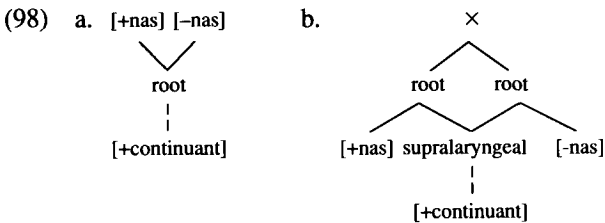
I have not so far discussed the standard theory of nasal contours or that of segmental contours in general. Implicit in my discussion throughout the article has been the claim that the standard theory must be abandoned because it fails to predict the restrictions observed on the distribution of nasal contours. I conclude with a brief review of the differences between my proposals and the established views.

What is the standard theory of segmental contours? Following Anderson's (1976) lead, most phonologists assume that certain features or certain types of autosegments have the ability of creating intrasegmental sequences. Whether a given [ $\alpha$ F][ $\beta$ F] sequence represents an intrasegmental or a cross-segmental sequence depends exclusively, according to this view, on what autosegment F represents. Thus Anderson's discussion leads to the conclusion that any [ $\alpha$ nas][ $\beta$ nas] sequence can be intrasegmental, but that an [ $\alpha$ continuant][ $\beta$ continuant] sequence cannot be. Similarly, according to Sagey (1986), a sequence of distinct [nasal] or [continuant] specifications may be traced to the same root node and hence may be considered intrasegmental, but a sequence of distinct class nodes (e.g., two place nodes or two laryngeal nodes) cannot. Anderson and Sagey, although proposing substantially different hypotheses, appear to agree on one central point: whether the sequence is intrasegmental or not depends exclusively on the autosegments involved.<sup>33</sup> The task of a theory of contours, then, becomes that of defining the set of autosegments that can create intrasegmental sequences. This is the core of what I call here the standard theory of segmental contours.

My proposal is that the factor controlling the possibility of intrasegmental contours is the number of *A* positions of the segment, not the nature of the relevant features. Contours may occur inside released plosives because these segments contain two distinct *A* positions. A nasal contour, I have argued, is a plosive in which only one of the two *A* positions is linked to [nasal]. A laryngeal contour segment, such as a postaspirated stop, is a plosive in which only one *A* position is linked to the relevant laryngeal feature. A lateral contour, a laterally released plosive like /tʎ/, is a plosive whose release alone instantiates the underlying specification [lateral]. (An affricate, previously viewed as a continuancy contour, emerges not as a contour segment but as a stop with fricated release.) Contours may not occur internal to an *A* position for two reasons. First, some features, such as [nasal], are privative. Second, the features likely to emerge as binary, such as [back] or [high], cannot have two distinct values—such as [+high] and

[–high]—associated to a single *A* position, as a consequence of the constraint formulated in (10) (a principle whose motivation was outlined in the preceding section).

This study has shown that the pre- and postnasal segments are exclusively plosives. This is exactly the prediction of a theory of aperture positions such as the one sketched here. The standard theory—whether in Anderson’s, Sagey’s, or Piggott and Rosenthal’s versions—cannot explain what rules out configurations such as those given in (98), in which the nasal contour appears inside a continuant.



The structure in (98a) reflects Sagey’s (and indirectly Anderson’s) ideas on nasal contour segments. The structure in (98b) is compatible with Piggott’s and Rosenthal’s proposal that nasal contours involve distinct root nodes. It has been shown here that the structures corresponding to either (98a) or (98b) are unattested: they are not found either as members of phonemic inventories or as derived outputs of phonological rules. In particular, the bounded rules propagating [nasal], the most likely sources of derived [nasal] contours, have been shown to generate contours only on plosives, never on continuants.

A related finding is that plosives permit nasal contours only to the extent that they contain a release position. Unreleased plosives are not prenasal or postnasal: they are indistinguishable from plain nasals. This too remains an unexplained fact under all versions of the standard theory, in large part because the distinction between released and unreleased stops is not represented phonologically. The results presented here indicate, moreover, that it is not sufficient to distinguish [+released] from [–released] stops, as suggested in the pioneering work of Kim-Renaud, McCawley, and Selkirk. A contrast such as [–continuant, –released] versus [–continuant, +released] would not explain why nasal contours can be associated to [+released] but not to [–released].

Finally, the standard theory of nasal contours implies an untenable general theory of segmental contours. Untenable, because it cannot answer a fundamental question: Which feature contours are intrasegmental?

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## NOTES

<sup>1</sup> Catford points out that, according to the criteria outlined in the text, high vowels are approximants rather than resonants. I nonetheless assume that it is possible to minimally amend his definitions of stricture degrees in such a way as to keep all vowels in the resonant class. This is not attempted here, as I do not address the issue of structural differences between vowels and approximants.

<sup>2</sup> McCawley (1967:528) makes a similar point: “the system of features which play a role within the phonological component is anything but the extremely limited class of largely ‘distinctive’ features which it until recently was generally assumed to be. . . . The phonological component, rather than affecting the ‘more distinctive features’ in the ‘earlier’ rules, and the ‘less distinctive’ features in the ‘later’ rules, as is sometimes supposed, must operate in terms of highly non-distinctive features even in very early rules of the grammar, such as the rule making syllable final stops unreleased indeed is.”

<sup>3</sup> Some writers (Clements & Keyser, 1983; van der Hulst & Smith, 1982a) also mention short diphthongs as instances of segmental contours. But no language known to me has distinctive contrasts such as monomoraic /ai/ vs. bimoraic /ai:/; the quantity of diphthongs appears to be always predictable from their segmental composition or from the metrical position they occur in. Given this, I do not count them as viable candidates for contour representations.

<sup>4</sup> See also Trigo (this volume); and, for an opposing viewpoint, Cohn (1990).

<sup>5</sup> One can only guess at the reasons for using ⟨nr⟩ or ⟨nz⟩ digraphs when representing fully nasal continuants. One possibility is that the major perceptual clue to the nasality of these sounds is the anticipatory nasalization of the preceding vowel: the consonant itself—a trill ⟨nr⟩ or a fricative ⟨nz⟩—is probably only weakly nasalized, for reasons discussed by Ohala (1975:300) and Ohala and Ohala (this volume). The weak nasality on the trill or spirant may require the hearer to rely heavily on contextual clues, such as the nasality of the preceding vowel. This explains the choice of digraphs, as well as the fact, observed by Caprile (1968:30), that Mbay ⟨nr⟩ is limited to word-medial position: word-initially, the nasality will be confined to the rhotic itself and may become difficult to detect.

<sup>6</sup> Piggott (1988), followed by Rosenthal (1989), propose bisegmental representations for what they consider to be genuine prenasal fricatives. Thus /ns/ is represented as a [−cont][+nas] root node followed by a [+cont][−nas] root node. Such representations appear to embody a claim similar to mine, that these sounds are affricates rather than fricatives. Unlike me, however, Piggott and Rosenthal claim that prenasal affricates and “fricatives” can contrast within one language; consequently they propose structural differences between the two sound classes. I dispute this point. Other differences between my approach and theirs are discussed in the last section of the article.

<sup>7</sup> I list Lua here because of its treatment of nasal–fricative sequences in loanwords like [konʃe] from French [kõʒe] ‘vacation’. Lua has a native prenasal /nʃ/ which belongs to a series of prenasal plosives but has no demonstrable native sequences of N-fricative. Presumably the Lua speakers analyze the nasal vowels of French as consisting of vowels followed by nasal consonants. Hence [kõʒe] is analyzed as underlying /konʒe/ and realized as a prenasal affricate identical to the native [nʃ].

<sup>8</sup> Meeussen does not appear to differentiate moraic from nonmoraic nasals in his grammar, except in the case where the former bear a distinctive tone.

<sup>9</sup> What is transcribed as [mbv] involves presumably not only a labiodental release but also a labiodental closure. We assume, in any case, that phonologically speaking, there is a

single point of articulation present in [mbv] and that it is labiodental. On the necessity of [labiodental] as a point of articulation phonologically distinct from [labial] see Ladefoged & Maddieson (1986) and Gorecka (1988).

<sup>10</sup>My source on Lega and Ganda is Herbert (1986); on Rundi, see Meeussen (1959); on Kinyarwanda, see Kimenyi (1979). The phonology of Bamileke-Ghomala is analyzed in careful detail by Nissim (1981). A brief look at the phonology of Venda appears in Zier-vogel, Wentzel, & Makuya (1972).

<sup>11</sup>The Rwanda change from /p/ to /Φ/ to /h/—like many parallel cases elsewhere—fails to apply to the prenasal /mp/, but it is likely that the prenasal segment blocks not the debuccalization step but rather the change from a stop /mp/ to a nasal fricative /Φ̃/.

<sup>12</sup>Herbert (1986:247) points out that there are Ntomba stems in which /s/ no longer undergoes the change to /h/, as well as stems in which the rule applies variably (e.g., /lohai/ ~ /losai/ 'vanity', plural /nsai/). I see no reason to conclude from this that the synchronic Ntomba rule is a postnasal fricativization of /h/, as Herbert seems to suggest.

(i)  $h \rightarrow s/N\_\_\_$

Rule (i) will still face the difficulty of requiring some lexical distinction between the stems that undergo it invariably and vacillating stems like /lohai/ ~ /losai/. Moreover, as Herbert notes, the change of /h/ to /s/ is simply unattested elsewhere.

<sup>13</sup>An affricate [dr̥] is found in Fijian as the oral counterpart of [nr̥] or [ndr̥]. Sounds transcribed as [tθ] are attested, for instance, in Chipewyan (Li, 1946).

<sup>14</sup>We will see below that the additional constraints of structure preservation modify this prediction slightly.

<sup>15</sup>The following articulatory details provided by Saint and Pike show that the process of nasalization creating the prenasal stops is more than a minor phonetic implementation process:

Approximate timing of velic action with delayed closure of the nasal passage may . . . lead to a very slight optional nasal at the beginning of the voiced stops [<sup>m</sup>b, <sup>n</sup>d, <sup>ŋ</sup>g] when utterance initial. /beka/ [bika], [<sup>m</sup>bika] 'he drinks'. This nasal attack, however, becomes stronger, leading to nasal segments of the length of regular segmental phonemes, when the attack occurs between a nasal vowel and a stop: in this environment the nasal attack is obligatory. (1962:4)

<sup>16</sup>A. Cohn notes (personal communication) that invoking Structure Preservation in this case implies that stop releases can be a feature of underlying representation. This conclusion is reached in the following way: prenasals differ from nasal stops in the oral quality of their release. If plosive releases are absent underlyingly—as suggested in my Introduction—the distinction between nasals and prenasals cannot be present as such in underlying representations and we would not be able to invoke Structure Preservation as motivating the rule of Suffixal Nasalization. A possible resolution of this problem is to view Structure Preservation as the continuing enforcement of underlying filters on phonological representations, as argued in Calabrese (1988). The operative filter in the Auca case is that [nasal] linked to closure must also be linked to release. This filter is obviously not activated until releases are projected; but, once releases are present, the filter constrains the lexical representations of Auca.



<sup>17</sup>My analysis is still easily falsifiable, since structure-preserving processes are typically associated with a cluster of properties identifying lexical rules: one of these properties is the presence of lexical exceptions, which the Auca structure-preserving nasalization displays.

<sup>18</sup>Zoque obstruents become voiced after nasals, regardless of whether the nasal-obstruent cluster is homorganic or not. This process is also observed in the effect nasalization has when it attaches to the closure of a voiceless stop.

<sup>19</sup>The same tendency to write sequentially articulatory gestures that are in fact simultaneous is evidenced in Wonderly's transcription of a sound he characterizes as a front rounded glide ("an unrounded bilabial spirant with the tongue in palatal position," p. 107) as ⟨wy⟩.

<sup>20</sup>Although Hyman is not explicit on this point, I assume that he meant to adopt a single unspecified liquid—which I write L—as the underlying source of [l], [r], and [n].

<sup>21</sup>I am not claiming that every sequence transcribed as [dã], [bã] is necessarily representing a postnasal stop, only that those in which nasality extends into the release of the stop are. For many examples of [bã], [dã] sequences in which the stop release is oral, see Cohn's (1990) work on the relation between the phonetic implementation and the phonological representation of nasality. See also Huffman (this volume). Such sequences would be analyzed as instances where nasality has not spread onto the preceding A position. At this point we lack the instrumental data to verify the status of the relevant Gokana sequences.

<sup>22</sup>Another point whose phonetics and phonology bear further investigation is the nature of the nasal consonants arising from the nasalization of continuants. In Auca, nasalization of the flap [f] yields a nasal flap [f̃]. In Gokana, however, nasalization of the spirant [z] is not transcribed as a nasal spirant [z̃] but as a stop [ɲ]. For the moment, we can assume that a further constraint active in Gokana requires all nonsyllabic nasals to be stops: this will ensure the transition from intermediate [z̃] to [ɲ]. The details of this, however, remain to be worked out.

<sup>23</sup>M. Huffman (personal communication) points out that an additional reason why phonological [Vb.dnṼ], [Ṽm.dnṼ] are perceived as [Vb.nṼ], [Ṽm.nṼ], without the oral portion of the onset stop, is that there are no VC transitions into the [d] portion of the postnasal stop and no CV transitions after it. The absence of these cues may be a sufficient explanation for Callow's nonnative perceptions and transcription.

<sup>24</sup>There appears, however, to exist an iterative rightward nasal assimilation in approximant sequences, as indicated by Smith and Smith's comment (pp. 84–85) that a nasal vowel is followed by a nasalized sequence to the end of the word. The data provided, however, were insufficient to allow a closer look at this process.

<sup>25</sup>Cubeo, whose phonology has been briefly described by Salser (1971), also belongs to the Eastern Tucanoan family and shares a significant number of features with Barasano. The distribution of oral, prenasal, and nasal stops is essentially identical to that of Northern Barasano. The approximants [y] and [h] have nasal allophones [ɲ] and [h̃] before nasal vowels; this too suggests a syllable-bounded leftward spreading rule. However, not enough details are given on the distribution of the other voiced continuants [w] and [ð] to allow a complete analysis. I would tentatively suggest that Cubeo nasalization is identical to that of Northern Barasano.

<sup>26</sup>An occasional exception is word-final codas, which may be released, on a language-

specific basis. Sinhala appears to disallow released codas across the board.

<sup>27</sup>Feinstein's notation records the difference between prenasals and the corresponding geminates in terms of syllable boundaries: /ka.ndu/ vs. geminated /kan.du/. I write [n<sup>d</sup>] vs. [nd].

<sup>28</sup>The structures proposed by Pigott (1988) and Rosenthal (1989) for prenasals do not face this particular problem, since these authors propose two root nodes for each nasal contour consonant. Their approach is much closer to mine but fails to explain what exactly disallows the second of the two root nodes in syllable-final position. I resolve this by identifying the second root node with the release position of the stop.

<sup>29</sup>It is not possible to claim that prenasals such as the one in [tomb-aa] are due to the leftward spread of orality from the suffixal vowel. As Samarina points out (1966:29), alternations like [tom]/[tombaa] take place only in stems containing oral vowels: a stem like /dūm/ 'to spear' will be realized as [dūm-ãã], not \*[dumb-aa], because it contains a spreading nasal autosegment that propagates to the end of the domain, onto oral vowels as well as consonants. This observation is inconsistent with an analysis that would require oral vowels to possess contrary [-nasal] specifications.

<sup>30</sup>Boyeldieu (p. 81) records one isolated example of coda /j/, which is exceptional in a number of other phonotactic respects.

<sup>31</sup>Cf. Ewen (1982), Clements & Keyser (1983), to cite only some of the earlier work on this subject. Anderson (1976) is the only writer to have pointed out, correctly, I believe, that "internal structure in terms of the feature [continuant] is not the correct way to describe affricates," because the fricative nature of the release is largely predictable from other properties of the plosive.

<sup>32</sup>Here I am not discussing the case in which sequential transcriptions like ⟨pt⟩, ⟨kp⟩ correspond to simultaneous articulations, but rather only cases in which there is reason to analyze the string as involving a sequence of distinct and temporally ordered closures. On multiple articulations see below.

<sup>33</sup>Rosenthal (1989) has proposed an interesting revision of Sagey's theory of contours which does not fall squarely under this characterization. The technical nature of Rosenthal's proposals—in particular his reliance on the somewhat obscure notion of *segment head*—precludes a full discussion of his views here. But the chief objections I raise below against the standard theory do appear to carry over to Rosenthal's theory as well.

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