Meinhof's Law and the Representation of Nasality*

G. L. Piggott
McGill University

1. Introduction

The oral-nasal contrast is present in many languages (Hockett 1955, Ferguson 1966, Maddieson 1986). The conventional representation of this contrast is in terms of the binary feature [+/-nasal], and this still seems to be the prevailing view (see Clements and Hume, to appear). However, the assumption that nasals are phonologically marked as [+nasal] and contrasting oral segments are [-nasal] leads to analyses of the distribution of nasality that are transparently ad hoc. The core of the problem is the apparent inability to provide a principled account of the conditions that determine when oral segments are specified as [-nasal]. For example, nasal harmony systems in languages like Warao and Malay seem to require that liquids and obstruents be specified as [-nasal] to explain why they are opaque to nasal spreading (van der Hulst and Smith 1982, Piggott 1989). In contrast, the corresponding consonants in Guaraní and Southern Barasano cannot be specified as [-nasal], because they are either targeted by nasal spreading or are transparent to the process. The specification of the nasal-oral contrast in languages with superficially similar consonant systems (i.e., Warao and Guaraní) seems to be completely arbitrary.

Nasal harmony patterns like those in Guaraní and Southern Barasano in which there are no opaque consonants pose another problem for the conventional specification of the nasal-oral contrast. In a system without underlying [-nasal] consonants, the feature [nasal] is functionally monovalent. This feature appears to have an equivalent status in expressing underlying nasal-oral contrast in vowel systems. Cases in which [-nasal] vowels pattern consistently with [-nasal] consonants are unattested. If orality can be the phonetic instantiation of the absence of specification for [nasal] in vowel systems and some consonant systems, one has to question whether the specification [-nasal] ever identifies a well-defined phonological unit. Further indication that the [-nasal] specification is not the appropriate description of non-nasal segments comes from the observation that [+nasal] segments never lose their nasality simply by assimilating [-nasal] from an adjacent consonant.

The resolution of the problems identified in the above paragraphs requires a radical rethinking of the conventional representation of the nasal-oral contrast. Such a rethinking is reflected in the proposals by Piggott (1992). Assuming the model of feature dependency, the so-called feature geometry, proposed by Clements (1985), Piggott proposes that the feature [nasal] is variably dependent of a Soft Palate (SP) node or a Sonorant (SV) node. The first part of the hypothesis agrees with Sagey (1986), the second part with Rice and Avery (1989) and Rice (1993). The variable dependency hypothesis allows for two distinct patterns of nasal-oral contrast. In one pattern the contrast is relevant to sonorants only, while the other reflects an opposition within a wider class of consonants that also includes obstruents. Piggott demonstrates that these patterns of contrast account for the distribution of transparent, opaque and targeted segments in nasal harmony systems. The present paper provides additional support for the hypothesis of the variable dependency of nasality by showing that it leads to an explanation of important features of the assimilation process referred to as Meinhof's Law or Ganda Law, which occurs in a

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number of Bantu languages (Herbert 1986). The analysis makes use of some of the significant insights of Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993a, b).

The organization of the paper is as follows. After the introduction, section 1.1 spells out the two ways of representing the nasal-oral contrast and provides a brief review of the evidence from nasal harmony patterns that support the variable dependency hypothesis. We also draw attention to the phonetic correlates of the SP and SV nodes. Because Meinhof’s Law applies to prenasalized stops, section 2.0 illustrates how such segments are derived in Bantu languages. The facts of Meinhof’s Law are then presented in section 2.1. The analysis begins in the next section. First, in section 3.1, we present our representations of the types of prenasalized consonants found in Bantu. Section 3.2 develops the traditional analysis of Meinhof’s Law as an assimilation process that spreads the feature [nasal] but restates it in a constraint-based theory in terms of alignment of a feature with the edge of a segment. This section also explains why only some of the prenasalized consonants are targeted by the process. In section 3.3, we offer some structurally-based reasons for the fact that the trigger of Meinhof’s Law varies across the Bantu languages. Section 4, the conclusion, discusses the merits of the proposed analysis over some current alternatives.

1.1 Variable Dependency and the Representation of Nasal-Oral Contrast

One of the earliest representations of the nasal-oral contrast in feature-geometric terms is found in Sagey (1986). She proposes that the theory of segment structure must recognize a set of monovalent articulator features, each of which is correlated with a specific active articulator. The set of articulator features includes place features like Labial, Coronal and Dorsal, associated with the lips, tongue front and tongue body, respectively, and the Soft Palate (SP) feature, associated with the action of the velum or soft palate. The articulator features have the status of superordinate nodes in the geometry, since they can dominate other features. Coronal, for example, may dominate the features [anterior] and/or [distributed], while the SP node dominates the feature [nasal].

The relationship between an articulator node and its dependents is phonetically significant. For example, the presence of Coronal in the representation of a segment is an indication that the tongue front is the active articulator, while the incorporation of [anterior] as a dependent is correlated with the point of articulation. The absence of a Coronal dependent does not mean that the place of articulation of the segment is completely unpredictable within the range of coronal possibilities. This is because interpretation is regulated by a theory of markedness which defines the apical/alveolar coronal as unmarked.1 The logic of this characterization of the relationship between phonological structure and phonetic interpretation can be extended to representations involving the SP node. The presence of the SP node is a phonological indication that the soft palate is the active articulator. There are only two positions of this articulator that is generally considered to be relevant to segmental contrast. It is either raised to block or impede airflow through the nasal passage or it is lowered to allow for unobstructed nasal airflow. The raised position, according to Chomsky and Halle (1968:300), is considered to be the neutral position and can, therefore, be assigned the status of the unmarked position. This means that, when the phonology indicates that the SP node is active and there is no further phonological indication of the position of the soft palate, it will be interpreted as being in the raised position. Phonological indication of a lowered velum is provided by the specification of the [nasal] feature as an SP dependent. A feature geometry that includes

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1 The articles in Paradis and Prunet (1991) contain a number of proposals addressing the issue of how the unmarked status of coronals is to be represented. Other proposals are offered by Prince and Smolensky (1993).
the SP node with [nasal] as a dependent, therefore, makes it possible to capture the nasal-oral contrast without appealing to a [nasal] specification at the phonological level. The representation of the difference between the two types of consonants is illustrated below, where C-Root (or C-R) identifies a consonant and N abbreviates the nasal feature.

(1)  
\[ \begin{array}{lll}
\text{a. Nasal C's} & \text{b. Oral C's} & \text{c. Other segments} \\
\text{C-Root} & \text{C-Root} & \text{R} \\
\text{SP} & \text{SP} & \\
\text{N} & & \\
\end{array} \]

The above description of the difference between nasal and oral consonants is essentially what is proposed by Sagey (1986) except that [nasal] can be treated as a monovalent feature.

The difference defined in (1) is fundamental to the account of one of the nasal harmony patterns. Piggott (1992) attributes the distribution of nasality in one pattern to the spreading of the SP node. Such a process targets vowels, semivowels and laryngeals but will always be arrested by a segment specified for an SP node. The following derivation of the word *mēhōkohi* [mēhōkohi] 'shadow' in the Venezuelan language, Warao, described by Osborn (1966) illustrates this pattern.

(2)  
\[ \begin{array}{llllllllll}
\text{mēhōkohi} & \text{R} & \text{R} & \text{R} & \text{R} & \text{R} & \text{R} \\
\text{SP} & \text{SP} & \text{SP} & \text{SP} & \text{SP} & \text{SP} & \text{SP} & \text{SP} & \text{SP} & \text{SP} \\
\text{N} & & & & & & & & & & \\
\end{array} \]

Because the nasal-oral contrast in this system is defined as in (1), there will always be a set of opaque consonants.

The representation of nasality in (1) cannot be universal, because it does not lead to an explanation of the observation in Anderson (1976) that nasals in some languages are in complementary distribution with prenasalized or plain oral voiced stops. These languages often manifest a nasal harmony pattern in which sonorants are targeted, non-sonorants transparent and there are no opaque segments. South American languages of the Tupi and Tucanoan family are examples of this type of language. To account for the properties of such languages, Piggott (1992) advances three hypotheses. First, the nasals, prenasals and plain voiced stops which are in complementary distribution or free variation must all be analyzed as sonorants. Secondly, the feature [sonorant] must be organized as a superordinate node in the feature geometry. Thirdly, there is a grammatical option which allows the feature [nasal] to be organized as a dependent of the sonorant node. The latter node has been renamed Spontaneous Voicing (Piggott 1992) or Sonorant Voice (cf. Rice 1993). The abbreviation SV is adopted as a neutral designation. The option of organizing [nasal] under this node yields underlying contrasts like the following.

(3)  
\[ \begin{array}{lll}
\text{a. Nasal Sonorants} & \text{b. Oral Sonorants} & \text{c. Non-sonorants} \\
\text{R} & \text{R} & \text{R} \\
\text{SV} & \text{SV} & \\
\text{N} & & \\
\end{array} \]
The SV node is considered to be a universal feature of the representation of sonorant segments (i.e. nasals, liquids, semivowels and vowels). This hypothesis entails that nasal sonorants must contain the SV node even when the feature [nasal] is a dependent of the SP node. In Piggott (1992), a full nasal stop is represented as in (4), where [nasal] is linked to only one of two potential mother nodes for the feature.

(4) C-Root
   / \  
  SP SV
   / \ 
  N

An alternative representation of full nasality is one in which [nasal] is linked to the SP and SV nodes.

(5) C-Root
   / \  
  SP SV
   / \ 
  N

The postulation of (5) as the appropriate features of a nasal consonant is actually a logical consequence of the variable dependency hypothesis. If both candidates for the mother of the feature [nasal] are present in a segment, the feature should be simultaneously linked to both. However, the choice of (4) over (5) is justified in Piggott (1993) by invoking a principle called the Uniplanar Condition which prevents a single feature from being simultaneously associated with nodes on different tiers. The proposal of such a principle was motivated not by positive evidence from observed phenomena but by the absence of evidence that languages ever make use of a representation like (5). Like any vulnerable principle, the Uniplanar Condition must be modified or abandoned on the basis of empirical evidence. Such counter evidence is provided in this paper by the conditions under which Meinhof's Law applies. The abandonment of the Uniplanar Condition means that there is no reason to reject (5). I will, therefore, adopt the latter representation as appropriate for full nasal stops, although the analysis developed later is also compatible with (4).2

The hypothesis of the variable dependency of nasality does not mean that languages freely choose whether to organize the feature under one node or the other. The fundamental choice, according to Piggott (1992), is whether or not the SP feature is phonologically active. If SP is active, then [nasal] is organized under this node. The relevant constraint might be formulated as in (6).

(6) SP/NAS
The feature [nasal] is a dependent of the SP node.

However, when this constraint is considered in the framework of Optimality Theory (Prince and Smolensky 1993), it is subject to the overarching principle that constraints are violable. Violations may occur because constraints are ranked. The satisfaction of a higher ranked constraint will forced a violation of a lower ranked one, when two constraints are in conflict. Among the constraints introduced by Prince and Smolensky (1993) is a set of the form PARSE X, where X is some phonological unit. The family of PARSE constraints

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2 There might be an entailment that, if [nasal] is an SP dependent in the representation of a sonorant, it is also linked to the SV node. This would make (4) and (5) are phonologically indistinguishable.
determine whether elements are sanctioned to appear in output representations. There must, therefore, be one like (7), forcing the feature [nasal] to be licensed in segment structure.

(7) **PARSE NAS**  
The feature [nasal] is associated with a superordinate node.

A ranking that makes SP/NAS and PARSE NAS inviolable regulates the representation of nasal consonants in Warao, English, French, Japanese and many other languages with contrasting nasal and oral consonants.  
Suppose, now, that there is a constraint (e.g. (8)) that blocks the licensing of [nasal] by the SP node in a particular context.

(8) ***PARSE SPIQ**  
The feature SP cannot be parsed in context Q.

If an SP node is unparsed, it cannot licensed the occurrence of a dependent feature. SP/NAS and *PARSE SPIQ would, therefore, be potentially in conflict in context Q. How the conflict is resolved in a particular grammar depends on the ranking of the two constraints.

To understand how grammars organize the feature [nasal], given the three constraints identified as SP/NAS, PARSE NAS and *PARSE SPIQ, we might consider the possible representations that might occur in context Q as outputs of a segment with the features of a full nasal.

(9)  

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If the conjecture in footnote (2) is correct, (9a) and (9c) are equivalent. Therefore, we are only concerned with the status of three options, (9a), (9b) and (9d). Of these, (9a) satisfies PARSE NAS and SP/NAS but violates *PARSE SPIQ. This representation is optimal in a grammar in which PARSE NAS and SP/NAS outrank *PARSE SPIQ. The second candidate (9b) violates SP/NAS but satisfies both *PARSE SPIQ and PARSE NAS. It wins when the last two both outrank SP/NAS. Finally, in (9d) the [nasal] feature remains unparsed and, therefore, PARSE NAS must be ranked below the other two constraints in a grammar that permits this output.

Both (9b) and (9d) are phonologically well-formed, they are indistinguishable from (3a) and (3b), respectively. A segment with the characteristics of (9b) is still a nasal, while (9d) is a non-nasal sonorant. The traditional taxonomy of sonorant consonants include approximants and nasals. The approximants are arguably the sonorant counterparts of the fricatives of the obstruent set. The nasals have generally been considered to the equivalent to the obstructed stops. An obvious gap in this taxonomy is a set of oral sonorant stops, and there is no phonological or phonetic reason why such a gap should exist. In fact, there is no gap. Piggott (1992) argues that some languages contain a set of stops which differs from nasals only in not being specified for nasality. Rice & Avery (1989) and Rice (1993) make a similar claim. The structure of these oral sonorant stops would contain an SV node without a dependent. These stops are realized phonetically as prenasals or plain voiced oral stops. These are the segment types that Anderson (1976) identify as the alternants of nasals. Given representations like those in (3), nasals can be derived from an oral sonorant stop by adding [nasal] to an SV node, and prenasals or plain stops can be derived by delinking [nasal] from from the SV node of nasal stops. According to Piggott (1992),
the latter situation is found in Guarani and the former in Southern Barasano. Segmental variant like those illustrated in (10) below are found in Southern Barasano.

(10)  a. wa-mba/wa-ba  'come!'
    b. māhā-mā  'go up!'

The initial consonant of the imperative suffix varies freely between a plain stop and a prenasal when the preceding morpheme is oral. The same consonant in (10b) is a full nasal when the preceding morpheme contains nasalality. The alternation is accounted for by a nasal harmony process that spreads the feature [nasal] rightward, targeting SV nodes. In the illustration below, the underlying sonorant stops are represented in capitals and the feature [nasal] is initially floating (see Piggott (1992) for details).

\[
\begin{array}{cccc}
B & a & h & a & -& B & a\\
R & R & R & R & R & R\\
/ & | & | & | & | & |\\
\text{SV} & \text{SV} & \text{SV} & \text{SV} & \text{SV} & \text{SV}\\
\rightarrow & \text{SV} & \text{SV} & \text{SV} & \text{SV} & \text{SV}\\
\text{N} & \text{N} & \text{N} & \text{N} & \text{N} & \text{N}
\end{array}
\]

The above derivation exemplifies the second nasal harmony pattern.

The prenasalization in the first of the forms in (10a) is not an instantiation of the phonological specification of the feature [nasal] but is a manifestation of spontaneous voicing, which is an inherent property of sonorants (Chomsky and Halle 1968:300-301). Voicing in sonorant is generally considered to have a different phonological status from voicing in obstruct. The traditional laryngeal feature [voice] is redundant for sonorants which are, therefore, not specified underlyingly for this feature. In contrast, this feature is an underlying component of voiced obstructs. The difference between the two representations of voicing is phonologically detectable. One of the best known illustrations of this difference is provided by Japanese (Itō & Mester 1986; Mester & Itō 1989) where the voicing of the initial obstruct of words under compounding, Rendaku, can be blocked by the presence of a following voiced obstruct but not by the presence of a sonorant. In the geometry proposed in this paper and in Rice (1993) the specification of a segment for the SV node is sufficient to ensure its realization as a voiced segment.

In the most familiar cases, segments that carry the different voicing specifications are phonetically distinguishable. For example, since the most common sonorant stops are nasals, they are readily distinguished from voiced obstructs (e.g. [m] vs [b]). But we have just seen that [nasal] is not an invariant feature of a sonorant stop. When such a stop lacks a nasal specification, it is still possible for the spontaneous prenasalization described in Piggott (1992:48) to distinguish the sonorant from the obstruct. However, as we saw in (10a), prenasalization is not always triggered. This means that there are likely to be cases in which the presence of the two types of voicing gives rise to surface phonetic ambiguity. A particular phonetic shape (e.g. [g]) might be the realization of either a sonorant or an obstruct. Rice (1993) uses a range of arguments and evidence to show that sonorant stops are phonologically distinguishable from their obstruct counterpart, even if there is no phonetic difference between them. Additional support for this position comes from the study of Meinhoft's Law in Bantu. I demonstrate in section 3 below that crucial aspects of the structure of prenasalized segments which figure prominently in the analysis of this process requires recognition of the SV node.
2.0 Derived Prenasalized Stops in Bantu

The process known as Meinhof's Law applies to prenasalized stops. It is, therefore, crucial that the structure of these stops be explicitly defined. An important source of information about this structure is available from the observation that these units are often transparently derived from combinations of nasal and oral consonants. Usually, the class 9/10 nominal prefixes or the 1st person marker can combine with certain root-initial consonants to form prenasalized stops. The root-initial consonant may be a voiced or voiceless stop. (The data to follow are taken primarily from Herbert 1977, Mugane and Gerfen 1993, Polomé 1967, Rosenthall 1989.)

(12) a. \text{n-bala} [m\text{bala}] \hspace{5mm} 'I count' (Ganda)  
\text{n-gaba} [\text{gaba}] \hspace{5mm} 'I divide' (Ganda)  
\text{n-dizi} [\text{dizi}] \hspace{5mm} 'banana' (Swahili)  

b. \text{n-\text{te}} [m\text{te}] \hspace{5mm} 'cow' (Ganda)  
\text{n-koko} [\text{koko}] \hspace{5mm} 'fowl' (Ganda)

In (12a) the root-initial stop remains voiceless, but in many languages similar consonants become voiced.

(13) a. \text{Ndali}  
\text{in-puno} [\text{mbuno}] \hspace{5mm} 'nose' (Ndali)  
\text{in-tunye} [\text{dunye}] \hspace{5mm} 'banana' (Ndali)  
\text{in-kun}a [\text{gu}na] \hspace{5mm} 'dove' (Ndali)

b. \text{Gikuyu} (Mugane and Gerfen 1993)\(^3\)  
\text{n-tema} [\text{dema}] \hspace{5mm} 'cut me'  
\text{n-tina} [\text{dina}] \hspace{5mm} 'buttocks'  
\text{n-kona} [\text{gona}] \hspace{5mm} 'hit me'

Postnasal voicing also affects some fricatives in Gikuyu, but the result is a voiced affricate.

(14) a. \text{n-\text{\text{i}ona}} [\text{i\text{jona}]} \hspace{5mm} 'lick me'  

b. \text{n-\text{\text{i}ina}} [\text{i\text{jina}]} \hspace{5mm} 'burn me'

Gikuyu data show root-initial segments that resemble voiced fricatives changing to voiced stops under prenasalization.

(15) a. \text{n-\text{\text{m}uta}} [\text{mbuta}] \hspace{5mm} 'lop me off'  

b. \text{n-\text{\text{g}ucia}} [\text{gucia}] \hspace{5mm} 'pull me'

Similar results are obtained from the prenasalization of liquids (16a) and semivowels (16b).

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\(^3\) Mugane and Gerfen use the name Gikuyu rather than Kikuyu for the variety they describe.
(16) a. n-limi [n̪dimi]  'tongues' (Swahili)
    n-lira [n̪dira]  'I sound' (Ganda)
    n-refu [n̪defu]  'tall' (Shona)

b. n-wati [n̪bati]  'hut poles' (Swahili)
    n-yuki [n̪juki]  'bees' (Ndali)

Prefixation of the relevant nasal consonant to vowel-initial roots also yields prenasalized stops, but none of these cases is considered in this paper.

2.1 The Application of Meinhof's Law

An adequate description of Bantu prenasalization must explain why liquids, approximants and segments that resemble voiced fricatives become stops. But an equal challenge is to account for the phenomenon known as Meinhof’s Law. The latter is traditionally described as a process which causes a prenasalized stop to change to a nasal when the following syllable begins with a prenasalized stop or nasal. Herbert (1977) points out that the result in Ganda is a geminate nasal. Typical examples are provided in (17a) and (17b).

(17) a. Ganda
    n-bumba [mmu̥mba]  'I mould'
    n-linda [nni̥nda]  'I wait'
    n-limi [nnimi]  'tongues'
    n-genda [ŋŋe̥nda]  'I go'

b. Other languages
    i-n-βango [imḁgo]  'bonds' (Lamba)
    i-n-lima [inima]  'I dig' (Lumasaaba)
    n-rema [nema]  'defeat' (Gikuyu)
    n-roo̥ndeete [noo̥ndeete]  'I have thrown down' (Kikuyu)
    n-γaneete [ŋaneete]  'I have recounted' (Kikuyu)

Herbert (1977:340) attributes to Meeussen (1963) the very significant observation that the process "applies only to prenasalized b, l/r, (y), and g (l/mb, nd, ńj, ńg/), which have direct correspondences in other Bantu languages, and not to consonants lacking those parallels". This observation is confirmed by data reported by Mugane and Gerfen (1993). Gikuyu prenasalized stops derived from root-initial voiceless obstruents are not changed by Meinhof's Law.

(18) a. n-tema [n̪dem]  'cut me'
    n-kona [ŋgona]  'hit me'
    n-tina [n̪dina]  'buttocks'

b. n-śona [n̪jona]  'lick me'
    n-śina [n̪jina]  'burn me'
Notice that because the prenasalized stops in (18) are fully voiced they are superficially indistinguishable from the other derived prenasalized stops that become nasals.

While the units that undergo the change are restricted to the types of prenasalized consonants illustrated in (17), the units that trigger or condition the change are cross-linguistically, more variable. Herbert (1977) cites Ganda, Lumaasaaba and Kikuyu as languages in which the triggers include both prenasalized consonants and simple nasals. The same source (p. 341) asserts that "in some languages, where only nasal compounds condition the change, only prenasalized voiced stops act as catalysts while in other languages any prenasalized consonant will condition". Lamba seems to be a language in which any prenasalized consonant can be a trigger.

(19) a. i-n-βaŋgo [imaŋgo]  'bonds'
    b. i-n-lembo [imembó]  'tattoo'
    c. i-n-βaŋsa [imaŋsa]  'courtyards'

Pending further investigation, I interpret Herbert's observation to mean that languages select from among the following sets of triggers.

(20) Triggers of Meinhof's Law
    a. Only prenasalized consonants
    b. Only prenasalized voiced consonants
    c. Only consonants containing the feature [nasal]

The variability of the trigger and the constancy of the target must become part of a full account of the phenomenon known as Meinhof's Law.

3.0 The Analysis of Meinhof's Law

Any analysis of this phenomenon must begin with a description of the structure of prenasalized consonants. We have seen that these segments are both triggers and targets.

3.1 The Structure of Derived Prenasalized Consonants

The starting point of this analysis is the standard assumption that prenasalized consonants in Bantu are sequences of segments that are fused into a single unit. In support of the single unit analysis, the arguments and evidence based on compensatory lengthening (e.g. Clements 1986) seem to me to be particularly compelling. The evidence that these units are composed of sequences of segments is also quite strong (Herbert 1975). Some of the evidence for the compositionality of prenasalized consonants comes from Swahili. When the class 9/10 prefix appears before roots containing at least two vowels, it combines with voiced stops to produce prenasalized consonants.

(21) a. n-bovu [mbóvu]  'rotten'
    b. n-dizi [ndízi]  'banana'
    c. n-goma [ngóma]  'drum'

When the same prefix is attached to roots containing just one vowel, the autonomy of the nasal consonant is manifested in the fact that it is obligatorily syllabic.

(22) a. n-bu [nбу]  'mosquito'
    b. n-pya [npya]  'new'
c. n-ta [ŋta] 'wax'
d. n-ge [ŋga] 'scorpion'

The syllabic nasal in (22) is a consequence of the enforcement of a bisyllabic minimal word requirement.

Every theory must explain how two independent segments combine to form a single unit. The characterization of derived prenasalized segments as simultaneously a single unit and a sequence of units is captured in Clements (1987), Piggott (1988), Rosenthal (1988, 1989), Steriade (1993) and Clements and Hume (to appear) as a sequence of root nodes linked to a single position (23a). An alternative (23b) might be adopted in a theory that does not recognize skeletal positions, provided that adjunction permits one root node to dominate another root node. It is not necessary to decide between skeletal and non-skeletal theories in this paper.

(23) Derived Contour^4

\[
\begin{array}{ccc}
\text{a.} & \text{x} & \text{b.} \\
R & / \backslash & R \\
/ \backslash & R & R
\end{array}
\]

Whether (23a) or (23b) is adopted, it is important to emphasize that a derived contour is a single segment.^5

Both representations in (23) mean that Bantu prenasalization involves the combination of a nasal consonant and an oral consonant as sisters. It is clear that the adjunction of the two root nodes is accompanied by a number of structural adjustments to reduce the differences between the two components and ensure the integrity of the single unit. A condition on the well-formedness of derived contours is the following.

(24) Contour Integrity

Below the level of the Root nodes, a contour segment may contain no more than one node of the same type.

Contour Integrity is a restatement of the Contour Node Condition of Rosenthal (1989), with the crucial difference that it restricts branching to the level of the Root nodes (cf. also Sagey 1986:50).

One obvious adjustment to accommodate (24) is the obligatory sharing of Place nodes; the nasal always assimilates place features from the following consonant. I propose that, in addition, full nasals with the features in (5) undergo some loss of structure as a result of a constraint that blocks the parsing of an SP node if it is a sister to a following SP node. Such a constraint has an effect very much like the elimination of a segment-internal OCP violation.

(25) *PARSE SP_i:SP_i...SP_i
The SP node cannot be parsed if is a sister to a following SP node.

---

4 The reference to derived contour is meant to distinguish such a unit from the non-nasal sonorant stop described earlier in this paper. Recall that the latter contains a single root node dominating a bare SV node, and prenasalization is an optional phonetic feature.

5 Clements and Hume (to appear) maintain that the two-root representation can be interpreted in accordance with the theory of contours proposed by Steriade (1993), if the sister root nodes are identified with distinct aperture phases of a segment. I consider this possibility to be entirely derivative of the fact that the contour is a single segment. The interpretation of the derived contour as a single segment with two phases means that it must be a stop, because, as Steriade points out, only a stop can have two distinct aperture phases, a closure and a release.
This constraint is obviously a version of (8). Given the appropriate ranking of (25) in Bantu, an optimality-theoretic analysis selects the output in (26) from an input sequence of nasal and oral consonants. (Only the relevant parts of the structure are shown.)

(26)
```
  x
 / \
R   R
 /   /
SV <SP> SP
 /   /
N
```

The fact that [nasal] is parsed ensures that the first part of the segment is nasal, while the presence of the bare SP node under the second root node ensures that the second part of the segment is oral.

The sharing of place features and the non-parsing of the first SP node are two of the obligatory adjustments that apply to Bantu derived contours. Another obligatory change is responsible for the derivation of prenasalized stops from nasal-liquid and nasal-semivowel sequences (16). An understanding of this change presupposes an understanding of the structure of liquids and semivowels. Rice and Avery (1991) and Rice (1993) argue that the features that define liquids are dependents of the SV node. Piggott (1993) identifies the relevant feature as [approximant] (= A) and propose that it is also a property of (some) semivowels. The important parts of the structure of Bantu liquids and semivowels are shown below.

(27)  
```
   R
  / \
SV SP
 /   
A
```

When a nasal combines with a consonant with the features in (27), the two SV nodes must be reduced to one to satisfy the Contour Integrity principle (24). This reduction is achieved by the same mechanism that is responsible for the homorganicity of adjacent nasal-obstruent sequences. This mechanism is identified in Piggott (1992) as Fusion, where one of the fused nodes is designated as dominant.

(28)  **SV Fusion**
Within a contour, SV nodes are fused with the left node dominant.

I attribute this left dominance to the fact that it is the nasal which adjoins to the oral consonant and subordinates some of the features of the latter. The dominance of the leftmost SV node is responsible for the loss of the [approximant] feature of both liquids and semivowels. Because the first part of the contour contains features of a nasal stop, it cannot also be specified as [approximant]. The satisfaction of SV fusion determines an output like (29).
Input sequences of nasal plus liquid or nasal plus semivowel will, therefore, correspond to prenasalized stops as outputs.

Prenasalization has the same effect on liquids as it does on segments like those in (15) that have the appearance of voiced continuants. The analysis of the adjustment of liquids to yield stops can be extended to explain the behavior of the voiced continuants by appealing to the fundamental insight of Rice (1993). As indicated earlier, Rice argues that, in certain cases, voicing in segments that would traditionally be regarded as obstructs should really be attributed to the fact that these segments contain the SV node. In essence, some ‘obstructs’ are really sonorants. Such a reanalysis of the segments $\beta$ and $\gamma$ in (15) means that these segments are sonorant continuants (i.e. approximants). The labial and velar continuants are, therefore, the counterparts of the coronal approximants (i.e. the liquids). Since all approximant consonants in Bantu languages would have the features in (27), the prenasalization of $\beta$ and $\gamma$ must yield $m^b$ and $0^g$, respectively.

The analysis of Bantu labial and velar voiced continuants as sonorants not only explains their behavior under prenasalization but also throws light on the patterns of contrast in the consonant systems in which they are found. For example, in Kikuyu (Armstrong 1940, Benson 1964, Rosenthall 1989, Mugane and Gerfen 1993) the voiced continuants have no voiceless counterparts and there are no contrasting voiced stops. A system of obstruents with such characteristics is generally considered to be highly marked. When voiced obstruct continuants are present in a consonant system, the less marked voiced stops are usually present. Even more expected is the occurrence of the voiceless counterpart. These implications have often resulted in an analysis in which the voiced continuants are derived from underlying voiced stops (cf. Pulleyblank 1986). However, if Kikuyu voiced continuants are really sonorants, they could be postulated as underlying without engendering marked patterns of contrast. As approximants, they contrast with nasals and would not be expected to have obstruct counterparts. It should also be noted that an analysis of the labial and velar voiced continuants as approximants would readily distinguish them from segments derived from voiceless continuants by postnasal voicing.

The prenasalized stops derived from combinations of nasal plus approximant are fully voiced because both components are sonorant, but it is not an obligatory feature of prenasalization that both parts of the contour be voiced. The Ganda data in (12b) show that the second component can be voiceless. This type of derived contour is compatible with the Contour Integrity principle, because sonorants and obstructs are not specified for voicing in the same way. Assuming a monovalent laryngeal feature [voice] (=Vo), the contrast between a voiced and voiceless obstruct is represented as follows (where L represents the Laryngeal node).

\[ \begin{align*}
R & \quad \text{x} \\
SV & \quad <SP> \\
N & \quad <A>
\end{align*} \]

---

6 An analysis of the voiced continuants as underlying voiced stops would be compatible with the representation of Bantu derived nasal contours proposed in this paper, provided that the voiced stops are underlying sonorants.
I assume that (30b) is the appropriate feature geometric representation of voicelessness in a released obstruent; an unreleased obstruent would probably lack a laryngeal node.

In addition to the features in (30b), the voiceless stops of Ganda would also be specified for a bare SP node. Prenasalization of such stops would, therefore, yield the following output.

The second part of such a contour is both oral and voiceless.

The constraints that regulate the output shapes of nasal contours must allow for (31), but they must also allow for the postnasal voicing manifested by languages like Ndali (13a) and Gikuyu (13b). In these cases, the root-initial voiceless consonants clearly become voiced. The traditional analysis attributes postnasal voicing to the spreading of the feature [voice] from the nasal to the following obstruent (cf. Herbert 1986, Rosenthal 1989). Such a description is somewhat problematic, because, as pointed out earlier, the feature [voice] is not an underlying property of nasals. This problem is addressed by Rice (1993) where postnasal voicing in Japanese and a number of other languages is attributed to the spreading of the SV node from a sonorant to a voiceless obstruent.

The following Japanese data from Itô and Mester (1986:69) illustrate the phenomenon.

Although the nasal-oral sequences in (33) are not demonstrably nasal contours, the mechanism that is responsible for postnasal voicing in Japanese is undoubtedly the same as in Ndali and Gikuyu.

The theoretical significance of Japanese postnasal voicing is addressed by Itô and Mester (1986) and Itô, Mester and Padgett (1993). The relevant facts are now well known and seem remarkably clear. A constraint called Lyman's Law limits the number of voiced obstruents in a native Japanese morpheme to just one (34a). This restriction does not apply to sonorants (34b) or combinations of sonorants and obstruents (34c) in morphemes.
(34) a. kaze 'wind'
kugi 'nail'
*gage
*bugi

b. nuri 'lacquered'
maru 'completely'

c. naga 'long'
garasu 'glass'

Lyman's Law interacts with the process referred to earlier as Rendaku to prevent the voicing of the root-initial obstruent, if the word already contains a voiced obstruent; again the presence of sonorants is irrelevant.

(35) a. ori - kami [origami] 'paper folding'
yama - tera [yamadera] 'mountain temple'

b. ore - kugi [orekugi] 'broken nail'
*[oregugi]
onna - kotoba [onnakotoba] 'feminine speech'
*[onnagotoba]

Itô and Mester (1986) deduce from facts like those in (34) and (35) that Lyman's Law is a restriction on occurrence of the feature [voice] and sonorants are not specified for this feature. However, postnasal voicing in Japanese confronts this analysis with a host of problems, summarized by Itô and Mester (1986:69-71).

The Japanese problem of postnasal voicing would appear to be resolved if Rice's proposal to attribute the phenomenon to the spreading of the SV node could be adopted. But evidence presented by Itô, Mester and Padgett (1993) undermines the SV-based analysis. The blocking of Rendaku in a compound like (36) cannot be explained, if the feature that is responsible for postnasal voicing is different from the feature that determines voicing in obstruents.

(36) șirootto - kaŋgae [șirootokæŋgæ] 'layman's idea'
*[șirootogæŋgæ]

Itô, Mester and Padgett's solution in the framework of Optimality Theory is to assume that [voice] is an underlying feature of both obstruents and sonorants but it is unparsed in the Japanese nasal because of an undominated constraint which prevents the licensing of [voice] by a Root node dominating the feature [nasal]. When a nasal is followed by a voiceless obstruent, the [voice] feature of the nasal can be licensed by being assigned to the following obstruent without incurring a fatal constraint violation. The result is a postnasal voiced obstruent, which should behave like an underlying voiced obstruent because the same feature is present in both.

The Itô-Mester-Padgett analysis of postnasal voicing can be incorporated into the feature geometry proposed in this paper. The point of departure is the assumption that [voice] like [nasal] is a variably dependent feature. When the Laryngeal node is present, it must license [voice]. However, this feature can be licensed by the SV node, if the segment does not contain a Laryngeal node. Both sonorants and voiced obstruents can, therefore, be underlyingly specified for the feature [voice], but the crucial difference between them remains that the former have the SV node and the latter the Laryngeal node. This proposal might appear to miss the generalization that [voice] is a redundant feature of
sonorants. To capture this redundancy, the following constraint must be part of the universal set.

(37) *SV/VOICE

The feature [voice] cannot be a dependent of the SV node

This is actually one of a family of constraints that formally encode redundancies. In Japanese and Bantu languages, (37) is undominated. Consequently, voicing in a nasal stop would be represented as in (38).

(38) R
     l \ SP SV
     l /
     N <Vo>

Although the feature [voice] is unparsed in the output representation of a nasal, the presence of the SV node still guarantees that nasals are phonetically voiced.

When a nasal in Japanese, Ndali or Gikuyu is immediately followed by a voiceless obstruent, the underlying [voice] feature can be faithfully parsed as a component of the obstruent without incurring a violation of (37). The voicing of obstruents under prenasalization can, therefore, be represented in the following manner.

(39) Postnasal Voicing

An important feature of the above representation is that the second component of the prenasalized contour retains the properties of an obstruent.\(^7\)

The constraints that result in postnasal voicing of stops can also trigger postnasal voicing of fricatives. However, the prenasalization of fricatives has the additional complication that the output can be prenasalized affricates (14).\(^8\) The issue of the formal representation of prenasalized affricates is not addressed in this paper, because it is not relevant to the central concern, i.e., the analysis of Meinhof's Law.

Since prenasalized consonants function as both targets and triggers of Meinhof's Law, it would be useful to draw attention to the crucial features of these segments as revealed in the foregoing discussion before proceeding to the analysis of this process. We

---

7 The hypothesis that [voice] can be a dependent of the SV node is theoretically significant but not crucial to the analysis of postnasal voicing. An alternative might be to adapt a proposal by Rice (1993:313) and represent voicing in sonorants by the feature [voice] as a Laryngeal dependent. This would then entail that the redundancy of voicing in sonorant would be expressed as non-parsing of the Laryngeal node in sonorants rather than as in (37). Such a description of redundancy seems less adequate than the one adopted here, because it gives the impression that there is an arbitrary relationship between voicing and sonorancy.

8 Steriade (1993) claims that, when fricatives undergo prenasalization they invariably surface as affricates. This observation can be accommodated in the theory of derived contours developed in this paper. Given the interpretation of the two components of a prenasalized segment in footnote (5), the combination of a nasal stop and a fricative in a single segment must yield an affricate.
have established that Bantu derived contours are of two types. Some are like (29) where the two Root nodes dominate a single SV node; both parts are, therefore, sonorants. The second represented by (31) and (39) are really sonorant-obstruent sequences.

3.2 Meinhof's Law: The Process and its Targets

Meinhof's Law seems to reflect conditions under which the feature [nasal] may occur in adjacent syllables. The restriction to adjacent syllables is revealed by the occurrence of data like the following Gikuyu words (Mugane and Gerfen 1993).

\[(40)\]  
\[\begin{align*}
\text{a.} & \quad n-\gamma\text{orana} [0\text{gorana}] \quad \text{'I marry'} \\
\text{b.} & \quad n\text{-rarama} [0\text{darama}] \quad \text{'I roar'} \\
\end{align*}\]

In the above examples, the prenasalized stops that remain unchanged in word-initial position are indistinguishable from segments in (17b) that change, but the two occurrences of [nasal] are not in adjacent syllables. The implication is that the process or constraint must apply to fully syllabified representations.

The conventional analysis of Meinhof's Law reflects the position of Herbert (1977) that it is a process of assimilation, captured in non-linear terms as the spreading of the feature [nasal] to the second component of a prenasalized consonant. (In the following and later formulations C and V represent onset and nucleus, respectively. Only the relevant aspects of structure are shown.)

\[(41)\]  
\[
\begin{array}{cccccc}
C & V & C & V \\
\times & \times & \times & \times \\
/ \backslash & / \backslash & / \backslash & / \backslash \\
R & R & R & R & (R) & R \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
N & N & N & N & N & N \\
\end{array}
\]

The output of nasal spreading is the geminate nasal that occurs in Ganda (17a). In other languages, a constraint against geminates forces an output with a simple nasal as the first onset. The latter output (42) can be derived from (41) by an operation that fuses the adjacent Root nodes in the contour.

\[(42)\]  
\[
\begin{array}{cccccc}
C & V & C & V \\
\times & \times & \times & \times \\
/ \backslash & / \backslash & / \backslash & / \backslash \\
R & R & R & (R) & R \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
N & N & N & N & N \\
\end{array}
\]

In a non-derivational, constraint-based theory like Optimality Theory, the difference between (41) and (42) must be attributed to the satisfaction of different constraint rankings. There are two reasonable candidates for the relevant constraints; one is from the ALIGN family and the other is probably from the *PARSE family. The spreading operation in (41) can be viewed as the manifestation of a feature alignment constraint that holds between
onsets of adjacent syllables. Let us refer to the relevant onset sequence as $O_1$ and $O_2$. We can now formulate the alignment constraint as in (43).

(43) \textbf{ALIGN NAS}

The feature [nasal] in $O_2$ is aligned with the right edge of a consonant in $O_1$.

It is to satisfy this constraint that the second nasal feature spreads to the second Root node of a contour segment in the first onset, yielding an output like (41).

The second observable output of Meinhof's Law (42) is the result of a conflict between the ALIGN NAS constraint and a constraint against geminates in contours. There is cross-linguistic evidence that the latter constraint is quite robust. Something like (44) is, therefore, clearly justified.

(44) \textbf{PARSE} R_j:[R_i..R_j], where $i = j$

A Root node cannot be parsed, if it is a sister to a preceding Root node and the two nodes dominate the same terminal features.

If (43) outranks (44) as it does in Ganda, geminate nasals are derived. If, however, (44) is dominant (cf. Lambda, Kikuyu), then a structure that shows a degemination effect (42) is selected as the best output.

The analysis of Meinhof's Law in terms of alignment constraints is actually superior to a rule-based one. Rule-based descriptions of the process (Herbert 1977; Mugane and Geren 1993) usually stipulate that the target is a prenasalized consonant. No such stipulation is necessary if we adopt the representation of a derived contour proposed in this paper and assume that ALIGN NAS (43) is active in Bantu. The crucial difference between the contour and a single segment is presence of the two Root nodes that mark the left and right edges. Non-contour segments have only one Root node. A feature like [nasal] or [voice], associated with such a segment, would be phonologically coextensive with it and would, therefore, be aligned with both the left and right edges. The fact that simple segments are never targeted by Meinhof's Law can be accounted for by restricting the alignment of the feature [nasal] to just the right edge of a segment. This can be accomplished by the following inviolable constraint.

(45) \textbf{ALIGN NAS}

The feature [nasal] in $O_2$ cannot be aligned with the left edge of a consonant in $O_1$.

Input strings like *ge*"da, re*ma and *pa*go would not be affected by ALIGN NAS, because the association of the feature [nasal] with the root-initial segment would result in a violation of (45).

In summary, the constraint ranking that accounts for the surface manifestation of Meinhof's Law in Ganda is the following: *ALIGN NAS >> ALIGN NAS >> *PARSE R_j:[R_i..R_j], where $i = j$. For languages that proscribe geminate nasals the last two constraints are reranked: *ALIGN NAS >> *PARSE R_j:[R_i..R_j], where $i = j >>$ ALIGN NAS.

Although Meinhof's Law targets only prenasalized consonants, we have already observed that not all such segments are affected (see (18) above). A well-defined class of exceptions is the prenasalized segment derived from a nasal plus voiceless obstruent. When this class is compared with the targeted set, there is a obvious difference. The targeted contours are composed of nasal-sonorant sequences and therefore have the features in (46a), synthesized from (29). By comparison, contours derived from nasal-obstruent sequences have the features in (46b).
The crucial difference between (46a) and (46b) is that the second Root node of the former dominates an SV node and is therefore sonorant, while the second Root node of the latter is that of an obstruent. There is a very strong cross-linguistic tendency for the feature [nasal] to be restricted to sonorants. Only a small number of languages like Igbo (Dunstan 1969) and Applecross Gaelic (Ternes 1973) are reported to have nasalized obstruents (restricted to fricatives). It is therefore safe to postulate a constraint that makes the presence of the feature [nasal] dependent on a segment being sonorant.

(47) **Nasal-Sonorant Dependency**

The feature [nasal] can be associated only with sonorant segments.

It is this constraint that makes (48a) a possible output of Meinhof's Law but (48b) is not.

(48) a. C V C V

\[ \begin{array}{cccc}
\times & \times & \times & \times \\
R & R & R & R \\
SV & SP & SV & SP \\
N & N
\end{array} \]

*b. C V C V

\[ \begin{array}{cccc}
\times & \times & \times & \times \\
R & R & R & R \\
SV & SP & SV & SP \\
N & N
\end{array} \]

Note that this analysis of the targets of Meinhof's Law provides the same explanation for the exceptionality of prenasalized stops which are derived from nasal plus obstruents, whether the obstruents are fricatives or stops.

3.3 **Meinhof's Law: The Triggers**

The feature geometry and the theory of contours adopted in this paper not only lead to an explanation for the restrictions on the target of Meinhof's Law but also throws some light on the possible reasons why the trigger varies as identified in (20). The triggers are, of course, the consonants in the second onset position. When any nasal segment in this position (20c) is a trigger, nothing needs to be added to the analysis developed so far. Consider next the restriction to any type of prenasalized segments (20a). This is best...
captured by directly excluding full nasals. The representation that is not permitted, when a full nasal is in the trigger position, is the following.

\[
\begin{array}{cccc}
C & V & C & V \\
\times & \times & \times & \times \\
\_ & \_ & \_ & \_ \\
R & R & R & R \\
SV & SP & SV & SP \\
N & N
\end{array}
\]

Such a representation can be excluded by a constraint, blocking the association of the feature [nasal] to more than one node on the same tier, equivalent to a constraint against spreading [nasal]. I suggest that it is the association of this feature to the two SP nodes in (49) that renders this representation non-optimal in some grammars. The finals restriction (20b), limiting the targets to prenasalized voiced consonants, is potentially a more difficult one to characterize because there are two types of prenasalized voiced stops. The statement in Herbert (1977:341) does not distinguish between the two types. If the restriction covers both types, the representation of contours proposed in this paper does not permit us to distinguish such a group from prenasalized voiceless consonants. If, however, the prenasalized voiced consonants in the trigger position always have the features of (46a), the restriction in (20b) can be expressed as a requirement that the nasal feature in the second onset position must be immediately dominated by no more than one node and must also be associated with all the components of the onset. The first part of the restriction would exclude full nasals, while the second part excludes prenasalized stops composed of nasal-obstruent sequences. The appropriateness of such an explanation requires further investigation.

4. Conclusion

We have shown that the phenomenon known as Meinhof's Law is illuminated by a two-root theory of nasal contours and a feature geometry in which [nasal] can be a dependent of two superordinate nodes. The two-root theory of nasal-sequences is an elaboration and refinement of proposals by Clements (1987), Piggott (1988) and Rosenthal (1988, 1989). As far as I am aware, there has been no direct refutation of this theory. Steriade (1993) proposes an alternative representation of nasal contours which also recognizes the presence of two components. This "aperture" theory is a very significant contribution to our understanding of the structure of contour segments. However, as Steriade herself recognizes, it does not necessarily lead to the rejection of the two-root theory. As I have pointed out earlier, Steriade's representation of a nasal contour can be reformulated in terms of the two-root theory. This does not mean, however, that the two theories are notational variants. If this were the case, the description of the various aspects of Meinhof's Law in terms of Steriade's theory would be just as explanatory as the one proposed in this paper. This does not appear to be the case.

Fundamental to Steriade's "aperture" theory is the thesis that prenasalized consonants are structurally similar to released stops. The similarity is shown in the following representations (where \(A_0\) refers to the closure phase of a stop and \(A_{\text{max}}\) the release phase).
(50) a. Released Stop
\[\begin{array}{c}
 x \\
 / \ \\
 A_0 \ \ A_{\text{max}} \\
\end{array}\]  

b. Prenasalized Stop
\[\begin{array}{c}
 x \\
 / \ \\
 A_0 \ \ A_{\text{max}} \\
| \ \\
N \\
\end{array}\]

If these representations are adopted, the essence of Meinhof's Law cannot be captured by the simple ALIGN constraints proposed in (43) and (45). The alignment of the feature [nasal] with the right edge of a contour should target both types of stops. This is clearly not the case. Meinhof's Law can only be restricted to prenasalized targets by specifically referring to the nasal component of these segments in the appropriate statement of the process. Steriade (1993:411) provides an example of such a statement. The theory that requires or allows for this type of statement would have no principled basis for excluding a formulation like the following that makes no reference to the nasal component of a prenasalized stop.

(51) **Hypothetical Meinhof's Rule**
\[\begin{array}{c}
 x \\
 / \ \\
 A_0 \ \ A_{\text{max}} \\
| \ \\
V \ \ A_0 \ \ A_{\text{max}} \\
| \\
\end{array}\]

The possibility of rule like (51) predicts a grammar in which both released and prenasalized stops are targeted, yielding postnasalized stops and full nasals, respectively. To my knowledge, no such grammar has been attested. The problematic features of the statement of Meinhof's Law in Steriade's framework might be eliminated by assuming that Bantu oral stops are unreleased.

(52) **Oral Unreleased Stop**
\[\begin{array}{c}
 x \\
| \\
A_0 \\
\end{array}\]

The fact that such a segment is not a targeted can now be attributed to the absence of a release phase. Only prenasalized stops would, then, have the appropriate release phase. Such an account would only be a partial solution to the problems identified. The problem of overgeneralization represented by the hypothetical Meinhof's Law (51) still remains. Moreover, a new problem is created. The prenasalization of a stop like (52) should either be blocked because the adjunction of a nasal stop to such a segment does not automatically result in a representation like (50b). The required representation would only be possible by adjusting both the structure of the nasal and that of the oral stop.

Meinhof's Law poses other problems for the "aperture" theory of contours. The assumption that prenasalized contours have the same internal shape, apart from differences in place specification, makes it difficult to explain why the targets are restricted to just the set of prenasalized stops identified by Herbert (1977:340). Recall that prenasalized stops derived from nasal-obstruent sequences are never targeted. Mugane and Gerfen (1993) tries to resolve this problem by exploiting the fact that the obstruent in a nasal-obstruent sequence is usually voiceless. They propose a cooccurrence restriction in the spirit of the grounded conditions of Archangeli and Pulleyblank (in press), blocking the association of the feature [nasal] to an underlying voiceless stop.
(53) NAS/VOICE
   a. If [NASAL], then [+VOICE]
   b. If [NASAL], then NOT [-VOICE]

I do not fully understand how such a regulatory restriction is supposed to work in a framework in which sonorants are not specified for the traditional feature [voice]. However, it would certainly allow [nasal] to be assigned to a segment that is specified [+voice]. Nevertheless, the data in (13) and (14) show that, even when obstruents undergo postnasal voicing, they do not become targets of Meinhof's Law.

The only obvious solution to this new problem compatible with (53) is to propose that postnasal voicing is ordered after Meinhof's Law has applied. Such an ordering would have to stipulated, because it is not derivable from general principles of a theory. But even such a proposal could not be sustained across the Bantu languages that manifest Meinhof's Law. Herbert (1977:340) cites an example of prenasalized voiced stops in Lumasaaba where the voicing is not attributable to postnasal voicing but the segment is still not targeted. It appears that occurrences of voiced coronal stops which are not derivable from liquids are not targetable. Compare the data in (54a) and (54b).

(54) a. ku-lima [kulima]  'to dig'
    i-n-lima [linima]  'I dig'

b. ku-dima [kudima]  'to run'
    i-n-dima [indima]  'I run'

The root-initial voiced stop in (54b) must be underlying, but the presence of the feature [voice] does not condition the application of Meinhof's Law. The possibility of both (54a) and (54b) is clearly predicted by a theory that distinguishes between oral sonorant stops and voiced obstruent stops, both of which are possible components of prenasalized stops.

Meinhof's Law provides important new evidence in support of the hypothesis that the nasal-oral contrast can be captured formally in more than one way. It also strengthens the hypothesis that nasal contours, in some languages, are composed of sequences of units and are, consequently, different from single segments. The representation of contours defended in this paper does raise some new issues which cannot be fully explored. For example, given the representations of full nasals in (5) and prenasals in (46), one would expect that the nasal feature of both types would behave in the same way. But there is some indication that this is not the case. Cross-linguistic evidence reveals that the nasal dependent of a full nasal can spread either rightward or leftward (Piggott 1992, Steriade 1993). There is also evidence from languages like Sinhalese (Feinstein 1979) and Ganda (Herbert 1977) that the nasal feature of a prenasalized consonant can spread leftward. Strikingly, there are no attested cases of rightward spreading of nasality from a prenasalized consonant. This is a potential problem for both the two-root theory of contours and the aperture theory.

A possible reason for the difference between full nasals and prenasals might again involve reference to the edge of a domain. Recall the claim that the nasal in a prenasalized consonant is associated with the left edge, while the same feature in a full nasal is associated with both edges. It seems to be the case that the feature alignment constraint or its derivational equivalent, feature spreading, is governed by an edge-to-edge restriction. The nasal component of a prenasalized consonant can spread leftward, because it is at the left edge, but it can never spread rightward. If the edge-to-edge restriction holds universally, it would have to be assigned to the GEN component of Optimality Theory, thereby regulating possible outputs. This restriction and other implications of the theory of contours adopted in this paper must be explored in later studies.
References


Clements, G. N. and E. Hume (to appear) 'The internal organization of speech sounds'. In J. Goldsmith (ed.), *Handbook of Phonology*.


McCarthy, J. and A. Prince (1993b) 'Generalized alignment'. Unpublished ms., University of Massachusetts-Amherst and Rutgers University


Ternes, E. (1973) Phonemic Analysis of Scottish Gaelic. Forum Phonetico 1, Helmut Buske Verlag, Hamburg