NASALIZATION, NEUTRAL SEGMENTS, 
AND OPACITY EFFECTS

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Abstract
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NASALIZATION, NEUTRAL SEGMENTS, AND OPACITY EFFECTS

This thesis explores cross-linguistic variation in nasal harmony. The goal is to unify our understanding of nasal harmony so that patterns across languages conform to one basic character and to examine the wider implications of this account for phonological theory.

The analysis builds on generalizations from a comprehensive survey documenting variation in three descriptive sets of segments in nasal harmony: targets, which become nasalized, blockers, which remain oral and block spreading, and transparent segments, which remain oral but do not block. The typological generalizations established by this study provide strong support for a unified view of nasal harmony in which variation is limited in a hierarchical fashion.

To capture cross-linguistic variation, this analysis draws on a phonetically-grounded constraint hierarchy ranking segments according to their incompatibility with nasalization (building on Schourup ... points in relation to the hierarchy of violable nasalization constraints achieves precisely the attested set of patterns.

Another typological discovery is that transparent segments pattern with targets and should be regarded as belonging to this set of segments. A phonological consequence is that nasal spreading never occurs in a neutral finding new support for other scenarios in which [nasal] spreading never occurs in a neutral.

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incompatibility constraints for segments that behave transparent. Importantly, by bringing segmental transparency under the wing of derivational opacity, transparency-specific representations can be eliminated from the theory.

Chapter 1 presents background. In chapter 2, I develop a unified description and analysis of a cross-linguistic typology of nasal harmony. Chapter 3 turns to the analysis of transparent segments and a discussion of cases that may be mistaken for [nasal] feature spreading. Nasal agreement in Mbe forms a case study involving reduplication.

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I feel as if I have been introduced to many interesting people in the NSF-funded phonology conference. I am grateful to them for their patience and for sharing their knowledge and enthusiasm with me. I would like to thank them for their comments and suggestions. The participants at my committee meetings have been a great source of inspiration.

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Hollebrandse and Winnie Lechner for their friendship. For useful discussions I am grateful to Eric Bakovic, Jill Beckman, Andy Dolbey, Larry Hyman, Orhan Orgun, Joe Pater, Alan Prince, Sharon Rose, Ron Sprouse, Su Turkewitz, Moira Yip, and Cheryl Zoll.

For all the support they have given me over the years, thanks to my family, Mom and Richard, Dad and Laurie, and Rebecca and Aaron. Grandma and Grandpa Hamill were both an inspiration. Finally, to my husband Geoff, thank you for the endless love and support.

Wealthy.

Based on these ideas discussed in meetings for NSF grant SBR-94-2494 to John Hollebrandse, these discussions have led to discussions with Keren Rice, who has been a continual support, advisor, and friend. I am also grateful to Andrew Carnie, who I have known since that first introductory class in linguistics has been a great friend throughout the years.

For all the support they have given me over the years, thanks to my family, Mom and Richard, Dad and Laurie, and Rebecca and Aaron. Grandma and Grandpa Hamill were both an inspiration. Finally, to my husband Geoff, thank you for the endless love and support you have given me; this is dedicated to you.
Chapter 1
BACKGROUND

1.1 Introduction
It has long been known that the feature [nasal], which corresponds to the property of having a lowered velum during a segment, can come out as the property of not just one segment but a string of segments in the words of some languages. Descriptively speaking, this comes about when an underlyingly nasal segment, such as a phonemic nasal stop or nasal vowel, triggers the nasalization of an adjacent string of segments in a predictable and phonologized way. This is the phenomenon known as nasal feature spreading or 'nasal harmony', which will be examined here. The aims of this work are two-fold. The goal is first to unify our understanding of nasal harmony so that patterns across languages conform to one basic character, something that has not been achieved before. The second goal is to examine the wider implications of this account for phonological theory. The theoretical findings are sketched in (1) with amplification below.

(1) Sketch of theoretical findings:

i. Patterns of nasal harmony across languages can be unified into one basic type.

ii. Cross-linguistic variation in nasal harmony is governed by a phonetically-grounded constraint hierarchy ranking segments according to their compatibility with nasalization (building on insights of previous studies: Schourup 1972; Pulleyblank 1989; Piggott 1992; Cohn 1993a, c; Padgett 1995c; Walker 1995; cf. also Hume and Odden 1994).

iii. Constraint ranking and violability, fundamental concepts in Optimality Theory (Prince and Smolensky 1993), are crucial to obtaining a unified understanding of nasal harmony. Cross-linguistic variation is achieved by ranking the spreading constraint at all points in relation to the nasalization hierarchy. The unified typology is obtained by positing all nasalization constraints as violable.

iv. Descriptively transparent segments should be understood as belonging to the set of target segments, i.e. segments which undergo nasal spreading. A theoretical consequence is that [nasal] spreading (and all feature spreading) takes place only between adjacent segments, finding new support for the concept of strict segmental locality in feature spreading (after a proposal of Ní Chiosáin and Padgett 1997; cf. Gafos 1996; foundational analyses appear in Ní Chiosáin and Padgett 1993; McCarthy 1994; Flemming 1995b; Padgett 1995a; for related ideas see Allen 1951; Stampe 1979).

v. Building on previous derivationally-opaque rule-ordered accounts of segmental transparency (e.g. Clements 1976; Vago 1976), true surface transparency can be obtained through opaque constraint interaction (McCarthy 1997; Itô and Mester 1997a, b), a mechanism with independent motivation in phonological theory. This obviates the need for calling on the 'gapped configuration', an ad hoc device specific to segmental transparency.

The account developed here is built on a solid empirical basis; the claim that there is just one basic kind of nasal harmony is motivated by generalizations established by a comprehensive cross-linguistic survey encompassing the nasal harmony patterns of over 75 languages. From a theoretical perspective, there are several important issues illuminated by this work. These are outlined above and are explained in more detail in what follows.

One important aspect of this account is that it draws on a phonetic basis for the formal analysis of limitations on cross-linguistic variation. This is expressed in the form of a phonetically-grounded constraint hierarchy ranking segments according to their (in)compatibility with nasalization. The concept of a hierarchical (in)compatibility of nasalization can be traced back to Schourup (1972) and gains subsequent foundation from the work of Pulleyblank (1989); Piggott (1992); Cohn (1993a, c); Padgett (1995c); and Walker (1995) (Hume and Odden 1994 propose a different yet related hierarchy based on impedance). The proposed fixed ranking of the nasalization constraints in relation to one another derives the implications (observed in the present study and by researchers cited above) that if a segment blocks nasal spreading, all less compatible segments will also block, and if a segment is targeted by nasal spreading, all more compatible segments will also be targeted. Most phonological theories agree that
phonology has at least some basis in phonetic universals, and recently there has been an increased emphasis — in works too numerous to list — on seeking the 'phonetic grounding' for phonological generalizations. A central finding of this work is that certain key theoretical assumptions in Optimality Theory (Prince and Smolensky 1993) are fundamental to achieving a unified understanding of different systems of...and a relatively high ranking for fricatives, corresponding to their patterning across languages.

A focal discovery emerging from the descriptive typological generalizations is that transparent segments (i.e. segments that remain oral but do not block nasal spreading) pattern with the set of targets (segments that undergo nasal spreading in nasals) and should be regarded as undergoers of nasal harmony. It is observed first that all segments have the potential to block nasal spreading; yet all segments except some obstruents have the potential to undergo nasal harmony and only obstruents ever behave transparent. Positing descriptively transparent segments as undergoers of nasal harmony addresses this otherwise missing harmonic behavior.

With descriptively transparent segments in nasal harmony and constraint violations precisely the cross-linguistic variation which is attested. Importantly, the unified typology is obtained by positing all of the nasalization constraints as violable.

A new question emerges: what produces the surface transparent outcome for these segments? An acoustic analysis may relate these nasalizations to a representation in which nasalization has spread to all target or transparent segments ([a]ta)fi([a]ta)ta) with subsequent rule application or mapping to a form with nasalization of all segments except obstruents ([a]ta)ta)ta). In a derivational approach, the representation with full nasal spreading constitutes a form derived at an intermediate stage. In the optimality-theoretic account developed here, the fully-nasalized form is a failed candidate from the descriptively transparent generalization and a focal discovery emerging from the constraint violations which produce the transparent outcome.
member of the output candidate set, designated the special status of 'sympathy' candidate, following the proposal of McCarthy (1997) with further developments by Itô and Mester (1997a, b). After ... transparency is brought into the fold of a widespread phonological phenomenon, namely derivational opacity effects.

1.2 Neutral segments and representations

In talking about nasal harmony it will be necessary to refer to different kinds of segmental behavior. I outline four categories of segments in (2) with the segment in question underlined and nasalization marked with tildes. The first category is trigger segments; these are segments that initiate the spreading of nasality (2a). Second is the category of target segments, which become nasalized in nasal harmony (2b). Next is the category known as blocking or opaque segments; these segments remain oral and block the continuation of spreading (2c). Last is the category of transparent segments, which remain oral themselves but allow spreading to continue (2d).

(2) a. Trigger segments: Segments that initiate nasal spreading, e.g. /na/ [na).]
b. Target segments: Segments that undergo nasal spreading, e.g. /na/ [n].
c. Blocking or opaque segments: Segments that remain oral and block spreading, e.g. /nata/ [na)ta].
d. Transparent segments: Segments that remain oral but do not block nasal spreading, e.g. /nata/ [na)ta).]

It should be noted that these categories are for descriptive purposes only and do not necessarily correspond to the analytical distinctions that will be made. As previewed in the preceding section, it will be shown later that the categories of target and transparent segments should be collapsed in some respects in the analysis.

The descriptive classes of segments that fail to become nasalized in nasal harmony, i.e. the blocking and transparent segments, together constitute the neutral segments. The canonical derivational autosegmental or feature-geometric approach to segmental neutrality calls on representations that provide for the blocking of spreading. The segmental neutrality assumption of the No Crossing Constraint, which forbids the crossing of autosegmental linkage in terms of feature-geometric representations, plays a central role in these accounts.

The constraints and representations in nasal harmony should be considered in some respects in the analysis. The No Crossing Constraint on tiered representations of the type $\lambda^\alpha \beta \gamma \delta$ forbids crossing of tiers on different segments, allowing no autosegmental links to be formed across tiers. On the one hand, this prevents the spreading of features across tiers, which is one of the main features of nasal harmony. On the other hand, this allows for the representation of segments that block spreading, such as the presence of the [-nasal] segment. Spreading across the [-nasal] segment is ruled out by No Crossing (3).

(3) No Crossing Constraint

As various analysts have noted, the ill-formedness of line crossing can be understood in terms of contradictory precedence relations (see Sagey 1988; Hammond 1988; Scobbie 1991; Archangeli and Pulleyblank 1994). On the one hand, $a$ precedes $b$ on one tier, and $F_1$ precedes $F_2$ on another. However, since $a$ is linked to $F_2$ and $b$ is linked to $F_1$, $F_1$ precedes $F_2$ on one tier. As a result, the spreading of features is blocked, giving a precedence contradiction.

Using the No Crossing Constraint, many representationally-based accounts achieve blocking of spreading through the presence of structure. In nasal harmony, this could consist of the presence of the [-nasal] segment as in (4b).
For segmental transparency, representational accounts make use of a configuration in which spreading takes place across an intervening segment. In some accounts, this may occur by simply skipping the target node, yielding a gapped configuration across the transparent segment (\(g\)), as in (5a). Feature-geometric approaches avoid gapping across a target node by positing a more elaborate segment structure in which spreading occurs over a more extended tier (organizing tier, nasal tier), as in (5b). This kind of approach for nasal harmony is employed by Piggott (1992), and it has been widely utilized in other feature-geometric accounts of transparency of various kinds. The optimality-theoretic account that I propose turns away from using the device of segmental skipping in spreading to obtain transparency; in fact, it is the assumption of this kind of representation that spreading takes place across transparent segments, which lacks target structure.

The need for calling on segmental skipping configurations in feature linking is subject of more detailed analysis in the context of representation. In (5c), the spreading across transparent segments is constrained by a formal constraint which will be discussed in chapter 2. In addition to the formal constraint, the spreading across transparent segments is constrained by the assumption that spreading from a root node justifies the spreading across transparent segments. In (5d), the spreading across transparent segments is constrained by the assumption that spreading from a root node justifies the spreading across transparent segments. In (5e), the spreading across transparent segments is constrained by the assumption that spreading from a root node justifies the spreading across transparent segments.
have been explained independent of feature organizing structure in Optimality Theory under Feature Class Theory, developed by Padgett (1995a). I put forth a typological argument that transparent segments ... of ranked and violable constraints, the account brings new insight to the understanding of the typology of nasal harmony.

1.3 Optimality theory
1.3.1 Constraint ranking and violability

The theoretical framework that I assume here is that of Optimality Theory (OT; Prince and Smolensky 1993). This approach ... of grammars as a hierarchy of ranked and violable universal constraints which evaluate the well-formedness of output forms. Parallel evaluation of a set of candidate outputs with respect to the constraint hierarchy selects the actual output by virtue of it being the most harmonic or \textit{optimal} with respect to the constraint hierarchy.

The goal of constraint ranking is thus to order all and only those constraints which are ranked and violable in a given language. knit evaluation is carried out by constraint rankings which reflect the constraint hierarchy, hence ranked violation evaluation of a set of candidate outputs picks the most optimal by selecting a candidate from the infinite set of candidate outputs for a given input.

The optimality-theoretic evaluation of an output form is illustrated with a concrete example in (7). Evaluation is displayed in a tableau which arrays the input and candidate outputs at the left, and the candidate output selected by Eval at the right. Eval is a function that comparatively evaluates the set of output candidates with respect to a given constraint hierarchy, the ranking of constraints that constitutes the grammar $G$. The structure of an optimality-theoretic grammar is outlined in (6). The function Gen operates on an input to yield an (infinite) set of candidate outputs. Eval then evaluates this set of candidate outputs in relation to $G$ to select the optimal candidate, the actual output form for the input.

(6) Schema for an optimality-based grammar:

a. Gen (input $i$) $\Rightarrow \{cand1, cand2, ...\}$

b. Eval ($G$, $\{cand1, cand2, ...\}$) $\Rightarrow \{cand_{real}\}$

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Another important kind of markedness constraint is the family of markedness constraints, which comprise the set of constraints ordering the relative possibility of sizes of phonological segments. This family can be represented in a tableau (8) (after McCarthy and Prince 1993: 2).

<table>
<thead>
<tr>
<th>Constraint tableau:</th>
<th>*NASLIQUID &gt;&gt; SPREAD[+nasal]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input /nar/</td>
<td>*NASLIQUID SPREAD[+nasal]</td>
</tr>
<tr>
<td>a.</td>
<td>(cand1)*</td>
</tr>
<tr>
<td>b.</td>
<td>(cand2)**</td>
</tr>
<tr>
<td>c.</td>
<td>(cand3)**!</td>
</tr>
</tbody>
</table>

An important feature of OT illustrated by the above example is that constraints are ranked and violable. Constraints are ranked in a strict dominance hierarchy such that each constraint has absolute priority over any constraint that it dominates (i.e., that is ranked lower) (Prince and Smolensky 1993). As noted above, the universal constraints of Con are ranked in a hierarchy of markedness constraints and faithfulness constraints.

### 1.3.2 Constraints and Correspondence Theory

Constraints according to their compatibility with material

- **Markedness constraints** evaluate the well-formedness of elements of the phonological structure (e.g., constraints on prosodic structure, feature cooccurrence, the OCP, nonfinality, alignment, spreading, etc.). Feature cooccurrence constraints, such as *NASLIQUID* (i.e., [+nasal, +approximant, +consonantal]), are a kind of markedness constraint that will play an important role in the constraints. A family of markedness constraints that play an important role in the constraints are constraints on prosodic structure, the OCP, nonfinality, alignment, spreading, etc. Constraints on prosodic structure, the OCP, nonfinality, alignment, spreading, etc.

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Alignment constraint schema

\[ \text{ALIGN} (\text{Cat}_1, \text{Edge}_1, \text{Cat}_2, \text{Edge}_2) \overset{\text{def}}{=} \text{Cat}_1 \overset{\text{such that}}{\vdash} \text{Cat}_2 \overset{\text{such that}}{\vdash} \text{Edge}_1 \overset{\text{of}}{\vdash} \text{Cat}_1 \overset{\text{and}}{\vdash} \text{Edge}_2 \overset{\text{of}}{\vdash} \text{Cat}_2. \]

Constraints in the alignment category have been utilized in the optimality-theoretic analysis of a wide range of phenomena, especially in the area of prosodic morphology, an application that will be briefly discussed in Chapter 5. The nature of nasal spreading in languages like Tuyuca; however, this distinction is not a crucial one in the analysis.

The second main constraint category is that of faithfulness. Following McCarthy and Prince (1995), I adopt the Correspondence view of faithfulness. Faithfulness constraints in correspondence are evaluated by constraints on correspondent elements with only complete identity and correspondence between input and output. Constraints on segments will be outlined here with others detailed in the text of later chapters as they become relevant.

Three families of correspondence constraints on segments are given in (11), following the formulation of McCarthy and Prince (1995: 264). The MAX family of constraints expresses the requirement that segments not be deleted (11a). MAX-IO demands this of an output in relation to an input, and MAX-BR demands this for a reduplicant in relation to a base. The DEP family of constraints acts against the insertion of elements in an output or reduplicant which are not in correspondence with segments in the input or base (11b). DEP constraints refer to the featural content of segments, requiring that correspondent segments be featurally identical to each other (11c). Importantly, DEP constraints demand identity of featural properties of correspondent segments and do not evaluate correspondence between features of segments.

Gen may freely posit correspondence relations or the lack thereof, and these relations are evaluated by constraints on correspondent elements with only complete identity and correspondence between input and output. Constraints on correspondences between features of segments will be outlined in a later chapter. For the moment when gap-filling, the assumption that segments can be deleted is violated. The assumption that segments cannot be deleted is violated in a later chapter. For the moment when gap-filling, the assumption that segments can be deleted is violated.
c. IDENT\[F\]

Let \( a \) be a segment in \( S_1 \) and \( b \) be any correspondent of \( a \) in \( S_2 \). If \( a \) is \([g F]\), then \( b \) is \([g F]\). (Correspondent segments are identical in feature \( F \).)

The above outlines the basics of Correspondence theory. In chapter 3, another correspondence relation will be added, one holding between a 'sympathy' candidate and the actual output (after McCarthy 1997). This will be discussed in the text when it becomes relevant.

1.3.3 Inputs and emergent contrast

On the subject of inputs, I assume the principle of 'Richness of the Base' (Prince and Smolensky 1993: 191), which compares the potentially infinite number of all possible inputs for the same output. Unelicited forms will thus occur in the general case, after the merger and merger of \([g F]\) in (12) which compares the harmonically invariant form of an elicited voiceless nasalized vowel with the underlying representation. This is shown by the input of nasalized vowels without respect to the consonant harmony. The issue is whether we would expect to see identical representations because there is more optimization, which would be expected in the underlying representation because there is more optimization.

The general case in the underlying representation of the language:

The general case in the underlying representation of the language:

With the principle of Richness of the Base and constraints holding of outputs not inputs, segmental inventories and contrasts are not properties assumed to hold of inputs, rather they must be derived by faith and markedness constraints.

2 I illustrate with an example of a language exhibiting a distribution in which vowels are phonemically only oral, but are contextually nasalized following a nasal stop. This follows the details of the analysis of Madurese proposed by McCarthy and Prince (1995).

In the general case, nasal vowels are prohibited in the language. This may be obtained in the outputs of the language by ranking a constraint against nasal vowels (*N ASVOWEL) over a constraint requiring identity for [nasal] (IDENT-IO [±nasal]). Thus, if an input were to contain a nasal vowel (a possibility given by Richness of the Base), it would map to an oral vowel. This is illustrated in (12).

(12) *N ASVOWEL >> IDENT-IO [±nasal]

<table>
<thead>
<tr>
<th>*N ASVOWEL</th>
<th>IDENT-IO [±nasal]</th>
</tr>
</thead>
<tbody>
<tr>
<td>da</td>
<td>*NASVOWEL</td>
</tr>
<tr>
<td>da</td>
<td>!NASVOWEL</td>
</tr>
</tbody>
</table>

Note that another input /da/ would also map to the same output. By Lexicon Optimization, /da/ would be selected as the underlying representation because it is more harmonic with respect to the constraint hierarchy. This is shown by the input of nasalized vowels without respect to the consonant harmony. The issue is whether we would expect to see identical representations because there is more optimization, which would be expected in the underlying representation because there is more optimization.

In OT, a distinction may be drawn between inputs and underlying representations.

In the general case, inputs are drawn between inputs and underlying representations. Input forms belong to the universal set for all languages, and this is the set to which the constraint hierarchy of the language is mapped. Thus, of all the possible inputs that map to a particular output, the one that is most closely resembles the output form is the optimal input or underlying form.
Lexicon Optimization: selecting the underlying representation

In the environment of a nasal consonant, nasal vowels do occur; in fact they must be nasalized in this context. This may be driven by a general nasal spreading constraint, which I will express as $\text{SPREAD} [+\text{nasal}]$, requiring that the feature [+nasal] spread to all segments when it occurs in the output of a word. To enforce the occurrence of a nasal vowel in the output, $\text{SPREAD} [+\text{nasal}]$ must outrank $\text{NASVOWEL}$. The outcome for a nasal + oral vowel input is shown in (14); the vowel is nasalized in the output. This is an example where faith and markedness interact to produce allophony.

Another input that will map to the same output as in (14) is the one with nasalization of the vowel /na/ itself. Since this form is closer to the actual output than /na/, Lexicon Optimization will select the form with the nasalized vowel as underlying in this case.

Nasalized vowels are thus not excluded from underlying representations, in fact they are posited in underlying representations in this language precisely where they occur with an allophonic distribution. Rather it is a distributional generalization holding of outputs that is obtained by the ranking of faith and markedness constraints.

Chapter 4 presents an acoustic study of Guaraní nasal harmony. I propose that nasal harmony reflects the nasal harmony constraint rather than a nasal spreading constraint. In this chapter, Nasal Harmony is posited as a faith principle in the organization of the Nasal Harmony constraint, which is ranked above Nasal Spreading. 

In chapter 5 I consider other proposals for the analysis of nasal harmony and the typology of nasal harmony. Finally, in chapter 6 I examine other phenomena that may be mistaken for nasal harmony but are not in fact instances of nasal harmony. I include an analysis of nasal harmony in the typology of nasal harmony and the typology of nasal harmony, showing how these proposals for the analysis of nasal harmony differ in their approach to nasal harmony and the typology of nasal harmony.
direction for further pursuit of this approach is outlined. A

Bryan's influential work is suggested that these are instances of cooccurrence effects. A

coincidence with a brief examination of long-distance nasal agreement effects in some

languages and additional remarks provided by Kralakk. The chapter

Language and constraint frameworks provided few additional remarks in the

a nasal segment is shown to fall out from independent-monotonic rankings in the

the nasal agreement as a case of nasal copy? It is copy. The limitation of copy to

and morphological evidence from the language is assembled to support an analysis of

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Chapter 2
A CROSS-LINGUISTIC TYPOLOGY OF NASAL HARMONY

In this chapter I develop a description and analysis of a cross-linguistic typology of nasal harmony, focusing on variability in the set of segments undergoing nasalization and in those that block or behave transparent to nasal spreading. Across these variables, I propose to unify our understanding of nasal harmony as conforming to one basic type of pattern. As the basis for this study, I have compiled a database of nasal harmony systems, which comprises descriptions from over 75 languages. Each language entry includes information about the inventory of segments, the set of segments undergoing nasalization, and any blocking or transparent segments. The cross-linguistic generalizations established in this research define the facts to be explained by the analysis. These facts are summarized in this chapter and a condensed version of the database itself is appended.

Two central theoretical points illuminate the unified account of nasal harmony. First, building on previous studies of the compatibility of nasalization with different segments, it is argued that cross-linguistic variation in nasal harmony is limited by a phonetically-grounded hierarchy which ranks segments in terms of their harmonicity under nasalization. After nasal stops, vowels are ranked as most compatible with nasalization in this hierarchy. Obstruents, on the other hand, are ranked as least compatible. The nasalization hierarchy is implicational in the sense that if a segment undergoes nasal spreading, all segments more compatible with nasalization will also be targetted. The hierarchy is analyzed in an optimality-theoretic framework as composed of intrinsically-ranked nasal feature cooccurrence constraints. Variation in the set of undergoing segments is then derived by ranking the nasal spreading constraint at different points in the constraint hierarchy, generating just the variability which is attested.

The second point concerns transparent segments in nasal harmony. To begin, there appears to be a gap in the set of variants predicted by the implicational hierarchy: there is no language in which all segments are nasalized in nasal harmony; some obstruents resist nasalization (see second row in (1a)). Also, as diagrammed in (1a), the typology of nasal harmony outlined here finds that while the majority of segments either block spreading or become nasalized, some obstruents (typically voiceless ones) behave differently, either blocking or behaving transparent. When transparent, obstruents remain oral but permit the continuation of nasal spreading. These two observations fit together like pieces of a puzzle: systems with a set of transparent segments form the complement to those with blocking segments. To explain this complementarity, it is proposed that systems with transparent obstruents fill the gap of a system targetting all segments, i.e. transparent obstruents should be understood as belonging to the set of segments undergoing nasal harmony, as outlined in (1b).

(1) a. Observed possible patterning of segments in nasal harmony:

<table>
<thead>
<tr>
<th>Vowoids</th>
<th>Liquids</th>
<th>Obstruents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blockers (block spreading)</td>
<td>✔️ ✔️ ✔️</td>
<td></td>
</tr>
<tr>
<td>Targets (become nasalized)</td>
<td>✔️ ✔️ X</td>
<td></td>
</tr>
<tr>
<td>Transparent segments (remain oral, do not block)</td>
<td>X ✔️ ✔️</td>
<td></td>
</tr>
</tbody>
</table>

b. Proposed analysis of segmental behavior in nasal harmony:

<table>
<thead>
<tr>
<th>Vowoids</th>
<th>Liquids</th>
<th>Obstruents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blockers (block spreading)</td>
<td>✔️ ✔️ ✔️</td>
<td></td>
</tr>
<tr>
<td>Targets (undergo [nasal] spreading)</td>
<td>✔️ ✔️ ✔️</td>
<td></td>
</tr>
</tbody>
</table>

Factorial ranking in the optimality-theoretic framework (Prince and Smolensky (1993) predicts the possibility of a grammar in which nasal spreading would be ranked high enough to derive even nasalized segments at the extreme of incompatibility. With this move, nasal harmony is unified into a basic pattern in which segments simply either undergo or block, and all possible variations produced by different rankings are attested. In this unified analysis of the typology, transparency arises as a resolution for an incompatible segment that undergoes nasal spreading.

In further support of this claim, it is observed that there is an implication in the occurrence of voiceless transparent obstruents and the behavior of other segments. When voiceless obstruents behave transparent to nasal harmony, all other classes of segments undergo nasalization, that is, they exhibit a nasal alternant in nasal contexts. Voiceless obstruents never behave transparent when segments more compatible with nasalization block nasal spreading. As I will show, this asymmetry suggests that all segments, including obstruents, are targetted by nasalization in these languages. Importantly, the finding that descriptively transparent segments pattern with undergoers
lends support to phonological studies arguing that spreading or sharing of structure can never skip an intervening segment, a result derived by claiming that a gapped configuration in feature linking is resonanceless. The surface-transparent resolution for transparent segments, while still maintaining locality, is worked out in chapter 3.

This chapter is organized as follows. First in section 2.1 I present the descriptive facts, exhibiting the hierarchical cross-linguistic variation in nasal harmony and summarizing the key generalizations. I then provide a condensed version of the nasal harmony database and discuss some of the findings from this survey in more detail.

2.1 Hierarchical variation in nasal harmony

The behavior of segments in nasal harmony falls into three descriptive categories: target segments are those that undergo nasal spread, blocking segments remain oral and block nasal spreading, and transparent segments remain oral but do not block nasalization of subsequent segments. In this section I show that languages which divide their segments exhaustively into blockers and targets exhibit nasal spreading. A central insight in this examination of the typology is that systems with transparency form the complement to those just mentioned by including all consonants, including obstruent stops, in the set of supralaryngeal targets. Central to this claim is the idea that variation in nasal harmony must adhere to a hierarchy of segments.

As discussed in Walker (1995), previous surveys of nasalization (Schourup 1972; Piggott 1992; Cohn 1993c; cf. also Pulleyblank 1989) find that variation in the sets of supralaryngeal targets and blocking segments is related to the hierarchical organization of the segments. In previous work this hierarchy of segments has only been assumed to apply to certain languages with blocking and spreading, but the framework in this work allows for a more general hypothesis.

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Sundanese

a. ¯a)i'an
   'to wet'

b. kuma)h)a)
   'how?'

c. bFNh)a)r
   'to be rich'

d. mi'/)a)sih
   'to love'

e. Na)ja
   'to sift'

f. ma)wur
   'to spread'

g. mo)lohok
   'to stare'

h. ma)ro
   'to halve'

i. Nu)dag
   'to pursue'

j. Na)tur
   'to arrange'

The Johore dialect of Malay, another Malayo-Polynesian language, illustrates the second variation, in which glides also undergo a rightward spreading of nasality from anasal consonant (Onn 1980). Liquids and obstruents block spreading. The Malay inventory contains the following consonants

\[ p, b, t, d, tÉS, dÉZ, k, g, s, m, n, ¯, N, l, r, j, w, h, / \] (glottal stop is again non-phonemic).

Malay (Johore dialect)

a. mi'no)m
   'to drink'

b. baNo)n
   'to rise'

c. ma)/)a)p
   'pardon'

d. p´n´)Na)h)a)n
   'central focus'

e. ma)j'a)N
   'stalk (palm)'

f. m´)na)w)a)n
   'to capture' (active)

g. m´)ratappi
   'to cause to cry'

h. p´Na)w)a)san
   'supervision'

i. ma)kan
   'to eat'

Jjo, a Kwa language of Nigeria, is an example of the third variation, where liquids are added to the set of undergoing segments (Williamson 1965, 1969b, 1987). In this language, nasality spreads from a nasalized vowel to the nasally harmonized consonants of the following coda (Williamson 1969, 1987). In this example of the third variation, where liquids are added to the set of undergoing segments (Williamson 1965, 1969b, 1987).

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Ijo (Kolokuma dialect)

a. U)mba
   'breath'

b. a)nda
   'wrestle'

c. w)a)i'
   'prepare sugarcane'

d. j'a)R)I'
   'shake'

e. sç)R)ç)
   'five'

f. sa)nlo
   'gills'

g. izo)Ngo
   'jug'

h. aba)mu
   'loft'

i. oto)Ngbolo
   'mosquito'

j. tç)ni'
   'light (a lamp)'

The Applecross dialect of Scottish Gaelic, a Celtic language spoken in Scotland, illustrates the fourth variation in which nasalization carries through fricatives (Ternes 1973). It nasalizes the onset of the syllable containing the stressed vowel, provided the onset is not an obstruent stop. Two vowel lengths are distinguished: long and short vowels are marked. The inventory contains the following consonants:

\[ p, b, t, tÉS, d, dÉZ, k, g, kÉp, gÉb, f, v, s, S, C, ∆, x, ƒ, m, n, nJ, N, r, {, l, lJ, ;, j, h \] (voiced aspirated stops are used by conservative speakers only).

Scottish Gaelic (Applecross dialect)

a. /ma)>har/
   '/ma)>h)a)r/ 'mother'

b. /tJi'anu/
   '/tJi'a)nu/ 'to do, to make'

c. /f'r)i'a)>v/
   '/f'r)i'a)>v/ 'root' (plural)

d. /SE)nE>var/
   '/S)E)nE)v)a)r/ 'grandmother'

Ternes notes some complexities in relation to the mid-high vowels. These will be discussed in section 2.4.
The above examples illustrate four hierarchical variations in the set of segments undergoing nasal harmony. In general terms, the hierarchy governing the variants has five segmental classes: Vowels, Consonants, Nasal plus voiced stops, Nasal plus voiceless stops, and Obstruents. Voiceless fricatives behave transparently in nasal spreading and some obstruents behave transparently in nasal spreading and some obstruents behave transparently in nasal spreading. For example, the nasalization of [b] from [p] to [b] in a nasal morpheme is an instance of this case. This kind of pattern occurs in Tuyuca.

Tuyuca is a Tucanoan language spoken in Colombia and Brazil (Barnes and Takagi de Silzer 1976; Barnes 1996). Its inventory of consonants is as follows: [p, b, t, d, k, g, m, n, N, s, r, w, j, h] with nasal and voiced stops in complementary distribution in outputs, as defined by nasal harmony contexts (Barnes 1996: 33). Morphemes in Tuyuca are descriptively characterized as nasal or oral, in which nasals and voiced stops are described to occur as separate phonological units. In nasal morphemes, all nasal stops are nasalized for voiceless obstruents. In oral morphemes, all nasal stops are nasalized, except for voiced obstruents. In nasal morphemes, nasalization affects distribution in outputs, as defined by nasal harmony contexts (Barnes 1996: 33).

In attributing a special status to the first syllable, I follow Beckman (1995, 1997, 1998), who finds that the root-initial syllable often has a privileged status in triggering spreading and resisting change to other segmental features. Because nasal spreading and resisting change to other segmental features.

In Tuyuca, spreading from the trigger segment is bidirectional, and it is not blocked by any segments within the morpheme. Voiceless obstruents are transparent to nasal spreading, and some obstruents behave transparently in nasal spreading. For example, the nasalization of [b] from [p] to [b] in a nasal morpheme is an instance of this case. This kind of pattern occurs in Tuyuca.
Continuous sequence of voiced segments; voiceless segments block spreading.

Importantly, nasalization is contrastive for vowels only in the initial syllable. I assume that both voiced oral and nasal stops are 'phonemic' in Tuyuca, i.e. they may both occur underlying. This will be motivated as the analysis of Tuyucadevelops: I posit underlying nasalization of the stem to which they are affixed (8) or they are fixed in their nasality (9) (there are no prefixes in Tuyuca).

5 Nasality alternations with /-ri/ ‘imperative of warning’

a. Oral suffix alternant with oral stem

/tuțiê/ - ri /fi/ [tutir] 'watch out or you will get scolded!'

scold - imp. of warning

b. Nasal suffix alternant with nasal stem

/h)ˆ'ˆ'ê/ - ri /fi/ [h)ˆ'ˆ'êr]i' 'watch out or you will get burned!'

burn - imp. of warning

5 Suffixes with fixed nasality

a. Fixed oral suffix

/w)a)ka)è/ - go /fi/ [w)a)ka)go] 'she awakens'

wake up - evidential

b. Fixed nasal suffix

/koa - ma)/ /fi/ [koama)è] 'allow me to dig'

dig - imp. of permission

Voiced velar stops behave somewhat differently from the others because they can occur in

A list of some Tuyuca suffixes by their nasalization categories is given in (10-11). Interestingly, suffixes that alternate exclude ones with initial stops or fricatives.

5 As Barnes (1996: 34) observes, this indicates that obstruents block nasal spread from stem to suffix, otherwise the gap of obstruent-initial suffixes in the alternating set would be purely accidental.

(10) Alternating suffixes:

a. - a animate plural
b. - ha contrast
c. - ja imperative
d. - wê evidential
e. - wo evidential
f. - ri imperative of warning
g. - re specifier
h. - ro adverbializer
i. - ra pl. nominative

(11) Fixed oral suffixes:

a. - a recent past
b. - ja evidential
c. - wê classifier
d. - wo classifier
e. - ri inanimate sg. nominative
f. - re inanimate pl. nominative
g. - sa classifier
h. - ba classifier
i. - da classifier
j. - na) at that instant

Fixed nasal suffixes:

a. - h)a) emphatic
b. - ja evidential
c. - wê singularizer
d. - w)o) classifier
e. - ri inanimate sg. nominative
f. - re inanimate pl. nominative
g. - sa classifier
h. - ma) classifier
i. - na) at that instant

Trigo (1988) offers a possible

explanation. In her discussion of the related language, Tucano, which exhibits the same suffixal blocking effects, she says...
The fact that voiced stops pattern with the obstruents in blocking nasal spreading across morphemes is strong evidence that when oral they are obstruents themselves. This blocking effect would be wholly absent if nasal spreading were blocked by obstruents. The full system of Tuyuca nasal harmony forms a case study in chapter 3.

Nasal harmony within Tuyuca morphemes provides an example in which nasal spreading targets all classes of segments, including obstruents. This completes the exemplification of the hierarchical typology, summarized in (12).

(12) Hierarchical typology of nasal harmony

<table>
<thead>
<tr>
<th></th>
<th>Vowels</th>
<th>Glides</th>
<th>Liquids</th>
<th>Fricatives</th>
<th>Obstruent Stops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spanish</td>
<td>Vowels</td>
<td>Glides</td>
<td>Liquids</td>
<td>Fricatives</td>
<td>Obstruent Stops</td>
</tr>
<tr>
<td>Sundanese</td>
<td>fi</td>
<td>fi</td>
<td>fi</td>
<td>fi</td>
<td>°</td>
</tr>
<tr>
<td>Malay (Johore)</td>
<td>fl</td>
<td>fl</td>
<td>fl</td>
<td>fl</td>
<td>–</td>
</tr>
<tr>
<td>Ijo (Kolokuma)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>°</td>
</tr>
<tr>
<td>Gaelic (A.cross)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Tuyuca</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

All of the variation in the set of non-undergoing (blocking segments) conforms to the fixed hierarchy of segments and all variations given by the hierarchy are attested.

An analytical assumption I make for this typology is that all nasal harmony is strictly segmentally local, so the only possible nasalization of each segment is within its morpheme. This claim is key to achieving a complete typology with all hierarchical variants.

In order to verify the cross-linguistic application of this hierarchical typology, I compiled a database of nasal harmony patterns in over 75 languages, building on the background of surveys by Schourup, etc. This database is summarized in an appendix to this chapter in section 2.4. I summarize here the key findings and relate them to the typology in (12).

The focal finding of the database is that variation in nasal harmony across languages bears out the implicational hierarchy outlined in (2). The study finds that if a segment blocks nasalization, so if a segment becomes nasalized or behaves transparently whereby if a segment becomes nasalized or behaves transparently, then all more compatible segments also undergo nasalization.

The cross-linguistic generalizations thus support the hierarchical view of nasal harmony and the proposal that transparent segments and all nasalization are blocked by the segments Categorize
spreading. In chapter 3 I argue that transparency only occurs as the result of an opaque constraint interaction: one that arises to resolve a conflict between fully satisfying the nasal spreading constraint and nasal markedness constraints. I begin by examining the required spreading constraints and nasal markedness constraints. I then go on to clarify the compatibility of certain spreading constraints and nasal markedness constraints. I then go on to clarify the compatibility of certain spreading constraints and nasal markedness constraints.

2.2 Analysis of the typology

The typology established by the database confirms that cross-linguistic variation in nasal harmony obeys the implicational hierarchy in (2). On the subject of transparent nasal spreading, I argued that the typology in (2) is the only segments to ever behave transparently to nasal harmony, and when they act transparent, all higher-ranked segments are as well.

2.2.1 The constraints

To characterize the basic typology of nasal harmony, two kinds of constraints will be required: spreading constraints and nasal markedness constraints. I then go on to clarify the compatibility of certain spreading constraints and nasal markedness constraints. I then go on to clarify the compatibility of certain spreading constraints and nasal markedness constraints.
The nasalized segment constraints will conflict with the constraint driving the nasality hierarchy, (13), and we can explain the variation in nasal harmony as variability in where languages make the cut between segments that are sufficiently compatible with [+nasal] to be nasalized. The approach of using feature cooccurrence constraints to achieve segmental blocking is one that builds on previous work by Kiparsky (1985), Pulleyblank (1989), and Archangeli and Pulleyblank (1994).

With the harmony scale in (13), we can explain the variation in nasal harmony from the perspective of constraint hierarchies (e.g., Prince and Smolensky 1993; Prince and Pulleyblank 1994, 1995). The nasalized segment constraints will conflict with the constraint driving the nasality hierarchy, (13), and we can explain the variation in nasal harmony as variability in where languages make the cut between segments that are sufficiently compatible with [+nasal] to be nasalized. The approach of using feature cooccurrence constraints to achieve segmental blocking is one that builds on previous work by Kiparsky (1985), Pulleyblank (1989), and Archangeli and Pulleyblank (1994).

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Every rule enforcing the optional spreading constraint makes a mandatory domain of occurrence assumption. Thus, if a given feature spreading operation is specified to apply only in a domain $D$, it is not satisfied if any $+$ feature spreading violations occur outside $D$. Therefore, the spreading constraint is not satisfied if any segmentation that is not in $D$ is assigned a spreading violation.

The spreading constraint in (17) expresses the requirement that for any segment linked to an occurrence of a feature specification $+F$ in some domain $D$, a violation $\text{SPREAD}(+F, D)$ holds if and only if:

1. For each feature occurrence $f$ associated to some segment in $D$, a violation $[[[[[(+f) \Rightarrow (\text{Assoc}(f, s_i))] \Rightarrow s_i \in S]]]] 

2. For each feature occurrence $f$ associated to some segment in $D$, a violation $[[[[[(+f) \Rightarrow (\text{Assoc}(f, s_j))] \Rightarrow s_j \in S]]]]$

The spreading constraint in (17) formalizes these requirements in a way that captures the essential nature of the spreading constraint. It specifies that spreading must hold for all occurrences of a feature specification $+F$, and that spreading can only be satisfied if all segments in the domain are linked to spreading violations.

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The formulation of the spreading constraint so far incorporates nothing explicit about the direction of spreading. For the bidirectional spreading of [+nasal] in Tuyucamorphemes, this is sufficient; ... direction is regressive from anasal stop, whether from a syllable onset or a syllable coda. Examples are given in (19).

(19) Capanahua
a. /)o)nap/ 'I will learn'
b. /po)j'a)n/ 'arm'
c. /ba)w)i'n/ 'catfish'
d. /war aç/ 'squash'
e. /bi'mµ/ 'fruit'
f. /tÉSipo)Nki/ 'downriver'
g. /kajata)nai/ 'I went and jumped'
h. /kµ)ntÉSap/ 'bowl'

Word-final nasals in Capanahua are deleted but still trigger nasal spreading, so I have shown them in the transcription here. It should be noted that Capanahua also deletes nasals in clusters containing a continuant, even when there is no feature [-nasal] in the prosodic word. For an interesting case it triggers bidirectional spreading. For analysis of this interesting phenomenon, see Loos (1969) and Trigo (1988).

To obtain the different direction of spreading in languages like Malay and Capanahua, it must be possible to encode directionality in the spreading constraint. I propose to formulate directional spreading as in (20).

(20) S
PREAD-R/osexual(⟨F⟩, D)

Let f be a variable ranging over occurrences of a feature specification ⟨+nasal⟩, and S be the ordered set of segments s₁...sk in a domain D. Let Assoc(f, si) mean that f is associated to si, where si ∈ S.

SPREAD-R(⟨F⟩, D) holds iff
i. (si ∈ S) \[ f (Assoc(f, si)) \] f[(sj ∈ S) \[ j > i \] f (Assoc(f, sj))]

where 1 ≤ i, j, k.

ii. For each feature occurrence f associated to some segment in D, a violation is incurred for every sj ∈ S for which (i) is false.

The formulation of spreading in (20) adds directionality by making reference to the place occurrence of the feature specification that will be incorporated into any counting domain in the sentence. A feature greater than +nasal R expresses a similar domain but requires that a feature occurrence of the spreading constraint be linked to any segment si which comes after si in the sequence of segments in the domain. For any occurrence of a feature in a segment within the sequence of segments in the domain, for any occurrence of a feature in a segment before si in the sequence.

(21) Capanahua

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(21) Spread-R(⟨F⟩, Pwd)

Let n be a variable ranging over occurrences of the feature specification ⟨+nasal⟩, and S consist of the sequence of segments s₁...sk in the prosodic word P. Let Assoc(n, si) mean that n is associated to si, where si ∈ S.
Then $SPREAD_R([\text{+nasal}], Pwd)$ holds iff

i. \( (si \in S) \bigwedge (\exists n (Assoc(n, si))) \bigwedge (sj \in S) \forall i > j \bigwedge (\exists n (Assoc(n, sj))) \) where \( 1 \leq i, j, k \).

ii. For each feature occurrence \( n \) associated to some segment in \( P \), a violation is incurred for every \( sj \in S \) for which (i) is false.

Let us consider the evaluation of the representations in (22) in relation to this constraint. The structures in (a) and (b) each perfectly satisfy $SPREAD_R$, because for any segment linked to $[\text{+nasal}]$, all segments to the right of it are also linked to that same occurrence of the $[\text{+nasal}]$ feature specification. On the other hand, (c) incurs one violation with respect to $SPREAD_R$, because one segment to the right of $S_2$ is not linked to $[\text{+nasal}]$.

(22)

\[
\begin{align*}
(a) & \quad S_1 \ S_2 \ S_3 \\
(b) & \quad S_1 \ S_2 \ S_3 \\
(c) & \quad S_1 \ S_2 \ S_3
\end{align*}
\]

In cases of spreading where directionality need not be stated in the constraint, I will continue to use a simpler formulation like that in (17). Alternatively, this kind of spreading could be captured with two constraints, one spreading to the left and the other to the right.

Interaction of nasal spreading constraints and the nasalized segment constraint will derive the hierarchical variation in the typology of nasal harmony. The spreading constraint and nasalized feature specification capture spreading of features such as spreading of place features from one consonant to another across vowels. The view of locality that I adopt here is a segmental view of locality, as termed by Ní Chiosáin and Padgett (1997). Segmental locality prevents multiple linking of a feature from skipping an intervening segment.

The motivation for a segmentally strict view of locality is reviewed and argued for in a paper by Ní Chiosáin and Padgett (1997). There work seeks to understand

\[
\begin{align*}
[\text{N}^+], & \quad [\text{N}^+] \\
\quad & \quad [\text{N}^+] \\
\quad & \quad [\text{N}^+]
\end{align*}
\]

The spreading constraint and nasalized segment constraint interact in the following way: For example, spreading of nasal harmony is possible in (a) and (b) because the nasalized segment is to the right of the spreading constraint. On the other hand, spreading of nasal harmony is not possible in (c) because the nasalized segment is to the left of the spreading constraint.

Interaction of nasal spreading constraints and the nasalized segment constraint will derive the hierarchical variation in the typology of nasal harmony. The spreading constraint and nasalized feature specification capture spreading of features such as spreading of place features from one consonant to another across vowels. The view of locality that I adopt here is a segmental view of locality, as termed by Ní Chiosáin and Padgett (1997). Segmental locality prevents multiple linking of a feature from skipping an intervening segment.

The motivation for a segmentally strict view of locality is reviewed and argued for in a paper by Ní Chiosáin and Padgett (1997). There work seeks to understand
the implicational nasalization hierarchy are attested. It also explains why voiced stops always undergo nasalization rather than block when voiceless stops behave transparently. The requirement of segmentally strict locality follows more generally from the claim that a 'gapped configuration' like that in (23) is universally ill-formed.

\[(23) \quad \text{The gapped configuration: universally ill-formed}\]

\[a \quad b \quad \underbar{g} \]

where \(a\), \(b\), and \(g\) are any segment.

In prohibiting a configuration like that in (23), which violates segmental adjacency in feature linking, I follow Ní Chiosáin and Padgett (1993, 1997), Padgett (1995a), and Walker (1996) (McCarthy 1994; ... (1994), and Pulleyblank (1993, 1996), among others. It should be noted that some previous conceptions of locality permit \(a\), \(b\), and \(g\) to be defined as projected targets, allowing skipping of non-target segments (see, for example, Archangeli and Pulleyblank on 'prosodic transparency' 1994: 358-9, also feature-geometric approaches make use of elaborated structure below the segment; Piggott 1992); however, under segmentally strict locality, \(a\), \(b\), and \(g\) are interpreted as any segment, so spreading and linking must be between adjacent segments. In prohibiting a structure like that in (23), the featural gesture must carry on uninterrupted between each of those segments to which it is linked.

In describing the gapped configuration as universally ill-formed, I mean that it represents a structural configuration that may never be violated in the candidate set: it is not a structure that Gen is licensed to realize. Instead, Gen is licensed to realize a common occurrence of some property of surface. A representation of a common occurrence of some property of surface is a manifestation of a convex featural event. As Ní Chiosáin and Padgett suggest, it is reasonable to assume that convexity holds of phonological representations without exception.10 The ill-formedness of the gapped configuration in (23) may thus be understood in these terms: the gapped configuration is not a possible phonological representation because it is not a convex featural event.

The consequence of segmentally strict locality for the analysis of nasal harmony is this: spreading of [+nasal] may never skip a segment by linking across it. If nasalization of a particular segment is markedness constraints outranking spreading, the only outcome that may occur is that the segment blocks nasalization.

2.2.2 A factorial ranking typology

Prince and Smolensky (1993) hypothesize that typologies are derived by factorial constraint ranking, that is, the set of constraints in a typology is determined by the set of constraints in a factorial constraint ranking. Sinceskipping segments is not an option in spreading, any nasalized segment constraints must be high in spreading.

\[\text{where } \alpha, \beta, \gamma \text{ are any segment}\]
which dominate spreading will produce blocking effects, as it would be worse to form these nasalized segments than violate spreading. In contrast, nasalized segment constraints outranked by spreading will not produce blocking effects, as it is better to violate these constraints by forming the nasalized segments, than it is to violate spreading instead.

(25) Hierarchical variation through constraint ranking:

- **Spanish**: 
  
  *NASOBSSTOP » *NASFRIC » *NASLIQUID » *NASGLIDE » *NASVOWEL » SPREAD\(+nas\)\[+nas\]

- **Sundanese**: 
  
  *NASOBSSTOP » *NASFRIC » *NASLIQUID » *NASGLIDE » *NASVOWEL » SPREAD\(+nas\)\[+nas\] » *NASVOWEL

- **Malay (Johore)**: 
  
  *NASOBSSTOP » *NASFRIC » *NASLIQUID » *NASGLIDE » *NASVOWEL » SPREAD\(+nas\)\[+nas\] » *NASVOWEL

- **Ijo (Kolokuma)**: 
  
  *NASOBSSTOP » *NASFRIC » *NASLIQUID » *NASGLIDE » *NASVOWEL » SPREAD\(+nas\)\[+nas\] » *NASVOWEL

- **Scottish Gaelic (Applecross)**: 
  
  *NASOBSSTOP » SPREAD\(+nas\)\[+nas\] » *NASFRIC » *NASLIQUID » *NASGLIDE » *NASVOWEL

- **Tuyuca**: 
  
  *NASOBSSTOP » SPREAD\(+nas\) » *NASFRIC » *NASLIQUID » *NASGLIDE » *NASVOWEL

For case (Spanish), which exhibits no nasal harmony, SPREAD\(+nas\)\[+nas\] is ranked below all nasalization constraints, as it fails to force violations of any of these constraints. For (Sundanese), where only vowels undergo nasal harmony, SPREAD\(+nas\)\[+nas\] dominates just the constraint against nasalized vowels; other nasalization constraints are ranked above SPREAD\(+nas\)\[+nas\], since they remain unviolated. (Malay) maintains the same ranking of the nasalization constraints with respect to each other across nasalized vowels, while only vowels undergo nasal harmony. SPREAD\(+nas\)\[+nas\] moves over the nasalized glide constraint as well.

(Ijo) moves SPREAD\(+nas\) up one more to dominate the constraint against nasalized liquids, and for (Scottish Gaelic) SPREAD\(+nas\) moves one more again so that fricatives also undergo nasal harmony. Finally for (Tuyuca), SPREAD\(+nas\) dominates all nasalization constraints, giving a pattern in which all segments undergo harmony. The *NASSONSTOP constraint is not shown here, because all of the underlying sonorant stops are already nasal, so this constraint would not interactiable with nasalization.

The overall ranking that has been established for the typology of nasal harmony is given in (26). A crucial feature of this pattern is that the ranking of nasalization constraints with respect to each other remains constant according to the intrinsically-ranked hierarchy in (14).

(26) Summary of constraint ranking:

<table>
<thead>
<tr>
<th>Nasalized segment constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPREAD(+nas)[+nas]</td>
</tr>
<tr>
<td>(blocking segments)</td>
</tr>
<tr>
<td>(target segments)</td>
</tr>
</tbody>
</table>

The ranking pattern is exemplified in (27-29). The tableau in (27) illustrates the pattern for Sundanese, with rightward spreading.

11 In this variation, only vowels undergo harmony, so the spreading constraint dominates the nasalized segment constraints up to the constraint against nasalized vowels. The optimal tableau shows the optimal nasalization pattern for Sundanese, with rightward spreading. In the tableau below, the nasalization pattern is completed in (27), (28), and (29), while still providing a framework for the Data Analysis Theorem that is used to determine the nasalized constraint's ranking. The tableau in (28) illustrates the constraint ranking, which is determined by the Data Analysis Theorem. The tableau in (29) shows the optimal tableau. In the tableau below, the nasalization pattern is completed in (27), (28), and (29), while still providing a framework for the Data Analysis Theorem that is used to determine the nasalized constraint's ranking. The tableau in (28) illustrates the constraint ranking, which is determined by the Data Analysis Theorem. The tableau in (29) shows the optimal tableau.
When the spreading constraint dominates all of the nasalized segment constraints, all segments will participate in nasal harmony. This is how I propose to real Tuyuca.

The optimal output selected on the basis of this ranking is the one in (a), in which all segments are nasalized, including the voiceless obstruent stop. This segment is described as oral, corresponding to a representation like that in (d), with a separate nasal feature.

We have now seen how the spreading constraint ranking of the nasalized segments in nasal harmony spans, I have marked them as nasalized throughout the transcription of these segments with nasal harmony spans. I have marked them as nasalized throughout the transcription of these segments with nasal harmony spans. I have marked them as nasalized throughout the transcription of these segments with nasal harmony spans. I have marked them as nasalized throughout the transcription of these segments with nasal harmony spans.
necessarily nasal airflow (Howard 1973; Cohn 1993a; Walker and Pullum 1997), the phonetic nasalization of glottal segments within nasal spans is uncontroversial (Howard 1973; Cohn 1990, 1993a; Ohala 1993a). Walker and Pullum (1997), on the other hand, argue that glottals can be nasalized in the phonology of a language.

Working in a feature-geometric framework, Cohn tentatively suggests that the feature [nasal] is not phonologically relevant for glottal segments. To implement this proposal, she proposes that there is a subnode that is absent in glottals and present in all supralaryngeal segments, as illustrated in (30) (from Cohn 1993a: 349).

(30) Root

```
Laryngeal   Supralaryngeal
```

With this model of segmental structure, spreading of [+nasal] will target only supralaryngeal segments (i.e. those with a supralaryngeal node), and glottal segments will be skipped. The locality and full generalization of nasalization of glottal segments in nasal harmony spans, she draws on a separate level of phonetic implementation. Walker and Pullum (1997) argue for a different view in which glottal segments can be nasalized in phonological representations. Walker and Pullum note that strong evidence for the possibility of phonologically nasalized glottals is provided by instances of languages with a phonemic nasal glottal continuant ([ŋ]) in Kwangali, Arabela).

12 Further support comes from the finding that nasal spreading is strictly local, as noted by Walker (1996) and argued for in this chapter. The skipping approach suggested by Walker (1996) and noted for this chapter. The spreading approach suggested by Cohn (1993a) and Walker and Pullum (1997) provide support for the idea that nasal spreading is locally blocked. However, the evidence for the possibility of phonologically nasalized glottals is provided by instances of languages with a phonemic nasal glottal continuant ([ŋ]).

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Finally, it is worth pointing out that glottal stops in nasal harmony provide an interesting example where a segment undergoes nasal spreading even though there is no perceptual cue to the nasalization of the target segment. This kind of false transparency can be distinguished from cases of true transparency, where a segment that is highly compatible with a spreading feature behaves transparently, i.e. the case of transparent obstruents in nasal harmony. Thes
The constraints may be ranked at separate points in the same language. I will now briefly examine two such cases.

The first example is found in Epena Pedee, a Choco language spoken in Colombia described by Harms (1985, 1994). Epena Pedee has two separate nasal harmony phenomena. It exhibits a rightward spreading nasalization of sonorants but is blocked by obstruents, while the (leftward) nasalization within the syllable nasalizes sonorants and obstruents. This indicates that two nasal spreading constraints are active in Epena Pedee.

Interestingly, the two nasal harmony phenomena of Epena Pedee differ in their degree of strength. The rightward nasal spreading nasalizes sonorants but is blocked by obstruents, while the (leftward) nasalization within the syllable nasalizes sonorants and obstruents.

The second example of constraints ranked at separate points in relation to the nasalization hierarchy comes from Ijo (Williamson 1965, 1969b, 1987). The nasal harmony pattern of Ijo was discussed in section 2.1: a nasal stop or nasal vowel introduces the nasalization hierarchy. The nasalization that comes from the nasal consonant of Ijo (Williamson 1965, 1969, 1998) is blocked by devoicing of nasals. The rightward nasal spreading nasalizes sonorants but is blocked by devoicing of nasals.

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In Ijo, the two nasal harmony phenomena of Epena Pedee differ in their degree of strength. The rightward nasal spreading nasalizes sonorants but is blocked by obstruents, while the (leftward) nasalization within the syllable nasalizes sonorants and obstruents. This indicates that two nasal spreading constraints are active in Epena Pedee.
After McCarthy and Prince (1995: 280), I use F'[nas] to indicate the class of constraints that dispose of other possible ways of satisfying nasal spreading, for example through deletion or denasalization of the nasal trigger segment.

(34) Nasal vowel triggers in Ijo

<table>
<thead>
<tr>
<th></th>
<th>*NAS</th>
<th>OBSST</th>
<th>FRIC</th>
<th>F'[nas]</th>
<th>SPREAD-L ( [+n], Pwd)</th>
<th>*NAS LIQUID</th>
<th>*NAS GLIDE</th>
<th>ID-IO [ +nas ]</th>
<th>*NAS VOWEL</th>
<th>*NAS SONST</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>c.</td>
<td>*!</td>
<td></td>
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<td>*</td>
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<tr>
<td>d.</td>
<td>*!</td>
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<td></td>
</tr>
</tbody>
</table>

The tableau in (35) shows the operation of the constraint hierarchy on an input with a nasalized liquid. Here, the ranking of IDENT-IO [ +nasal ] below *NAS LIQUID will cause the liquid to surface as oral.

(35) No 'phonemic' nasal liquids in Ijo

<table>
<thead>
<tr>
<th></th>
<th>*NAS</th>
<th>OBSST</th>
<th>FRIC</th>
<th>F'[nas]</th>
<th>SPREAD-L ( [+n], Pwd)</th>
<th>*NAS LIQUID</th>
<th>*NAS GLIDE</th>
<th>IDENT-IO [ +nas ]</th>
<th>*NAS VOWEL</th>
<th>*NAS SONST</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

More generally on the subject of inventories, the nasalization hierarchy predicts that inventories will exhibit the same kinds of implications as spreading, that is, if a nasalized segment occurs in the inventory of a language, then nasalization will always occur in the inventory of the same language.

In a survey of the status of nasalized continuants, Cohn (1993a) notes that the languages with nasalized continuant consonants (including nasalized fricatives) all exhibit restrictions on the distribution of nasals.

The appendix to this chapter contains a compact version of the database of nasal harmony patterns. This database contains entries for languages that exhibit interesting variability in the ranking of glottals and voiced stops versus voiceless fricatives, which is discussed below.

Appendix: The nasal harmony database

<table>
<thead>
<tr>
<th></th>
<th>*</th>
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</tr>
</thead>
<tbody>
<tr>
<td>SVN*</td>
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<td></td>
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<tr>
<td>SVN*</td>
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<td>SVN*</td>
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<td>SVN*</td>
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<td></td>
</tr>
<tr>
<td>SVN*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This inventory (97%; UPSID; Maddieson 1984) contains nasalized vowels considerably less frequently (in less than 25% of the languages in UPSID). Nasalized continuant consonants are more commonly found in the inventory. Ijo provides an example of a language which has distinctively nasalized vowels in its inventory as well as nasal stops.

16 UMbundu, a Benue-Congo language of Angola, is a more extreme case. UMbundu is noted by Schadeberg (1982) to have a contrastively nasalized voiced fricative /

17 In a survey of the status of nasalized continuants, Cohn (1993a) notes that the languages with nasalized continuant consonants (including nasalized fricatives) all exhibit restrictions on the distribution of nasals.

15 Thompson and Thompson 1972 cite three language families of the Pacific Northwest region some members of which have no nasal in their inventory: Chemakuan, Wakashan, and Salishan.

16 For several Amazonian languages, it has been observed by various researchers that a phonemic analysis of the language need only posit nasality as 'underlying' on vowels. However, all of these languages still allow nasalization in the vowel inventory (97%; UPSID; Maddieson 1984).
The database assembles substantial information about each language, including the language name, family, and location, the inventory of segments, the segments triggering nasal spreading, blocking nasalization, and those that are transparent with nasalization. The segments propagating nasalization, i.e., those that are nasalized or descriptively transparent, are also included. Information included in these entries is as follows (organized by columns in data presentation):

1. Language: Language name, dialect, language family, and where spoken.
2. Triggers: Segments initiating nasal spreading.
3. Through: Segments propagating nasalization, i.e., those that are nasalized or descriptively transparent.
5. Comments: Details related to nasal harmony in the language.
6. Selected references.

Nasal spreading patterns included here are those in which nasality spreads across syllables or nasalization targets nonvocalic segments in the syllable. The information is based on my own examination of primary source descriptions (wherever possible). In addition, three secondary sources were consulted: (1996), Beddor (1983), Bivin (1986), Kawasaki (1986), Pulleyblank (1989), and papers in Huffman and Krakow, eds., (1993).

The main finding of the survey is that variation in nasal harmony across languages verifies the implicational hierarchy outlined in section 2.1. The study finds that if a segment blocks nasalization, all segments will undergo nasal spreading. Transparency effects are limited to the class of obstruents, that is, only obstruents have ever been shown to surface as oral within a nasal harmony span; other segments become nasalized in this context. Obstruents are the class for which nasal spreading becomes blocked in nasal harmony spans. The implicational hierarchy defined five basic patterns of nasalization, corresponding to each step in the hierarchy of segmental classes (excluding patterns in which no segments undergo nasalization). This signals some variability in the cross-linguistic compatibility of glides with nasal harmony.

A long-distance nasalization pattern occurring in certain Bantu languages (Ao 1991, Odden 1994, Hyman 1995, Piggott 1996) is discussed in chapter 6. I argue that these alternations are examples of cooccurrence effects, not nasal spreading.

9 examples in database:

<table>
<thead>
<tr>
<th>Language</th>
<th>Dialect</th>
<th>Family</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barasano</td>
<td>Northern Tucanoan</td>
<td>Colombia</td>
<td></td>
</tr>
<tr>
<td>Guahibo</td>
<td>Guahibo-Pamaguan</td>
<td>Colombia, Brazil</td>
<td></td>
</tr>
<tr>
<td>Mixtec Ayutla</td>
<td>Mixtecan</td>
<td>Mexico</td>
<td></td>
</tr>
<tr>
<td>Mixtec Mixtepec</td>
<td>Mixtecan</td>
<td>Mexico</td>
<td></td>
</tr>
<tr>
<td>Mixtec Molinos</td>
<td>Mixtecan</td>
<td>Mexico</td>
<td></td>
</tr>
</tbody>
</table>

Summary of languages in the live main patterns of nasal harmony:

- **Voices (Glottals)**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Guahibo, Mixtec

- **Stops**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Guahibo, Mixtec

- **Syllables**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Mixtec

- **Glides**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Mixtec

- **Liquids**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Mixtec

- **Fricatives**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Mixtec

- **Consonants**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Mixtec

- **Vowels**
  - **Direction**: Harmonic nasalization
  - **Examples**: Barasano, Mixtec

Selected references:

1. [Language name, author, year]
2. [Language name, author, year, second author, year]
3. [Language name, author, year, second author, year, third author, year]
4. [Language name, author, year, second author, year, third author, year]
5. [Language name, author, year, second author, year, third author, year, fourth author, year]
6. [Language name, author, year, second author, year, third author, year, fourth author, year, fifth author, year]

![Table of Language Data]
ii. Vowels (Glottals) Glides Liquids Fricatives Obstruent stops

Language Dialect Family Location

28 examples in database:

<table>
<thead>
<tr>
<th>Language</th>
<th>Dialect</th>
<th>Family</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acehnese</td>
<td>Hesperonesian</td>
<td>Indonesia</td>
<td>Aguaruna, Jivaroan, Peru</td>
</tr>
<tr>
<td>Arabela</td>
<td>Zaparoan</td>
<td>Peru</td>
<td></td>
</tr>
<tr>
<td>Bariba</td>
<td>Voltaic</td>
<td>Nigeria</td>
<td></td>
</tr>
<tr>
<td>Breton</td>
<td>Celtic</td>
<td>France</td>
<td></td>
</tr>
<tr>
<td>Capanahua</td>
<td>Panoan</td>
<td>Peru</td>
<td></td>
</tr>
<tr>
<td>Chinantec</td>
<td>Tepetotutla, Chinantecan</td>
<td>Mexico</td>
<td></td>
</tr>
<tr>
<td>Dayak Kendayan</td>
<td>Hesperonesian</td>
<td>Indonesia, Sarawak</td>
<td></td>
</tr>
<tr>
<td>Dayak Me &amp; Intu</td>
<td>Hesperonesian</td>
<td>Indonesia, Sarawak</td>
<td></td>
</tr>
<tr>
<td>Dayak Sea</td>
<td>Indonesian</td>
<td>Sarawak</td>
<td></td>
</tr>
<tr>
<td>Konkani</td>
<td>Indo-Iranian</td>
<td>India</td>
<td>Lamani, India</td>
</tr>
<tr>
<td>Madurese</td>
<td>Malayo-Polynesian</td>
<td>Indonesia</td>
<td>Malay, Johore, Malaysia</td>
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<td>Malay</td>
<td>Ulu Muar, Indonesian</td>
<td>Malaysia</td>
<td></td>
</tr>
<tr>
<td>Marathi</td>
<td>Indo-Aryan</td>
<td>India</td>
<td>Lamani, India</td>
</tr>
<tr>
<td>Melanau</td>
<td>Austronesian</td>
<td>Sarawak</td>
<td>Mukah, Malaysia</td>
</tr>
<tr>
<td>Orejon (after Velie &amp; Velie)</td>
<td>Tucanoan</td>
<td>Peru</td>
<td></td>
</tr>
<tr>
<td>Oriya</td>
<td>Colloquial variety</td>
<td>India</td>
<td></td>
</tr>
<tr>
<td>Rejang</td>
<td>Austronesian</td>
<td>South Sumatra</td>
<td></td>
</tr>
<tr>
<td>Saramaccan (creole)</td>
<td></td>
<td>Surinam</td>
<td></td>
</tr>
<tr>
<td>Seneca</td>
<td>Iroquoian</td>
<td>Canada, USA</td>
<td></td>
</tr>
<tr>
<td>Terena/o</td>
<td>Arawakan</td>
<td>Brazil</td>
<td></td>
</tr>
<tr>
<td>Warao (isolate)</td>
<td>Venezuela, Guyana</td>
<td>Venezuela</td>
<td></td>
</tr>
<tr>
<td>Urak Lawoi’</td>
<td>Hesperonesian</td>
<td>Thailand, Malaysia</td>
<td></td>
</tr>
<tr>
<td>Urdu</td>
<td>Indo-Iranian</td>
<td>Pakistan, India</td>
<td></td>
</tr>
</tbody>
</table>

iii. Vowels (Glottals) Glides Liquids Fricatives Obstruent stops

Language Dialect Family Location

15 examples in database:

<table>
<thead>
<tr>
<th>Language</th>
<th>Dialect</th>
<th>Family</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edo</td>
<td>Kwa</td>
<td>Nigeria</td>
<td>Midwestern, Germanic, USA</td>
</tr>
<tr>
<td>Epena Pedee</td>
<td>Choco</td>
<td>Colombia</td>
<td></td>
</tr>
<tr>
<td>Epera</td>
<td>Choco</td>
<td>Panama (cross-morph.)</td>
<td></td>
</tr>
<tr>
<td>Ewe/Gbe</td>
<td>Kwa</td>
<td>Ghana, Togo, Benin, Nigeria</td>
<td></td>
</tr>
<tr>
<td>Hindi</td>
<td></td>
<td>India, Pakistan</td>
<td></td>
</tr>
<tr>
<td>Ijo</td>
<td>Kolokuma Kwa</td>
<td>Nigeria</td>
<td></td>
</tr>
<tr>
<td>Isoko</td>
<td>Kwa</td>
<td>Nigeria</td>
<td></td>
</tr>
<tr>
<td>Kpelle</td>
<td>Mande</td>
<td>Liberia, Guinea</td>
<td></td>
</tr>
<tr>
<td>Mandan</td>
<td>Siouan</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Spanish</td>
<td>South Castilian</td>
<td>Romance</td>
<td>Romance</td>
</tr>
<tr>
<td>Tuyuca</td>
<td>Tucanoan</td>
<td>Colombia, Brazil (cross-morph.)</td>
<td></td>
</tr>
<tr>
<td>Urhobo</td>
<td>Kwa</td>
<td>Nigeria</td>
<td></td>
</tr>
<tr>
<td>Yoruba</td>
<td>Kwa</td>
<td>Nigeria</td>
<td></td>
</tr>
</tbody>
</table>

iv. Vowels (Glottals) Glides Liquids Fricatives Obstruent stops

Language Dialect Family Location

4 examples in database:

<table>
<thead>
<tr>
<th>Language</th>
<th>Dialect</th>
<th>Family</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ennemor</td>
<td>Semitic</td>
<td>Ethiopia</td>
<td></td>
</tr>
<tr>
<td>Itsekeri</td>
<td>Kwa</td>
<td>Nigeria</td>
<td></td>
</tr>
<tr>
<td>Scottish Gaelic</td>
<td></td>
<td>Scotland</td>
<td>Applecross, Celtic</td>
</tr>
<tr>
<td>Umbundu</td>
<td>Benue-Congo</td>
<td>Angola</td>
<td>Chandua, Benue-Congo</td>
</tr>
</tbody>
</table>

Language Dialect Family Location

15 examples in database:

<table>
<thead>
<tr>
<th>Language</th>
<th>Dialect</th>
<th>Family</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bido</td>
<td>Khoisan</td>
<td>Cape</td>
<td>Baban可怜, South Africa</td>
</tr>
<tr>
<td>Bika</td>
<td></td>
<td>South Africa</td>
<td></td>
</tr>
<tr>
<td>Dia</td>
<td></td>
<td>Angola, Congo</td>
<td>Ngala,</td>
</tr>
</tbody>
</table>
The above summary shows that all of the cases of nasal harmony examined in the data in (6) exhibit strong enough evidence that a voiced nasalized fricative can occur after a voiceless fricative. In this way, nasal harmony is shown to be a widespread phenomenon in the languages of the world. The fact that nasal harmony is found in such a wide variety of languages suggests that it is a universal feature of human language. The fact that nasal harmony is found in so many different languages suggests that it is a basic property of human language. The fact that nasal harmony is found in so many different languages suggests that it is a basic property of human language.
nasalized labial continuant, transcribed as [v])], and after explicitly remarking on Ohala's claim that such segments are impossible, Schadeberg notes that this segment contrasts with a nasalized labial approximant [w] (1982: 127). Evidence for a voiceless nasalized fricative comes from Gerfen's (1996) instrumental investigation of Coatzospan Mixtec (Mixtecan, Mexico), where he finds that nasal airflow persists through a so-called 'transparent' voiceless coronal fricative [S]. It should be noted that while Gerfen's results are strongly suggestive that it is possible to produce a voiceless fricative with a lowered velum, his technique ... through airflow measurements. For absolute certainty on this issue, a direct measurement of velum position is needed.

Recent work by Ohala, Solé, and Ying (1998) investigated the matter of nasalized fricatives by creating a pseudo-velopharyngeal valve. They created the valve by inserting catheters of various sizes into the nasal passage, with the assumption that if the catheter area was greater than the length of the nasal passage, proper functioning of the catheter would be impeded. They discovered that for the smallest catheter, 7.9 mm², there was no significant effect on the level of pharyngeal pressure (i.e. pressure behind the constriction for the buccal fricative) and no detectable effect on the quality of the fricative. For catheters with areas of 17.9 mm² and above, they found that pharyngeal pressure dropped considerably, especially for voiced fricatives. The pressure drop was weaker ... typically either degree of frication or perceptibility of nasalization will suffer in the production of these segments.

Examination of the languages in which nasalization spreads through some obstruents will suffer in the production of these segments.

Table 37: Cross-linguistic variation in nasalization of obstruents

<table>
<thead>
<tr>
<th>Obstruents</th>
<th>Vcd. fricatives</th>
<th>Vcls. fricatives</th>
<th>Vcd. stops</th>
<th>Vcls. stops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eitsekeri, Ennemor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scottish Gaelic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epera, Orejon, Parintintin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuyuca, Tucano, Barasano</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examination of the languages in which nasalization spreads through some obstruents will suffer in the production of these segments.

Table 37: Cross-linguistic variation in nasalization of obstruents

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<tr>
<th>Obstruents</th>
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<th>Vcd. stops</th>
<th>Vcls. stops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eitsekeri, Ennemor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scottish Gaelic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epera, Orejon, Parintintin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuyuca, Tucano, Barasano</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examination of the languages in which nasalization spreads through some obstruents will suffer in the production of these segments.
with the glottal articulation (see Walker and Pullum 1997 and references therein; also discussion in 2.2.3; cf. Cohn 1993a). Further, as noted in discussion of the ‘rhinoglottophilia’ phenomenon (Matisoff ... Arawakan language of Brazil. Terena marks first person forms with nasalization of a morpheme from left to right, and \[h\] and \[hJ\] pattern with the obstruents in blocking nasal spread. Bendor-Samuel (1960: 349) analyzes these segments as true fricatives (rather than glides, for example), noting that \[hJ\] is actually produced with an alveolar constriction and that both \[h\] and \[hJ\] function phonologically in the same way as \[s\] and \[S\]. For glottal stop, blocking occurs in the Austronesian language, Rejang, spoken in South Sumatra. McGinn (1979: 187) observes that glottal stop patterns with the obstruents in blocking the rightward spread of nasality from a nasal stop, e.g. \[ma)/a/\] ‘approach’; cf. \[ni’j)o)w)a)\] ‘coconut’. Harrison and Taylor (1971: 17) note that in Kaiwá, a Tupí-Guaraní language of Brazil, nasalization spreads through glottal stop in normal speech, but in slow speech \[/\] blocks nasal spreading. It is also conceivable that the dispreference in some languages for a nasalized glottal stop has an acoustic/perceptual basis. Ní Chiosáin and ... of these segments with obstruents rather than glides or perhaps the perceptibility of nasalization.

The implicational hierarchy is a good predictor of the likelihood of segments to undergo nasalization, but the nasal harmony database finds that other factors can also contribute to patterns of nasalization. For example, by the universal generalization that the number of nasal vowels in a language never exceeds the number of oral vowels, one would expect nasalization of oral mid-high vowels to be rare. However, the data show that nasalization tends to obscure the perceptibility of vowel height contrasts, evidenced, for example, by the universal generalization that nasalization tends to obscure the perceptibility of vowel height contrasts. For example, by the universal...
may have some neutralizing effect on the perception of vowel backness. However, if

### 2.4.2 The nasal harmony database (condensed version)

#### i. Vowels (Glottals)

<table>
<thead>
<tr>
<th>Language</th>
<th>Triggers</th>
<th>Thru:Dir:</th>
<th>Comments</th>
<th>Selected Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barasano (Northern dialect; Tucanoan; Colombia)</td>
<td></td>
<td></td>
<td></td>
<td>Barasano 1997; Stolte &amp; Stolte 1971; Steriade 1993a</td>
</tr>
<tr>
<td>Guahibo (Guahibo-Pamaguan; Colombia, Venezuela)</td>
<td></td>
<td></td>
<td></td>
<td>Kondo &amp; Kondo 1967</td>
</tr>
<tr>
<td>Mixtec (Ayutla dialect; Mixtecan; Mexico)</td>
<td></td>
<td></td>
<td></td>
<td>Pankratz &amp; Pike 1967</td>
</tr>
<tr>
<td>Mixtec (Mixtepec dialect; Mixtecan; Mexico)</td>
<td></td>
<td></td>
<td></td>
<td>Pike &amp; Ibach 1978</td>
</tr>
<tr>
<td>Mixtec (Molinos dialect; Mixtecan; Mexico)</td>
<td></td>
<td></td>
<td></td>
<td>Hunter &amp; Pike 1969; Beddor 1983</td>
</tr>
<tr>
<td>Mixtec (Silacayoapandialect; Mixtecan; Mexico)</td>
<td></td>
<td></td>
<td></td>
<td>North &amp; Shields 1977; Marlett 1992</td>
</tr>
<tr>
<td>Pame Otomi (Otopamean; Mexico)</td>
<td></td>
<td></td>
<td></td>
<td>Gibson 1956; Schourup 1973; Beddor 1983</td>
</tr>
<tr>
<td>Tinrin (Melanesian)</td>
<td></td>
<td></td>
<td></td>
<td>Osumi 1995</td>
</tr>
</tbody>
</table>

#### ii. Vowels (Glides)

<table>
<thead>
<tr>
<th>Language</th>
<th>Triggers</th>
<th>Thru:Dir:</th>
<th>Comments</th>
<th>Selected Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acehnese (Hesperonesian; Indonesia)</td>
<td></td>
<td></td>
<td></td>
<td>Durie 1985</td>
</tr>
<tr>
<td>Aguaruna (Jivaroan; Peru)</td>
<td></td>
<td></td>
<td></td>
<td>Payne 1974; Bivin 1986; Trigo 1988; Walker &amp; Pullum 1997</td>
</tr>
</tbody>
</table>

### 2.4 The nasal harmony database (condensed version)
<table>
<thead>
<tr>
<th>Language</th>
<th>方言</th>
<th>Nasal Stops, Nasal Vowels, H, /</th>
<th>Right Spreading</th>
<th>Comments</th>
<th>Selected Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabela</td>
<td>Zaparoan; Peru</td>
<td>Nasal stops, h, j, w</td>
<td>Right</td>
<td>Nasal stop is nasal in all environments.</td>
<td>Rich 1963; Howard 1973; Beddor 1983; Walker &amp; Pullum 1997</td>
</tr>
<tr>
<td>Bariba</td>
<td>Voltaic; Nigeria</td>
<td>Nasal stops, Nasal Vowels, V, j, w</td>
<td>Left and Right Spreading seems to be restricted to the syllable.</td>
<td></td>
<td>Welmers 1952; Beddor 1983</td>
</tr>
<tr>
<td>Capanahua</td>
<td>Panoan; Peru</td>
<td>Nasal stop, j, w, h, /</td>
<td>Right</td>
<td>Nasality spreads to left, but if nasal C is deleted, spreading is bidirectional.</td>
<td>Loos 1969; Halle &amp; Vergnaud 1981; van der Hulst &amp; Smith 1982; Safir 1982; Piggott 1987, 1992; Trigo 1988</td>
</tr>
<tr>
<td>Chinantec</td>
<td>Tepetotula dialect; Chiantecan; Mexico</td>
<td>Nasal stops, Nasal Vowels, V, j, w, weak velar (semi)-cons.</td>
<td>Right</td>
<td>Spreading is syllable-bound.</td>
<td>Westley 1971; Walker &amp; Pullum 1997</td>
</tr>
<tr>
<td>Dayak</td>
<td>Kenday dialect; Indonesian; Borneo</td>
<td>Nasal stops</td>
<td>Right</td>
<td>Description from Court (1970) citing Dunselman.</td>
<td>Dunselman 1949; Court 1970</td>
</tr>
<tr>
<td>Dayak</td>
<td>Land - Bukar Sadong dialect; Hesperonesian; Indonesia</td>
<td>Nasal stops, j, w, h, /</td>
<td>Right</td>
<td>Glottal stop is described by Scott as a 'junction feature'. Glides/glottals block in some words.</td>
<td>Scott 1964; Court 1970; Schourup 1973</td>
</tr>
<tr>
<td>Dayak</td>
<td>Land - Mentu dialect; Indonesian; Sarawak</td>
<td>Nasal stops, j, w, h, /</td>
<td>Right</td>
<td>Glides/glottals block in some words.</td>
<td>Court 1970</td>
</tr>
<tr>
<td>Dayak</td>
<td>Sea dialect; Indonesian; Sarawak</td>
<td>Nasal stops, j, w, glottals</td>
<td>Right</td>
<td>Scott 1957; Kenstowicz &amp; Kisseberth 1979</td>
<td></td>
</tr>
<tr>
<td>Konkani</td>
<td>Indo-Iranian; India</td>
<td>Nasal stops, Nasal Vowels, V, j</td>
<td>Left</td>
<td>Spreading also to right but just to word-final segments.</td>
<td>Fellbaum 1981; Ghatage 1963; Beddor 1983; Walker &amp; Pullum 1997</td>
</tr>
<tr>
<td>Lamani</td>
<td>Indo-Aryan; Gulbarga District, India</td>
<td>Nasal Vowels, j, w</td>
<td>Right</td>
<td>Trail is not explicit about the behavior of [h] in nasalization.</td>
<td>Trail 1970</td>
</tr>
<tr>
<td>Malay</td>
<td>Johore dialect; Indonesian; Malaysia</td>
<td>Nasal stops, j, w, h, /</td>
<td>Right</td>
<td>Glottal stop is not phonemic.</td>
<td>Dyen 1945; Court 1970; Kenstowicz &amp; Kisseberth 1979; Onn 1980; Pulleyblank 1989; Piggott 1992</td>
</tr>
<tr>
<td>Malay</td>
<td>Ulu Muar dialect; Indonesian; Malaysia</td>
<td>Nasal vowels, j, w, h, /</td>
<td>Left</td>
<td>Nasal vowels occur phonemically only in stressed syllables.</td>
<td>Scott 1964; Hendon 1966</td>
</tr>
<tr>
<td>Marathi</td>
<td>Indo-Aryan; India</td>
<td>Nasal stops, j, w</td>
<td>Left</td>
<td>Nasalization is limited to the syllable. There is no glottal stop. [h] is described as voiced. Whether [h] can be nasalized is unclear.</td>
<td>Pandharipande 1997</td>
</tr>
<tr>
<td>Maxakali</td>
<td>Isolate; Brazil</td>
<td>Nasal stops, j, w, h, /</td>
<td>Right Bidir.</td>
<td>Gudschinsky et al. 1970; Anderson 1976; Walker &amp; Pullum 1997</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**** The table contains information on languages with specific nasalization traits, including the types of nasal sounds (naso-fricatives, nasal stops, nasal vowels, etc.), and the direction and scope of spreading. The references listed provide further details and scholarly perspectives on these phenomena.
<table>
<thead>
<tr>
<th>Language</th>
<th>Trigger</th>
<th>Thru</th>
<th>Dir</th>
<th>Comments</th>
<th>Selected Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melanau</td>
<td>Nasal stops, j, w, /</td>
<td>Right</td>
<td>Bidir</td>
<td>Nasalization is contrastive only in initial syllable.</td>
<td>Right Nasalization is morphemic (marks 1st pers). [h, hJ] pattern as fricatives, not glottals. It is not clear whether /, r/ block or undergo.</td>
</tr>
<tr>
<td>Orejon</td>
<td>Nasal vowels, j, h</td>
<td>Right</td>
<td>Nasalization is morphemic (marks 1st pers).</td>
<td>There is no phonemic glottal stop in the language.</td>
<td></td>
</tr>
<tr>
<td>Oriya</td>
<td>Nasal stops, j, w</td>
<td>Bidir</td>
<td>Nasalization of vocoids occurs under deletion of a nasal stop in colloquial speech.</td>
<td></td>
<td>Patnaik 1984; Piggott 1987</td>
</tr>
<tr>
<td>Rejang</td>
<td>Nasal stops, j, w</td>
<td>Right</td>
<td>Nasalization is morphemic (marks 1st pers).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saramaccan</td>
<td>Nasal stops, j, ¯</td>
<td>Right</td>
<td>Nasalization in syllable rhyme spreads across laminal (palatal) sonorants.</td>
<td></td>
<td>Rountree 1972</td>
</tr>
<tr>
<td>Seneca</td>
<td>Nasal stops, j, w, /</td>
<td>Right</td>
<td>Bidir</td>
<td>There is no phonemic glottal stop in the language.</td>
<td></td>
</tr>
<tr>
<td>Terena/o</td>
<td>Nasal morpheme</td>
<td>Right</td>
<td>Nasalization is morphemic (marks 1st pers).</td>
<td></td>
<td>Terena/o (Arawakan; Brazil)</td>
</tr>
<tr>
<td>Warao</td>
<td>Nasal stops, j, w, h</td>
<td>Right</td>
<td>Nasalization is contrastive only in initial syllable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urdu</td>
<td>Nasal stops, j, w, h</td>
<td>Bidir</td>
<td>Nasalization is contrastive only in initial syllable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edo</td>
<td>Nasal vowels</td>
<td>Right</td>
<td>Bidir</td>
<td>Nasal spreading targets sonorants in suffixes after a nasal stem vowel (glides/glottals do not occur in relevant affixes).</td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>Nasal stops, j, w, h</td>
<td>Left</td>
<td>Description from Schourup (1972, 1973) citing Stampe (p.c.).</td>
<td>Nasalization spreads only up to stressed syllable.</td>
<td></td>
</tr>
<tr>
<td>Epena Pedee</td>
<td>Nasal vowels</td>
<td>Left</td>
<td>Nasalization of vowels is contrastive only in initial syllable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epera</td>
<td>Nasal morpheme</td>
<td>Left</td>
<td>Cross-morpheme spreading.</td>
<td>Patterning of voiced fricatives is unclear.</td>
<td></td>
</tr>
<tr>
<td>Ewe/Gbe</td>
<td>Nasal vowels</td>
<td>Left</td>
<td>There are no glottals. Spreading is in the syllable. [^f, b] alternate with [^n, m] and might be treated as sonorants.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hindi</td>
<td>Nasal vowels</td>
<td>Left</td>
<td>Nasalization supports nasograph data (M.Ohala 1975).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td>Triggers</td>
<td>Thru</td>
<td>Dir</td>
<td>Comments</td>
<td>Selected Refs</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------</td>
<td>------</td>
<td>-----</td>
<td>----------</td>
<td>---------------</td>
</tr>
<tr>
<td>Isoko (Ozoro dialect; Kwa; Nigeria)</td>
<td>Nasal vowels j, w, R,®</td>
<td>Left</td>
<td>Spreading appears to be syllable-bound.</td>
<td>Patterning of [h] is unclear.</td>
<td></td>
</tr>
<tr>
<td>Kayan (Uma Jumandialect; Austronesian; Sarawak)</td>
<td>Nasal stops V, j, w, h, /, l</td>
<td>Right</td>
<td>Blust notes that it could not be determined whether /r/ permits carry-over of nasalization.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kpelle (Mande; Liberia, Guinea)</td>
<td>Nasal vowels V, j, l, ƒ</td>
<td>Right</td>
<td>[ƒ] represents a velar resonant.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandan (Siouan, USA)</td>
<td>V, w, h, r</td>
<td>Description from Schourup (1972) citing Hollow (1970)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spanish (South Castilian dialect; Romance)</td>
<td>Nasal segment [+son]</td>
<td>Bidir.</td>
<td>Clements 1977; Safir 1982</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tucano (Tucanoan; Colombia)</td>
<td>Nasal morpheme V, j, w, h, r</td>
<td>Right</td>
<td>This pattern occurs in spreading across morphemes (to alternating affixes). [g] also does not block spreading.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuyuca (Tucanoan; Colombia, Brazil)</td>
<td>Nasal morpheme V, j, w, h, r</td>
<td>Right</td>
<td>This pattern occurs in spreading across morphemes (to alternating affixes). [g] also does not block spreading.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urhobo (Kwa, Nigeria)</td>
<td>Nasal vowels, Nasal stops V, j, w, B, R</td>
<td>Left</td>
<td>[B] represents a bilabial frictionless continuant. There are no glottals in the language.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Obstruent stops**

- Spanish (South Castilian dialect; Romance)
- Tucano (Tucanoan; Colombia)
- Tuyuca (Tucanoan; Colombia, Brazil)
- Umundu (Benue-Congo; Angola)
- Yoruba (Oyo - Standarddialect; Kwa; Nigeria)
Vowels

- Nasal vowels: j, r, v, nasal or voiced stops
- Nasal/voiced stops are fully nasal in nasal syllables; otherwise they are pre/post-nasalized.

- Morpheme-level property (ornasal vowel/stop)
- All segments behave transparent.

- Voiceless obstruents block spreading.
- Spreading targets at tonicsyllables.

- Voiceless segments do not occur in the environment for nasalization (they occur only initially). There are no glottals.

- Voiceless stops remain oral.
- Voiceless stops are reportedly nasalized. Left spreading is restricted to syllable.

- Voiceless stops remain oral. Voiceless fricatives are reportedly nasalized. Left spreading is restricted to syllable.
<table>
<thead>
<tr>
<th>Language</th>
<th>Trigger</th>
<th>Thru:Dir</th>
<th>Comments</th>
<th>Selected Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guaraní</td>
<td>Nasal vowel in a stressed syllable</td>
<td>All segs</td>
<td>Bidir. Voiceless segments behave transparent. Stressed syllables containing an oral vowel block spreading.</td>
<td>Gregores &amp; Suárez 1967; Rivas 1974, 1975 (for others see chapter 4)</td>
</tr>
<tr>
<td>Guaymi</td>
<td>Near past completed action morpheme</td>
<td>All classes of segs</td>
<td>Right Nasalization marks near past completed action in class II verbs. Voiceless consonants and back vowels block. Voiced obstruents are variable in their behavior.</td>
<td>Kopesec &amp; Kopesec 1974, 1975; Bivin 1986</td>
</tr>
<tr>
<td>Igbo</td>
<td>Syllable-level property (or nasal stops and nasal vowels)</td>
<td>All classes of segs</td>
<td>Bidir. With the exception of voiceless stops, all segments are reported to have nasal alternants, including fricatives.</td>
<td>Green &amp; Igwe 1963; Williamson 1969a; Clark 1990; Bivin 1986</td>
</tr>
<tr>
<td>Icua Tupí</td>
<td>Morpheme-level property (or nasal vowel/stop)</td>
<td>All classes of segs</td>
<td>Bidir. Description is only tentative: based on speakers. Realization of /h/ and /r/ in a nasal context is unclear.</td>
<td>Abrahamson 1968; Bivin 1986</td>
</tr>
<tr>
<td>Mixtec</td>
<td>Morpheme-level property or last vowel</td>
<td>All classes of segs</td>
<td>Left. Voiceless obstruents generally block spreading. Voiced obstruents behave transparent.</td>
<td>Alexander 1980; Marlett 1992</td>
</tr>
<tr>
<td>Mixtec</td>
<td>Second person familiar morpheme</td>
<td>All classes of segs</td>
<td>Left. Voiceless obstruents generally block spreading. Voiced obstruents are nasalized.</td>
<td>Pike &amp; Small 1974; Piggott 1992; Gerfen 1996</td>
</tr>
<tr>
<td>Mixtec</td>
<td>Morpheme-level property or last vowel</td>
<td>All classes of segs</td>
<td>Left. Voiceless obstruents behave transparent to spreading. Voiced segments become nasalized.</td>
<td>Marlett 1992</td>
</tr>
<tr>
<td>Orejon</td>
<td>Morpheme-level property or first syllable</td>
<td>All classes of segs</td>
<td>Right. Description from Pulleyblank citing Arnaiz. Voiceless obstruents block spreading. Voiced obstruents are nasalized.</td>
<td>Arnaiz 1988; Pulleyblank 1989</td>
</tr>
<tr>
<td>Parintintin</td>
<td>Nasal vowels (or morpheme-level property)</td>
<td>All classes of segs</td>
<td>? Voiceless obstruents block spreading. Voiced obstruents are nasalized.</td>
<td>Pease &amp; Betts 1971; Hart 1981; Bivin 1986</td>
</tr>
<tr>
<td>Shiriana</td>
<td>Nasal vowel (or foot-level property)</td>
<td>All classes of segs</td>
<td>Bidir. Nasal spreading is bounded by the foot. It is unclear whether all obstruents behave transparent or whether some become nasalized.</td>
<td>Migliazza &amp; Grimes 1961; Beddor 1983</td>
</tr>
<tr>
<td>Siriano</td>
<td>Morpheme-level property (or nasal vowel/stop)</td>
<td>All segs</td>
<td>Bidir. Voiceless segments behave transparent.</td>
<td>Bivin 1986 (citing Malone et al. 1985)</td>
</tr>
<tr>
<td>Tatuyo</td>
<td>Morpheme-level property (or nasal vowel/stop)</td>
<td>All segs</td>
<td>Bidir. Voiceless segments behave transparent.</td>
<td>Gomez-Imbert 1980; Steriade 1993a</td>
</tr>
<tr>
<td>Tucano</td>
<td>Morpheme-level property (or nasal vowel/stop)</td>
<td>All segs</td>
<td>Bidir. Voiceless segments behave transparent. This pattern occurs in morpheme-internal spreading.</td>
<td>West &amp; Welch 1967, 1972; West 1980; Bivin 1986; Trigo 1988, Noske 1995</td>
</tr>
</tbody>
</table>
All voiceless segments behave transparent. This pattern occurs in morpheme-internally spreading.

Barnes & Takagi deSilzer 1976; Bivin 1986; Barnes & Malone 1988; Barnes 1996.
Chapter 3

SEGMENTAL TRANSPARENCY AS AN OPACITY EFFECT

This chapter examines the analysis of transparent segments in nasal harmony, that is, segments which are produced with a raised velum within a nasal span. This realization of a truly oral segment within a nasal spreading domain is problematic because it presents a case which appears to deny the claim that feature spreading is segmentally strictly local. Chapter two maintained that a spreading nasal feature propagates only between immediately adjacent segments; skipping a segment is not a possible outcome in spreading. This result follows from the well-motivated assumption that the gapped configuration is universally ill-formed: a representational consequence of interpreting a multiply-linked feature as a continuous property or gesture. In the previous chapter, evidence was adduced from the typology of nasal harmony in support of the claim that descriptively transparent segments should be analytically grouped with undergoers of nasal spreading. Some antecedent derivational or sequential multi-level accounts of truly transparent segments have maintained the strict locality of spreading by positing a level of representation at which the transparent segment undergoes spreading (e.g. Clements 1976; Vago 1976; Walker 1996; Ní Chiosáin and Padgett 1997). A subsequent rule or constraint then applies to this representation to change the feature specification on the transparent segment to realize its surface transparency. More generally, this kind of approach analyzes true transparency as an instance of a ‘derivational opacity effect’ (Kiparsky 1971, 1973), in the sense of an outcome that is derived through an opaque interaction of rules or constraints. For transparent segments in nasal harmony, I follow this core idea by analyzing transparency as the outcome of an opaque interaction of optimality-theoretic constraints.

In Optimality Theory, it has recently been proposed that derivational opacity effects can be achieved by calling on a correspondence relation that enforces faith between co-candidates in the evaluation set: the output candidate and a designated ‘sympathy’ candidate (McCarthy 1997, with developments proposed by Itô and Mester 1997a, b). The sympathy approach to opacity effects is capable of producing transparent segments in spreading without producing gapped configurations, and it is independently motivated by other derivational opacity effects known to occur in language. This chapter develops a version of Sympathy theory in which opacity effects arise from the organization of the phonological constraint hierarchy into contiguous subgroups. Within this organizational structure, sympathetic faith is utilized to produce opaque constraint interactions, including transparency in nasal harmony. This is the harmonic sympathy model of opacity in grammar.

This chapter is organized as follows. First, in section 3.1 I review the arguments that some kinds of transparent segments truly are surface-transparent to a spreading feature and I preview the sympathy-based analysis of transparency in Tuyuca. Section 3.2 then establishes the harmonic sympathy model of the grammar, with exemplification from a derivational opacity effect in Tiberian Hebrew. In section 3.3 I develop the full analysis of transparency in Tuyuca as well as the blocking effects in spreading to suffixes. Section 3.4 presents some points of comparison between the harmonic sympathy model and the ‘constraint-based’ model of sympathy introduced by McCarthy (1997) with modifications proposed by Itô and Mester (1997a,b). It is argued that harmonic sympathy brings a firmer understanding to what brings about opaque constraint interactions and the evaluative mechanisms involved in selection of the sympathy candidate. Section 3.5 then applies the harmonic sympathy framework to Finnish, analyzing the transparent behavior of certain vowels in vowel harmony as a (derivational) opacity effect. Section 3.6 discusses an evaluation metric for derivational opacity in a grammar. And finally, an appendix in section 3.7 presents a possible account of German truncation under harmonic sympathy, reworking a recent analysis of these facts in the constraint-based model proposed by Itô and Mester (1997a). A drawback for harmonic sympathy is discussed and a revision is proposed which better incorporates the strengths of constraint-based model.

3.1 Antagonistic transparency

A few different proposals have been made to preserve the segmentally strict locality of spreading in cases where there appears to be transparency, that is, where it appears that feature spreading has skipped a segment. These proposals fall into two main analytical directions. One line of research has argued that in certain kinds of so-called ‘transparency’, the relevant gesture is actually carried though a segment. I call this kind of transparency, false transparency. Ní Chiosáin and Padgett (1997) take this approach for ‘transparent’ consonants in vowel harmonies, arguing that consonants actually undergo the feature spreading but may be perceived as transparent because the consequences of the spreading property are small in terms of contrast potential for these segments. Gafos (1996) also claims that transparent segments in coronal consonant harmonies are falsely transparent. He too argues that all segments undergo the harmony, but perceived transparency arises when the spreading gesture does not produce
acoustic/perceptual consequences in a given segment. Flemming (1995b) makes the same point in his analysis of the coronal harmony facts. Building on Walker (1996), Walker and Pullum (1997) take a...translaryngeal vowel harmony. All of the false transparency analyses are unified by the claim that the spreading feature is compatible with the 'transparent' segment.

A second kind of analysis addresses cases where the transparent segment truly appears to surface with an opposing feature specification to the spreading property. This kind of true neutrality I will refer to as *antagonistic transparency*, borrowing terminology from Archangeli and Pulleyblank (1994: 232). For these cases, it has been proposed that the transparent... in the output, i.e. this analysis concedes transparency, and second, it makes use of an additional level of representation. The previous proposals are not incompatible with each other, rather they have shown that apparent transparency may arise under two different sets of circumstances. Our concern lies with antagonistic... specification of the spreading feature in the actual output, but I will show we need not call on a second level of input-output mapping to achieve this result — it can be captured in a one-level framework, following the core 'Sympathy' theory... from derivationally-opaque rule interactions: so-called 'opacity effects' ('opacity' in the sense of Kiparsky 1971, 1973).

In antagonistic transparency, the spreading feature specification is incompatible with some acoustic or articulatory property of the transparent segment. Archangeli and Pulleyblank (1994) point out that... +low\], high in the hierarchy of [+ATR] cooccurrence constraints. Indeed, this constraint is often undominated. Although a strong dispreference for a feature combination in a language can drive transparency in the case of vowel harmony, the transparency of buccal obstruent stops to nasal spreading is somewhat more complex. Buccal obstruents are those with a place of articulation forward of the place where the velar valve joins the nasal and oral cavities (Ohala and Ohala 1993a, Walker and Pullum 1997), conflicts with satisfaction of the property defining the segment as an obstruent stop.
Analysts differ to some extent on the precise characterization of the property defining an obstruent stop, but all agree that at least in buccal segments it is incompatible with a velic opening. Ohala ... (1993a, d, 1994) makes another release-related characterization in the form of aperture-theoretic representations. Many feature-based approaches make use of the feature \([-\text{sonorant}]\). The feature \(\pm\text{sonorant}\) distinguishes sounds with a cavity configuration that inhibits airflow through the glottis, thereby inhibiting voicing. 

1 \([-\text{sonorant}]\) precludes simultaneous implementation of \(+\text{nasal}\) in a buccal segment, because the nasal airflow conflicts with the increase in supralaryngeal pressure required in a nonsonorant stop. However, when the nasal airflow is blocked by nasal constriction, then it escapes through the nostrils. In this configuration, the voiced nasal stop is classified as sonorant because the airflow permitted by the open nasal passage normally induces voicing. 

1 Chomsky and Halle observe that there are occasionally instances of contrast between voiced and voiceless nasals (1968: 316). However, voiceless nasals are still classified as sonorants, because the failure of these sounds to induce voicing in some cases the context makes the nasal portion of the sound more sonorant. In some cases, the nasal airflow is blocked by partial nasal constriction, which is less sonorous than other nasal sounds. The nasal airflow escapes through the nostrils, which is why nasalized obstruent stops are classified as sonorant. 

The key generalization that emerges from each of the different approaches to characterizing obstruents is that a buccal obstruent stop cannot be produced simultaneously with nasality, and so a nasalized obstruent stop cannot be produced. The force of Faith-O (for feature-arguments of the form \([-\text{sonorant}, -\text{continuant}]\) that bars nasalized obstruent stops is itself a consequence of the positions that the different approaches to characterizing obstruents take about the failure of nasal airflow to occur in the口腔, as opposed to the nasal, segments of the stops. 

The idea of a faith relation from one candidate to another within a single candidate set is due to McCarthy (1997) and elaborated in the work of Itô and Mester (1997a, b) in breakthrough studies in generative grammar. Faith relations provide a mechanism for selecting between alternative candidates, thereby ensuring that the output candidate closely resembles the input candidate. In some cases, Faith relations will result in the output candidate being identical to the input candidate. In other cases, Faith relations will result in the output candidate being different from the input candidate, but still resembling it. 

In some cases, the constraint hierarchy will be such that the sympathy candidate will be ranked lower than the faith candidate, which will result in the output candidate being identical to the faith candidate. In other cases, the constraint hierarchy will be such that the sympathy candidate will be ranked higher than the faith candidate, which will result in the output candidate being different from the faith candidate. In still other cases, the constraint hierarchy will be such that both the sympathy candidate and the faith candidate will be ranked equally, which will result in the output candidate being identical to the sympathy candidate.
The emergence of truly transparent segments in spreading has been analyzed in derivational models with opaque rule interactions. An example of this kind of analysis for nasal harmony in an SPE-style framework is summarized in (1) (using a hypothetical form).

(1) Transparency through derivationally-opaque rule interaction:

a. Rules:
   i. Nasal Spreading (iterative):
      \[ \text{X}^\text{fi} [+\text{nasal}] / [+\text{nasal}] \] (X is any segment)
   ii. Obstruent stop denasalization:
      \[ -\text{sonorant}, -\text{continuant} \] fi \[ -\text{nasal} \]

   Nasal spreading is ordered before obstruent stop denasalization.

b. Derivation:
   Underlying representation /\text{a)rato}\/  
   Nasal spreading
   /\text{a)r)a)t)o)\/ Obstruent stop denasalization
   /\text{a)r)a)to)\/ Surface representation 

Examples of this basic type of approach to transparency in vowel harmony appear in Clements (1976) and Vago (1976) (cf. Lightner 1965). Analyses of this kind are typically abstract in the sense that at some level of representation it calls on a segmental structure that never actually surfaces in any output form of the language. In the above example, the abstract segment is never actually used in any output form of the language. In the above example, the abstract representation is never actually used in any output form of the language. In the above example, the abstract representation is never actually used in any output form of the language.

It is important to note that all of the candidate representations belong to one well-known class of constraints in Optimality Theory, the abstract treatment of transparency. The abstract treatment of transparency can be reproduced in Optimality Theory under the sympathy approach to deriving opacity effects. The diagram in (2) illustrates the structure of the candidate set with Faith-IO constraints.

(2) Sympathetic correspondence and segmental transparency:

Output candidates:             
\[ a)r)a)to) \] 
\[ \overline{a)r)a)to)\] 
Sympathy   FAITH-IO  Actual

In order for the sympathy candidate not to win itself, it must lose on the basis of some high-ranked constraint. This will be the constraint banning nasal obstruent stops, which plays the role of the obstruent stop denasalization rule. The same applies to the other high-ranked constraints that will be the dominant condition implied by this representation (after Kiparsky 1971, 1973), i.e. its contrast with another underlying form is neutralized at some level of representation (e.g. Kiparsky 1969). Hence, the underlying harmony is a neutralized vowel alternation stop. Where harmony is surface, the abstract segment is never actually used in any output form of the language. In the above example, the abstract representation is never actually used in any output form of the language. The abstract representation is never actually used in any output form of the language.
As observed in Chapter 2, an outcome like that in (4a) cannot be obtained directly from spreading. Spreading requires that each occurrence of a feature specification be linked to all segments in the model, which involves the interaction of the faith constraint with the faith constraint under spreading. The faith constraint under spreading (in (4b)) is driven by its similarity in surface properties to the faith constraint under spreading (in (4a)), the former being a direct consequence of the faith constraint. The relative ranking of spreading with respect to the faith constraint under spreading (in (4b)) is obtained by the faith constraint under spreading (in (4a)).

The tableau in (5) shows how spreading can derive the effect of an opaque rule.

### Preview of sympathy analysis of segmental transparency

<table>
<thead>
<tr>
<th>Feature</th>
<th>Sympathy Candidate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+nasal]</td>
<td><img src="image" alt="Sympathy Candidate" /></td>
<td><img src="image" alt="Outcome" /></td>
</tr>
</tbody>
</table>

The tableau in (5) shows how sympathy can derive the effect of an opaque rule.
word-final consonant cluster (Malone 1993: 93) and the second deletes glottal stop in a coda (Malone 1993: 59).

(6) Tiberian Hebrew

a. Vowel epenthesis into final clusters:

\[ \text{Ø fi} \ V / C _ C# \]

\text{e.g.} /melk/ \[\text{melEk}'king'\]

b. /-deletion in codas:

\[ / fi \Ø / _ \]

\text{e.g.} /qara/ \[\text{qara}'he called'\]

The rules in (6) have the potential to interact with one another. As shown in (7), they operate in a counterbleeding order, whereby epenthesis takes place before /-deletion. This gives a surface form \[\text{deS}\]

\text{S\ E} for /deS/ 'tender grass', which is opaque with respect to epenthesis, that is, there is an occurrence of an epenthetic vowel in a surface environment that does not meet the structural description of the epenthesis rule.

(7) Counterbleeding in Tiberian Hebrew:

Underlying representation /deS/ V-epenthesis deS E /-deletion deS E Surface representation \[\text{deS\ E}\] *deS

Following McCarthy's (1997) insightful and innovative analysis, the basic architecture of the sympathy-based account of this derivational opacity will be as illustrated in (8). Candidate (b), \[\text{deS\ E}\], is designated as the sympathy candidate, but it loses in the competition for the optimal output on the basis of a high-ranked constraint prohibiting glottal stop in a coda. The sympathetic faith constraint, \[\text{MAX'-O}\], then decides between the two alternative candidates in (a) and (c). Candidate (a), \[\text{deS}\], which corresponds to the opaque rule interaction, is the winner, omitting only one segment that appears in the sympathetic candidate. Candidate (c), \[\text{deS}\], which corresponds to a transparent rule interaction, loses because it omits two segments that appear in the sympathetic candidate.

(8) Overview of the sympathy account

<table>
<thead>
<tr>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>/melk/</td>
</tr>
<tr>
<td>*epenthesis DEP-IO</td>
</tr>
<tr>
<td>+ DELETE</td>
</tr>
<tr>
<td>a. melEk</td>
</tr>
<tr>
<td>b. melk</td>
</tr>
</tbody>
</table>

In order to resolve the cluster by epenthesis rather than deletion, MAX'-O must outrank DEP-IO.

To develop the full sympathy account of this opacity effect in Tiberian Hebrew, we must begin by reviewing the constraints and preliminary rankings established by McCarthy (1997) that correspond to the rules outlined in the derivational analysis. First, to drive epenthesis into a consonant cluster, \[\text{COMPLEX} (Prince and Smolensky 1993), \text{which penalizes complex syllable margins, must outrank the faith constraint prohibiting addition of structure, DEP-IO (McCarthy and Prince 1995).}

(9) \[\text{*COMPLEX} \gg \text{DEP-IO}

In order to resolve the cluster by epenthesis rather than deletion, MAX'-IO must outrank DEP-IO.

(10) \[\text{MAX'-IO} \gg \text{DEP-IO}

\text{Input} /\text{deS}/ *epenthesis DEP-IO

a. \text{melEk} |
| b. \text{melk} |
| + DELETE |
| a. melEK |
| b. mel |

In order to resolve the cluster by epenthesis rather than deletion, MAX'-IO must outrank DEP-IO.

(12) \[\text{MAX'-IO} \gg \text{DEP-IO}

\text{Input} /\text{deS}/ MAX'-IO

a. \text{melEk} |
| b. \text{mel} |

The rules in (6) have the potential to interact with one another, as shown in (7).
Locating the site of epenthesis between the consonants rather than after them is achieved with the correspondence constraint, R-ANCHOR-IO (McCarthy and Prince 1995: 371), which requires that the rightmost element of the input have a correspondent in the rightmost element of the output. This constraint is abbreviated below as ANCHOR-R.5

(11) ANCHOR-R

/ melk/ ANCHOR-R +

(12) *

/ s ] MAX-IO / qara/ /* ] s MAX-IO +

a. qara  

b. qara/ *

As McCarthy notes, the constraint hierarchy that has been established thus far cannot be the full story because it determines the wrong outcome for an input like / deS/ . The outcome that would be selected here is [ deS/ E] rather than [ deS E]. This incorrect outcome is signalled by the left-pointing hand beside the predicted but incorrect winner. The right-pointing hand indicates the desired winner.  

5 Rather than ANCHOR-R, McCarthy's account makes use of the constraint, ALIGN-RIO(Root, s).

6 McCarthy calls the constraint prohibiting glottal stops in codas: 'CODACOND'.

Because candidate (c) incurs a subset of the violations that (a) does, no reranking will serve to select candidate (a) over (c). Even if another constraint were invoked to rule out (c), a second problematic competitor is the transparent derivational candidate [ deS], which also incurs a subset of the violations that (a) does. To realize the correct outcome, it will be necessary to call on a derivational rule by invoking a constraint that is ranked above MAX-IO. This kind of outcome can be realized in Optimality Theory by ranking a constraint above the constraint hierarchy. The second rule in the derivational analysis performs glottal stop coda deletion.
This influencing candidate is the sympathetic one in (b). It fails because of its glottal stop coda; but setting the glottal stop coda constraint aside, we may observe that it is the most harmonic candidate with respect to the remainder of the hierarchy. If we were to split *\[\textit{s}\]/ from the rest of the hierarchy, candidate (b) would win. The actual surface form is (a), the candidate which most closely resembles the special failed candidate (b). This outcome does not mean that the sympathetic faith constraint has lost; it just means that the sympathetic faith constraint has been split off into the higher segment, which I will call the P1 component. The competing constraint, here ANCHOR-R, remains with the rest of the hierarchy in the P2 component. The P1 component outranks the P2 component. As the constraint that breaks into the P1 component, *\[\textit{s}\]/ triumphs in the conflict: it will be respected in all surface forms. The conflicting constraint, ANCHOR-R, loses by virtue of its domination by the P1 component; however, it gains a consolation prize. I propose that the candidate which is most harmonic with respect to the P2 hierarchy is the sympathy candidate. The high-ranked status of ANCHOR-R within the P2 component thus enables its force to be reflected in the form of the sympathy candidate.

Let us examine the resulting organization of the grammar in (15). This shows the bifurcation of the phonological constraint hierarchy into two segments, as induced by the conflict between the undominated constraint, *\[\textit{s}\]/, and ANCHOR-R. In this tableau I have shaded the P1 component to focus on the selection of the sympathy candidate in P2. Because *\[\textit{s}\]/ has been elevated to P1 in the resolution of its conflict with ANCHOR-R, the coda constraint is the one that will be respected in the optimal output. However, it is ANCHOR-R, along with the rest of the constraint hierarchy, that will determine the sympathy candidate. With the component-based organization of the syntactic structure, we can now exhibit in (16) a tableau selecting the opaque optimal output. Since the sympathy candidate violates *\[\textit{s}\]/ in P1, it falls out of the running for the optimal output early. Candidates (a) and (c) survive the glottal stop coda constraint and the deciding constraint is the sympathetic faith constraint, MAX-O. This chooses \[\textit{deS}\]/ over \[\textit{deS}\], because \[\textit{deS}\] more closely resembles the sympathy candidate. (Note that candidate (e) from (15) is omitted here; I will return to this form presently.)
The complete tableau with the additional Faith-O constraints is given in (19):

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>**</td>
<td>*</td>
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<td>*</td>
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<tr>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>*</td>
<td>D E P - O</td>
</tr>
<tr>
<td>*</td>
<td>M A X - O</td>
</tr>
<tr>
<td>C O M P L E X - A N C H O R</td>
<td>D E P - I O</td>
</tr>
<tr>
<td>D E P - O</td>
<td>M A X - O</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>d e S</td>
<td>e S</td>
</tr>
</tbody>
</table>

For verification of the harmonic sympathy analysis, tableaux are exhibited in (20-21), showing that the constraint hierarchy correctly produces /melk/ and /qara/.

(20) /melk/

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>**</td>
<td>*</td>
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<td>*</td>
<td>D E P - O</td>
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<tr>
<td>*</td>
<td>M A X - O</td>
</tr>
<tr>
<td>C O M P L E X - A N C H O R</td>
<td>D E P - I O</td>
</tr>
<tr>
<td>D E P - O</td>
<td>M A X - O</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>m e l</td>
<td>k</td>
</tr>
</tbody>
</table>

(21) /qara/

<table>
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(19) Expanded Faith-O

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(18) D E P - O >> M A X - O

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(17) L I N E A R I T Y - O >> M A X - O

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(16) The winning candidate incurs one violation with regard to M A X - O, since the perfectly faithful sympathy candidate cannot win. However, two other candidates incur different kinds of sympathetic鞑靼 violations. One failed candidate, [de S/E] shows that M A X - O must be outranked by L I N E A R I T Y - O (McCarthy and Prince 1995: 371), which enforces consistency of precedence structure between the sympathetic candidate and the output (17). Another failed candidate, [de S/E] indicates that D E P - O must also dominate M A X - O (18).
A summary of the constraint hierarchy needed for Tiberian Hebrew is given in (22):

(22) Bifurcation triggered by opaque resolution of conflict between *

\[ / | \]
\[ s \]
\[ \] ANCHOR-R.

a. P1: *

\[ / | \]
\[ s \]
\[ Sympathy. DEP-'O, LINEARITY-'O >> MAX-'O \]

b. P2: ANCHOR-R

Epenthesis. *COMPLEX, MAX-IO >> DEP-IO

To summarize, we have seen that the harmonic sympathy model is capable of capturing the opacity effect in Tiberian Hebrew epenthesis. This model admits a second kind of resolution of conflict that results from the relative ranking of constraints in the grammar. An explanation for this tendency is discussed in section 3.6.

From a broader perspective, this means for obtaining derivational opacity effects draws on independently supported mechanisms, namely ranking separate modular components. The overall structure of the grammatical components is given in (23).

(23) Syntax >> Phonology 1 >> Phonology 2

I suggest that the default status for a grammar is for no bifurcation to exist in the phonological constraint hierarchy (this is discussed further in section 3.6); however, evidence of opacity induced by resolution of conflict among high-ranking constraints points to some component to influence the decision between candidates respecting the constraints of higher-ranked components.

3.3 Tuyuca

I turn now to the analysis of antagonistic transparency in nasal harmony. This analysis calls on a phonological approach to the understanding of the contrasts which hold in the grammar. An explanation for the fact that opaque representations are preferred is discussed in section 3.6.

3.3.1 Phonetic versus phonological possibility

First it is necessary to make clear my assumptions about the phonetic versus phonological possibility of the segments in question. Let us consider the representation of the sympathetic candidate from (4) for a hypothetical representation of the Tuyuca language.

(24) The representation of the sympathetic candidate

\[ +nasal \]

\[ \] [t] o)

7 A different kind of split is proposed in Lexical Phonology, e.g. Kiparsky (1982, 1985), also related work cited in Mohanan (1995).
In (24) [+nasal] has spread to every segment in the word; this is necessary to produce nasalization of the final vowel since segments cannot be skipped in spreading. The fully-spread representation posits a nasalized voiceless alveolar obstruent stop, transcribed as \( t \). This segment combines the feature specification [+nasal] with those defining an obstruent stop, [-sonorant] and [-continuant]. As observed in section 3.1, a segment of this kind cannot be physically produced because the demands that a segment be a buccal obstruent stop and nasal cannot both be satisfied at the same time. The specific problem is that the oral closure needed to inhibit spontaneous voicing, a property required for an obstruent stop. A segment like \( t \) is thus phonetically impossible—understanding phonetically possible segments as those that can be pronounced, i.e. those that can realize the implementational requirements of all of their phonological features (after Walker and Pullum 1997). It is important to note that the phonetic impossibility of a nasalized obstruent stop does not stem from a contradiction in its description—i.e. \([-nasal\) & \(+nasal\)] (i.e. P & ~P)—the phonetic impossibility is instead a consequence of the interpretations of the features yielding a logical falsehood for realizable segments (following a line proposed by Walker and Pullum 1997: 3). By this, I mean that the segments described by the feature specifications [+nasal], -sonorant, and -continuant correspond to disjoint sets of phonetically produceable segments; no segment can be realized as nasal and at the same time be produced as an obstruent stop. These opposing realizational requirements prevent any candidate containing \( t \) from ever being selected as the optimal output.

I propose, however, that the unpronounceability of a nasalized obstruent stop does not exclude forms containing nasalized obstruents from being generated (by the function Gen, Prince and Smolensky 1993). By this, I mean that the set of segments produceable by Gen is not an infinite one, but it includes some segments which are not phonetically possible. These segments are described with feature specifications of the kind [-sonorant], [-continuant], [+nasal].

Phonetic versus phonological possibility of a nasalized obstruent stop. Phosphatically possible segments. Shaded area: Phonologically possible segments that are phonetically impossible. Nonshaded area: Phonetically possible segments.

Whole group: Phonologically possible segments. Shaded area: Phonologically possible segments that are phonetically possible. Nonshaded area: Phonetically possible segments.

The hypothesis is that the set of phonologically possible segments describes the set of phonetically possible segments: the set of possible representations of nasalized obstruents. This set of segments produceable by the feature specifications [-sonorant], [-continuant], and [+nasal] is denoted \( P \) in section 3.1, and \( P \) is a subset of the set of segments produceable by the feature specifications [-nasal], [-sonorant], and [+continuant]. These segments are described with feature specifications of the kind [+nasal], [-sonorant], and [-continuant].

The hypothesis is that the set of phonologically possible segments represents the union of the three sets of segments (A, B, and C): (25).

The hypothesis is that the set of phonologically possible segments represents the union of the three sets of segments (A, B, and C): (25).

Phonetically possible segments. Shaded area: Phonologically possible segments that are phonetically possible. Nonshaded area: Phonetically possible segments.

Entire group: Phonetically possible segments.
implications for analysis. If a constraint is part of Gen, no candidates in the evaluation set can violate it. On the other hand, if a constraint is simply undominated, a candidate violating it can be compared to other candidates that also violate it. The constraints include phonological constraints (e.g. [+low]), cooccurrence constraints (e.g. [+ATR, +low]), constraints on sequencing (e.g. C-OMPLEX, phonotactic constraints), constraints on structural coincidence (e.g. alignment), and constraints on strict layering (e.g. PARSE-structure).

Of course any constraint that is violated in the output of some language must belong to the evaluative hierarchy and not to Gen, but this need not be the only criterion by which the status of a constraint is determined. For example, a constraint that is not violated in the output of every language should not be considered to be undominated. This does not in principle undermine the optimality-theoretic claim that constraints are ranked and violable. Forms violating undominated constraints will still be part of the candidate set and evaluated, forming the optimal combination of candidates. However, the constraint hierarchy will help to narrow down the possible candidates in each evaluation.

The transparency of nasal obstruents to nasal harmony is precisely the kind of evidence needed to indicate that *NASO Stops is violable in generation. Let us recall the result from chapter 2 for languages with obstruent transparency. For these languages, the constraint *S-PREAD-NASAL was posited as undominated in every learned grammar. However, there are candidate forms with outgoing nasalization in which the nasal harmony requirement is met. Moreover, even nasalized representations are still possible for Gen, since the constraint against nasalized obstruents is undominated. These feature combinations can still be produced by Gen — there is no reason why nasal obstruents should not be nasalized.

3.3.2 Harmonic Sympathy in Tuyúca

Because constraints against phonetically impossible feature combinations will never be violated in an optimal output, they will be posited as undominated in every learned grammar. However, given sympathetic candidates, these constraints can be optimal except by a correspondence relation to a co-candidate which violates an undominated constraint in the grammar. This is precisely the kind of evidence needed to indicate that *NASO Stops is violable in generation. Let us recall the result from chapter 2 for languages with obstruent transparency. For these languages, the constraint *S-PREAD-NASAL was posited as undominated in every learned grammar. However, there are candidate forms with outgoing nasalization in which the nasal harmony requirement is met. Moreover, even nasalized representations are still possible for Gen, since the constraint against nasalized obstruents is undominated. These feature combinations can still be produced by Gen — there is no reason why nasal obstruents should not be nasalized.
Although this constraint hierarchy selects candidate (a), combining the P1 component of faith and markedness constraints preventing an underlying /t/ from surfacing as an [n], which I refer to here as *tfin (to be explored in the next section), the analysis of transparent obstruents in Tuyuca can now be presented in (28). This tableau incorporates the sympathetic correspondence constraint, IDENT-’O, in P1. For a nasal morpheme containing a voiceless obstruent, the harmonic sympathy candidate is the abstract one in (a), with nasalization of all segments. This candidate loses on the basis of the P1 component constraint against nasalized obstruent stops. IDENT-’O then acts to select the sympathetic candidate of those remaining that most closely matches the content of the abstract correspondent. The sympathetic candidate is the one that is surface-true in the language, so it must be the winner. If this constraint conflict were resolved by ranking within the P2 component, the sympathetic candidate would lose on the basis of the P1 component constraint against nasalized obstruent stops. Because of this markedness constraint preventing the underlying /t/ from surfacing as an [n], the harmonic sympathy candidate will be selected as the phonetically possible candidate. Without a constraint preventing impossible nasalization on the obstruent stop, the abstract correspondent candidate will lose on the basis of faith. The opposition of these constraints will also prevent the encoding of candidates (b) and (c) in the tableau. As such, the optimal candidate is the one corresponding to the abstract candidate (a).


Within this model, if the markedness constraint Transp becomes operational at the surface, its satisfaction will ensure that the output contains the banned structure to be selected as the sympathy candidate.

For an analysis of the marked structure to be selected as the sympathy candidate, it is necessary that Transp constraints in the P1 component of the competition are ranked prior to Transp constraints in P2. Constraints that are possible under consistent constraint operations in the P1 component may be reduced to that of Transp constraints in the P2 component, which are ranked higher in the hierarchy.

An evaluation metric for opacity effects is discussed in section 3.6.
As outlined in Chapter 1, I follow Prince and Smolensky (1993) in assuming that inventories and contrast are emergent properties of the ranking of faith and markedness constraints.

The rankings responsible for representations and contrast in Tuyuca will make an important contribution to understanding the realization of obstruent stops under nasalization and why certain transparency for voiceless obstruent stops do not occur. Recall that the consonantal inventory of Tuyuca is as follows:

\[
p, b, t, d, k, g, m, n, N, s, r, w, j, h
\]

with nasal and voiced stops in complementary distribution as defined by nasal harmony environments (Barnes 1996).

I start with the occurrence of voiced stops and nasals in outputs of Tuyuca. It is important that we admit both of these segments as 'phonemic' in the language in the sense that both kinds of segments in Tuyuca are contrastive. This affects the order of nasal harmony on the output distribution of these segments as well as the effect of nasal harmony on the output distribution of voiceless stops. As noted in Chapter 1, the assumption that contrast is an emergent property of faith and markedness constraint rankings is not crucial to the core of the analysis of nasal harmony. It may be that segmental harmony is not a constraint on order, but that is not an issue to be decided here.

The occurrence of voiced obstruent stops in the inventory of a language is a property that emerges from ranking: the faith constraint preserving obstruency, \[\text{IDENT-IO[-sonorant]}\], must outrank the markedness constraint against voiced obstruent stops, \[*[-voice, -continuant, -sonorant]\]. The effect of this ranking for an input containing /d/ is shown in (30) (\[\text{dièa}\] 'river').

\[(30)\]

\[\begin{array}{c|c}
\text{IDENT-IO[-sonorant]} & \text{IDENT-IO[-sonorant]} \\
\hline
\text{a. dia} & \text{b. nia} \\
\end{array}\]

The winner in (30) is the faithful candidate in (a), which preserves the input [-sonorant] property of the stop. The claim of obstruent status is uncontroversial for voiceless stops. The ranking, \[\text{IDENT-IO[-sonorant]} >> *[-voice, -continuant, -sonorant]\], will produce the same result for voiceless stops: a voiceless obstruent stop in the input will remain an obstruent in the output. It is clear that the constraint against voiceless obstruents will always be ranked quite low in the hierarchy of markedness constraints.

While it is clear that there are voiced and voiceless obstruent stops in the vocabulary of Tuyuca, there is also reason to posit nasal stops as well. It is generally recognized that nasal stops are contrastive. This arises from nasal harmony, which as noted above, is a factor in the output distribution of these segments as well as in the effect of nasal harmony on the output distribution of voiceless stops.

The occurrence of voiced obstruent stops in the inventory of a language is a property that emerges from ranking: the faith constraint preserving obstruency, \[\text{IDENT-IO[-sonorant]}\], must outrank the markedness constraint against voiced obstruent stops, \[*[-voice, -continuant, -sonorant]\]. The effect of this ranking for an input containing /d/ is shown in (31) (\[\text{moa}èa\] 'salt').

\[(31)\]

\[\begin{array}{c|c}
\text{IDENT-IO[+sonorant]} & \text{IDENT-IO[+sonorant]} \\
\hline
\text{a. moa} & \text{b. boa} \\
\end{array}\]

We have achieved the three series of stops in the Tuyuca inventory: voiceless, voiced, and nasal. Let us now consider the outcomes for these segments in nasalized environments.
harmony. The case of a morpheme containing a nasal stop is shown in (32). I consider here a possible input in which the only underlying nasal segment is the nasal stop. Here the nasal stop triggers nasal spreading to all segments in the morpheme. Morphemes containing a nasal segment in the input will come out as nasal morphemes.

Identity constraints for [±sonorant] features are collapsed here and are high-ranked in P2. To simplify the tableau, [±voice, -continuant] constraints are collapsed, as are ones against nasalized sonorants; also, only constraints which are immediately relevant are shown.

(32) /m/ triggers nasal spreading.

\[ \begin{array}{cccc}
\text{P1} & \text{P2} \\
\text{moa} & \text{moa} \\
\ast \text{NASOBSIDENT}^\prime & \ast \text{NASOBSIDENT}^\prime \\
\ast \text{OIDENT-IO} & \ast \text{OIDENT-IO} \\
\ast \text{[±son]} & \ast \text{[±son]} \\
\end{array} \]

In (32), the sympathetic candidate is the one which fully satisfies the nasal spreading constraint, while obeying IDENT[±son]. This chooses (a), with nasalization across the morpheme, as the sympathetic form. Because (a) does not contain any nasalized obstruents, it also is selected as the optimal output, since it best satisfies 'O-Faith.

Thus far we have not explored the content of the IDENT-O constraints in P1. The outcomes for obstruent stops in nasal spreading help to clarify the required ranking. First I consider the case of voiced stops. Although in isolation the ranking of IDENT[-sonorant] over *[+voice, -continuant, -sonorant] forces voiced obstruent stops in the input to be maintained as obstruents in the output, this preservation of sonorant identity can be violated in nasal morphemes, i.e. /b, d, g/ [m, n, N]. Because this outcome involves changing the [sonorant] property of the stop, it has a cost not found in the nasalization of other stops. To accommodate this change in sonorancy, I suggest that sympathetic faith is capable of mapping an obstruent to a sonorant through IDENT-O [+nasal] outranking IDENT-O [-sonorant]. The outcome for a nasal morpheme containing a voiced obstruent stop is shown in (33).

(33) Realization of /d/ in a nasal morpheme.

\[ \begin{array}{cccc}
\text{P1} & \text{P2} \\
\text{wi'do} & \text{wi'do} \\
\ast \text{NASOBSIDENT}^- & \ast \text{NASOBSIDENT}^- \\
\ast \text{OIDENT-IO} & \ast \text{OIDENT-IO} \\
\ast \text{[±son]} & \ast \text{[±son]} \\
\ast \text{[+voi, -cont, -son]} & \ast \text{[+voi, -cont, -son]} \\
\ast \text{SPREAD}([+\text{n}], M) & \ast \text{SPREAD}([+\text{n}], M) \\
\ast \text{NAS} & \ast \text{NAS} \\
\end{array} \]

Note that I assume here that /d/ [n] takes place in the sympathy mapping, and is not achieved by nasal spreading itself, that is, for the purposes of nasal spreading, nasalization of /d/ produces a very marked segment [n] rather than a very harmonic one.

Finally, I consider the case of voiceless obstruent stops. For these segments in a nasal morpheme, the sympathetic candidate will be the same as the optimal. An oral stop will undergo sympathetic nasalization in the output of a nasal morpheme. An oral stop in the original input of a morpheme that undergoes sympathetic nasalization will come out nasalized in (32) (though this is explained in section 3.3.5. where nasal spreading occurs). The relationship between the sympathetic candidate is discussed (and regarded) in section 3.3.5. The high-ranking status of IDENT-[±sonorant] in P2 will select a sympathetic candidate with a nasalized voiceless obstruent stop. For these segments in a nasal morpheme, the sympathetic candidate is the one which fully satisfies the nasal spreading constraint, while obeying IDENT[±sonorant]. This is explained in section 3.3.5. where nasal spreading occurs. The outcomes for obstruent stops in nasal spreading help to clarify the required ranking.

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(33) Realization of /d/ in a nasal morpheme.

\[ \begin{array}{cccc}
\text{P1} & \text{P2} \\
\text{wi'do} & \text{wi'do} \\
\ast \text{NASOBSIDENT}^- & \ast \text{NASOBSIDENT}^- \\
\ast \text{OIDENT-IO} & \ast \text{OIDENT-IO} \\
\ast \text{[±son]} & \ast \text{[±son]} \\
\ast \text{[+voi, -cont, -son]} & \ast \text{[+voi, -cont, -son]} \\
\ast \text{SPREAD}([+\text{n}], M) & \ast \text{SPREAD}([+\text{n}], M) \\
\ast \text{NAS} & \ast \text{NAS} \\
\end{array} \]

Note that I assume here that /d/ [n] takes place in the sympathy mapping, and is not achieved by nasal spreading itself, that is, for the purposes of nasal spreading, nasalization of /d/ produces a very marked segment [n] rather than a very harmonic one.

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most influenced, this constraint will be ranked high. In Tuyuca it is unbound.

In contrast to the outcome for voiced stops in nasal morphemes, voiceless stops do not become full nasals in the optimal output. We have established that sympathetic faith can change an obstruent into a sonorant in order to preserve a [+nasal] specification. This kind of faith is not common in consonant cross-linguistically, but is when the faithfulness rule is the faithfulness rule. This result is also stated by (35) above.

Voice specifications in sympathy candidates are preserved.

We have seen now that sympathetic faith must preserve voicing contrasts but it may change a voiced obstruent into a sonorant nasal. I turn now to the question of voiceless nasal outcomes for voiceless nasals.

To understand these different resolutions, it is important to recognize that voiced nasal stops are extremely common across languages, but voiceless nasals are very marked cross-linguistically, that is, they do not occur in nasals in Tuyuca. I will encode the cross-linguistic markedness of voiceless nasals with the constraint *N̄, which prohibits voiceless nasal sonorants. In most languages, this constraint will be ranked quite high. In Tuyuca it is undominated.

Aspiration occurs in voiceless obstruent stops in Tuyuca in the environment of high vowels (Barnes and Takagi de Silzer 1976: 125-6); however, across languages aspiration of obstruent stops is a great deal more common than aspiration of nasals. Ladefoged and Maddieson (1996) note that in

---

13 Aspiration occurs in voiceless obstruent stops in Tuyuca in the environment of high vowels (Barnes and Takagi de Silzer 1976: 125-6); however, across languages aspiration of obstruent stops is a great deal more common than aspiration of nasals. Ladefoged and Maddieson (1996) note that in
In Tuyuca, *N8 actually belongs to P1 along with the nasalized obstruent constraints, because it must dominate sympathetic faith, specifically IDENT-O[±nasal]. This ranking is needed to ensure that a [t] in a sympathy candidate comes out as an oral [t] rather than a nasal [n8]. This is illustrated in (36) (showing only immediately relevant constraints). Importantly, *N8 rules out candidate (f), with a voiceless nasal, giving (d), with a transparent voiceless stop as the optimal output.

(36) Ruling out voiceless nasals.

\[
\begin{array}{|c|c|c|c|}
\hline
 & P1 & P2 & \\
\hline
 & *NASOBS & *N8 & IDENT-O[+nas] \\
\hline
 & IDENT-O[±voi] & IDENT-O[±nas] & SPREAD([+n], M) \\
\hline
 & *NASSON & & \\
\hline
\end{array}
\]

I conclude this section with a summary of the sympathetic faith hierarchy and contrast rankings for Tuyuca stops in (37). The stop inventory rankings admit three series of stops in Tuyuca: voiceless, voiceless nasals, and nasalized obstruents.

(a) Stop inventory rankings:

- Voiced & voiceless obstruent stops: IDENT-IO[-son] >> *[±voi, -cont, -son]
- Voiced nasal stops: IDENT-IO[+son] >> *[+voi, -cont, +son]

(b) Tuyuca sympathetic faith:


3.3.4 Cross-morphemic spreading and fixed affixes

Next I consider the pattern of cross-morphemic spreading in Tuyuca. As outlined in 2.1, nasality spreads from the root to the suffix in Tuyuca. There are no prefixes in Tuyuca. Examples of alternations with the suffix /-ri/ 'imperative of warning' are repeated below.

(a) Oral suffix alternant with oral stem

\[
/\text{tutie-ri} \quad \text{tutie-ri} \quad \text{tutie-ri}
\]

(b) Nasal suffix alternant with nasal stem

\[
/\text{h)\hat{e}}\hat{e}r)i' \quad /\text{h)\hat{e}}\hat{e}r)i' \quad /\text{h)\hat{e}}\hat{e}r)i'
\]

As discussed in Chapter 2, Barnes (1996) notes that alternating suffixes share a common phonological property: their initial segment is a sonorant continuant; stop- and fricative-initial suffixes always belong to the class of suffixes which are fixed in their relation to obstruent stops, 'aspiration' sometimes describes a delayed timing of voice onset rather than a specific glottal aperture. Voiceless nasals, on the other hand, always require a wide glottal aperture and may or may not have aspiration.

If the latter, it may be that the wide glottis gesture simply does not occur in any segment in Tuyuca aside from [h].

14 Alternatively, this could be handled by IDENT-O[±aspiration], assuming that the kind of aspiration involved in voiceless nasals differs somewhat from the contextual aspiration occurring in voiceless stops in Tuyuca (as evident in contrast /d/ vs. /n/ in a word final position or before a voiceless stop). If voiceless stops in Tuyuca are to have an underlying aspiration, the kind of aspiration on /n/ in contrast to /d/ must be different from the contextual aspiration on voiceless stops in Tuyuca. The outcome of contrast reranking is that /d/ could be realized as a transparent [d] in the output of nasal harmony (by IDENT-O+[nasal]).

This outcome does in fact occur in the nasal harmony of Coatzospan Mixtec (Pike and Small 1974; Gerfen 1996). If the former, the wide glottis gesture simply does not occur in any segment in Tuyuca aside from [h].
oral/nasal quality. Voiced oral stops pattern with the obstruents in never appearing in the alternating affix category, i.e., in affixes a voiced stop/nasal stop alternation never occurs.

16 Examples of obstruent-initial fixed oral suffixes are given in (39).

(39) a. \[h)o)oè) - pˆ\] 'at that place (over there)

b. \[j'u)ka)- da\] no gloss

The phonological generalization concerning obstruents in fixed affixes is explained if obstruents block nasal spreading across morphemes. Otherwise the exclusion of obstruent-initial forms in the set of affixes would block the nasalized affixes. This makes apparent a mismatch in the common terminology: (derivationally)

opaque constraint interactions yield

transparent behavior of segments

and (derivationally)

transparent constraint interactions yield blocking or opaque behavior of segments.

The straightforward interaction of nasalized obstruent constraints with cross-morpheme spreading versus the opaque interaction with intra-morpheme spreading raises a kind of complexity in spreading nasalized obstruents. I propose that cross-morpheme spreading is driven by the word-spreading constraint in (40).

(40) \[\text{SPREAD(\([\text{+nasal}], W)\)}\]

Let n be a variable ranging over occurrences of the feature specification \([\text{+nasal}],\) and S consist of the ordered set of segments s₁...sk in a word W. Let Assoc(n, si) mean that n is associated to si, where si \(\in S\).

Then \[\text{SPREAD(\([\text{+nasal}], W)\)}\] holds iff

i. \[\forall s \in S \exists n \in \text{Assoc(n, s)}\]

ii. For each feature occurrence, n, associated to some segment in W, a violation is incurred for every sj \(\in S\) for which (i) is false.

The constraint in (40) analyzes spreading across morphemes as a demand on spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word. In Tuyuca, the set of segments ... blocking effects in spreading across morphemes but not within morphemes.

The occurrence of blocking effects in spreading across morphemes as a demand on spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word.

The constraint in (40) controls the cross-morpheme vs. intra-morpheme blocking effects in spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word.

(41) \[\text{SPREAD(\([\text{+nasal}], M) >> \text{SPREAD(\([\text{+nasal}], W)\)}\)}\]

The occurrence of blocking effects in spreading across morphemes but not within morphemes would be handled by introducing a novel inter-morpheme constraint between morphemes.

The occurrence of blocking effects in spreading across morphemes as a demand on spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word.

The constraint in (40) controls the cross-morpheme vs. intra-morpheme blocking effects in spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word.

The occurrence of blocking effects in spreading across morphemes as a demand on spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word.

The constraint in (40) controls the cross-morpheme vs. intra-morpheme blocking effects in spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word.

The occurrence of blocking effects in spreading across morphemes as a demand on spreading any occurrence of a \([\text{+nasal}]\) feature to all segments within the word.
If *NASOBS outranks both SPREAD([+nasal], M) and SPREAD([+nasal], W) by moving to P1, then we cannot realize the different behavior of nasalized obstruents with respect to the two spreading constraints. We predict instead that nasalized obstruents will behave transparently in spreading within and across morphemes. This undesirable outcome is illustrated in (44) with a hypothetical form. Here *NASOBS outranks both spreading constraints by appearing in P1. Candidate (e), with a transparent suffix obstruent, is chosen over (d), where the obstruent blocks spreading. (Constraints against nasalized sonorants are collapsed in the last column.)

Incorrect outcome: obstruents are transparent in cross-morpheme spreading

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
</table>
| P1 | *NASOBSIDENT- O [+nasal] | SPREAD([+nasal], M) | SPREAD([+nasal], W) | *NASOBSNON | *
|  a. | ![Diagram A](image1) | ![Diagram B](image2) | ![Diagram C](image3) | ![Diagram D](image4) | ![Diagram E](image5) |
|  b. | ![Diagram A](image1) | ![Diagram B](image2) | ![Diagram C](image3) | ![Diagram D](image4) | ![Diagram E](image5) |
|  c. | ![Diagram A](image1) | ![Diagram B](image2) | ![Diagram C](image3) | ![Diagram D](image4) | ![Diagram E](image5) |
|  d. | ![Diagram A](image1) | ![Diagram B](image2) | ![Diagram C](image3) | ![Diagram D](image4) | ![Diagram E](image5) |
|  e. | ![Diagram A](image1) | ![Diagram B](image2) | ![Diagram C](image3) | ![Diagram D](image4) | ![Diagram E](image5) |

The problem comes about because P2 selects candidate (c), with full word spreading, as the sympathy candidate. Candidate (a), where [t] blocks in spreading across morphemes, is the one that we instead want to be selected as sympathetic.

The issue is summarized in (45). For each of the spreading constraints, the ban on nasalized obstruents wins over perfect satisfaction of spreading. One of these constraint conflicts is resolved with a blocking obstruent, and the other is resolved with a (derivationally) transparent interaction, yielding blocking obstruents.

### Constraint Interactions: nasalized obstruents behave transparent

#### a. *NASOBS >> SPREAD([+nasal], M)

Opaque constraint interaction: nasalized obstruents behave transparent.

#### b. *NASOBS >> SPREAD([+nasal], W)

Transparent constraint interaction: nasalized obstruents block (in affixes).

We may note that opaque constraint interactions come when combining constraints on affixes and base phonology (in similar ways). If opaque constraint interactions are collapsed in the last column, opaque constraint interactions come when combining constraints on affixes and base phonology (in similar ways). In a careful examination of a range of positional licensing effects, Zoll presents evidence demonstrating a need for positional markedness (1996, 1997, in press). Zoll (1997) focuses on two positional licensing effects: cross-morpheme licensing and cross-affix licensing. These effects are due to the ranking of positional markedness constraints. For example, in a language like French, where word stress is determined by positional markedness, the positional markedness constraint may rank higher than other constraints. This ranking ensures that words with stressed syllables are preferred over those with unstressed syllables, leading to the observed stress patterns in French.
syllables, a domain which may be defined as the head (or innermost) prosodic word (Kager 1995). Positional markedness can explain this restriction by requiring that a heavy syllable belong to the head position. The licensing effect in Guugu Yimidhirr is not of this kind, and is one that must be handled by positional markedness.

Zoll's second argument comes from the relocation of marked structure from a weak position to a strong position. She observes that a positional markedness constraint requiring that marked structure originate from a strong position can cause marked structure to migrate to a weak position in which it originates to a strong position. This outcome retains the marked structure in the output rather than losing it all together, better satisfying MAX. Zoll shows that a phenomenon of this kind occurs in the mimetic palatalization of Japanese, described by Mester and Itô (1989). Positional faith, on the other hand, cannot explain the situation, as it incorrectly predicts that a heavy syllable should be more resistant to change than weak syllables (e.g., non-head positions). Instead, the positional licencing effect in Guugu Yimidhirr is not of this kind, and is one that must be handled by positional markedness.

Zoll makes a convincing case for positional markedness constraints. Her finding that only positional markedness constraints can block the derivation of marked structure in weak positions is directly relevant in the present context. We have seen that the non-positional markedness constraint has an opaque interaction with the morpheme-domain nasal spreading constraint: this yields transparent obstruent stops in the general case; however, in affixes there is a transparent interaction of word-internal nasal spreading with markedness yielding nasalized segments. This is because non-positional markedness constraints are ranked separately in the grammar that asymmetries between the status of nasalized segments in roots and affixes becomes apparent.


(46) *NASOBSaffix

Affix-specific markedness constraints occur in addition to the more general non-positional markedness constraint. However, the constraint against nasalized segments in roots is not present in the grammar.

The tableau in (47) illustrates selection of the sympathy candidate. Within P2, *NASOBSaffix outranks the cross-morpheme nasal spreading constraint, which in turn outranks constraints against nasalized sonorants. The tableau in (47) illustrates selection of the sympathy candidate. Within P2, *NASOBSaffix over-ranks the cross-morpheme nasal spreading constraint, placing nasalized segments in roots and affixes becomes apparent.

The constraint against nasalized obstructions in affixes is given in (46). The constraint against markedness yielding nasalized segments is given in (47) (cf. Zoll 1996).

Zoll makes a convincing case for positional markedness constraints. Her finding that only positional markedness constraints can block the derivation of marked structure in weak positions is directly relevant in the present context. We have seen that the non-positional markedness constraint has an opaque interaction with the morpheme-domain nasal spreading constraint: this yields transparent obstruent stops in the general case; however, in affixes there is a transparent interaction of word-internal nasal spreading with markedness yielding nasalized segments. This is because non-positional markedness constraints are ranked separately in the grammar that asymmetries between the status of nasalized segments in roots and affixes becomes apparent.
Selection of the sympathy candidate in cross-morpheme spreading

(47) Selection of the sympathy candidate in cross-morpheme spreading

\[ \text{P1} \quad \text{P2} \]

a) \( \text{ta} - \text{ta} \)

* \( \text{NASOBS} \) \( \text{IDENT-} \)

\( \text{[+nasal]} \)

\( \text{SPREAD} \) \([\text{[+n], M}] \)

* \( \text{NASOBS} \) \( \text{afSPREAD} \) \([\text{[+n], W}] \)

* \( \text{NASSON} \)


b. \( \text{[a)\text{t}a)\text{t}a)] } - \text{ta} *!*

** **


c. \( \text{[a)\text{t}a)\text{t}a)] } - \text{t)a)\text{t}a)\]

** *


d. \( \text{[a)\text{t}a)\text{t}a)] } - \text{ta} * ****

****** *!


e. \( \text{[a)\text{t}a)\text{t}a)] } - \text{t)a)\text{a)\text{t}a)] *! ****

********** *!


The tableau in (48) shows selection of the actual output. This is the candidate which most closely resembles the sympathy candidate, while respecting the non-positional *NASOBS.18 Since the sympathy candidate is the one with full spreading in the root and blocking by obstruents across morphemes, the actual output is the one in (d) with an oral suffix and ... introduces nasalization in the output that is not present in the sympathetic candidate. This could be ruled out by I 

DENT-'

O[-nasal] or simply by the spreading constraint, as shown here.

(48) Selection of the actual output in cross-morpheme spreading

\[ \text{P1} \quad \text{P2} \]

a. \( \text{h)o\text{h)o} - \text{p}\hat{\text{p}} \)

* \( \text{NASOBS} \) \( \text{IDENT-} \)

\( \text{[+nasal]} \)

\( \text{SPREAD} \) \([\text{[+n], M}] \)

* \( \text{NASOBS} \) \( \text{afSPREAD} \) \([\text{[+n], W}] \)

* \( \text{NASSON} \)


b. \( \text{h}[\text{o)\text{h)o}] - \text{p}\hat{\text{p}} \)

** *!

**** *


c. \( \text{h)[o)\text{h)o}} - \text{p}\hat{\text{p}} \)

*!

**** *


d. \( \text{h)[o)\text{h)o}} - \text{p}[\text{\text{\hat{p}}} \)

*!

****** *

********


e. \( \text{h)[o)\text{h)o}} - \text{t}\text{a}[\text{\text{\hat{p}}} \)

*!

********

****

18 The occurrence of the non-positional *NASOBS in P1 ranked over *NASOBS affix in P2 is somewhat unexpected given the positional markedness context. However, this ranking of the markedness constraints gives a positional markedness effect through the transparent interaction of *NASOBS affix with spreading constraints in contrast to the opaque interaction of *NASOBS. An alternative without a positional markedness constraint and placing *NASOBS in both P1 and P2 is outlined in section 3.7.

To verify the analysis, I exhibit three tableaux below illustrating the analysis of cross-morpheme spreading in Tuyuca with actual forms from the language. The first example shows the blocking effect of a liquid in the root to a suffix. In the case with no obstruent in the root, the sympathy candidate coincides with the actual output. The next example shows the blocking effect of a liquid in the root to an oral suffix. The last example shows the blocking effect of a liquid in the root to an oral suffix that introduces nasalization in the output that is not present in the sympathy candidate. This could be ruled out by the spreading constraint, as shown here.

(49) /ho)o - p\hat{p} '/at that place (over there)'

\[ \text{P1} \quad \text{P2} \]

a. \( \text{h)o\text{h)o} - \text{p}\hat{\text{p}} \)

* \( \text{NASOBS} \) \( \text{IDENT-} \)

\( \text{[+nasal]} \)

\( \text{SPREAD} \) \([\text{[+n], M}] \)

* \( \text{NASOBS} \) \( \text{afSPREAD} \) \([\text{[+n], W}] \)

* \( \text{NASSON} \)


b. \( \text{h}[o)\text{h)o} - \text{p}\hat{\text{p}} \)

** *!

**** *


c. \( \text{h)[o)\text{h)o}} - \text{p}\hat{\text{p}} \)

*!

**** *


d. \( \text{h)[o)\text{h)o}} - \text{p}[\text{\text{\hat{p}}} \)

*!

****** *

********


e. \( \text{h)[o)\text{h)o}} - \text{t}\text{a}[\text{\text{\hat{p}}} \)

*!

********

****

Next, we see an example of a voiced obstruent blocking across morphemes.

(50) /ju)ka - da/ no gloss

\[ \text{P1} \quad \text{P2} \]

a. \( \text{ju)ka - da} \)

* \( \text{NASOBS} \) \( \text{IDENT-} \)

\( \text{[+nasal]} \)

\( \text{SPREAD} \) \([\text{[+n], M}] \)

* \( \text{NASOBS} \) \( \text{afSPREAD} \) \([\text{[+n], W}] \)

* \( \text{NAS}\text{SON} \)


b. \( \text{j[u)ka} - \text{da} \)

**!*!

**** *


c. \( \text{j[u)ka) - d)a]} \)

*!

**** *


d. \( \text{j[u)ka)} - \text{d}[a]} \)

*!

****** *

**** *

The tableau in (51) shows nasalization across a morpheme boundary to a liquid-final suffix.

(51) /ho)o - p\hat{p}/

\[ \text{P1} \quad \text{P2} \]

a. \( \text{h)o\text{h)o} - \text{p}\hat{\text{p}} \)

* \( \text{NASOBS} \) \( \text{IDENT-} \)

\( \text{[+nasal]} \)

\( \text{SPREAD} \) \([\text{[+n], M}] \)

* \( \text{NASOBS} \) \( \text{afSPREAD} \) \([\text{[+n], W}] \)

* \( \text{NAS}\text{SON} \)


b. \( \text{h}[o)\text{h)o} - \text{p}\hat{\text{p}} \)

** *!

**** *


c. \( \text{h)[o)\text{h)o}} - \text{p}\hat{\text{p}} \)

*!

**** *


d. \( \text{h)[o)\text{h)o}} - \text{p}[\text{\text{\hat{p}}} \)

*!

****** *

********


We have not seen a case crucially calling on a distinction between morpheme-domain versus word-domain spreading. An example of this kind will be addressed in the upcoming discussion of suffixes which are fixed in their oral/nasal property.

In Tuyuca, we have seen that the interaction between *NASOBSaffix and nasal spreading is a transparent one, coming about from *NASOBSaffix dominating the nasal word spreading constraint within the P2 component. Interestingly, another Tucanoan language chooses the alternative...

Examples of alternating affixes beginning with obstruent stops are given in (52) (data from Jones and Jones 1991).

(52) Obstruent-initial alternating affixes in Southern Barasano

a. /-ti/ 'question'
   Oral alternant: /ahi-a-ti m¨/  
   Nasal alternant: /¯a)-g¨-ti j¨/  
   hear-pres.-question  you

b. /-b¨/ 'past nonthird person animate'
   Oral alternant: /ahi-b¨-j¨/  
   Nasal alternant: /¯a)-N¨-b¨-j¨/  
   hear-nonthird person past 1 sg.

In analytical terms, the difference between Tuyuca and Southern Barasano comes out as a difference in where *NASOBSaffix occurs in P2, as shown in (53). In Southern Barasano, *NASOBSaffix is dominated by the nasal word-domain spreading constraint in P2, yielding a sympathy candidate with full spreading, even across affixes. In Tuyuca, *NASOBSaffix outranks word spreading to give blocking by obstruents in affixes. Tuyuca thus shows an affixal positional markedness effect with respect to nasalized segments, but Southern Barasano does not.

(53) a. Southern Barasano:
   P1: *NASOBS >>
   P2: SPREAD([+nasal], W) >> *NASOBSaffix

b. Tuyuca:
   P1: *NASOBS >>
   P2: *NASOBSaffix >> SPREAD([+nasal], W)

Nasalization in other Tucanoan languages also falls into one of these two patterns.

We believe the above see a case crucially calling on a distinction between morpheme-
with the distribution of obstruents in this grouping explained, we might consider the possibility that fixed affixes fall into an identifiable grammatical class or later 'level' of affixation, where nasalization grounds are insufficient to predict the distribution of fixed affixes.  There does not appear to be any significance to the fixed nasality of aspectual and mood suffixes, and this remains an issue for further research.

The occurrence of different linear orderings of fixed and alternating suffixes is illustrated in (56-57) below (data from Barnes and Malone 1988).  (56a) shows an example where a nasal root is followed by an alternating suffix, and (56b) shows the reverse linear ordering where an alternating root is followed by a nasal suffix.  I have marked nasality on the first vowel in the input here for nasal morphemes.

<p>| | | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>wa</td>
<td>ku</td>
<td>ri</td>
<td>wa</td>
<td>fi</td>
</tr>
<tr>
<td>a</td>
<td>sio</td>
<td>ha</td>
<td>w</td>
<td>fi</td>
</tr>
</tbody>
</table>

' _'wa)kuè)riwa 'they did not think'

' _'asiow)È' 'I heated it'

20.  Barnes (personal communication 1997) notes that there does not appear to be any correlation between more 'external' suffixes and their probability of being fixed in nasality, and she reports a similar apparent lack in Tatuyo (Tucanoan).  But she points out that there is still more work to be done in the investigation of this broad class of nasal affixes.

21.  The absence of a clear grammatical category basis for the fixed nasality versus alternating status of a morpheme is consistent with the Kaye's (1971) findings concerning Desano (Tucanoan).  Like Barnes, Kaye finds that there is a common basis distinguishing the set of categories which are fixed in nasality versus those that are alternant.

The occurrence of different linear orderings of fixed and alternating suffixes is illustrated in (55-57) below (data from Barnes and Malone 1988).  Where a nasal root is followed by an alternating suffix, and (56b) shows the reverse linear ordering where an alternating root is followed by a nasal suffix.
The data in (57) give examples of an alternating suffix occurring between a root and a fixed suffix. In this configuration, the alternating suffix takes on the oral/nasal quality of the preceding element. This property will be built into the analysis below.

(57) a. atiê-a-wî\[\]fi 'he recently came'
    \begin{tabular}{l}
    come - recent past - evidential
    \end{tabular}

b. ba)ka-ri-pî\[\]fi 'to the towns'
    \begin{tabular}{l}
    town - inan. pl. - clitic
    \end{tabular}

In (58) we see a word consisting of six morphemes each fixed in their oral/nasal property. This form clearly shows that fixed morphemes do not affect each other and multiple switches between oral and nasal morphemes is possible.

(58) si'diê-peti-ho)a-dûgà-bi'jigî\[\]fi 'he wanted to drink it all up but...'

I propose to attribute the alternating versus fixed status of morphemes to differences in demands on input-output faith for the different sets of morphemes (following proposals of Itô and Mester 1994; 1996). The nasal specification for a root originates in the first syllable (see discussion in chapter 2). This outcome can be obtained by appealing to positional faith constraints. Beckman (1998) presents a central role in her analysis: I

DENT-\[\]s >> MarkednessConstraint >> IDENT-\[\]s. This ranking places faith for the root-initial position over some markedness constraint, which in turn dominates non-positional faith. Beckman presents an elegant account of these positional asymmetries by making use of positional faith constraints specific to the root-initial position, where the availability of this position comes from the input-output faith in contrast to non-initial positions. These positional asymmetries in the assignment of faith are captured by a model of faith-based faith constraints for the root-initial syllable (see also McCarthy and Prince 1994a, 1995). Beckman shows that fixed morphemes are not subject to faith constraints on oral/nasal specification, as opposed to the alternating suffixes. The following ranking schema plays a central role in her analysis: I

DENT-\[\]s >> MarkednessConstraint >> IDENT-\[\]s. This ranking places faith for the root-initial position over some markedness constraint, which in turn dominates non-positional faith. As a consequence, the root-initial faith alone can enforce violations of the markedness constraint. Beckman shows that this ranking has two important consequences.
consequences: (1) it yields triggering of phonological processes by the root-initial syllable, and (2) it produces blocking of neutralizing phenomena in this position. These consequences of the ranking are also relevant in the analysis of the Bantu language, Shona, as well as in the analysis of the South Dravidian language, Tamil (Beckman 1998).

As noted above in the discussion of Zoll's work, positional markedness constraints are needed to explain some positional licensing effects. However, for the kinds of positional neutralization involved in alternating affixes, positional markedness constraints will not be sufficient, since a root segment will always force nasal spreading to the right. The tableau in (59) presents a hypothetical input where a suffix belonging to the alternating class of affixes comes with a [+nasal] specification and is affixed to an underlyingly oral root. The word-spreading constraint in the analysis is to achieve spreading across morphemes, and this is always left-to-right.

22 To focus on the issue at hand, the tableau here is somewhat simplified. Only candidates containing sonorants in the relevant contexts will be shown. Sympathy and the P1/P2 split are not shown. Sonorant nasalization constraints are collapsed (*NASSON). The constraint IDENTs1-IOroot[±nasal] demands identity of [nasal] feature specifications for correspondent segments in the first syllable of the root, and IDENT-IO[±nasal] expresses the same requirement for correspondent segments in any position. Since nasality is a phonemic contrast in the first syllable but not elsewhere, IDENTs1-IOroot[±nasal] will outrank *NASSON (and spreading for cases in which spreading is incomplete), and

23 Note that when an alternating affix is flanked by two fixed morphemes, the left of which is the root, the agreement of the alternating affix with the root rather than the following affix cannot be derived from a Faith Root >> Faith Affix ranking (McCarthy and Prince 1994a, 1995), since either outcome respects Root Faith.

Kaye (1971: 41) notes a few forms in Desano where spreading is leftward to an alternating suffix from a following fixed suffix. In these cases, he proposes that the alternating and fixed affix form a constituent in the word structure in Tucanoan may prove to obviate the need for stipulating directionality in cross-morpheme spreading.

*NASSON will in turn dominate the non-positional IDENT-IO[±nasal]. In (59) this ranking causes a suffix specified as [+nasal] in the input to lose this specification in the output. I also mention cases where nasal specification is preserved in the output.

The tableau in (61) shows a hypothetical case where the first syllable of the root is [+nasal] and the suffix is [-nasal]. The ranking of IDENTs1-IOroot[±nasal] over *NASSON will preserve this input [+nasal] property and spreading will cause it to spread to other segments and the suffix in the output. Note how the feature 

The tableau in (62) shows the effect of spreading on nasalization in the input and output.

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
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<tbody>
<tr>
<td>wia·ri'</td>
<td>wia·ri'</td>
</tr>
<tr>
<td>wia·[r)i']</td>
<td>wia·[r)i']</td>
</tr>
<tr>
<td>wia·[r)i']</td>
<td>wia·[r)i']</td>
</tr>
</tbody>
</table>

Note that suffixes beginning in a nasal stop never exhibit nasal alternations. In these cases, the failure of the suffix to become oral after an oral root may be explained by IDENTs1-IOroot[±sonorant] dominating the spreading constraint. This prevents a nasal stop from changing to an oral voiced obstruent, as shown in (60) for a possible input for hoa@-masi'-ri'-ga' 'I can't (do not know the way) to leave the clearing' (Barnes 1996: 42). This form contains an oral root followed by a nasal suffix followed by two fixed oral suffixes. In this tableau I abstract away from transparency, showing [s] as nasalized in the output.

The tableau in (63) shows a hypothetical case where the first syllable of the root is [+nasal] in the input and the suffix is [-nasal]. The ranking of IDENTs1-IOroot[±nasal] over *NASSON will preserve this input [+nasal] property and spreading will cause it to spread to other root segments and the suffix in the output. Note that because nasal spreading can produce nasalization of input oral segments in weak positions, non-positional faith for [-nasal] must be dominated by the spreading constraint.

These cases raise a number of issues regarding nasal spreading in cross-morpheme spreading.
Thus far we have seen that the following ranking calling on faith for the initial syllable of the root versus non-positional faith can produce the fixed property of roots versus the alternating property of affixes (with further exemplification to follow).

There is a third set of morphemes that we still must consider. These are the fixed suffixes. Since it will be necessary to distinguish alternating from fixed suffixes, I will call fixed suffixes 'Class 1 suffixes. For this reason, faith must be reformulated as specific to the initial syllable of the root (Barnes 1996). The faith constraint for Class 1 suffixes must be formulated as specific to the initial syllable of the morpheme, because there are a few affixes/clitics with two syllables and there are always full nasalspreading within these dependent morphemes.

Evidence for the ranking of IDENT₁ over the spreading constraint is not included in this or subsequent arguments. In (64), we see that the faith constraint (IDENT₁-Ort[+nas]) is not included in the faith chain within the spreading constraint. To simplify the presentation, the matrix of constraints is shown in (66-69) (data from (57)). In each of these instances, the second syllable is shown in (66-69) (data from (57)). In each of these instances, the second syllable is shown in (66-69) (data from (57)).

(64) 

<table>
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</thead>
<tbody>
<tr>
<td>a</td>
<td>[ma)ka)</td>
<td>-r)i'</td>
<td>-p)ˆ</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>b</td>
<td>[ma)ka)</td>
<td>-ri</td>
<td>-p)ˆ</td>
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</tr>
<tr>
<td>c</td>
<td>[ma)ka)</td>
<td>-r)i'</td>
<td>-p)ˆ'</td>
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<tr>
<td>d</td>
<td>[ma)ka]</td>
<td>-ri</td>
<td>-p)ˆ</td>
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<td>e</td>
<td>[baka]</td>
<td>-ri</td>
<td>-p)ˆ</td>
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<td></td>
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</tr>
</tbody>
</table>

The tableau in (66) shows a case with an alternating suffix flanked by an oral root. The tableau in (67) shows a case with an alternating suffix flanked by a fixed nasal suffix. The tableau in (68) shows a case with an alternating suffix flanked by an oral root and a fixed nasal suffix. This case in (68) shows the crucial interaction between faith and spreading constraints. The tableau in (69) shows a case with an alternating suffix flanked by a fixed nasal suffix. The tableau in (69) shows a case with an alternating suffix flanked by a fixed nasal suffix. The tableau in (69) shows a case with an alternating suffix flanked by a fixed nasal suffix.
The final issue I will address in this section is the full nasal spreading within reduplication prefixes.

In (66) we see that even with nasalization posited on the alternating morpheme in the input, this affix will still come out as oral in the output following an oral root.

At this point the analysis has addressed the blocking behavior of obstruents in cross-morpheme nasal spreading and the distinction between alternating suffixes versus those that are fixed in their nasalization. Early in this section it was established that voiced obstruents block the spreading of nasalization across morphemes, because spreading is dominated by the faithfulness constraint on nasal specification. The last issue I will address in this section is the full nasal spreading within reduplication prefixes. Atoms in a language contrast nasalization with a null nasal option. The input is a nasal vowel and voiced obstruent stops in the first syllable of the root. The output is a nasal vowel and voiced obstruent stops in the first syllable of the root.

<table>
<thead>
<tr>
<th>Oral</th>
<th>Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. -ba</td>
<td>d. -ma</td>
</tr>
<tr>
<td>b. -da</td>
<td>e. -na</td>
</tr>
<tr>
<td>c. -ga</td>
<td>f. -Na</td>
</tr>
</tbody>
</table>

If a nasal stop occurs in the input of a suffix, it will trigger nasal spreading:

\[ (**\) \]

The problem of mapping a nasal vowel and nasalized obstruent stops in the first syllable of a morpheme contrasts with a null nasal option in the output. We have already established a nasal vowel and nasalized obstruent stops in the first syllable of a morpheme contrast with a null nasal option in the output.

\[ (**\) \]

With voiced stops are given in (67):

<table>
<thead>
<tr>
<th>Oral</th>
<th>Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. -ba</td>
<td>d. -ma</td>
</tr>
<tr>
<td>b. -da</td>
<td>e. -na</td>
</tr>
<tr>
<td>c. -ga</td>
<td>f. -Na</td>
</tr>
</tbody>
</table>

If a nasal stop occurs in the input of a suffix, it will trigger nasal spreading:

\[ (**\) \]

The faithfulness constraint on nasal specification in OT is contrasted with a constraint on nasal specification in OT that is contrasted with a constraint on nasal specification in OT. The last issue I will address in this section is the full nasal spreading within reduplication prefixes. Atoms in a language contrast nasalization with a null nasal option. The input is a nasal vowel and voiced obstruent stops in the first syllable of the root.

\[ (**\) \]

The problem of mapping a nasal vowel and nasalized obstruent stops in the first syllable of a morpheme contrasts with a null nasal option in the output.

\[ (**\) \]

With voiced stops are given in (67):
The tableau in (69) shows selection of the sympathy candidate for obstruent spreading and blocking in P2 in (70).

A final summary of the rankings established for cross-morpheme spreading and blocking in P2 is given in (70).

<table>
<thead>
<tr>
<th>(3)</th>
<th>(3)</th>
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</table>

To review, the undominated ranking of initial syllable identity for [+nasal] in roots and Class 1 affixes produces the triggering of nasal spread from the first syllable of these morphemes. In combination with positional IDENT and nasal markedness constraints for all classes of segments, the constraint on nasal spreading realizes the blocking effect of obstruents in cross-morpheme spreading and the targeting of obstruents in spreading within morphemes. Both spreading constraints produce nasalization of sonorants, so NASOBSaffix is ranked below spreading. Interpreting positional oppositions in spreading within morphemes, spreading constraints select morphemes with positional NASOBSaffix between morpheme and word. The triggering of spreading within morphemes NASOBSaffix between morpheme and word and positional markedness constraints IDENT-IO[-sonorant] are all ranked above the triggering of spreading cross-morpheme spreading NASOBSaffix between morpheme and word. The positional markedness constraint IDENT-IO[-sonorant] is ranked above spreading constraints.

Another abstract alternative

In this section, I return to the issue of the abstract representation called on in the sympathy candidate for obstruent spreading. This abstract alternative with phonologically possible but highly marked nasalized obstruents has a strong motivation: obstruents are reluctant undergoers of nasal spreading. This is why the sympathy candidate is rejected in (71).
reluctance is evidenced in two ways, one concerning implications when obstruents undergo nasal spreading and the other concerning implications when obstruents block. First, when obstruents become nasalized in the output (e.g. /d/-\[n\]) or behave transparently, all other segments in the system also undergo nasalization; thus there are no cases of nasal harmony where obstruents are blocked. The tableau below shows the case of a nasal morpheme with a nasal obstruent stop:  

It is possible, however, to construct an account of nasal spreading if we assume that nasalized obstruents are not well-formed representations and are never accessible. The sympathetic candidate would then contain a nasal sonorant rather than a nasal obstruent. In 3.3.3, a high-ranked constraint in P2, DENT-IO[-sonorant], forced the sympathetic candidate to choose an obstruent over a sonorant stop. If this constraint were to dominate spreading, as shown below with a hypothetical form where \[d\] undergoes nasal spreading and \[l\] blocks.

The above tableaux show that there is a ranking which is capable of analyzing nasal harmony without calling on phonetically-impossible representations. The question is whether to construct an account of nasal spreading if we assume it is possible to construct an account of nasal spreading if we assume it is not a well-formed representation.

The tableaux in (72) show the case of a nasal morpheme with a nasal obstruent stop:  

The above tableaux show that there is a ranking which is capable of analyzing nasal harmony without calling on phonetically-impossible representations. The question is whether to construct an account of nasal spreading if we assume it is not a well-formed representation.
The problem is that if obstruent stops (e.g. [t, d]) can correspond to nasal stops (e.g. [n]) in a sympathy candidate, violating only a low-ranked nasalization constraint, their reluctance to undergo (or behave ... not arise under the account making reference to nasalized obstruents.  Under one scenario with nasalized obstruents, *N

ASOBSSTOP will be top-ranked in P2, producing blocking by obstruent stops.  Under another, the sympathy candidate will contain a nasalized stop, violating *N

ASOBSSTOP in P1, and this configuration only comes about when spreading dominates all lower-ranked nasalization constraints occurring in P2.  The reason for this is that the promotion of *N

ASOBSSTOP to P1 comes about as a resolution of the conflict between the nasal markedness constraint and SPREAD([+nas], M), and I assume that the promotion arises as an alternative outcome when SPREAD([+nas], M) threatens to dominate *NASOBSSTOP.  In order for SPREAD([+nas], M) to be in a position to dominate *NASOBSSTOP, it must dominate the nasalization constraints occurring in P2.  This ranking would prevent nasal spreading from changing underlying [-sonorant] specifications.  The consequence would be that sympathetic faith could induce changes in the underlying faith production blocks, and the mapping between nasalized obstruents in the input and sonorant obstruents in the output could not correspond.  Under the account making reference to nasalized obstruents, the constraint would be that sympathetic faith production blocks would be used to synchronize with nasalized faith production blocks.  This analysis would provide a natural account of harmonic correspondence between obstruents and sonorants.

The problem presented by a harmonic approach to the Tiberian phenomenon is resolved as follows:

In 3.2, I presented an account of opaque [d]-deletion and epenthesis in Tiberian Hebrew in the model of harmonic sympathy.  This approach follows that of McCarthy (1997) in most of the particulars of the account: it uses the same underlying faith production blocks and sympathetic faith production blocks that he does, but it differs in how the faith constraints are ranked in the grammar.  The account provided here avoids the problems McCarthy's approach is said to face with explaining opacity effects in a spurious faith production block, and it provides a more satisfactory explanation of the data.  The main difference is that in McCarthy's analysis, the faith production blocks are ranked according to the faith production block specification, while in my analysis, the blocks are ranked according to the faith specifications.  The consequence is that in McCarthy's analysis, the faith production blocks are not synchronized with the faith production blocks in the input, while in my analysis, the faith production blocks are synchronized with the faith production blocks in the input.

In section 3.4 some points of comparison between harmonic and constraint-based sympathy are made.  In section 3.2 I presented an account of opacity in /-deletion and epenthesis in Tiberian Hebrew in the model of harmonic sympathy.  This account followed that of McCarthy (1997) in most of the particulars of the account: it uses the same underlying faith production blocks and sympathetic faith production blocks that he does, but it differs in how the faith constraints are ranked in the grammar.  The account provided here avoids the problems McCarthy's approach is said to face with explaining opacity effects in a spurious faith production block, and it provides a more satisfactory explanation of the data.  The main difference is that in McCarthy's analysis, the faith production blocks are ranked according to the faith production block specification, while in my analysis, the blocks are ranked according to the faith specifications.  The consequence is that in McCarthy's analysis, the faith production blocks are not synchronized with the faith production blocks in the input, while in my analysis, the faith production blocks are synchronized with the faith production blocks in the input.
Incorrect outcome for /deS/ under a transparent account:

1. *COMPLEX ANCHOR-R MAX-IO DEP-IO
2. *COMPLEX ANCHOR-R MAX-IO DEP-IO
3. *COMPLEX ANCHOR-R MAX-IO DEP-IO
4. *COMPLEX ANCHOR-R MAX-IO DEP-IO
5. *COMPLEX ANCHOR-R MAX-IO DEP-IO

The winner under this ranking is candidate (d); however this does not correspond to the attested form in Hebrew. The attested form, in (c), incurs a superset of the violations that (d) does, so no reranking of candidate (d) is to designate candidate (b) as sympathetic and then select (c) by virtue of its resemblance to (b).

Under the harmonic sympathy account, this situation is resolved by bifurcating the hierarchy so that **!** belongs to the P1 component. The sympathy candidate is then selected by being the most harmonic with respect to the P2 constraint hierarchy. In McCarthy's original approach, he notes that of the candidates respecting A\_ANCHOR-R, candidate (b) is the most harmonic, and he proposes to single out the sympathy candidate on this basis. McCarthy suggests that the use of the sympathy candidate, as in (75), is illustrated in (76). The sympathy status of A\_ANCHOR-R is signified by the raised **!** symbol. Constraint rows for candidates violating this constraint are shaded; the most harmonic of the remaining candidates is the sympathy candidate.

---

26 McCarthy formulates ANCHOR-R as an IO root to syllable right-alignment faithfulness constraint. This will be discussed presently.
note that it is necessary to allow other constraints, besides faithfulness, to serve as
sympathy candidates. Once this is done, the constraint hierarchy structure that emerges
must be acknowledged as sympathy candidates. To make the constraint-based model work, the spreading
constraint needs to be ranked after the faithfulness constraint. This is a
positive result in the sense that the model is able to predict the behavior of the spreading constraint in
the language. The constraint hierarchy structure that emerges from
this analysis is also consistent with the predictions of the
sympathy-based model. However, the sympathy-based model is
able to predict the behavior of the spreading constraint in
the language better than the constraint-based model. This is
because the sympathy-based model allows for the possibility of
sympathy interactions between constraints. In the constraint-based
model, the spreading constraint is ranked directly below the
faithfulness constraint, which means that it cannot interact with
other constraints. In the sympathy-based model, the spreading
constraint is ranked below the faithfulness constraint, which
means that it can interact with other constraints. This allows
the sympathy-based model to predict the behavior of the spreading
constraint in the language better than the constraint-based
model.
For example, assigning sympathy status to *P/i while ranking Faith-O over DEP-IO results in epenthesis of a vowel to make /i/ a margin rather than a peak, as shown in (79).

(79) /i/ must be a margin
\[ \text{Faith-O} \]
\[ \text{DEP-IO} \]
\[ *\text{P}/t \]
\[ *\text{P}/d \]
\[ *\text{P}/e \]
\[ *\text{P}/a \]
\[ + \]
\[ \text{a. ta.di.} *! \]
\[ \text{b. ta.dAj.} *! \]

However, ranking DEP-IO over peak constraints dominating *P/i results in segments less sonorous than [i] as peaks:

(80) /n/ can be syllabic:
\[ \text{tadn} \]
\[ \text{Max-IO} \]
\[ *\text{P}/t \]
\[ *\text{P}/d \]
\[ *\text{P}/e \]
\[ *\text{P}/a \]
\[ + \]
\[ \text{a. ta.dn.} *! \]
\[ \text{b. ta.dAn.} *! \]

This kind of use of constraint-based sympathy in relation to a markedness hierarchy singles out one constraint to behave as if it had undominated status in selection of the sympathy candidate, even though its markedness constraint dominates. The effects of universal hierarchies will thus be preserved.

A second case derivable under constraint-based sympathy is also worth considering. This example could be classified as involving a type of Duke of York Gambit. In this instance, a segmental... It resolves inputs with such a structure by epenthesizing a vowel. This outcome is produced by the following ranking:

Epenthesis to avoid complex syllable margins:
\[ \text{MAX-IO >> DEP-IO} \]
\[ *\text{COMPLEX} \]
\[ + \]
\[ \text{a. tark} \]
\[ \text{b. tar} *! \]
\[ \text{c. tark} *! \]

Suppose that the markedness constraint, *p, was assigned sympathy status. Since [p] occurs freely in words of the language, MAX-IO must dominate *p. However, the sympathy status of *p will serve to select candidates without [p] as the sympathy form. Selection of the sympathetic output is thus illustrated in (82). A column containing other segmental markedness constraints, *k and *r, is added here for comparison.

(82) *p as the sympathy constraint:
\[ \text{tarp} \]
\[ \text{MAX-IO} \]
\[ *\text{p} \]
\[ *\text{k}, *\text{r} \]
\[ DEP-IO \]
\[ + \]
\[ \text{a. tarIp} \]
\[ \text{b. tarp} *! \]
\[ \text{c. tar} *! \]
\[ \text{d. ta} *! \]

Ranking DEP-IO below MAX-IO will now select as optimal the candidate that satisfies MAX which most closely resembles the sympathy form. For an input like /tarp/, this will be the completely faithful output, even though it violates *COMPLEX.

In contrast, coda clusters that do not contain [p] will be unaffected by the derivational opacity effect; they will be resolved by epenthesis:

Results in epenthesis of a vowel to make /i/ a margin rather than a peak, as shown in (79).
forms not containing \[p\] are unaffected: \[tark/ \textsc{MAX-IO DEP-'}\textsc{O}^* \textsc{p} \textsc{r, k COMPLEXDEP-IO}^+\]

Because the constraint-based model can potentially single out any constraint for sympathy status, it is capable of producing this segment-specific exceptionality to general phonological phenomena in the language. This seems to be a power that would best be eschewed.

In this respect, the present model of harmonic sympathy is distinct from constraint-based sympathy: harmonic sympathy cannot derive the segment-specific invisibility of the sort derived above. If we attempt to reproduce this effect under harmonic sympathy, we must invoke a constraint hierarchy bifurcation between \textsc{MAX-IO} and \textsc{*p}, with \textsc{MAX} moving into the \textsc{P1} component. As in the ranking under constraint-based sympathy, this means that \textsc{MAX-IO} will be respected in the actual output and \textsc{*p} will contribute to selection of the sympathy candidate. However, harmonic sympathy does not actually designate \textsc{*p} as special in determining the sympathy candidate; this role is played by the entire \textsc{P2} hierarchy. With \textsc{MAX-IO} out of the picture in \textsc{P2}, all of the segmental markedness constraints will contribute to selection of the sympathy form. This ... the unmarked' (McCarthy and Prince 1994b): the sympathetic candidate will be of unmarked shape, e.g. always a CV syllable.

\[\text{P1} \text{P2}\]

\[
\begin{array}{c|c|c|c}
\text{MAX-IO} & \text{DEP-'}\textsc{O}^* & \textsc{COMPLEXDEP-IO}^+ & \textsc{d}_a \\
\hline
\text{MAX-IO} & \text{DEP-'}\textsc{O}^* & \textsc{COMPLEXDEP-IO}^+ & \textsc{d}_a \\
\end{array}
\]

The above has shown that opacity induced by a conflict between MAX-IO and sympathetic faith will now select the completely faithful output in both cases. Epenthesis into coda clusters will simply never take place.

\[\text{P1} \text{P2}\]

\[
\begin{array}{c|c|c|c}
\text{MAX-IO} & \text{DEP-'}\textsc{O}^* & \textsc{COMPLEXDEP-IO}^+ & \textsc{d}_a \\
\hline
\text{MAX-IO} & \text{DEP-'}\textsc{O}^* & \textsc{COMPLEXDEP-IO}^+ & \textsc{d}_a \\
\end{array}
\]

From a broader perspective, constraint-based sympathy and this model of harmonic sympathy differ in the following respect. Both models are capable of producing what price 1994b) \textsc{sympathy} cannot produce the effect of \textsc{p-specific intermediate invisibility if MAX-IO is promoted to P1}. The alternative resolution would be to promote \textsc{d}_a to P1. In this case, \textsc{d}_a cannot produce the effect of \textsc{p-specific intermediate invisibility if MAX-IO is promoted to P1}. The above has shown that opacity induced by a conflict between MAX-IO and sympathetic faith will now select the completely faithful output in both cases. Epenthesis into coda clusters will simply never take place.

\[\text{P1} \text{P2}\]

\[
\begin{array}{c|c|c|c}
\text{MAX-IO} & \text{DEP-'}\textsc{O}^* & \textsc{COMPLEXDEP-IO}^+ & \textsc{d}_a \\
\hline
\text{MAX-IO} & \text{DEP-'}\textsc{O}^* & \textsc{COMPLEXDEP-IO}^+ & \textsc{d}_a \\
\end{array}
\]
be considered Duke of York gambit effects for a specific segment, but harmonic sympathy achieves this only when that segment never surfaces in the language (or at least not in that environment); harmonic sympathy provides a framework in which the unattested nature of certain opacity effects can be better understood.

To summarize, in this section I have considered the alternative constraint-based model for identifying sympathetic candidates. While this approach has brought important insight to our understanding of the sympathetic candidate, harmonic sympathy is a promising step in this direction. In section 3.7, I consider some further...

### 3.5 Finnish

I now turn to a consideration of harmonic sympathy in relation to another (derivational) opacity effect, namely rounding, and [ATR], which have been much discussed in the literature. In Finnish, it is vowel backness that spreads. The surface vowel inventory of Finnish is given in (89) (each vowel may be long or short) (Ringen 1975; Kiparsky 1981; data taken from van der Hulst & van de Weijer 1995).

\[ \begin{array}{ll}
\text{front} & \text{back} \\
\text{high} & i, y & u \\
\text{mid} & e, o & o \\
\text{low} & Q & Q \\
\end{array} \]

The interesting asymmetry in the Finnish inventory is the presence of back vowels while no such vowel appears in the front. This is a harmonization effect, where the harmony is dependent on the stem. Harmonic sympathy is a vowel harmony in which all vowels must either be front or back, and no back vowels are permitted in which all vowels must either be front or back. These two unpaired vowels are neutral in the system.
Suffixes containing an /i/ or /e/ do not have a back alternant, because of the absence of a back counterpart for these vowels. However, these non-alternating vowels do not determine the front-back quality of the vowel in question. The front-back quality of the vowel will follow /i/ and /e/ if there is a back vowel in the stem. /i/ and /e/ thus behave transparent to the harmony:

(91) a. *vÖrtitinQ - llÖ - ni - hÖn 'with spinning wheel, as you know'
    b. *palttina - lla - ni - han 'with linen cloth, as you know'
    c. *ljÖ - dÖ - kse - ni - kÖ 'for me to hit'
    d. *ljÖ - da - kse - ni - ko 'for me to create'

The analysis of nasal harmony has shown that there is good reason to believe that spreading is a strictly local phenomenon taking place only between adjacent segments. Non-local outcomes cannot be driven by spreading features, as the transparent vowels (*µ, *F) are disallowed by the markedness constraints prohibiting the occurrence of the back counterpart to these vowels. Thus, /i/ and /e/ behave transparent in Finnish simply because the markedness constraints are the ones that win in the ranking. The constraint conflict that brings about the occurrence of transparent segments in Finnish is between the spreading constraint, $\text{SPREAD}_{\pm\text{back}}$, and the markedness constraints, *µ, *F (abbreviating feature cooccurrence constraints corresponding to these segments). The markedness constraints are the ones that win in the ranking, as they are surface-true in the language. On the other hand, $\text{SPREAD}_{\pm\text{back}}$ wins in the sympathy competition. The constraint conflict is thus resolved with a hierarchy bifurcation with *µ, *F advancing to $P_1$ and $\text{SPREAD}_{\pm\text{back}}$ located at the top of the $P_2$ hierarchy. The outcome is illustrated in (92-93). The spreading constraint dominates the markedness constraints against vowels that actually occur in Finnish. Also shown here is that high-ranked *µ, *F are blocked from entering the tableau in (93) shows selection of the actual output. This is the candidate which most closely resembles the sympathy candidate in [±back] specifications, while still respecting the markedness constraints prohibiting *µ and *F. This is the output in which /i/ behaves transparent.

(93) Selection of the actual output

The above tableaux outline how the transparent vowels in vowel harmony can be analyzed as arising through an opaque constraint interaction. This simply presents an overview of the general principles involved. The crucial point about the above account is that it brings antagonistic transparency in both vowel harmony and nasal harmony under the spreading/µ interaction. There are no spreading constraints on any of the vowels that actually occur in Finnish. As shown in (90-92), the spreading constraint dominates the outcome. The outcome is illustrated in (90-92).

---

The tableau in (93) illustrates selection of the actual candidate, which is the one with full spreading from the initial syllable.

---

The tableau in (93) shows selection of the sympathy candidate (sympathetic input).
the umbrella of the more general phonological phenomenon of derivational opacity effects. Under this approach, true transparency is not analyzed with parochial constraints specific to skipping of ... is rather one instantiation of the opacity effects that are pervasive in the phonologies of languages of the world.

3.6. An evaluation metric for opacity

I conclude this discussion by reviewing where we stand now on the subject of derivational opacity, segmental transparency ... and Padgett 1993; McCarthy 1994; Padgett 1995a; Flemming 1995b; Walker and Pullum 1997; among others).

Importantly, in addition to these various motivations for rejecting a violable conception of the gapped configuration, the analysis in this chapter has laid out one more: the gapped configuration is ... of the languages of the world. In analyzing segmental transparency as a derivational opacity effect, transparency is understood as one of a set of well-documented effects of this kind, not as a unique event requiring a phenomenon-specific theory.

Under the treatment of transparency as a derivational opacity effect, the notion of feature spreading as strictly local can be maintained, consistent with the findings of other work cited above. However, the cross-linguistic variation in the application of spreading phenomena to target structures is a matter of opacity effects. Under this approach, the opacity effects are parsed in the phonology of the language. The spread phenomenon can include a gapped phenomenon, as in the derivational opacity effect transparency.

Yet consider how the pronounced outputs of such a language would be perceived by the learner. An oral liquid or glide occurring between two nasal vowels would be extremely difficult to distinguish from a nasalized liquid or glide in the same context. We may then expect all consonants to behave transparently to nasal spreading, as illustrated by the tableau in (94).

(94) Transparency of all consonants

```
<table>
<thead>
<tr>
<th>8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td><img src="image.png" alt="image" /></td>
</tr>
</tbody>
</table>
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In analyzing segmental transparency as a derivational opacity effect, transparency is understood as one of a set of well-documented effects of this kind, not as a unique event requiring a phenomenon-specific theory. Under this approach, the opacity effects are parsed in the phonology of the language. The spread phenomenon can include a gapped phenomenon, as in the derivational opacity effect transparency.
nality to overlap to some degree onto the neighboring consonant (Cohn 1993a). In addition, even when oral, approximants share similar acoustic properties with nasals, namely (weak) formant structures. This yields a grammar in which sonorants come out as targets rather than surface-transparent.

The matter of derivational transparency leads into the second issue of acquisition, concerning the relative difficulty of learning derivational opacity. In his discussion of derivational opacity, Kiparsky (1997) argues that the fewer optimizations required in selecting an output, the easier the grammar is to learn. Sympathetic faith gives us a means of evaluating the degree of difficulty. If optimizations in grammars with opacity effects are more difficult to acquire, then that grammar will be learned more slowly, with more resources being devoted to the acquisition of that grammar. In grammars with derivational opacity, the difficulty of acquiring that grammar will be greater, as the learner must resolve the interaction between the sympathy candidate and the actual output when opacity is required. Grammar optimization thus eschews opacity.

3.7 Appendix: German and Harmonic Sympathy Revisited

The sympathetic approach to the interaction of the sympathy candidate and the actual output in German and Harmonic sympathy is revisited. In derivational opacity, the constraints compete with each other, and the learner must resolve the interactions between the constraints. In Harmonic sympathy, the constraints cooperate with each other, and the learner must resolve the interactions between the constraints. In this case, the learner must resolve the interaction between two candidates that are competitive, as in the case of derivational opacity. The fact that the sympathy candidate is more competitive in the case of Harmonic sympathy, as opposed to derivational opacity, leads to the conclusion that the sympathy approach is more effective in resolving the interactions between the constraints.
analysis of Tuyuca and for issues of overgeneration of derivational opacity effects are briefly outlined.

German exhibits a productive pattern of truncation, deriving various kinds of shortenings including hypocoristics. Some examples are given in (95) (from Itô and Mester 1997a, see citations therein). The truncation involves the deletion of the preceding vowel, which remains a long vowel. It is thus the first sound of the following syllable, e.g., in Gorbatschow truncates to Gorbi not *Gorri.

(95) a. Truncata maximizing sequence C_0VC_1

Base Truncation

Gorbatschow,Gorbi *Gorri (name of politician)
Hans,Hansi *Hanni (personal name)
Alkoholiker,Alki *Alli 'alcoholic'
Gruft,Grufti *Gruffi 'older person'
Hirn,Hirni *Hirri 'brain'
Imperialist,Impi *Immi 'imperialist'
Tourist,Touri *Toui 'tourist'

Radenkovic,Radi *Rai (well-known goalkeeper)

b. Non-maximal truncata

Base Truncation

Gabriele,Gabi *Gabri (personal name)
Andreas,Andi *Andri (personal name)
Dagmar,Daggi *Dagmi (personal name)
Heinrich,Heini *Heinri (personal name)
Ulrich,Ui *Ulri (personal name)
Siegfried,Sigi *Siegf (r)i (personal name)
Klinsmann,Klinsi *Klinsi (name of soccer player)
Littbarski,Litti *Littbi (name of soccer player)
Imker,Immi *Imki 'beekeeper'
Knoblauch,Knobi *Knobli 'garlic'

As Itô and Mester point out, the challenge presented by these data is identifying the exact shape of the truncatum (the portion copied from the base and suffixed with [-i]). The output of the truncation is always a syllable in which the prefix [-i] is suffixed with the onset of the preceding vowel. The data in (95a) suggest that the copied material is always the maximal string matching the form: C_0VC_1, i.e., Gorbatschow truncates to Gorbi not *Gorri. However, the data in (95b) show that the medial consonant cluster is not maximized. For example, the truncation of Gabriele is Gabi not *Gabri.

Itô and Mester make the important observation that the general form the truncations take is produced (descriptively) by suffixing [-i] to the maximum possible syllable of German derivable from the sequence of segments in the base scanned from left to right. This is illustrated in (96), which expresses (95a) in a transparent framework.

(96) MAX-IO >> ALLFTL >> MAX-BT

The analytical assumption here is that input-output (IO) faith applies to truncation (following Benua 1997), such that identity is required between the output form of the truncatum (TRUNC) and material from the base. The faith relations are illustrated diagrammatically in (97) (from Itô and Mester 1997a).

(97) Base-truncatum faith relations:

The outcome selected by the ranking in (96) is illustrated in (98). MAX-IO is relevant only for [-i] in the input, because the TRUNC portion does not have underlying segmental material. MAX-BT promotes a candidate that fully copies the material in the base, however, the domination of this constraint by ALLFTL (ALIGN(foot, L, Pwd, L)) results in an output with at most two syllables. Since the rhyme of the second syllable must be [-i] (by MAX-IO), the truncatum will consist of as much material from the base as will fill the first syllable. The truncatum will consist of as much material from the base as will fill the first syllable.

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syllable and form the maximal possible onset to the second. PARSE-s is added here to prevent segmental material outside of the foot from surviving.

(98) Transparent account of truncation

Base: (.gor.ba).(.tÉSof.)

Input: /TRUNC - i/

\[
\begin{align*}
\text{a. (} & \text{gor.ba). (tÉS} \text{of. -i.)*!} \\
\text{b. (} & \text{gor.ba). tÉS} \text{-i.)*!} \\
\text{c. (} & \text{gor.b} \text{-i.) e} \text{lÉSof} \\
\text{d. (} & \text{go.r} \text{-i.) b} \text{atÉSof} \\
\text{e. (} & \text{gor.b} \text{a.)*! tÉSof} \\
\text{f. (} & \text{gorb.*! atÉSof} \\
\text{g. (} & \text{gor.)*! batÉSof}
\end{align*}
\]

While the transparent account is successful for instances of truncation which maximize the C0VC1 sequence, it fails for the non-maximal cases. This is illustrated in (99) for the truncated form of Gabriele.

(99) Transparent account fails

Base: (.ga.bri).(.e.le.)

Input: /TRUNC - i/

\[
\begin{align*}
\text{a. (} & \text{ga.bri}. (e.le.).-i.)*(!)*(!) \\
\text{b. (} & \text{ga.bri}. (e.l-} \text{i.)*! e \\
\text{c. (} & \text{ga.br} \text{-i.)} e \text{lÉS} \\
\text{d. (} & \text{ga.b} \text{-i.)} r \text{ie} \text{lÉ} \\
\text{e. (} & \text{gab.)*! rie} \text{lÉ} \\
\text{f. (} & \text{gab.)*! rie} \text{lÉ} \\
\text{g. (} & \text{ga.)*! brie} \text{lÉ}
\end{align*}
\]

The transparent account is insufficient to distinguish between the truncation of the maximizing forms in (95a) and the non-maximal ones in (95b). Itô and Mester propose instead to make use of the sympathy of segments. This candidate is identified by assigning sympathetic status to an alignment constraint: ALL L (ALIGN(s, L, Pwd, L)). Ranking this constraint between MAX-IO and MAX-BT selects as the sympathy candidate a single syllable containing maximal material from the base. Note this does not necessarily correspond to the actual syllabification of this sequence of segments in the base. Solution of this problem consists of precisely this form. This candidate is identified by assigning sympathetic status to a single syllable containing maximal material from the base. Note this does not necessarily correspond to the actual syllabification of this sequence of segments in the base. Solution of this problem consists of precisely this form.

The complete tableau is exhibited in (100). The candidate which makes the maximal possible syllable of German can be formed by the sequence of segments in the maximizing form in (95a) and the non-maximal ones in (95b). The actual output is the candidate which matches the segmental material in (f) with the addition of the [-i] suffix. This is achieved by ranking the sympathetic faithfulness constraint, D\textsuperscript{EP-FO}, below MAX-IO and above MAX-BT.
This sympathy account also achieves the correct results for a base like [gorbatÉSof]. In this case the sympathy candidate will be [gorbi], because the consonant cluster can constitute a well-formed coda, and the actual output is the candidate adding just [-i] to this form, giving [gorbi].

Itô and Mester's sympathy-based analysis brings new understanding to the German truncation phenomenon. In this constraint-based sympathy account, the dominated alignment constraint, ALIGN\(@\), is assigned sympathetic status, resulting in selection of the maximal monosyllabic candidate for German as the sympathy candidate.

Through sympathetic correspondence, if the P1 constraint is assigned sympathetic status, it will penalize all candidates in which the constraint is in conflict. To assess this possibility, I will present some experimental results for German in the next section.

### (101) Constraint-based sympathy constraint account of truncation

The unsyllabified status of [i] in candidate (b) is indicated by the angle brackets. Under a transparent interaction of PARSESEG and ALIGN\(\) to the left (102), the candidate satisfying affix-to-head alignment loses on a PARSESEG violation. This turns the competition over to (a) versus (c), which both have exhaustive parsing of segments into syllables. Candidate (c) is then selected.

<table>
<thead>
<tr>
<th>Rule</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALIGN()</td>
<td>*</td>
</tr>
<tr>
<td>PARSESEG()</td>
<td>+</td>
</tr>
<tr>
<td>MAX-BT</td>
<td></td>
</tr>
</tbody>
</table>

(The unsyllabified status of [i] in candidate (b) is indicated by the angle brackets.)
a stop. However, the details of those cases do not concern us here.

As pointed out in n. 29, this constraint may be violated by a coronal voiceless fricative adjacent to /ótisch/ 'chaotic'). This pattern is given by the ranking: ONSETFT, MAX >> DEP >> ONSET. For ONSET to have an opaque interaction with ALIGN-TO-

With these rankings and ONSET, giving a sympathy candidate of the form: 

Candidates (f-h) illustrate how the [-i] alignment constraint rules out candidates failing to place unparsed material in [-i]. The maximizing function of M aligns [-i] to the syllable edge. The constraint conflict here must thus not be resolved by simple ranking, but rather by a hierarchy split, so that 

In the P2 component which rules out various candidates for sympathy or optimal output status. This is a sonority effect: MAX-L >> MAX-BT. Second, I note a high-ranked constraint AX-IO. In this case the sympathy candidate contains the same segmental sequence as the output but with syllabification only of the truncatum. Serially, this loosely corresponds to the form after circumscription and i-suffixation but before resyllabification of the final string.

So far, we have determined that the harmonic sympathy account involves the correct one for German; (a) corresponds to the actual attested form. A harmonic sympathy analysis can obtain this...

The constraint-based sympathy analysis makes use of a truncatum-sized sympathy candidate which violates M and BT faith: MAX-IO >> ALL and BT faith MAX-IO >> ALL. Second, I note a high-ranked constraint...
The transparent competitor, [ga@b.ri.], loses on a DEP-O violation, as shown in (105). (The candidates [ga@b.] and [ga@i.] are not included in this tableau and will be discussed below.)

Although candidate (d) wins over (e) on DEP-O, it fares worse on another sympathetic faith constraint: SROLE-O, which requires that correspondent segments have identical syllable roles (McCarthy and Prince 1993a ch. 7; Gafos 1996). A violation of SROLE-O is incurred for [b], which appears in a coda in the sympathy candidate but in an onset in the actual output (d). In the alternative candidate (c), [b] maintains its coda status. Since (c) loses to (d) in spite of its satisfaction of SROLE-O, DEP-O must outrank SROLE-O.

A second sympathetic faith ranking is evident when we compare [(ga@.bi.)] with the alternatives [(ga@i.)] and [(ga@b.)]. In contrast to the winning candidate, [(ga@i.)] and [(ga@b.)] obey SROLE-O for [b] but violate MAX-O. This indicates that MAX-O also outranks SROLE-O. These rankings of sympathetic faith constraints will also obtain for SROLE-O. These rankings of sympathetic faith constraints will also obtain for SROLE-O. This indicates that MAX-O and SROLE-O play a maximizing role here. Concerning the sympathy candidate, I am simply working out the details of the account below. The account is set forth below for the cluster maximization example, [gorb@]<

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Selection of the sympathy candidate:

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base:</td>
<td>(<a href="mailto:go@r.ba">go@r.ba</a>).tÉSo$f.</td>
</tr>
<tr>
<td>Input:</td>
<td>/TRUNC - i/ PARSE SEG s ALIGN-TO-s @</td>
</tr>
<tr>
<td>Max-I0</td>
<td>MAX-IO &gt;&gt; ALL s LMAX-BT</td>
</tr>
<tr>
<td>1.</td>
<td><a href="mailto:go@r.ba.t">go@r.ba.t</a>ÉSo$f.i</td>
</tr>
<tr>
<td>2.</td>
<td><a href="mailto:go@r.ba.t">go@r.ba.t</a>ÉS-i</td>
</tr>
<tr>
<td>3.</td>
<td><a href="mailto:go@r.b-i">go@r.b-i</a></td>
</tr>
<tr>
<td>4.</td>
<td><a href="mailto:go@.r-i">go@.r-i</a></td>
</tr>
<tr>
<td>5.</td>
<td>go@r.-i</td>
</tr>
<tr>
<td>6.</td>
<td>go@r.-b.i</td>
</tr>
<tr>
<td>7.</td>
<td>go@rb.-i</td>
</tr>
<tr>
<td>8.</td>
<td>go@rb.-b.i</td>
</tr>
<tr>
<td>9.</td>
<td>go@rb.-i</td>
</tr>
<tr>
<td>10.</td>
<td>go@rb.-b.i</td>
</tr>
</tbody>
</table>

A summary of the rankings that have been established thus far for the harmonic sympathy analysis of German truncation is given in (110).

Bifurcation triggered by opaque resolution of conflict between PARSESEG and ALIGN-TO-s:

1. **Sympathy**
2. Size restriction. MAX-IO >> ALL s L >> MAX-BT
3. **Sympathy**
4. Place of PARSESEG

A summary of the rankings that have been established thus far for the harmonic sympathy analysis of German truncation is given in (110):
output, producing strings that do not actually occur in German. An example is given in (111) with a possible input for [gabriele] containing extraneous unsyllabifiable segments. Since truncation is not directly relevant here, I have omitted truncation-related constraints from the tableau.

(111) Predicting unattested strings in actual output:

P1                                P2
Input: bdgabriele
PARSE SEG
1. MAX-IO
2. DEP-IO
SSC
a. .
gabri.e.le.*!
**(1)
b. .
bdga.bri.e.le.*
**(1)
c. <
bd>. ga.bri.e.le.*
**(1)
d. .
b'd.gabri.e.le.*
**(2)
The sympathy candidate in (111) is [<bd>. gabri.e.le.], which satisfies MAX-IO by preserving all input segments and circumvents syllable well-formedness by failing to parse the first two consonants. DEP-IO is shown in this tableau to illustrate that parsing the segments into a well-formed syllable by epenthesizing a vowel, as in (d), will still be less harmonic than the sympathy candidate in (c), because candidate (d) violates DEP-IO, while the constraint that (c) violates, PARSE SEG, is not contained in P2. With candidate (c) selected as the sympathy candidate, the actual output is [bdgabriele], with the string of initial consonants syllabified into the first syllable. This output is selected because sympathetic faith forces the actual output to be identical in segmentism to the sympathetic candidate, and PARSE SEG requires that all segments be parsed into some syllable. The outputs that correspond to well-formed outcomes for German, in (a) and (d), lose on the basis of sympathetic faith. It should be noted that this kind of problem does not arise under constraint-based sympathy, because in that model all of the constraints contribute to selection of the sympathy candidate.

33 Thanks to Armin Mester for raising this issue.

34 I assume that high-ranked constraints in P2 rule out candidates in which [−i] forms a word on its own or occurs outside of a word boundary.
In (115) we see the selection of the sympathy candidate. This is one that adds the [-i] suffix to the truncatum.

This approach resolves the problem of predicting unattested strings in German by positing the P1 constraint as one specific to truncation. Because of this specificity, the placement of this constraint in P1 will not impact non-truncatory forms.

An alternative solution involves revising the opaque resolution of constraint conflict in harmonic sympathy. Recall that the problem for the analysis of German which placed PARSESEG in P1 was that this constraint no longer played any role whatsoever in selection of the sympathy candidate. This problem could be overcome if the opaque interaction of two constraints was resolved by the winning constraint being promoted to a P1 segment and also occurring dominated by the second constraint within the P2 segment.

In (116) we see the section of the actual output. This is one that adds the [-i] suffix to the truncatum.

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

In (117) we see the section of the actual output. This is one that adds the [-i] suffix to the truncatum.
can be derived involves an optimization operation corresponding to the previous section of the subject. This derived constraint in P2 occurs within P1 and is reflected in this optimization. The hierarchy for selection of the constraint is then P1 and P2, with a constraint that is higher in the hierarchy for constraint selection being dominant within the hierarchy. The hierarchy for constraint selection is illustrated in (117). The revised model of harmonic sympathy, in which a constraint in P1 also occurs dominated within P2, is important not just to resolve the problem for the analysis of German but also to address the more complexity involved in understanding a constraint in P1 that is also present in P2. However, in the case of the German opacity effect, the requirement for constraint selection is illustrated in (117). The revised model of harmonic sympathy, in which a constraint in P1 also occurs dominated within P2, is important not just to resolve the problem for the analysis of German but also to address the more complexity involved in understanding a constraint in P1 that is also present in P2.

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that selecting the actual output. Constraint-based sympathy expresses this through assigning a constraint sympathetic status; the revised version of harmonic sympathy expresses the ranking for the sympathy optimization, an idea central to sympathy theory.

Finally, I briefly return to the two kinds of unattested opacity effects discussed in section 3.4 which constraint-based sympathy was capable of generating. The earlier version of harmonic sympathy ruled out ... assignment of sympathy status to *P/i causes /i/ to come out as a margin but the less harmonic /n/ can still be syllabic.

(119) /i/ must be a margin

Faith-

ODEP-IO

*P/n

*P/i

*P/n

*P/i

Faith-

ODEP-IO

*P/n

*P/i

Faith-

ODEP-IO

*P/n

*P/i

a. .ta.di. *!

b. .ta.dAj. *!

(120) /n/ can be syllabic:

tadn

Faith-

ODEP-IO

*P/n

*P/i

*P/n

*P/i

Faith-

ODEP-IO

*P/n

*P/i

a. .ta.dn. *!

b. .ta.dAn. *!

Under the revised version of harmonic sympathy, this problem still does not come about. In order for *P/i to be respected in selection of the sympathy candidate, it must be obeyed in the output best-satisfying ... out the ranking for the sympathy optimization, it explains why universal hierarchies are respected in opacity effects.

For completeness, universal hierarchies should also be considered in relation to the occurrence of markedness constraints within P1. In the analysis of nasal harmony, it should be the case that if any nasal markedness constraint occurs in P1, all higher-ranked nasal constraints must also be observed in P1. For example, if *NASFRIC were to appear in P1 (as resolution of a conflict with SPREAD[+nasal]), then *NASOBSSTOP must also occur dominating *NASFRIC in P1. This can be explained if universal constraint hierarchies are respected. Thus, *NASFRIC in P1 is a constraint on a constraint, 

N V O S S T OP

NASFRIC

N ASFRIC

If a constraint in P1 is observed, then this constraint must be respected in all lower-ranked constraints. For example, *POSHARM must be respected in order for *P/i to be respected in section of the sympathy candidate. This must be observed in order for the revised version of harmonic sympathy to work. Under the revised version of harmonic sympathy, the problem still does not come about.
The above opacity effect remains an outstanding issue for constraint-based sympathy and inventory structure for further research.

The opacity effect does not occur, but I will leave explanation of the connection between P2 and inventory structure for another paper. This observation points towards a possible direction for understanding why this kind of phenomenon is possible. The inventory P2 minus a smaller subset of the inventory marked by P1 should be real. The inventory P2 minus a smaller subset of the inventory marked by P1 should be real.

### The Revised Version of Harmonic Sympathy

In the harmonic sympathy model, an opacity effect occurs when a segmental markedness constraint dominates faith (MAX-IO) in P2, but the faith constraint wins out in selection of the actual output by appearing in P1. This gives a P2 hierarchy in which [p] is excluded from the segmental inventory, and a P1 hierarchy in which [p] is excluded from the segmental inventory, and [p] is included in P1. This gives a P2 hierarchy in which [p] is included in P1. The opposite effect occurs when a segmental constraint comes about when a segmental constraint comes about when a segmental markedness constraint dominates faith (MAX-IO) in P1, but the faith constraint wins out in selection of the actual output by appearing in P2. This gives a P2 hierarchy in which [p] is included in P2, and a P1 hierarchy in which [p] is excluded from the segmental inventory.

The above example effects remain an outstanding issue for constraint-based sympathy.
In this chapter I report on an acoustic study of intervocalic voiceless stops in oral versus nasal contexts in Guarani. Guarani is a language well-known for its nasal harmony, in which all voiced segments become nasalized and voiceless segments behave transparent. An acoustic comparison of oral and nasal word pairs in Guarani provides information about what effect, if any, nasal harmony has on transparent voiceless stops. In the previous chapter I proposed an analysis of transparency as an opacity effect, producing surface orality of transparent segments in nasal harmony. The findings of the study of Guarani confirm the need for this result by showing that voiceless stops do typically surface as oral obstruent stops in nasal spreading domains.

In addition to establishing the basic transparent character of voiceless stops in Guarani, the study makes several findings concerning context-dependent differences in voice onset time, closure voicing, and closure duration in oral versus nasal environments. Although it is apparent that voiceless stops in nasal spans should be represented as phonologically oral, the study identifies some systematic phonetic effects of nasal contexts on voiceless stops. Another discovery is that the total period of voicelessness appears to be fixed independent of context. The period of voicelessness emerges as a feature that is preserved in its total duration but is shifted in relation to stop closure and release in nasal environments. This suggests that, at least in Guarani, the total voiceless duration is a quality contributing to the definition of voiceless stops. These results thus have implications for the phonetic correspondents of phonological features. An additional interesting set of findings concern the different patterning of the velar stop /k/ in contrast to the anterior stops, /p/ and /t/. The velar stop fails to conform to some of the generalizations established for the other places of articulation. I hypothesize that this separate behavior of /k/ is a consequence of a threshold effect in which the velar stop reaches either a sufficient or maximal limit in its voice onset time, preventing a rightward shift of the voiceless period with just these segments.

This chapter is organized as follows. In section 4.1, I give background on the pattern of nasal harmony in Guarani. Section 4.2 outlines the set-up of the acoustic study, describing how the data was collected and the method of instrumental analysis. In section 4.3 I report on the results of the study, first highlighting the general patterns, then detailing differences in timing in oral versus nasal contexts, and finally addressing the fixed quality of the total voiceless period. Section 4.4 discusses the implications of these results and provides a schematic scenario of what changes take place in oral versus nasal contexts. Section 4.5 briefly outlines a two-burst phenomenon observed in a small set of tokens, which appears to be correlated to nasal contexts. 4.6 is an appendix presenting the word pairs used in the study.

4.1 Nasal harmony in Guarani

Guarani belongs to the Tupi family of South America. The Tupi family is geographically located at points along the Amazon River and tributaries, in Paraguay, regions of Bolivia and Brazil, Northern areas of Peru and Argentina, and the South of French Guiana. The Guarani language is centered in Paraguay, where it is one of the country’s two official languages (along with Spanish) and is spoken by approximately two million people. Guarani is also spoken in bordering regions of Argentina and Brazil. A large number of Paraguayan Guarani speakers (over 50%) also speak Spanish; use of Guarani predominates in rural areas and in certain sociolinguistic contexts. There are several grammars and dictionaries of Guarani (e.g. Guasch 1948, 1956; Osuna 1952; Gregores and Suárez 1967), but little instrumental phonetic study of the language has been documented.

Nasal harmony in Guarani has excited much discussion amongst phonologists and phoneticians alike (see Gregores and Suárez 1967; Leben 1973; Lunt 1973; Rivas 1974, 1975; Anderson 1976; Goldsmith 1976; Sportiche 1977; Vergnaud and Halle 1978; Hart 1981; van der Hulst & Smith 1982; Poser 1982; Bivin 1986; Piggott 1992; Cohn 1993a; Trigo 1993; Flemming 1993; Steriade 1993d; Fenner 1994; Ladefoged & Maddieson 1996; Piggott and Humbert 1997; Beckman 1998; among others). Various aspects of the pattern of nasal harmony are of theoretical interest. These include the transparency of voiceless segments, the nasal allophones of voiced segments, the interaction with metrical structure, effects of spreading across morphemes, and the role of prenasalized segments. The present study focuses on the first point: the transparency of voiceless segments in nasal harmony. I will outline the other main points to establish the appropriate set-up for the phonetic investigation. The following description draws on Gregores and Suárez (1967) and Rivas (1974, 1975).

The surface consonant inventory for Guarani is given in (1) (after Rivas 1975: 134). The representation [a/b] indicates two allophones of the same phoneme.

---

1 Another Tupi-Guarani language, Guarayu, has had some acoustic investigation by Crowhurst (1998).
(1) Guaraní surface consonant inventory:

- **Labial**: vcls. stops: p t k
- **Dental**: kW /
- **Alveolar**: vcd. stop/affs.: mb / mnd / n
- **Velar**: dj / ¯Ng / NgW / Ng
- **Labiovelar**: / N w /
- **Glottal**: sSx / h

A few notes on these segments are in order. First, all the voiced segments have oral and nasal allophones, the oral allophones occurring in the onsets to an oral vowel and then the nasal allophones occurring before nasal vowels — consonants occur only in onsets, the basic syllable structure is open, (C)V (Rivas 1975: 135).

2. Voiced stops are realized as prenasalized in oral syllables and as fully nasal stops in nasal syllables. The alveolar voiced obstruent has variable oral realizations, ranging among [dj], [dÉZ], [Z], [j], with the prestopped forms occurring in stressed syllables and fully continuant variants occurring elsewhere. In nasal syllables, these segments are produced as nasal approximants. The segment transcribed as [r] represents a voiced alveolar flap. Voiceless segments are reported to have voiceless oral allophones in all environments. The velar fricative is in free variation with the glottal [h] (Gregores and Suárez 1967: 81).

The Guaraní vowels are listed in (2) (Rivas 1975: 134). There are three vowel heights and three degrees of tongue advancement. Nasalization is phonemic in vowels in stressed syllables and allophonic in unstressed syllables.

(2) Vowel inventory:

- **Front**: i / i' / ˆ / ˆ'
- **Central**: e / e) / o / o)
- **Back**: a / a)

Rivas notes three exceptions to the open syllable generalization. All these cases involve a coda nasal preceding a voiceless stop. Rivas points out that each of these words are interjections and can thereby be exceptional with regard to canonical structure (1975: 135).

Nasal harmony in Guaraní produces cross-segmental spans of nasalization in words. Bidirectional nasal spreading in words is shown in examples (c) and (d). Below G & S 1967 refer to the original source.

![Nasal harmony in Guaraní](attachment:image.png)

Nasal spreading is also triggered by the nasal closure of a prenasalized stop. In words with prefixes, nasalization in the root spreads to the prefix (see examples above). The situation is somewhat more complicated with suffixes. In general, suffixes can be grouped into two classes, depending on their effect on nasalization. Suffixes in the other class cause cross-segmental nasal spreading in the root. The suffixes in the first class do not cause nasal spreading in the root. Instead, the nasalization spreads to the root in the case of nasalized suffixes. Suffixes in the second class are nasalized in the root if they are nasalized in the suffix. The situation is further complicated by the presence of nasal stops in root syllables, which can cause nasal spreading in the root.

![Nasal spreading in Guaraní](attachment:image.png)
Alternating suffixes are unstressed in all but two cases; fixed oral suffixes are always stressed and fixed nasal suffixes may be stressed or unstressed. Fixed suffixes do not usually affect the oral/nasal status of a root. However, the oral suffix 
(re@) 'past'. The pattern is illustrated below with the fixed oral suffix, (Rivas 1975: 138). The pattern is illustrated below with the fixed oral suffix, (Rivas 1975: 138).

(a) /ir[uò]+re@/fi[r'uòre@] (Rivas 1975)
(b) /mb[eò<da]+re@/fi[me)ò<dare@] (Rivas 1975)

The purpose of this summary of the data is primarily to review the facts in order to avoid any complications in the nasalization patterns used in the study. The complexities of Guaraní nasal harmonization are only on the implications of this ranking for voiceless obstruents and will return to the matter of voiced stops presently.

3 The two alternating stressed affixes are the derivational suffixes: [−/o@/−/o)@] and [−/se@/−/se)@] (Gregores and Suárez 1967: 103). 4 Rivas also identifies a different kind of suffix behavior exhibited by a 'special class' of suffixes (1975: 138). Suffixes belonging to this class contain an oral stressed vowel and begin with either a voiceless stop or a voiced sonorant of the group [v, ƒ, ƒW]. After a nasal root, the suffix-initial consonant is changed to a homorganic voiced prenasalized stop and the suffix vowel remains oral. For some suffixes in this group the change is obligatory and for others it is optional.

Voiceless consonants are transparent to nasal harmony:

\[
P_1: \text{NASOBS} \gg \text{IDENT-}'O[±\text{voice}] \gg \text{IDENT-}'O[+\text{nasal}]
\]

Because the nasal spreading constraint outranks all P2 nasalization constraints, this ranking selects a sympathetic candidate in which nasalization spreads to all segments in a nasal morpheme. The P1 nasalization constraint then rules out any candidates containing nasalized obstruents, and I

\[
\text{DENT-}'O[±\text{voice}] \gg \text{IDENT-}'O[+\text{nasal}]
\]

selects the candidate with nasalization of all voiced segments. This analysis yields an output with surface-oral voiceless stops in oral versus nasal contexts.

Before proceeding to outlining the details of the set-up of the phonetic study, I will briefly review the analytical implications of some of the other aspects of Guaraní nasal harmony. First, it has been observed that morphemes containing a nasalized obstruent are often nasalized in all following vowels. This has led some to propose that nasal harmony first applies to the vowel of the morpheme in question, and then nasalization spreads to adjacent vowels.

On the subject of syllable patterns with voiced stops, Beckman (1998) also develops an insightful analysis, drawing on the aperture-theoretic representations of segments proposed by Steriade (1992). The approach in (6) assumes that the nasalization of voiced stops in oral contexts is aimed in part at verifying the oral output for 'transparent' segments.
Beckman is able to explain the syllable nasalization patterns for voiced stops in Guaraní. For the details of this account, the reader is again referred to Beckman's work.5

The core analysis of nasal spreading to voiced stops in Guaraní will parallel that of the Tucanoan family. In Guaraní, voiced stops undergo nasal spreading when the following vowel is nasal or becomes nasal. The primary analysis is that nasalized voiced obstruent stops are located in the P1 segment along with ones against voiceless obstruent stops. I

\[ \text{IDENT-O}^{+\text{nasal}} \]

O\[±\text{voice}\] is not violated by a nasal realization for voiced stops, so IDENT-O\[+\text{nasal}\] maps voiced stops to fully nasal sonorant stops. Guaraní also resembles the Tucanoan family in having a set of suffixes fixed in their nasality specification. This can be handled by positing a constraint that forces nasal spreading when the target is nasalized.

This concludes the overview of Guaraní nasal harmony and its analytical implications. With the pattern of Guaraní nasalization in mind, I turn in the next section to outlining the set-up of the acoustic study of transparent voiceless stops.

4.2 Set-up

4.2.1 Data and data collection

The goal of the present study is to compare the acoustic properties of intervocalic voiceless stops in oral versus nasal contexts. The data for this study consist of

\begin{itemize}
  \item Nasalized stops in oral contexts.
  \item Nasalized stops in nasal contexts.
\end{itemize}

The language consultant for the study was a Paraguayan male, 32 years of age, who has spoken Guaraní since before the age of 10. The consultant's language proficiency includes both native Guaraní and bilingual proficiency in Spanish. He has spoken Guaraní since before the age of 10. The consultant's proficiency in the language is rated as native by a native Guaraní speaker. The consultant has also been proficient in Spanish since before the age of 10.

The consultant was present during the data collection. He was present for 24 hours, during which time he spoke Guaraní and Spanish. The written word list was carefully prepared in advance of the data collection. Each word was recorded twice, once in oral and once in nasal context. The words were recorded at a rate of 60 words per minute, with pauses between words.

In an acoustic study, fricative nasalization could perhaps be judged by comparing the amplitude of the fricative energy — this might be stronger or focused at different frequencies if there were nasal airflow — however, a more direct technique, such as direct examination of the velum position, would yield more reliable results.

Examples of Guaraní bisyllabic word pairs:

<table>
<thead>
<tr>
<th>Nasal</th>
<th>Oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>CV</td>
</tr>
<tr>
<td>è</td>
<td>è</td>
</tr>
<tr>
<td>ê</td>
<td>ê</td>
</tr>
</tbody>
</table>

(7) Examples of Guaraní bisyllabic word pairs:

<table>
<thead>
<tr>
<th>Nasal</th>
<th>Oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>po)pi'è</td>
<td>djopiè</td>
</tr>
<tr>
<td>ta)ti'è</td>
<td>tatiè</td>
</tr>
<tr>
<td>o)ke)è)</td>
<td>okeè</td>
</tr>
</tbody>
</table>

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reviewed with the consultant in advance of the recording to ensure familiarity with all of the words. With this advance exposure, the written format of the list did not pose a problem, since many of the orthographic conventions of Guaraní follow Spanish ones.

Words were read in an oral word frame: [dəˈɡi] ‘say X again’. In this sentence, the main stress fell on the final vowel of the bisyllabic CVCV word. Nasal harmony did not extend across word boundaries, leaving the medial word unmarked by the frame words. Words were read at a normal speech rate grouped in random batches of 12 different words. Of each batch of 12 items, the first and last items were deleted. A total of six valid repetitions of each word were recorded.

7 I am grateful to John Kingston for permission to use the Phonetic Lab at the University of Massachusetts and for help with setting up the study as well as providing comments on analysis of the data. I would also like to express thanks to Jay Bousfield and John O'Brien for assistance in setting up the equipment. Thanks to John Kingston for assistance in setting up the study as well as providing comments on analysis of the data.

4.2.2 Instrumental analysis

The recordings were digitized using a sampling rate of 20,000 Hz. Durations of various segmental components were measured on a Kay Elemetrics Computerized Speech Lab Model 4300 at the University of California, Santa Cruz, making reference to both waveforms and spectrograms. On each digitized trace, four points were tagged: the occurrence of voicing into the stop, indicated by the end of periodic oscillations after the token vowel in the waveform. The second point (c) marks the release of stop closure. This is signalled by the beginning of periodic oscillations after the release of stop closure. The first point (a) marks the initiation of closure for the medial voiceless stop. This is signalled by the beginning of periodic oscillations after the release of stop closure. The last point (d) marks the onset of voicing in the following vowel, indicated on the waveform by the resumption of periodic oscillations after the voicing burst energy. On the spectrogram this corresponds to the beginning of a voicing burst and/or vertical striations.

The recordings were made with the speaker reading into a microphone in a sound-insulated room in the phonetics laboratory at the University of Massachusetts at Amherst. Words were read in an oral word frame: [dəˈɡi] ‘say X again’. In this sentence, the main stress fell on the final vowel of the bisyllabic CVCV word. Nasal harmony did not extend across word boundaries, leaving the medial word unmarked by the frame words. Words were read at a normal speech rate grouped in random batches of 12 different words. Of each batch of 12 items, the first and last items were deleted. A total of six valid repetitions of each word were recorded.
Because of the root-final stress in the bisyllabic words, the amplitude of the second vowel was much greater than the first, often resulting in a very weak spectrographic image for the first vowel. In addition, the other points were marked before pre-emphasis was performed (pre-emphasis is not performed in the spectrogram in (8)).

From the four marked points on each token, various durations were measured. The following report focuses on five of these durations: (i) Closure Voicing, which measures from initiation of stop consonant to point of closure; (ii) Voiceless Closure Duration, from the point of closure to the release of stop consonant; (iii) VoiceOnset Time, measured from the release of stop consonant; (iv) Voice Duration, measured from initiation of closure to the release of stop consonant; (v) Total Voiceless Period, from the onset of voiceless consonant to the release of stop consonant. Each of these durations was measured for all six tokens of each word.

The results of the study were presented at three levels of detail. First I summarize the general patterns of closure and voicing in both oral and nasal words. Then I discuss different properties of timing in oral versus nasal words and nasal nasal words in more detailed. This section focuses on and interpreted the results. The results are reported on and interpreted in the following section.

The results of the study are presented in three levels of detail. First I summarize the general patterns of closure and voice in oral and nasal words. Then I discuss different properties of timing in oral versus nasal words. Lastly, I propose a threshold effect for /k/, which I suggest achieves a sufficient or maximal voice onset time.

4.3.1 General patterns

I begin by remarking on the general patterning of voiceless stops in both oral and nasal words. A simple explanation and wavetrain for the nasal word [oke] is shown in (9). The stops were accompanied by a minor pause, showing the presence of closure in the noise category, and so the second vowel was much greater than the first. In addition, the other points were marked before pre-emphasis was performed (pre-emphasis is not performed in the spectrogram in (8)).

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This acoustic information confirms the transparency effect that has been reported in the Guaraní grammars. The surface orality of the transparent voiceless stops is consistent with the analysis of transparency as an opacity effect: the output representation posited for these segments is as oral, they are truly oral throughout the full duration of the segment.

Another point on the subject of common acoustic patterns concerns voice timing. In both oral and nasal environments, voicing persists part way into the stop closure. The closure voicing is followed by a period of voicelessness, which begins during the closure and persists for a period after the release. Although this basic model characterizes voiceless stops in both contexts, some of the details of the timing differ by environment.

4.3.2 Effect 1: Ratio of closure duration to voice onset time

One of the major context-induced effects found in this study is that the average ratio of closure duration to voice onset time (CDOT) is greater for oral contexts than in nasal ones. The reason that the CDOT ratio was calculated rather than only evaluating closure and voice onset time separately was to control for any word-to-word or token-to-token variation in speaking rate. The individual contributions of the differences in closure length and voice onset time will be examined presently. The difference in the mean of closure duration over voice onset time are given in (10), taken across all three places of articulation. The average for oral contexts of 7.96 is greater than the nasal average of 5.97, a difference which is statistically significant ($p < 0.0001$).

8 A cursory examination of some audio recordings of Desano (Tucanoan; Colombia) showed the same basic surface transparent character for voiceless stops in nasal morphemes (recordings were made by Jonathan Kaye 1965-1966). I am grateful to Jonathan Kaye for making his recordings of Desano available to me.
Closure duration/Voice onset time (CD/VOT): results across sample

<table>
<thead>
<tr>
<th>CD/VOT</th>
<th>Oral       &gt; Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tokens</td>
<td>108</td>
</tr>
<tr>
<td>Variance</td>
<td>9.990</td>
</tr>
<tr>
<td>Average CD/VOT</td>
<td>7.375</td>
</tr>
<tr>
<td>df</td>
<td>= 1</td>
</tr>
<tr>
<td>p</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

The cause for the difference in the ratio of closure to voice onset time can be traced to both of the logically possible contributors: in nasal contexts voice onset times are longer and closure durations are shorter. The average voice onset times are given in (11): 26.64 msec. in oral words and 32.80 msec. in nasal words (< 0.0001). The greater values in nasal words give a greater denominator in CD/VOT, yielding smaller ratios for nasal environments.

Average closure durations for the intervocalic voiceless stops are shown in (12).

<table>
<thead>
<tr>
<th>Closure dur.</th>
<th>Oral       &gt; Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tokens</td>
<td>108</td>
</tr>
<tr>
<td>Variance</td>
<td>0.38</td>
</tr>
<tr>
<td>Avg. closure dur. (msec.)</td>
<td>165.37</td>
</tr>
<tr>
<td>df</td>
<td>= 1</td>
</tr>
<tr>
<td>p</td>
<td>&lt; 0.005</td>
</tr>
</tbody>
</table>

So far we have considered results across the entire sample of data, but when the tokens are sorted by place of articulation of the medial stops, we find place interacts with the difference in CD/VOT... difference is greatest, with an average value in oral words of 8.880 comparing with an average of 5.859 in nasal words (< 0.0001). The figures for [t] are roughly similar: oral average 8.670 versus nasal average 6.838 (< 0.0001). The velar, [k], is the odd one out, having no significant difference in CD/VOT in oral versus nasal environments.

In computations by place of articulation, data from all seven words pairs for [t] are included, giving a total of 216 tokens (3 x 72). The word pair for [t] excluded in comparisons across all places of articulation is [patiê] chosen at random.
The closure properties of [\text{k}] in nasal contexts is discussed in the next section on closure.

The closure duration by place of articulation. An example of how this is achieved is given in the first table of (13).

<table>
<thead>
<tr>
<th>Place of Articulation</th>
<th>Oral</th>
<th>Nasal</th>
<th>Oral &gt; Nasal</th>
<th>Nasal &gt; Oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>[p]</td>
<td>0</td>
<td>1</td>
<td>&gt;</td>
<td></td>
</tr>
<tr>
<td>[t]</td>
<td>0</td>
<td>1</td>
<td>&gt;</td>
<td></td>
</tr>
<tr>
<td>[k]</td>
<td>0</td>
<td>1</td>
<td></td>
<td>&gt;</td>
</tr>
</tbody>
</table>

For closure stops, the findings of other studies on place of articulation in the literature and in this paper, are similar to those found in oral stops. However, for [\text{k}], the closure duration for [\text{k}] in nasal contexts is significantly greater than that for [\text{k}] in oral contexts.

In addition, the variance of closure duration is greater in nasal than in oral contexts for [\text{k}]. This difference will be discussed in section 4.5.

The voice onset time by place of articulation is shown in (14).

<table>
<thead>
<tr>
<th>Place of Articulation</th>
<th>Oral</th>
<th>Nasal</th>
<th>Oral &gt; Nasal</th>
<th>Nasal &gt; Oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>[p]</td>
<td>0</td>
<td>1</td>
<td>&gt;</td>
<td></td>
</tr>
<tr>
<td>[t]</td>
<td>0</td>
<td>1</td>
<td>&gt;</td>
<td></td>
</tr>
<tr>
<td>[k]</td>
<td>0</td>
<td>1</td>
<td></td>
<td>&gt;</td>
</tr>
</tbody>
</table>

For voice onset time, the differences between oral and nasal contexts are significant for [\text{p}] and [\text{t}]. However, for [\text{k}], the voice onset time is not significantly different in oral and nasal contexts.

In section 4.5, the closure properties of [\text{k}] in nasal contexts are discussed in the next section on closure.
When examined by place of articulation, it emerges that the difference in the closure duration by place of articulation is due to the fact that velar stops have a longer voice onset time and shorter closure.

To summarize, the findings reported so far are that the ratio of closure duration to voice onset time is greater in oral contexts than in nasal ones. A strong contributing factor is longer voice onset times in nasal words (p < 0.0001) and a somewhat weaker factor is shorter closure durations in nasal words (p < 0.005). The velar stop proves to be somewhat exceptional in not having a significantly different CD/VOT average in nasal versus oral words or a significantly different average voice onset time.

The general pattern that has been identified is that in nasal intervocalic environments, voiceless stops have longer voice onset times and shorter closures. It is interesting that there is an inverse relationship in the timing of the two segments: in oral environments, voiceless stops have longer voice onset times and shorter closures.

The general pattern that has been identified is that in oral environments, voiceless stops have longer voice onset times and shorter closures.

### 4.3.3 Effect 2: Ratio of closure duration to closure voicing duration

The second main effect discovered in the production of voiceless stops in oral versus nasal words is the average ratio of closure duration to closure voicing duration.

When examined by place of articulation, it emerges that the difference in the closure duration to closure voicing ratio holds specifically of tokens with [t]. The averages are shown in (17), with an average value for oral words of 7.83 and for nasal words of 6.69. The effect is significant across the sample.

When examined by place of articulation, it emerges that the closure duration to closure voicing ratio holds specifically of tokens with [t]. The averages are shown in (17), with an average value for oral words of 7.83 and for nasal words of 6.69. The effect is significant across the sample.
The difference in closure voicing for /p/ and /k/ is not statistically significant.\[10\]

(17) Closure duration/Closure voicing duration (CD/CV) by place of articulation.

<table>
<thead>
<tr>
<th>Place of Articulation</th>
<th>Oral</th>
<th>Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>/p/</td>
<td>22.98</td>
<td>26.95</td>
</tr>
<tr>
<td>/t/</td>
<td>24.78</td>
<td>34.07</td>
</tr>
<tr>
<td>/k/</td>
<td>22.42</td>
<td>24.54</td>
</tr>
</tbody>
</table>

Although closure durations were found to be shorter in nasal words for /p/ and /k/, no significant difference in closure voicing was found in nasal versus oral contexts, which accords with their lack of difference in CD/CV.

(18) Greater closure voicing for /t/ in nasal contexts.

<table>
<thead>
<tr>
<th>Place of Articulation</th>
<th>Oral</th>
<th>Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>/p/</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>/t/</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>/k/</td>
<td>0.09</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Although greater closure voicing was found to be shorter in nasal words for /p/ and /k/, no significant difference in closure voicing was found in nasal versus oral contexts, which accords with their lack of difference in CD/CV.
4.3.4 A fixed property: Total period of voicelessness

The last finding I will report on concerns a fixed property of voiceless stops in oral and nasal contexts. Across the sample of data, it was found that the total period of voicelessness is not different in oral versus nasal words. The values are given in (20) falling around 165 msec. ($p = 0.14$).

Interestingly, when we compare the averages for total period of voicelessness by place of articulation, [k] is once again singled out in contrast to [p] and [t]. This is shown in (21). [p] and [t] are not different, while [k] is significant in both oral and nasal words. The total period of voicelessness for [k] exceeds that of the anterior stops in oral or nasal environments.

To review, we have seen that the total period of voicelessness is not different in oral versus nasal words, but when we look at place of articulation, a significant difference is found in oral versus nasal words. The total period of voicelessness for [k] is significantly longer than for [p] and [t] in both oral and nasal words. This is reminiscent of the threshold effect in the voice onset time which was hypothesized to restrict the production of voiceless stops in nasal contexts. Further, the total period of voicelessness for [k] exceeds that of the anterior stops in oral or nasal environments.

### Discussion

I now will put the various findings together to construct an integrated picture of what timing changes take place in voiceless stops. For the anterior stops [p, t], the VOT is about 20 msec. in oral tokens, and for [k], the voiceless closure shorter in nasal contexts for all places of articulation. In oral words, the voice offset time in real versus nasal contexts is 140 msec. longer in nasal contexts. The voiceless closure duration for nasal words is 138.88 msec. longer than for oral words. This is shown in (22). The voiceless closure duration for nasal words is 138.88 msec. longer than for oral words. This is shown in (22).
The average VOT is considerably longer, at about 40 msec. In nasal tokens, these averages change so that voiceless closure decreases and VOT increases, except in the case of [k]. For [p] and [t], the voiceless closure increases, while the VOT decreases. This results in a nearly parallel shift in the voiceless period, with shorter closure and longer VOT. The above situation describes what has been observed for the anterior stops ([p] and [t]). [k] behaves somewhat differently, and the schematic representations corresponding to this segment are shown in (24). The voiceless closure decreases, while the VOT increases, and the shifts in the voiceless period are depicted in (25). The schematic representation of shift of voiceless period is given in (25).

<table>
<thead>
<tr>
<th></th>
<th>VOT</th>
<th>Voiceless Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In nasal words, voiceless closure increases, while VOT decreases. This results in a nearly parallel shift in the voiceless period, with shorter closure and longer VOT. The schematic representation of shift of voiceless period is given in (25).

---

**Legend:**
- [p, t, k]₀ = [p, t, k] (respectively) in oral context
- [p, t, k]₁ = [p, t, k] (respectively) in nasal context

---

**Schematic representation of voiceless closure:**

<table>
<thead>
<tr>
<th>V</th>
<th>C</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>ë</td>
<td>ë</td>
<td>ë</td>
</tr>
</tbody>
</table>

---

**Schematic representation of voiceless period:**

<table>
<thead>
<tr>
<th>Voiceless Period</th>
<th>VOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longer closure</td>
<td></td>
</tr>
<tr>
<td>Shorter closure</td>
<td></td>
</tr>
</tbody>
</table>

---

**Legend:**
- [p, t, k]₀ = [p, t, k] (respectively) in oral context
- [p, t, k]₁ = [p, t, k] (respectively) in nasal context
The voiceless period will not shift to the right, because it has reached the limit of its extension into the following vowel. As a result, the voiceless period (a) between oral vowels is greater than the voiceless period (b) between nasal vowels.

![Schematic representation of threshold effect for /k/](image)

**Oral:**

<table>
<thead>
<tr>
<th>V</th>
<th>C</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ÙÙÙÙÙÙÙÙÙÙÙÙÙÙÙ</td>
<td></td>
</tr>
<tr>
<td>______________________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) voiceless period</td>
<td>shorter closure</td>
<td></td>
</tr>
<tr>
<td>threshold-induced voicing</td>
<td>çççç</td>
<td>êêêê</td>
</tr>
</tbody>
</table>

**Nasal:**

<table>
<thead>
<tr>
<th>V</th>
<th>C</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ÙÙÙÙÙÙÙÙÙÙÙÙÙÙÙ</td>
<td></td>
</tr>
<tr>
<td>___________________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) voiceless period &lt; (a)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It was noted earlier that the threshold effect in the velar voice onset time could be one of sufficient length. From this perspective, the duration of post-release voicelessness would be sufficient to signal the voiceless quality of the stop, even under conditions of a shorter closure duration between nasal vowels. However, since the voice release does not occur before the threshold is crossed, the voice release could be delayed by the threshold effect. In this case, the duration of voice release could be a consequence of perceptual factors. If the threshold effect is produced late in the velar post-release voicelessness, it could also be a consequence of a general tendency to equalize the length of syllables (as noted by, for example, Ladefoged 1993; Laver 1994).

This account explains differences in timing as a result of a shift of voicelessness to the right in order to maintain a fixed voiceless period, and the exceptionality of velar stops is interpreted as the consequence of an interaction between voicing and the expiration of the voiceless period.
various models of phonetic implementation have been proposed which map from an abstract phonological representation to a more concrete articulatory representation. This includes a range of theories connecting abstract features with specific articulations or gestures, and I will briefly consider the Guaraní results in relation to some of these models.

Some analysts have argued that the phonetic correlates of features are coordinated with other articulations in systematic ways. For example, Kingston's (1990) 'binding principle' posits a... transparency extending Huffman's proposal in which the closure of the stop is nasal and only the release is oral.

13 In regard to voice timing, recall from (14) that the variances for VOT in nasal tokens were found to be at least twice that in oral tokens at all places of articulation. If... articulation from the onset of closure which takes place from the delay in glottal opening (occurring in [t]). This explanation posits a connection in the timing of the glottal articulation to both the onset and release of closure. In... the shift of the glottal articulation to persist longer into the vowel may also unbind the glottal and oral articulations.

An important property of the phonetic implementation of [-voice] found in this study is that the duration of voicelessness remains fixed and shifts into the following vowel when the voiceless segment... the tier representing oral constriction readily reflects this kind of shift in the overlap from one segment to the next.

The need for some flexibility in phonetic implementation is also recognized by Kingston and Diehl (1994). In their work on the realization of the feature [voice], they... may reflect the listener-oriented needs. This shift still obeys the constraint of producing voicelessness at the point of release.

14 In the case of [k], the voice onset time is conjectured to have reached a threshold. This threshold is listener-oriented if the... voiceless quality of the [k] seems to be readily perceptible. If the threshold is instead understood as maximal, with... period across oral and nasal tokens suggests that there is actually a controlled shift in glottal timing taking place.
voice onset as a consequence of aerodynamic factors, this would be a speaker-oriented effect. In either case, the fixed onset of voicing in the vowel following \( [k] \) is moderated by minimization of various and sometimes conflicting realizational requirements. Hence these are two apparently one kind of pattern seen in these exceptional tokens. Here these are two apparent types of \( [k] \) which shows the VCV portion of \( [ha] \) and \( [ta] \).

4.5 Two-burst events

In this last section, I outline a somewhat different pattern observed in the release of a small set of voiceless stops in nasal contexts. In these cases, the voiceless stops appear to have two rather than one events associated with the burst. Some samples.

The spectrogram in (25), which shows the VCV portion of \( [ha] \) and \( [ta] \), below.

The spectrogram in (25) and (26) below.

In this last section, I outline a somewhat different pattern observed in the release of a small set of voiceless stops in nasal contexts. In the case of \( [\hat{p}t] \) in (25) and (26) below,.

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In both of the two-burst patterns, the second of the burst events displayed the characteristics of the usual release of the stop with the first burst apparently resulting from a brief breach in the oral cavity. These observations provide information about the position of the oral stop, which may be extrapolated from nasal tokens. It is conceivable that some aspects of the velar closure and opening may contribute to the differences in nasal words. Furthermore, the nasal tokens may reveal some aspects of the nasal consonants.

An intriguing feature of the two-burst phenomena is their apparent correlation to nasal tokens. It is possible that some aspects of the velar closure and opening may contribute to the differences in nasal words. An instrumental study of such phenomena could provide information about the position of the oral stop, which may be extrapolated from nasal tokens. It is conceivable that some aspects of the velar closure and opening may contribute to the differences in nasal words (see (15)).
4.6 Appendix: Word pairs

1. rupaè / nupaè 'bed' (1st poss.)
2. djopiè / popi'è 'to itch, sting' / 'to peel, strip'
3. kepeè / mbope)è 'asleep' / 'he/she broke'
4. pepeè / djepe)è 'to flutter, flap wings' (lit.) / 'to break'
5. djapiè / djapi'è 'to throw, shoot at' / 'to cut hair'
6. hapˆè / Sapi'è 'to catch fire' / 'defective, amputated, cut off'

1. kutuè / pˆtu)è 'to stick (with), prick, strike' / 'dark'
2. itaè / ˆta)è 'stone, rock' / 'to swim'
3. mbotˆè / mboti'è 'to close, shut' / 'to cause shame'
4. potaè / teta)è 'to want, desire' / 'nation, country'
5. tatiè / tati'è 'daughter-in-law' / 'horn'
6. patiè / kati'è 'name of a fish' / 'stinking'

7. tataè / hata)è 'fire' / 'hard'

1. Sukaè / tuka)è 'to show' / 'toucan'
2. poköè / moko)è 'to touch' / 'to swallow'
3. okeè / oke)è 'to sleep' / 'door'
4. hekoè / hoke)è 'custom, behavior' (3 poss.) / 'door' (3 poss.)
5. djokaè / moka)è 'to break' / 'to wipe up, wash'
6. kakaè / haka)è 'to defecate' / 'branch'
Chapter 5
OTHER PROPOSALS

In this chapter I consider other proposals for the analysis of segmental transparency. The first of the alternative analyses is one calling on the gapped configuration. I argue that this alternative is weaker than the sympathy-based analysis proposed in the preceding chapters, because the sympathy-based approach obviates the need for transparency-specific gapped representations and brings segmental transparency into the larger realm of derivational opacity, a widespread phonological phenomenon with independent need for explanation. In addition, a gapping account offers no explanation for the asymmetry in blocking versus transparent outcomes for segments. In contrast, with the evaluation metric for opacity effects in grammar (discussed in 3.6), the sympathy-based account correctly predicts that blocking will be a less ‘marked’ outcome than segmental transparency for segments that are (gradiently) incompatible with nasalization. The second alternative I consider is the important representationally-driven account of nasal harmony proposed by Piggott (1992), where two different types of nasal harmony are posited. I argue that the fundamental advantage of the analysis of segmental transparency as an opacity effect proposed in the previous chapter is that it obtains a unified typology calling on only one basic type of nasal harmony. In addition, the unified analysis eliminates the need for any ad hoc representational assumptions. Finally, obviation of the gapped representation in the sympathy-based account offers an argument against further alternatives producing effects similar to gapping, such as violable feature expression or embedding of feature domains, which require parochial constraints to obtain segmental transparency.

5.1 A gapping alternative

I begin by considering an alternative calling on a violable NOGAP constraint, as in (1). This constraint prohibits linkage of a feature specification across an intervening segment. Because it is posited as violable in the alternative, which I will call the ‘gapping approach’, feature linkage may skip segments when compelled by a higher-ranked constraint.

(1) NOGAP
    * $\alpha \beta \gamma$
\[\text{where } \alpha, \beta, \text{ and } \gamma \text{ are any segment}\]

In nasal spreading contexts, NOGAP conflicts with the nasalized segment constraints. If NOGAP is dominated by a nasalized segment constraint, two outcomes are possible, either skipping of the segment for which nasalization is banned or blocking by this segment. The blocking outcome comes about if NOGAP dominates SPREAD[+nasal], as shown in (2) with a hypothetical form. Constraints against nasalized obstruents are collapsed here, as are constraints against nasalized sonorants. The bracketing in candidate (c) indicates that the [+nasal] linkage gaps across the [t]. Candidate (d) shows gapping across [t] and [l]. Here candidate (a), which respects both *NASOBS and NOGAP, wins over its competitors in (b-d), which fare better on spreading.

(2) Blocking: NOGAP >> SPREAD[+nasal]

<table>
<thead>
<tr>
<th>Candidate</th>
<th>*NASOBS</th>
<th>NOGAP</th>
<th>SPREAD[+nasal]</th>
<th>*NASSON</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ātala</td>
<td></td>
<td>****</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. ātālā</td>
<td>*!</td>
<td>****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. ā[t]ālā</td>
<td>*!</td>
<td>*</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>d. ā[t]ā[1]ā</td>
<td>*!</td>
<td>**</td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

The tableau in (3) shows the skipping outcome. Here the reverse ranking of NOGAP and SPREAD[+nasal] holds. Once again, *NASOBS is respected in the winning candidate. Since SPREAD now dominates NOGAP, the winner, in (c), is the one which spreads [+nasal] to all of the segments except the obstruent. Note that candidate (c) incurs only one spreading violation. This is because in this form there is a single [+nasal] feature specification linked to all of the segments except [t], which is skipped. The candidate with blocking in (a) loses on SPREAD. We may observe that candidate (d), with skipping of both [t] and [l], loses by virtue of an extra spreading violation. In the optimal output, any segments whose nasalization constraints are dominated by SPREAD[+nasal] will undergo nasal spreading.
The constraints and ranking shown in (3) illustrate the alternative gapping approach to segmental transparency. Like the analysis proposed in chapter 3, segmental transparency is driven by the constraint hierarchy of segmental features. However, the function of this constraint is specific to segmental transparency; it does no other work in the theory. In this respect, the gapping approach fails to explain why segment 'skipping' itself. In the optimal output, it need not call on the gapped configuration, it fares better on theoretical economy.

A second drawback of the gapping approach concerns explanation of the cross-linguistic asymmetry in blocking versus transparent segments. The tableaux in (4) show that the tableau in (5), which stipulates that NOGAP must always dominate *NASLIQUID (and by implication all lower-ranked nasalization constraints), NOGAP could only dominate other constraints. This would require the fixed ranking in (5), which was found in the cross-linguistic survey of nasal harmony.

The problem with this account of the limited set of segments is that it does not offer any explanation for this limitation. The restriction of transparency to obstruents is a product of the nasalization constraints. The nasalization constraints are in the mechanism which obtains segment 'skipping' itself. In the gapping approach, this is achieved with a violable NOGAP constraint. However, the function of this constraint is specific to segmental transparency; it does no other work in the theory. In this respect, the gapping approach fails to explain why segment 'skipping' itself. In the optimal output, it need not call on the gapped configuration, it fares better on theoretical economy.
5.2 The variable dependency hypothesis

In his important cross-linguistic study of nasal harmony, Piggott (1992) makes an interesting proposal: there is not one but two types of nasal harmony in the languages of the world. The two types of nasal harmony patterns he posits have the following different properties. In the blocking pattern (Piggott's 'Type A') segments are divided exhaustively into sets of targets or blockers; there are no transparent segments. The blocking segments are a subset of obstruents, with hierarchical variation in the set of targets according to the implicational hierarchy outlined in chapter 2.

On the other hand, in the transparency pattern (Piggott's 'Type B'), all segments are divided into sets of targets or transparent segments — no segments block spreading. Transparent segments are obstruents and the remaining segments are targets; voiced stops may belong to the latter set.

Piggott's proposal that there are two different kinds of nasal harmony is driven by his theoretical grounding. Piggott assumes a representationally-driven, feature-geometric approach, and he adopts a specific approach to the study of transparency in nasal harmony. (6) shows this for Piggott's analysis of Southern Barasano (Tucanoan; Colombia). ('R' represents a root node.)

Piggott (1992) obtains the effect of hierarchical variation in the set of targets from the 'Contrastive Nasality Principle' that he proposes. See Walker (1995) for empirical and theoretical arguments preferring a nasalized segment constraint hierarchy over the Contrastive Nasality approach.

In the majority of languages with the transparency kind of nasal harmony, voiced stops undergo nasal harmony. Since [nasal] can occur only in the representation of sonorants in these languages, Piggott claims that nasal harmony represents a series of sonorant stops in the inventory.

In the case of the blocking type of nasal harmony, rather than having

with context-dependent nasalization

the voiced stops are represented as sets of sonorant stops in the inventory and the posits the voiced stops represent a series of sonorant stops in the inventory. The sonorant between these is not phonetically continuant, and the voiced stops that are phonologically nasalized in a given language are only those that occur in the representation of sonorants. These stops include the representation of nasal harmony.

In the majority of languages with the transparency kind of nasal harmony, voiced stops

Transparency in Spontaneous Voicing (SVC; Colombia). (R: represents a root node.)

In the case of the blocking type of nasal harmony, rather than having

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In the majority of languages with the transparency kind of nasal harmony, voiced stops

Transparency in Spontaneous Voicing (SVC; Colombia). (R: represents a root node.)

In the case of the blocking type of nasal harmony, rather than having

with context-dependent nasalization

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Variability in the set of blockers is analyzed as variability in the set of segments which are specified underlyingly for the Soft Palate node (governed by Piggott’s Contrastive Nasality Principle). This set will be a subset of the consonants which includes the obstruent stops.

A driving force behind Piggott’s analysis is the assumption that transparency occurs when a segment is skipped. With this assumption, Piggott argues that the transparency systems cannot be unified (1996, p.159) for the spreading of the Soft Palate node, and they would then be expected to undergo harmony rather than be skipped.

Piggott thus posits two types of nasal harmony which differ in the node that spreads and in the dependency of [nasal]. Given the theoretical grounding in the assumptions of the (analogue) segmental nature of the Soft Palate node, these dependency relations within the inventory system are two supports for the former hypothesis, which Piggott claims will be successful in obtaining the needed transparency. However, the problem is that a parametric specification of nasal harmony which nasalizes all segments except voiceless stops is also apparent here: this was discussed in (9).

The problem that Piggott presents for the parametric dependency account is that the transparency of obstruent or stops of any tense of the stop harmony of the language in a very particular way. It predicts that blocking harmony will occur only in languages where there is a contrastive distribution of voiced and nasal stops. However, this is not the case, as nasalization of voiced stops is predictable from context. Therefore, the assumption that nasalization will occur only in languages where there is a contrastive distribution of voiced and nasal stops is contradicted by the observation that nasalization of voiced stops is predictable from context and nasal consonants the realization of voiced stops as nasalized stops is a feature of the language of Epena Pedee. This is a language where there is a contrastive distribution of voiced and nasal stops, and nasalization of voiced stops is predicted to occur only in languages where there is a contrastive distribution of voiced and nasal stops, which is the case for Epena Pedee.

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spreading will target only sonorant segments (via the SV node). Epena Pedee falsifies this claim. In addition, the blocking behavior of voiced stops in cross-morpheme spreading in Tuyuca (discussed in 3.3.4) indicates that voicing is not a sufficient condition for nasalization. The lack of a contrastive nasal series of consonants presents no problem.

Independent of the particulars of assumptions about inventories, the variable dependency analysis is faced with two more general kinds of drawbacks. The first point concerns the ad hoc nature of the assumptions about inventories. These constraints do not apply to the binary representation of nasal spreading, as shown in the table below.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Target</th>
<th>Transparent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Voicing</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

We have seen that all segments have the potential to block nasal spreading. Further, all segments except obstruents have the potential to undergo nasal harmony (pattern as targets), and only obstruents ever act transparent. This complementarity is a flag that target and transparent segments are different realizations for one kind of segmental patterning, namely undergoers of nasal harmony.

5.3 Other approaches to segmental transparency

Some recent approaches to segmental transparency in an optimality-theoretic framework move away from claims about the optimality of certain features. These constraints do not apply to the binary representation of nasal spreading, as shown in the table below.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Target</th>
<th>Transparent</th>
</tr>
</thead>
<tbody>
<tr>
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<td>No</td>
</tr>
<tr>
<td>Voicing</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The structure in (10) will incur one violation with respect to *EMBED[-nasal] for the occurrence of [-nasal] [-t] within the [+nasal] span of segments from [w) to [i']. The violation of *EMBED can be compelled by a segmental markedness constraint, such as *NASOBSSTOP. A related line is taken by Cole and Kisseberth (1994, 1995) with their constraint, EXPRESSION, which requires that a phonetic feature [F] must be expressed on every element in an F-domain. This take on segmental transparency posits the domain of [+nasal] as spanning the entire word in [+Nw)a)ti', with EXPRESSION violated by [t], again driven by the markedness of nasalizing this segment.

Like the NOGAP approach considered earlier, these accounts have in common with the sympathy-based analysis I have proposed the idea that segmental transparency is driven by markedness constraints; however, these accounts differ from the sympathy-based approach in that they call on constraints other than those posited in the OCP. The constraint *EMBED (or perhaps EXPRESSION) in this approach is a feature-based constraint that excludes the occurrence of a root node parsed into a feature domain embedded within another of an opposing specification; for example, *EMBED[-nasal] bans the occurrence of [+nasal] within a span of [-nasal] segments. This is illustrated by the representation in (10).

(10) An embedded feature domain structure:

[+Nw)a)ti'

The structure in (10) will incur one violation with respect to *EMBED[-nasal] for the occurrence of [-nasal] [-t] within the [+nasal] span of segments from [w) to [i'].

The principle of markedness posited for nasal spreading in (10) provides evidence that nasal spreading can be a surface-transparent outcome. The constraint *EMBED[+nasal] is a feature-based constraint that excludes the occurrence of [+nasal] within a span of [-nasal] segments. This is illustrated by the representation in (10).
capture a broader range of phonological phenomena, for example, if the notions underlying embedding or feature expression could be elaborated to extend to other kinds of derivational opacity, then this would be an interesting alternative to pursue, and one generally in harmony with the analysis proposed here.

In his recent analysis of vowel harmony, Pulleyblank (1996) also argues against using an ad hoc representational configuration, such as gapping, to obtain segmental transparency. The representations he favors are of the form shown in (11). In pulleyblank's approach, the vowel features should be interpreted with respect to spreading, rather than with respect to alignment. The representation shown in (11) is an example of a constraint-based approach to vowel harmony, where the feature [+nasal] is assigned to the vowel and the consonant in the local domain. Pulleyblank also proposes that violations of the constraint driving spreading in a transparent segment can be avoided, and this is achieved by the constraint in (12).

To realize this kind of outcome, Pulleyblank does not analyze segmental transparency as a kind of derivational opacity, rather he proposes to interpret violations of the constraint driving spreading in a transparent segment as a kind of blocking, where the spreading feature is assigned to a transparent segment, and the spreading feature is not assigned to a blocking segment. The constraint in (12) is an example of a constraint-based approach to vowel harmony, where the feature [+nasal] is assigned to the vowel and the consonant in the local domain. Pulleyblank also proposes that violations of the constraint driving spreading in a transparent segment can be avoided, and this is achieved by the constraint in (12).
Chapter 6
OTHER PHENOMENA:
REDUPLICATION AND COOCCURRENCE RESTRICTIONS

In this chapter I examine two cases of nasal agreement which may at first be mistaken for nasal spreading but I argue have properties identifying them as other kinds of phonological phenomena. The first is a case of nasal agreement in Mbe affixation (Bambgbose 1971), which I show to be an example of reduplication. Evidence for this conclusion is compiled both cross-linguistically and on the basis of a detailed analysis of various morpho-phonological phenomena in the language. The second is a condition of long-distance nasal agreement holding within and across morphemes in certain Bantu languages (Ao 1991; Odden 1994; Hyman 1995; Piggott 1996). I claim that this should be classified as an example of a cooccurrence restriction, paralleling a set of other languages in which cooccurrence restrictions over segments having similar but different properties are resolved by substitution of an identical feature rather than dissimilation. The direction for the cooccurrence analysis is sketched and the details are left for further research.

6.1 Reduplication in Mbe

In this case study of Mbe nasal agreement, I argue that what has been (atheoretically) termed ‘nasal harmony’ in Mbe (Bambgbose 1971) is in fact a case of reduplication in which material is copied as a nasal coda to a prefix with place features linked to the following onset; if place linking fails, no copy occurs. I demonstrate that this account is motivated on the basis of various other phenomena in Mbe, and it has implications illuminating the theory of reduplication. First, the place-linked nasal status of the copied segment is independently-motivated by conditions on Mbe syllable structure. Second, the size restriction on the reduplicant can be simply obtained through an atempatic alignment constraint, AllSyllableLeft, utilized in a ranking producing The Emergence of the Unmarked (acronymically TETU; McCarthy and Prince 1994b; size-restrictor ranking after Spaelti 1997 with foundation in proposals of McCarthy and Prince 1994a; Prince 1996, 1997). This atempatic account of size-restriction does work elsewhere in the language in limiting the size of other prefixation, both reduplicative and non-reduplicative. Further, I show that alternative atempatic approaches to size restriction are both insufficient and not required. TETU rankings as an analytical mechanism are pervasive in the account, playing a role not just in the analysis of size restriction but also in the analysis of reduplication in a second clearly reduplicative prefix.

Another issue that is addressed is the possibility of prespecification in reduplicative affixes. Analyzing prefixes exhibiting nasal agreement in Mbe as reduplicative would seem to require admitting prespecified segments in reduplication; however, evidence from Mbe morphology is adduced to show that what appears to be prespecified material in fact belongs to a separate prefix. The analysis thus supports the claim that fixed segmentism in reduplication is not prespecified but is either phonologically-determined (i.e. default, derived through TETU rankings) or morphologically-determined (what McCarthy and Prince term ‘melodic overwriting’)

The organization of this section is as follows. First, in section 6.1.1 I present the nasal agreement data in diminutive prefixation and present arguments that it is not nasal spreading and should instead be regarded as reduplication. The next section gives evidence supporting this claim, showing that syllable-size imperative reduplication exhibits a similar nasal agreement effect. An analysis of imperative reduplication is developed, and then in section 6.1.3, this analysis is extended to diminutive prefixation. Evidence is given to show that prefixation in diminutive nominalis is complex, consisting of a purely reduplicative affix and a separate non-reduplicative segmental affix; an alternative single reduplicative affix with prespecified material is insufficient. It is argued that what distinguishes the syllable-size reduplication in the imperative and coda/null size reduplication in the diminutive is simply the ranking of morpheme realization constraints. In 6.1.4, the analysis of diminutives is extended to nasal agreement in the formation of inhoative verbs. Section 6.1.5 gives data from Zoque which shows that a morpheme realization constraint is violated under similar phonological conditions in another language. 6.1.6 examines the role of the atempatic size-restrictor constraint in other affixation in Mbe, and 6.1.7 presents arguments that atempatic alternatives are inadequate. Finally, section 6.1.8 addresses the general question of prespecification in reduplication and develops a proposal to eliminate prespecification effects. 6.1.9 forms an appendix, presenting a constraint hierarchy which derives the coda condition in Mbe.

1 Building on McCarthy and Prince (1986), Alderete et al. (1996) suggest that melodic overwriting can occur when RED competes with another morpheme for the same space. Spaelti’s (1997) ‘syllable recycling’ builds on a somewhat similar idea, while seeking to explain what enforces the anchoring violation in the output shape of RED.
6.1.1 Nasal agreement in diminutive nouns

Mbe is a Benue-Congo language spoken in the Ogoja Province of Eastern Nigeria. Mbe exhibits a remarkable nasal agreement in the formation of diminutive nouns. 

I begin by examining nasal agreement in the formation of diminutive nouns and return later to nasal agreement in the formation of two verbal tense/aspects.

In Mbe, singular diminutive nominals are usually formed with a prefix of the form [kÉ-] (see second column in (1)). Vowel harmony produces a [ka-] variant before syllables containing [a]. In their non-diminutive form, nouns occur not as a bare root but with a prefix marking number category (singular or plural; see first column in (1)). Mbe is a 'class' language with seven noun classes (1-7). Nouns may also take place in diminutive formation. The diminutive tonal patterns are complex and will not be analyzed here.

![Table](image)

### Table

<table>
<thead>
<tr>
<th>Singular noun</th>
<th>Diminutive singular</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. bu$-tÉSiê</td>
<td>kE&amp;-tÉSiÊ</td>
</tr>
<tr>
<td>b. le$-bE@l</td>
<td>kE&amp;-bE^l</td>
</tr>
<tr>
<td>c. bE$-liêe</td>
<td>kE&amp;-liÊe</td>
</tr>
<tr>
<td>d. e$-fu@fu@</td>
<td>kE$-fu@fu@</td>
</tr>
<tr>
<td>e. e$-kiôkE$l</td>
<td>kE$-kiôkE$l</td>
</tr>
<tr>
<td>f. le$-ba$ro$</td>
<td>ka$-ba$ro$</td>
</tr>
<tr>
<td>g. e$-ba$m</td>
<td>ka$m-ba$m</td>
</tr>
<tr>
<td>h. bu$-mu$</td>
<td>kE$m-mu$</td>
</tr>
<tr>
<td>i. ka$M-fa$N</td>
<td>kE$m-fa$N</td>
</tr>
<tr>
<td>j. bu$-tE$m</td>
<td>kE&amp;n-tE@m</td>
</tr>
<tr>
<td>k. e$-re@n</td>
<td>kE&amp;n-re@n</td>
</tr>
<tr>
<td>l. le$-lE@m</td>
<td>kE&amp;n-lE^m</td>
</tr>
<tr>
<td>m. kE$-ne@n</td>
<td>kE&amp;n-ne^n</td>
</tr>
<tr>
<td>n. le@-Siêaniê</td>
<td>ka@n-Siêaniê</td>
</tr>
<tr>
<td>o. kE&amp;-¯iêen</td>
<td>kE&amp;-¯iêen</td>
</tr>
<tr>
<td>p. o@-ku$çm</td>
<td>kE@n-ku$çm</td>
</tr>
<tr>
<td>q. e@-gÉbe@no@</td>
<td>kE@n-gÉbe@no@</td>
</tr>
</tbody>
</table>

The above data show the formation of the diminutive when the noun stem contains no nasal segmental material. If the noun contains a nasal, the diminutive is formed as above but closed with a nasal stop which is homorganic with the following onset:

![Table](image)

### Table

<table>
<thead>
<tr>
<th>Singular noun</th>
<th>Diminutive singular</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. e$-ba$m</td>
<td>ka$m-ba$m</td>
</tr>
<tr>
<td>b. bu$-mu$</td>
<td>kE$m-mu$</td>
</tr>
<tr>
<td>c. —</td>
<td>ka$M-fa$N</td>
</tr>
<tr>
<td>d. bu$-tE$m</td>
<td>kE&amp;n-tE@m</td>
</tr>
<tr>
<td>e. e$-re@n</td>
<td>kE&amp;n-re@n</td>
</tr>
<tr>
<td>f. le$-lE@m</td>
<td>kE&amp;n-lE^m</td>
</tr>
<tr>
<td>g. kE$-ne@n</td>
<td>kE&amp;n-ne^n</td>
</tr>
<tr>
<td>h. le@-Siêaniê</td>
<td>ka@n-Siêaniê</td>
</tr>
<tr>
<td>i. kE&amp;-¯iêen</td>
<td>kE&amp;-¯iêen</td>
</tr>
<tr>
<td>j. o@-ku$çm</td>
<td>kE@n-ku$çm</td>
</tr>
<tr>
<td>k. e@-gÉbe@no@</td>
<td>kE@n-gÉbe@no@</td>
</tr>
</tbody>
</table>

It is reasonable to question what kind of phonological mechanism produces this complex and will not be analyzed here.

The diminutive noun phrase in diminutive formation. The diminutive noun phrase also takes place in diminutive formation. The diminutive noun phrase is formed by doubling the noun or noun phrase (1) followed by noun phrase (2) (2) (2). Combinations of the two elements in (1) and (2) are common in Mbe. Combinations of (1) and (2) are also common in Mbe. In (1), the second element of (2) is doubled in (2). Finally, the second element of (2) is doubled in (2). It is clear that Mbe exhibits a unique pattern of nasal agreement in the formation of diminutive nouns. Mbe is a Benue-Congo language spoken in the Ogoja Province of Eastern Nigeria. Mbe is a Benue-Congo language spoken in the Ogoja Province of Eastern Nigeria.
harmony summarized in chapter 2, spreading of [+nasal] between segments at an
unlimited distance is unattested.

Given these arguments we are left with the possibility that Mbe nasal agreement
is produced by reduplication. But this does not look like a typical case of reduplication.
Reduplicative affixation ... as a coda or fails to be copied at all. There also is a fixed
segmental component to the formation of diminutives ([kE]), which may seem
to suggest that the prefixation is not reduplicative; indeed the fixed segmentism has
led a previous analyst to reject the possibility of a reduplication account (Bamgbose 1971:102).

6 On the other hand, the nasal agreement has properties consistent with it being
reduplication. The limitation of nasal agreement to the formation of specific morphemes
is expected if this is a reduplicative form of [CV-CVN(V)] followed
by CV + n-CVN(V).

Based on the arguments against spreading and the properties consistent with
segment copying, I come to the interim conclusion that the nasal agreement is an
instance of reduplication, not nasal feature spreading.

In the remainder of this section I will show that analyzing nasal agreement in Mbe as
nasal copy is both plausible and motivated, and it has important implications for the
theory of reduplication.

6.1.2 Nasal copy in imperative verbs

Independent evidence for the nasal agreement phenomenon as a case of nasal copy comes
from a pattern of reduplication that involves copying material in the verb stem from left to right. The
prefix vowel is an identical copy for a high stem vowel and ´ for any non-high stem vowel.7 Only the first vowel of a

diphthong (high vowel followed by low) is copied. Tonal changes take place in the reduplicative form.

<table>
<thead>
<tr>
<th>Class 2, Imperative non-continuous singular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple verb form</td>
</tr>
<tr>
<td>Reduplicative verb form</td>
</tr>
<tr>
<td>Gloss</td>
</tr>
<tr>
<td>a. ru^ ru^</td>
</tr>
<tr>
<td>'pull'</td>
</tr>
<tr>
<td>b. tÉSiÊ tÉSiÊ</td>
</tr>
<tr>
<td>'help put on head'</td>
</tr>
<tr>
<td>c. ge^ g´^</td>
</tr>
<tr>
<td>'belch'</td>
</tr>
<tr>
<td>d. lç^ l´^</td>
</tr>
<tr>
<td>'burn'</td>
</tr>
<tr>
<td>e. kÉpa^ kÉp´^</td>
</tr>
<tr>
<td>'hang'</td>
</tr>
<tr>
<td>f. fu^el fu^</td>
</tr>
<tr>
<td>'blow'</td>
</tr>
<tr>
<td>g. tÉSu^e tÉSu^e</td>
</tr>
<tr>
<td>'bore (hole)'</td>
</tr>
<tr>
<td>h. SiÊe SiÊ</td>
</tr>
<tr>
<td>'sell'</td>
</tr>
<tr>
<td>i. ju@bo^ ju^</td>
</tr>
<tr>
<td>'go out'</td>
</tr>
<tr>
<td>j. gÉba@riÊ gÉb´^</td>
</tr>
<tr>
<td>'embrace'</td>
</tr>
<tr>
<td>k. bç@ro^ b´^</td>
</tr>
<tr>
<td>'help'</td>
</tr>
<tr>
<td>l. ta@ro^ t´^</td>
</tr>
<tr>
<td>'throw'</td>
</tr>
<tr>
<td>m. so@ro^ s´^</td>
</tr>
<tr>
<td>'descend'</td>
</tr>
<tr>
<td>n. ku@Elo^ ku^</td>
</tr>
<tr>
<td>'nibble at'</td>
</tr>
<tr>
<td>o. pu@abriÊ pu^</td>
</tr>
<tr>
<td>'stray'</td>
</tr>
<tr>
<td>p. SiêariÊ SiÊ</td>
</tr>
<tr>
<td>'scatter'</td>
</tr>
</tbody>
</table>

The data in (4) show that if the verb contains a nasal, the reduplicative prefix is
closed as shown in (4) below with a nasal stop homorganic to the following onset.

<table>
<thead>
<tr>
<th>Class 2, Imperative non-continuous singular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple verb form</td>
</tr>
<tr>
<td>Reduplicative verb form</td>
</tr>
<tr>
<td>Gloss</td>
</tr>
<tr>
<td>a. biÊem biÊm</td>
</tr>
<tr>
<td>'believe'</td>
</tr>
<tr>
<td>b. ju^en ju^¯</td>
</tr>
<tr>
<td>'learn'</td>
</tr>
<tr>
<td>c. dÉzu^çN dÉzu^n</td>
</tr>
<tr>
<td>'be higher'</td>
</tr>
</tbody>
</table>

7 This vowel is described as 'a peripherally central close unrounded vowel much lower, and
advanced from, Cardinal Vowel (Bamgbose 1967c: 8). This vowel thus is essentially mid-high and
central in character.

8 The tone pattern for a reduplicative form of a simple monosyllabic Class 2 verb is FF. If the
simple verb is disyllabic, the reduplicative form has the tone pattern FHL for verbs ending in [o] and
FFL for verbs ending in [i] (Bamgbose 1967a: 185).
The syllable-size reduplication in imperative verbs can be obtained through a TETU ranking. Spaelti (1997) observes that this can be achieved atempytically using a alignment constraint: A
\[
(6) \text{A}^{\text{LL}}\text{s}^{\text{L}}: \text{ALIGN} \quad (\text{s}, \text{L}, \text{Pwd}, \text{L})
\]

Following the generalized interpretation of alignment constraints, ATTACH \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACH} \text{ATTACK} \text{ATTACK} \text{ATTACK}
(9) a. \[ nÇntÇr \] 'lizard'
b. \[ eÇkuÇsaN \] 'millet'
c. \[ mÇbor \] 'palm trees'
d. \[ nÇsuÇniô \] 'soldier ant'
e. \[ NÇkuÇel \] 'tortoise'

From Bamgbose’s data it also appears that within the domain of \[ \text{prefix} + \text{root} \], a nasal is the only possible medial coda. Other consonants can occur in root-final position. The condition on codas or ‘\text{CodaCond}’ in Mbe thus consists of three parts (i) place features of a coda consonant must be linked to the following onset. (ii) TETU effects concerning vowels in imperative reduplication. The first of these effects is that TETU effects concerning vowels in imperative reduplication lend explanation to nasal assimilation in diminution formation. I will briefly examine two TETU effects and then explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

(10) **CODACOND:** Codas (except root-final) must be nasals with place linked to the following onset.

Because CODACOND is respected throughout the Mbe language, it must outrank \text{MAX-BR} and \text{Faith-IO} (I assume \text{MAX-IO}). This is shown for \text{BR} faith in (11) for the imperative form of \[ \text{fuel} \].

(11) Non-nasal codas are prohibited

\begin{tabular}{|c|c|}
\hline
Codas & \text{CODACOND} \text{MAX-IO} \text{MAX-BR} \text{Faith-IO} \text{Faith-IO} \\
\hline
\text{e} & 1 & 1 & 1 & 1 & 1 \\
\text{ê} & 1 & 1 & 1 & 1 & 1 \\
\text{â} & 1 & 1 & 1 & 1 & 1 \\
\hline
\end{tabular}

Before going on to explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

(12) Nasal codas are place-linked

\begin{tabular}{|c|c|}
\hline
\text{BR} & \text{CODACOND} \text{MAX-BR} \text{Faith-IO} \\
\hline
\text{e} & 1 & 1 & 1 \\
\text{ê} & 1 & 1 & 1 \\
\text{â} & 1 & 1 & 1 \\
\hline
\end{tabular}

Before exploring the CodaCond and syllable-size restriction, I will briefly examine two TETU effects concerning vowels in diminution formation. The first of these effects is that TETU effects concerning vowels in imperative reduplication lend explanation to nasal assimilation in diminution formation. I will briefly examine two TETU effects and then explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

(13) \text{NODIPH}: Two tautosyllabic moras linked to distinct vowels are prohibited.

The TETU ranking which permits diphthongs in stems but not reduplicants is given in (14). Its effect is illustrated in (15).

(14) \text{MAX-IO} \text{Faith-IO} \text{NODIPH} \text{MAX-BR}

(15) Examples of nasal components are \[ \text{ê} \text{p\text{"e}}, \text{ê\text{"ê}}, \text{ê\text{"ê}}, \text{ê\text{"ê}} \].

The TETU effects concerning vowels in imperative reduplication lend explanation to nasal assimilation in diminution formation. I will briefly examine two TETU effects and then explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

\begin{tabular}{|c|c|}
\hline
\text{BR} & \text{CODACOND} \text{MAX-BR} \\
\hline
\text{e} & 1 & 1 \\
\text{ê} & 1 & 1 \\
\text{â} & 1 & 1 \\
\hline
\end{tabular}

Before going on to explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

(16) \text{CODACOND}

The TETU effects concerning vowels in imperative reduplication lend explanation to nasal assimilation in diminution formation. I will briefly examine two TETU effects and then explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

\begin{tabular}{|c|c|}
\hline
\text{BR} & \text{CODACOND} \text{MAX-BR} \\
\hline
\text{e} & 1 & 1 \\
\text{ê} & 1 & 1 \\
\text{â} & 1 & 1 \\
\hline
\end{tabular}

Before going on to explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

(17) \text{CODACOND}

The TETU effects concerning vowels in imperative reduplication lend explanation to nasal assimilation in diminution formation. I will briefly examine two TETU effects and then explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

\begin{tabular}{|c|c|}
\hline
\text{BR} & \text{CODACOND} \text{MAX-BR} \\
\hline
\text{e} & 1 & 1 \\
\text{ê} & 1 & 1 \\
\text{â} & 1 & 1 \\
\hline
\end{tabular}

Before going on to explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

(18) \text{CODACOND}

The TETU effects concerning vowels in imperative reduplication lend explanation to nasal assimilation in diminution formation. I will briefly examine two TETU effects and then explore how the CodaCond and syllable-size restriction can cooperate to explain how the nasal is linked to the following onset.

\begin{tabular}{|c|c|}
\hline
\text{BR} & \text{CODACOND} \text{MAX-BR} \\
\hline
\text{e} & 1 & 1 \\
\text{ê} & 1 & 1 \\
\text{â} & 1 & 1 \\
\hline
\end{tabular}
No diphthongs in reduplication

(a) No diphthongs in reduplication

No diphthongs in reduplication

-RED BIEM

MAX IO NODIPHMAX BR

+ a. biem É

b. biem É

c. bim É

It should be noted that since imperative reduplication skips the second member of the diphthong and copies the non-contiguous nasal, MAX BR must outrank BASE CONTIGUITY (McCarthy and Prince 1995: 371).13

The second TETU effect for vowels concerns the occurrence of [ˈ] in place of all non-high vowels in the reduplicant. This can be seen as an effect of the markedness of [-high] vowels in relation to [+high] vowels. This markedness is encapsulated in the following ranking (see Beckman 1995 for another application of this ranking):

(16) *[-high] >> *[+high]

(i.e. *[e], *[o] >> *[i], *[u])

While [+high] vowels are less marked than [-high] ones, the mid-central vowel [ˈ] also has a default character. To explain this, I will assume that [ˈ] is a vowel unspecified for height features. The feature [-high] thus does not occur in reduplicants. This is obtained by the TETU ranking in (17a). On the other hand, [+high] vowels do copy faithfully, motivating the ranking in (17b). The substitution of [ˈ] rather than [i] or [u] for [-high] vowels in reduplicants is compelled by *[+high]. Even though this markedness constraint is low-ranked, it is violated by high vowels but not by the heightless [ˈ].

(17) a. I DENT IO [±high] >> *[-high] >> IDENT BR [±high] >> *[+high]

b. IDENT BR [±high] >> *[+high]

13 Note that an alternative candidate [bem - biem] ties with (15a) on contiguity (each candidate incurs one violation). Given that [bem - biem] copies the more sonorant member of the diphthong, it might actually be expected to be the winner. I suggest that copy of the first vocalic member of the diphthong can be attributed to an identity constraint for the consonantal release (I DENT REL IO, after Padgett 1995b, more detailed discussion of this kind of constraint follows in the appendix in section 6.1.9). Drawing on ... representations proposed by Steriade (1993a, d, 1994), where a released stop is composed of a closure node (A0) and a release node (Amax), the featural properties of the first vocalic element following the stop may be reasonably posited as affiliated with the release node of the stop. Padgett's constraint enforcing identity of features associated with a release position can be used to count the presence of the first member

The tableau in (18) shows the outcome for stems containing a [-high] vowel.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<td>*</td>
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<td>*</td>
</tr>
<tr>
<td>IDENT BR [±high]</td>
<td>*[-high]</td>
<td>IDENT IO [±high]</td>
</tr>
<tr>
<td>RED BR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The tableau in (19) shows the faithful copying of [+high] vowels:

(19) High vowels reduplicate faithfully

RED RU

IDENT IO [±high] >> *[-high] >> IDENT BR [±high] >> *[+high]

a. ru - ru **

b. rˈ - ru *! *

Three TETU rankings have now been established for the imperative reduplication; one producing the limitation to a syllable in size, and two producing unmarked vocalic structures. These rankings are summarized in (20). (21) gives the rankings of faith and CODACOND.

(20) TETU rankings:

a. Reduplicant is a syllable:

MAX IO >> ALL s L >> MAX BR

b. No diphthongs in reduplicant:

MAX IO >> NODIPH >> MAX BR

c. [ˈ] for [-high] vowels in reduplication:

IDENT IO [±high] >> *[-high] >> IDENT BR [±high] >> *[+high]
In the next section I explore how aspects of the analysis of imperative reduplication can lend insight to the nasal agreement phenomenon seen in the formation of diminutives.

6.1.3 Back to diminutives: Another pattern predicted by \textit{ALL}s

The previous section presented a clear case of reduplication in imperative verbs. Interestingly, the imperative and diminutive formations have in common that a coda is only added to the prefix when a nasal is present in the noun stem. However, this is not the case: diminutives are formed without any nasal coda in their constituent. The cross-linguistic evidence and the analysis of the imperative's nasal-agreement constraints revealed that reduplication produces a nasal coda. Therefore, we would expect that the nasal would be realized in the diminutive form. However, this is not the case: diminutives are formed without any nasal coda in their constituent. The cross-linguistic constraints on nasal-coda realization in reduplication are not found in the diminutive.

Let us review the key points of formation of diminutive nominals. Singular diminutives are formed with a prefix \([\text{ka}-]\) \([\text{ka}-]\) if \([\text{a-}\] occurs in the following syllable). If there is a nasal in the noun stem, then the prefix is closed with a nasal coda homorganic to the following onset. Tonal changes also take place in diminutive formation. Some examples from (1-2) are repeated below.

\begin{enumerate}
\item \text{\textbf{kaE-\(bE^l\)}} \quad \text{\textquoteleft little breast\textquoteright} \\
\item \text{\textbf{kaE-fu@fu@}} \quad \text{\textquoteleft little sweat\textquoteright} \\
\item \text{\textbf{ka$m-ba$m}} \quad \text{\textquoteleft little bag\textquoteright} \\
\item \text{\textbf{kaE&-tE@m}} \quad \text{\textquoteleft little heart\textquoteright} \\
\item \text{\textbf{kE@N-ku$çm}} \quad \text{\textquoteleft little snake skin\textquoteright} \\
\item \text{\textbf{kE@N-\text{g@be@no@}}} \quad \text{\textquoteleft little upper arm\textquoteright}
\end{enumerate}

Bamgbose (1966a: 48) notes that plural diminutive nouns are formed in the same way, but with \([\text{ke}-\] as the fixed portion of the prefixation. Given the diminutive formation combines nasal constraint on reduplication, important, I claim that diminutive formation does not consist of a single affix.

\begin{equation}
\begin{aligned}
\text{RED + noun stem (plus tonal information)}
\end{aligned}
\end{equation}

Importantly, I claim that diminutive formation does not consist of a single affix.

\begin{equation}
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The next point concerns nominal classes in Mbe. Recall that Mbe has seven primary nominal classes, which determine the form of number category prefixes and syntactic agreement markers. Bamgbose ... thus match those for Class 4. To illustrate syntactic agreement, an example of a thematic concord marker [kukue] (sg.) for a non-diminutive Class 4 noun is given in (25).

(25)

\[
\begin{array}{ll}
\text{kE$-} & \text{tç@r} \\
\text{ku@k»ue} & \text{n$} \\
\text{kiêle@} & 'It was a duiker that I saw'
\end{array}
\]

Interestingly, the Class 4 nominal prefixes, [kE-] (singular) and [ke-] (plural), precisely match the fixed segmentism in the singular and plural diminutive formation; however, non-diminutive Class 4 nouns do not ... counterparts when they do not contain a nasal, although they are generally distinguished by tonal properties (26b).

(26) Class 4 (non-diminutive) Diminutive form

a. [kE$-] \[tE$m \]
   'axe'

b. [kE&n-] \[tE@m \]
   'little axe'

Given that diminutives are Class 4 and have prefixal material identical to the usual Class 4 prefixes, I conclude that the [kE-/ke-] portion of diminutive formation is a Class 4 prefix, not part of the diminutive morpheme itself. I suggest that the phonological constituency of the diminutive ... segmental component (i.e. the coda nasal). This gives a modular view of diminutive formation, as shown in (27).

(27) Diminutive morpheme

The derived diminutive nominal is Class 4 and thus takes the [kE-/ke-] prefixes. This complex structure analysis explains the uniformity of Class 4 and diminutive affixes and agreement markers. If [kE-/ke-] material were a prespecified part of a reduplicative diminutive affix, this homophony would be accidental.

With the structure of diminutive formation now established, I turn to deriving the size of the reduplicative component of the diminutive morpheme. The diminutive reduplicant is restricted to filling a position in the diminutive morpheme. According to the derived structure of diminutive formation, the diminutive morpheme must have some phonological exponent in the output. For each modular component of diminutive formation in the input, each submodule must have some phonological exponent in the output. Part (i) of REALIZE MORPH: is given in (28) (with foundation in phonological realization constraints from Samek-Lodovici 1996, Rose 1999, and Hendricks 1999).

(28) REALIZE MORPH:

1. A morpheme must have some phonological exponent in the output. For morphemes composed of modular components in the input, each modular component must have some phonological exponent in the output.

2. A violation is incurred for each component failing to have some phonological exponent in the output. For morphemes with a modular structure, a violation is accrued for each component failing to have some phonological exponent in the output.

Both the diminutive and imperative morphemes have two modular elements demanding phonological expression: a reduplicative segmental component and a tonal pattern component. If the modular analysis of these morphemes in Mbe could be eliminated (see n. 15), then the morpheme realization constraint could be simplified to eliminate reference to modularity.
the constraint are reckoned (after Zoll 1996). One violation will be incurred for each component for which there is no phonological exponent in the output, i.e. in diminutive or imperative formation, there will be one violation if the tone pattern fails to be realized; if neither copy or the tone pattern appears in the output, two violations will be accrued.

In imperative reduplication, both the reduplicative and tonal components of the morpheme always have some phonological exponence in the output. In the case of the reduplicative component, this takes place at the cost of A\textsubscript{LL}s, since the reduplicative material adds a syllable to the word. This motivates the ranking in (29) (I assume that morpheme realization constraints may be specific to particular morphemes).

\begin{equation}
\text{REALIZEMORPHimp} \gg \text{ALL}s
\end{equation}

In contrast to the imperative, realization demands for the diminutive morpheme cannot compel the addition of a syllable. Reduplication occurs in diminutive formation only when material can be copied without adding a syllable (i.e. material is copied as a coda or not at all). A\textsubscript{LL}s must thus outrank the diminutive realization constraint:

\begin{equation}
\text{ALL}s \gg \text{REALIZEMORPHdim}
\end{equation}

Copy of a nasal along with tonal changes in the diminutive is illustrated in (31). The constraint hierarchy in this tableau combines the morpheme realization ranking in (30) with the TETU size-restriction ranking established earlier (MAX-IO \gg ALLs > MAX-BR). The complex constituency of the diminutive nominal is shown in the input.

The tableau in (32) illustrates a case where a candidate only incurs violations at the level of a single syllable. This is illustrated by candidate (a), where all material is copied as an extra syllable. The winning candidate in (32) is (b), where the reduplicative material is copied as a coda. This candidate's score is 0, since no additional material is added to the word. This segmentation constraint is reinforced by the fact that reduplication is only possible at the level of a single syllable. However, since candidate (b) fails to copy the necessary tonal information, this results in an extra violation (it is possible that the tone pattern is not realized). The winning candidate (c) is identical to (b), except that it copies a nasal as a coda. This results in a violation of MAX-BR at the level of a single syllable. The constraint hierarchy in (33) shows that the ranking of MAX-BR over ATT\textsubscript{L}D is crucial for minimizing violations.
In (32), Copy fails in diminutive; tonal changes occur.

Tone

kE

RED   -

bEl

MAX-IO, REALIZEMORPH

s

L

MAX-BR, REALIZEMORPH

dim

a.

kE&bE^l

*

bel

*(RED)

b.

kE&bE^bE^l

**

l

RED, tone

The tableau in (33) shows how the different ranking of REALIZEMORPH causes the TETU size-restriction ranking to produce syllable-size copy in the imperative.

The morpheme realization constraint in this case is undominated, forcing some segmental copy to take place along with the tone realization. The candidate (c), which fails to copy any material, loses on a violation of REALIZEMORPH. Both candidates (a) and (b) copy segments, but (b) loses on the basis of ALLs, because it adds more than one syllable. The winner (a) satisfies morpheme realization but copies just one syllable to minimally violate the alignment constraint. This gives us a second TETU size restriction from ALLs: copy is limited to one syllable.

(33) Syllable-size copy and tonal changes in imperative

Tone

RED   -

jubo

MAX-IO, REALIZEMORPH

s

L

MAX-BR

To review, we have now seen that the same atemporal size-restricting constraint in combination with differently-ranked morpheme realization constraints accounts for the coda/null size limitation in the diminutive and the syllable-size limitation in the imperative. The constraint hierarchy obtaining this result is given in (34).

(34) Size-restriction ranking summary

MAX-IO, REALIZEMORPHimp >> ALLs >> MAX-BR, REALIZEMORPHdim

The motivation from the analysis of reduplicative imperatives for the reduplication account of the diminutive is now two-fold. First, we have seen that the limitation on nasal copy falls out from the independent demand of CODACOND. Second, the TETU approach to the size-restriction on imperative reduplication can also explain the size-restriction seen in the diminutive.

An important aspect of the atemporal analysis of the size restriction on diminutive copy is that it explains the coda/null size of the reduplicant. Various analysts have examined cases of reduplication where an atemporal description of copying has been necessary, but none have been able to account for the specific details of the reduplication. Spaelti's (1997) account of Syllable recycling is one such attempt, and it is examined in the next section.

The syllable recycling phenomenon exemplified in Spaelti's work is the process of copying a single segment as a coda, as in the forms in (35). This is driven by the ALLs constraint, which minimizes the number of syllables in the output. In this case, the reduplication of a single segment results in a new syllable being created, with one of the original segments appearing as a coda.

(35) Rebi West Tarangan

a. bi»tEm

na bi

to

m»tEm

na

'middle'

b. paj»lawa

na paj

to

law»lawa

na

'friendly'

Spaelti observes that the copy of a single segment as a coda, as in the forms in (35), can be driven by ALLs, i.e. minimization of the number of syllables in the output. This is consistent with the basic principle of Syllable recycling, which states that a single segment can be copied as a coda in a new syllable. In (35b), the preceding syllable is closed, and a full CVC is copied (35b).
He obtains this single consonant copy pattern by ranking ALL \( \text{LALIGN}(\text{RED}, \text{L}, \text{s}, \text{L}) \). The tableau in (36) illustrates the analysis (from Spaelti 1997: 165). (For a full analysis of the details of reduplication in Rebi, see Spaelti 1997.)

(36) Syllable recycling in Rebi West Tarangan

\[
\begin{array}{c}
\text{RED - tapuran} \\
\text{LALIGN-L} (\text{RED}, \text{s}, \text{L}) \\
\text{ALL >> REALIZEMORPHdim} \\
\end{array}
\]

The analysis of nasal copy in Mbe diminutive formation draws on Spaelti's idea of using minimization of the number of syllables in the word to achieve reduplication that does not add a syllable. In Mbe diminutives this occurs when there is no nasal to copy (required by \( \text{CODACOND} \)), in which case reduplication fails altogether. In Rebi, single consonant copy is prevented when the preceding syllable is not a nasal (a complex coda). Mbe diminutive reduplication thus violates morpheme realization rather than add a syllable to the word (ALL \( \text{L} \) >> REALIZEMORPHdim), but Rebi will add a syllable when necessary to achieve some segmental exponent for RED (REALIZEMORPH >> ALL \( \text{L} \)). The case of CVC copy in Rebi is illustrated in (37).

(37) CVC copy driven by morpheme realization

\[
\begin{array}{c}
\text{RED - pajlawa} \\
\text{REALIZEMORPHALL} \\
\text{L >> REALIZEMORPHdim} \\
\end{array}
\]

In addition to always realizing a reduplicant, Rebi West Tarangan is distinct from Mbe in always choosing the segment following the stressed vowel to copy rather than the leftmost base segment (demanded by LEFT-ANCHOR-BR; McCarthy and Prince 1995). Drawing on a proposal of Moore (1996), Spaelti (1997) notes that this can be explained by the ban on geminates in West Tarangan. The tableau in (38) illustrates the approach (from Spaelti 1997: 30).

(38) Copy of second consonant after site of reduplicant

\[
\begin{array}{c}
\text{RED - tapuran} \\
\text{NOGEMINATEANCHOR-L} \\
\text{ALL >> REALIZEMORPHdim} \\
\end{array}
\]

Unlike Rebi, Mbe diminutive reduplication copies the first eligible segment (a nasal) in the base, even if this produces adjacent identical nasal segments (e.g. \( [kE^m - mu^s] 'little story', [kE^m - mE^s] 'little neck', [kE^n - ne^n] 'little bird', [kE^e - ïe^n] 'little thing'; Bamgbose 1971: 48). Since Bamgbose notes that coda nasals are always homorganic with a following onset consonant, these nasals could reasonably be treated as geminates, in which case ANCHOR-L dominates NOGEMINATE. However, no nasal was found in Rebi where a following onset consonant was nasal. The nasals are always homorganic with a following onset consonant (Bamgbose 1971: 48). Since Bamgbose notes that nasal nasals are always homorganic with a following onset consonant (Bamgbose 1971: 48), it is clear that nasal nasals are always homorganic with a following onset consonant.
6.1.4 Nasal agreement in inchoative verbs

An important claim underlying the account of the diminutive is its complex formation, consisting of a componential ... the nasal agreement of diminutive nouns. First, (39) shows that inchoative verbs are usually formed with a prefix \(-\)re-:

<table>
<thead>
<tr>
<th>Simple verb form</th>
<th>Gloss</th>
<th>Inchoative form</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>ta$</td>
<td>'touch'</td>
<td>re^-ta$</td>
<td>'has started to touch'</td>
</tr>
<tr>
<td>kE@l</td>
<td>'look'</td>
<td>re^-kE@l</td>
<td>'has started to look'</td>
</tr>
<tr>
<td>ka@b</td>
<td>'dig'</td>
<td>re^-ka@b</td>
<td>'has started to dig'</td>
</tr>
</tbody>
</table>

In (40) we see that if the verb contains a nasal, it is copied as a coda to the \(-\)re- prefix (note that \(\text{e}\) reduces to \(\text{´}\) in a closed syllable).

<table>
<thead>
<tr>
<th>Simple verb form</th>
<th>Gloss</th>
<th>Inchoative form</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>tu@çm</td>
<td>'send'</td>
<td>r´^n-tu@çm</td>
<td>'has started to send'</td>
</tr>
<tr>
<td>kE$n</td>
<td>'walk'</td>
<td>r´^N-kE@n</td>
<td>'has started to walk'</td>
</tr>
<tr>
<td>jiêçniÈ</td>
<td>'forget'</td>
<td>r´^-jiêçniô</td>
<td>'has started to forget'</td>
</tr>
</tbody>
</table>

Given the arguments against prespecification in reduplicative affixes and the complex structure proposed for diminutive formation, it is reasonable to posit a complex structure for inchoative verb formation as well:

Inchoative verbs: \(\text{re} + \text{RED} + \text{verb stem} \) (plus tonal information)

As in the case of diminutives, there is evidence from the morphology of Mbe's verbal tense/aspect system that supports the analysis of the fixed segmentism in inchoative formation as a separate prefix. The evidence comes from the fact that \(-\)re- occurs in the formation of four other verbal tense/aspect forms, either as the sole prefixal material or in combination with \(-\)ke- (it is conceivable that \(-\)reke- may have a complex structure \(-\)re + \(-\)ke-). This is shown in (42). Note that different tonal patterns also accompany different tense/aspect forms.

(42) a. Remote Past (sg.)

Gloss
re$-ta@
'had touched'
re$-jiêEm
'had sung'

b. Past Continuous (sg.)

Gloss
re$ke@-ta
'was touching'
re$ke@-jiôEmo@
'was singing'

c. Future (sg.)

Gloss
re$ke@-ta$
'will touch'
re$ke@-jiêEm
'will sing'
d. Future Continuous (sg.)

Gloss
re$ke@-ta@
'will be touching'
re$ke@-jiêEmo@
'will be singing'

Since the \(-\)re- segmentism occurs in the formation of a variety of verbal tense/aspect forms, I hypothesize that it is not segmental material specific to the inchoative morpheme, but rather it has some more general function across these verbal forms. This leaves an inchoative morpheme consisting of just RED and tonal information, matching the structure proposed in (41) above.

Reduplication in inchoative formation takes place only when material can be copied without adding a syllable. As established in the analysis of diminutives, this is achieved when the size-restricting constraint, ALLsL, outranks morpheme-realization. This motivates the following ranking:

(43) \(\text{ALLsL} \gg \text{REALIZEMORPHinc}\)

The inchoative data thus strengthens the reduplication analysis of nasal agreement by presenting independent support for a separate prefix with fixed material to which a nasal reduplicative affix may form a complex.

An important claim underlying the account of the diminutive is its complex formation...
6.1.5 Independent evidence for REALIZEMORPH: Zoque

Violable morpheme realization constraints play an important role in achieving coda/null-copy in diminutive and inchoative ... this section I show that prefixation in Zoque (Zoquean; Southern Mexico) provides cross-linguistic support for a violable \textsc{realizemorph} constraint.

In Zoque, morpheme realization fails when a nasal pronominal prefix fails to undergo place assimilation to a following consonant. Data and description are from Wonderly (1951), and for previous ... noted that post-nasal voicing in these data is an independent phenomenon taking place in non-homorganic sequences as well.

The data in (45) show that the nasal prefix fails to surface before a continuant consonant ([l] is assumed here to be [+continuant] after Padgett 1994: 485, 1995c: 41).

(45) a. N - faha fi faha 'my belt'
  b. N - sˆk fi sˆk 'my beans'
  c. N - Sapun fi Sapun 'my soap'
  d. N - rantÉSo fi rantÉSo 'my ranch'
  e. N - lawus fi lawus 'my nail'
  f. N - kwarto fi Kwarto 'my room'

The nasal prefix also deletes before [l, m, n, l]. It is retained before [w, j, h] (Wonderly 1951: 121). See Padgett (1995c: 64-5) for analysis of the latter cases as place assimilation with gliding.

It is reasonable to posit that the nasal prefix deletes before a continuant consonant because place assimilation has failed to take place (see, for example, Padgett 1994, 1995c). Note, however, that non-homorganic nasals are permitted before a continuant consonant word-initially, they can occur in word-medial position.

\begin{align*}
\text{N} & \rightarrow \text{N}\text{-}wente
\end{align*}

\begin{align*}
\text{N} & \rightarrow \text{N}\text{-}pente
\end{align*}

\begin{align*}
\text{N} & \rightarrow \text{N}\text{-}ntente
\end{align*}

Padgett (1994, 1995c) develops an insightful generative account of the nasal prefixation, which I will essentially follow here translated into an OT framework. My concern will be with \textsc{realizemorph} constraints deriving this effect. Note, however, that does not explain this restriction on place-linked nasals.

The nasal prefix, which refers to the combination of constraints deriving this expressed constraint in (47), which refers to the combination of constraints deriving this expressed constraint in (47), which refers to the combination of constraints deriving this expressed constraint in (47), which refers to the combination of constraints deriving this expressed constraint in (47).

For the present purposes I will simply use the descriptively expressed constraint, which refers to the combination of constraints deriving this expressed constraint in (47), which refers to the combination of constraints deriving this expressed constraint in (47), which refers to the combination of constraints deriving this expressed constraint in (47), which refers to the combination of constraints deriving this expressed constraint in (47).

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  b. N - sˆk fi sˆk 'my beans'
  c. N - Sapun fi Sapun 'my soap'
  d. N - rantÉSo fi rantÉSo 'my ranch'
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\begin{align*}
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\end{align*}

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Both the constraints \( \text{ZN}^+ \) and \( \text{C-PLACE} \) are unproductive in Zoque. When they

---

**Table 52**

<table>
<thead>
<tr>
<th>Constraint</th>
<th>ZN^+</th>
<th>C-PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REALIZE</strong></td>
<td>i+</td>
<td>i+</td>
</tr>
<tr>
<td><strong>PLACE</strong></td>
<td>i+</td>
<td>i+</td>
</tr>
<tr>
<td><strong>IDENT-IO [PLACE]</strong></td>
<td>i+</td>
<td>i+</td>
</tr>
</tbody>
</table>

---

(52) *NÉ \( \text{ZN}^+ \) C-PLACE IDENT-IO[PLACE] \>

---

![Diagram](image_url)
A similar cumulative affixation effect appears in diminutive formation. Nouns which take C or N prefixes in their non-diminutive form construct their diminutive counterpart by prefixing 
\[
\text{ke} - \text{N} - \text{pie}
\]
and 
\[
\text{ke} - \text{N} - \text{pie}
\]
in singular and plural non-diminutive forms respectively. Nouns with a V or CV prefix in their non-diminutive form replace this with 
\[
\text{kE} - / - \text{kE}
\]
in their diminutive counterpart. The reason for this is that cumulative prefixation takes place only when the combined prefixal material forms no more than a syllable. This is achieved by an affixal TETU ranking, as in (56):

\[
\text{Root-Faith >> A} - \text{LL} - \text{L} - \text{Nom-Affix-Faith}
\]

The ranking in (56) refers to nominal affixation in particular because verbal affixation proves to be capable of adding more than one syllable. In the case of nominal prefixation, ALL limits the total size of combined prefixation to one syllable. Root material is not limited, however. This is achieved by an affixal TETU ranking, as in (57):

\[
\text{Root-Faith >> ALL >> Nom-Affix-Faith}
\]

The table shows the results of combining various prefixes with a singular and plural root in (58).
6.1.7 A templatic versus templatic approaches to size restriction

In the analysis of prefixation in Mbe presented above, the size-restricting constraint $A_{\text{LL}s}$ explains a number of effects, including the syllable-size copy of the imperative, the coda/null copy of the diminutive and inchoative, and the limit of a syllable on combined nominal prefixation. It must be noted that the prosodically-defined constraints of the Prosodic Morphology Hypothesis, such as $\text{RED} = \text{CV}$, can handle the case of imperative syllable-size copy. However, these constraints are insufficient to account for the size-restricting behavior of prefixes in Mbe. For example, although the Prosodic Morphology Hypothesis enforces the same ordering relations between material in the input and material in the output, it cannot predict the optimal output $\text{leNkwor}$, as in (58) (McCarthy and Prince 1995: 371); alternatively, this could be ruled out by morphological demands on the ordering of morphemes. The problem is that the complete size restriction is specific to the context of complex prefixation. The constraints are insufficient for the more general cases of size-restriction.

The analysis focuses only on the implications of complex prefixation for the role of the size-restricting constraint in Mbe grammar. A separate and interesting issue that will not be examined here is why some forms are able to express the plural morpheme in plural nominals. This will rule out $\text{lekwor}$ as the optimal output for the form in (58) (this form also violates a left-anchoring constraint).

To understand the role of the size-restricting constraint in Mbe, a templatic approach is proposed. A second templatic alternative building on the insights of the Prosodic Morphology Hypothesis is known as 'Generalized Template Theory' (McCarthy and Prince 1994a, b; Urbanczyk 1995, 1996a, b). This approach allows the design of a generalized morphological category, such as $\text{Afx} \leq \text{syllable-size copy}$. One example of a generalized templatic constraint is $\text{Afx} \leq \text{syllable-size copy}$. Ranking this constraint between $\text{MAX-IO}$ and $\text{MAX-BR}$ will limit reduplicant size to one syllable. $\text{MAX-BR}$ will drive copy of the largest possible syllable, and the independently-required $\text{CODACOND}$ will restrict coda material to that allowed in the language. This is shown in (59).

Although generalized templates account for the majority of reduplication phenomena, they are insufficient for the more unusual cases of diminutive/inchoative coda/null reduplication. The problem is that the affix and not the root is the source of the size restriction. If the affix is in the foot, then the size restriction is applied to the foot, not to the root. The only solution is to rank the affix constraint higher than the root constraint. This will result in (60). Although the foot has the larger copy, the syllable-size constraint is applied to the root, not to the foot. This is because the foot is a separate morphological category, and the size-restricting constraint is applied to the root, not to the foot. The foot does not have the same size restriction as the root.

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<table>
<thead>
<tr>
<th>Attachment</th>
<th>Coda Size</th>
<th>Template Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>No attachment</td>
<td>Coda Size</td>
<td>Template Size</td>
</tr>
</tbody>
</table>

In Mbe, the size-restricting constraint applies to the root, not to the foot. The only solution is to rank the affix constraint higher than the root constraint. This will result in (60). Although the foot has the larger copy, the syllable-size constraint is applied to the root, not to the foot. This is because the foot is a separate morphological category, and the size-restricting constraint is applied to the root, not to the foot. The foot does not have the same size restriction as the root.
incorrect outcome is signalled by the reverse-pointing hand beside candidate (c). Candidate (a), which is the actual outcome, is not selected by this tableau.

60 Afx gives wrong outcome for diminutive kE - RED - tEm
CODACOMAX-IOAfx £s MAX-BR

61 a. kE t - tEm !

b. kE - tEm t !

62 c. kE tEn - tEm

The fact that reduplication for the diminutive and inchoative morphemes takes place only when it will not add a syllable to the word requires independent explanation. A

LL is what achieves this explanation; yet it is also capable of capturing the size-restriction on its own. It thus obviates the need for a generalized templatic constraint. A similar problem arises with the inchoative morpheme in Mbe. The need for templates is met empirically by the morphology of Mbe. The morphology of Mbe provides empirical evidence that it is a necessary step to take.

Finally, there is an argument concerning theoretical overgeneration against the use of templatic constraints. This argument, discussed by Prince (1996, 1997) and Spaelti (1997), is known as the Philip-Spauli argument. The argument points out that using a templatic alignment constraint to produce size restrictions is not faced with this problem. We have seen that templatic alternatives to size restriction are insufficient to obtain reduplicant size limits and are also not required. In addition, they are incapable of providing explanation for the range of size-restriction phenomena that attend.

6.1.8 Ruling out prespecification in reduplication

I conclude the discussion of Mbe by returning to the issue of prespecification in reduplication. The formation of reduplicants is considerably more than the mere addition of a syllable in reduplication. On the basis of these arguments, it is clear that we must use templates for reduplication.

On the other hand, the need for templates is met empirically by the morphology of Mbe. The morphology of Mbe provides empirical evidence that it is a necessary step to take.

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The Basic Model of reduplicative identity:

Input: /AfRED + Stem/

Output: R

The model in (61) posits a correspondence relation between (i) the input and output forms of the stem, and (ii) between the output form of the stem (the base) and the output form of the reduplicative affix. The model in (61) also posits a correspondence relation between the input and output forms of the reduplicative affix. This model is similar to the model in (62) which posits correspondence relations between the input and output forms of the base and the reduplicative affix. The model in (62) is similar to the model in (61) which posits correspondence relations between the input and output forms of the stem and the reduplicative affix.

In the case of reduplicative affixes, Affix-Faith has the potential to conflict with BR Identity. Constraint ranking gives the two possible outcomes in (63).

(63) a. Faithi-BR >> Affix-Faithj-IO
b. Affix-Faithi-IO >> Faithj-BR

The ranking in (63a), which places BR-Faith over Affix-Faith, yields a pattern in which maximal reduplication takes place (within the limits of any size-restriction) and wins over prespecified material. This is illustrated in (64) for a hypothetical language with a RED containing *so*.

(64) A ranking yielding combination of prespecified material with reduplication

<table>
<thead>
<tr>
<th>RED - bam</th>
<th>AFFIX-MAX-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>sobam</td>
<td>*</td>
</tr>
<tr>
<td>bam - bam</td>
<td>*</td>
</tr>
</tbody>
</table>

Another problematic kind of fixed segmentism arises under a combination of DEP and MAX constraints. The tableau in (65) shows how this can produce the output in (64) with the reduplicative affix.

(65) Prespecified material plus full copy

Input: RED - bam

Output:

<table>
<thead>
<tr>
<th>RED - bam</th>
</tr>
</thead>
<tbody>
<tr>
<td>sobam</td>
</tr>
<tr>
<td>bam - bam</td>
</tr>
</tbody>
</table>

Note that Affix-Faith and Affix-Faith-IO only have the potential to conflict when Affix-Faith holds for a given affix to both input material and base material. In the case of reduplicative affixes, Affix-Faith-IO outranks the potential to conflict with BR-Faith.

(66) Elaborated Basic Model of reduplicative identity

The model in (66) posits a correspondence relation between the input and output forms of the affix, as shown in (67).

(67) The Basic Model of reduplicative identity
The first argument is the one that is relevant, since the root-based constituent always forms the first argument in any root-to-affix correspondence relation (i.e. Faith-BR, following McCarthy and Prince 1995). The revised metaconstraint is given in (66):

(66) Revised Root-Affix Faith metaconstraint:

\[
\text{Faith}^i-\text{Root-}X >> \text{Faith}^j-\text{Affix-}Y
\]

The metaconstraint in (66) admits the rankings Root-Faithi-IO >> Affix-Faithj-IO and Faithi-BR >> Affix-Faithj-IO and rules out their reverse counterparts *Affix-Faithi-IO >> Root-Faithj-IO and *Affix-Faithi-IO >> Faithj-BR. We may thus eliminate the ranking in (63b), and consequently the emergence of prespecified material in a reduplicative affix, on the basis of the more general principle of Root over Affix Faith.

6.1.9 Appendix: Deriving CodaCond in Mbe

In section 6.1.2 I made use of a descriptive constraint, C\textsubscript{ODACOND}, noting that the effect of this constraint could be derived through the interaction of other more basic constraints. In this appendix, I derive CodaCond from the interaction of these underlying properties:

(i) Place features of a coda consonant must be linked to a following onset.
(ii) Coda consonants are limited to nasals.
(iii) The coda restrictions of (i) and (ii) are exempted in root-final position.

First, place features of a coda consonant must be linked to a following onset. Alderete et al. (1996) suggest that this may be driven by the interaction of markedness and faith constraints. Importantly, constraints driving multiple linking are place feature markedness constraints, which I refer to here as C\textsubscript{-PLACE/X} (collapsing the hierarchy *PL/DORS, *PL/LAB >> *PL/COR; after Prince and Smolensky 1993; Smolensky 1993; for applications see Padgett 1995a; Alderete et al. 1996; among others). Importantly,

violations of C\textsubscript{-PLACE/X} are reckoned on an autosegmental basis rather than a segmental one, so that one occurrence of a place feature linked to two segments incurs one violation for the single place feature, with no extra violations for each segment.

If C\textsubscript{-PL/X} outranks consonantal place feature identity constraints (both IO and BR), then place-linked structures for consonant clusters in roots and reduplicants will be selected over structures with two separate places. MAX constraints must also outrank place-identity constraints to prevent segments from deleting rather than undergoing place assimilation. This is shown in (69), restricting attention to candidates preserving onset place features. High-ranked O\textsubscript{NSET} is shown to prevent deletion of onset consonants. This tableau also includes an undominated constraint, HAVEPLACE, which requires that every consonant have some place feature specification (Itô and Mester 1993; Lombardi 1995b; Padgett 1995b). [T] represents a placeless consonant.

(69) Copied codas are place-linked

\[
\text{RED-}jiçni \text{HAVEPLACE \text{ONSET} C-\text{PL/X} MAX-IO MAX-BR IDENT-IO[Place] IDENT-BR[Place]}^+ \\
\text{+} \\
\text{a.} \quad \text{ji} \bar{E} \text{-jiçni j, } \bar{E}j, n \text{*(BR)} \\
\text{b.} \quad \text{jin} \text{-jiçni j, n, j, n} \\
\text{c.} \quad \text{ji} \text{-jiçni j, j, n n} \text{!(BR)} \\
\text{d.} \quad \text{ji} \text{-jiçi} \text{j, j} \text{n} \text{!(IO)} \\
\text{e.} \quad \text{ji} \text{T-jiçni} \text{j, j, n} \text{*(BR)} \\
\text{d. T-içji} \text{T-içji} \text{*(IO)**} \\
\]

A second property of the place assimilation must yet be explained: coda place features take on the place features of a neighboring onset but not the reverse. In his discussion of nasal place...
McCarthy 1995; Lombardi 1995b; Alderete 1995, 1996; Selkirk 1994 cited by Beckman 1998; Katayama 1998; Walker 1998). Padgett observes that the positional asymmetry for place assimilation has a phonetic basis: constraints specific to the perceptually-salient positions of release are capable of preventing the place feature of an onset from spreading to a coda consonant, unless the latter is word-finally.

Faith constraints specific to the perceptually-salient position of release are capable of preventing *C-PL/X from threatening the preservation of place features in onset position. The positional faith constraint that will be required is given in (70) (after Padgett 1995b: 19):

\[(70) \text{IDENTREL-IO[Place]} \]

Let \(S\) be a [+release] segment in the output. Then every place feature in the input correspondent of \(S\) has an output correspondent in \(S\).

The ranking needed for Mbe places release-sensitive IO-faith for place features over *C-PL/X, which in turn outranks general faith for place features:

\[(71) \text{IDENTREL-IO[Place]} >> \star \text{C-PL/X} >> \text{IDENT-IO[BR][Place]} \]

This ranking will produce spreading of place features from onsets to codas in consonant clusters, as illustrated in (72). Only candidates respecting \(\text{HAVEPLACE}\) and \(\text{ONSET}\) are considered here and in subsequent tableau.

\[(72) \text{Identifying features spread from coda to onset} \]

<table>
<thead>
<tr>
<th>IDENT-IO[BR][Place]</th>
<th>IDENT-IO[AP][Place]</th>
<th>IDENT-IO[BR][Place]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\star \text{C-PL/X})</td>
<td>(\star \text{C-PL/LAB})</td>
<td>(\star \text{C-PL/COR})</td>
</tr>
</tbody>
</table>

Next we must explain why consonants are limited to nasals (except in root-final position, which I will return to presently). In dealing with the failure of coda obstruents to assimilate in place, Padgett (1995b: 18) observes that the concept of IDENTREL-[Place] is insufficient to explain the patterns he observes. To this I propose to add that intervocalic place in approximants and approximant consonants is more difficult to preserve than intervocalic place (see Ohala and Ohala 1992: 29-32).

Therefore, I propose to add that intervocalic place in approximants and approximant consonants is more difficult to preserve than intervocalic place (see Ohala and Ohala 1992: 29-32).

The definition of IDENTREL-[Place] is given in (73) and the tableau showing its application is in (74) (considering only consonants). The definition of IDENTREL-[Place]

\[(73) \text{IDENTREL-[Place]} \]

Let \(S\) be a [+release] segment in the reduplicant. Then every place feature in the reduplicant correspondent of \(S\) has an output correspondent in the reduplicant.

\[(74) \text{Identifying features spread from onset to coda} \]

<table>
<thead>
<tr>
<th>IDENT-IO[BR][Place]</th>
<th>IDENT-IO[AP][Place]</th>
<th>IDENT-IO[BR][Place]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\star \text{PL/DOR})</td>
<td>(\star \text{PL/LAB})</td>
<td>(\star \text{PL/COR})</td>
</tr>
</tbody>
</table>

The ranking needed for the place features over place features for place features over \(\star \text{PL/X}\) is the same as in (71).

\[(75) \text{IDENTREL-IO[Place]} \]

If faith for place features occurring in onsets and approximants are limited to nasals (except in root-final position, which I will return to presently). In dealing with the failure of coda obstruents to assimilate in place, Padgett (1995b: 18) observes that the concept of IDENTREL-[Place] is insufficient to explain the patterns he observes. To this I propose to add that intervocalic place in approximants and approximant consonants is more difficult to preserve than intervocalic place (see Ohala and Ohala 1992: 29-32).

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\[(73) \text{IDENTREL-[Place]} \]

Let \(S\) be a [+release] segment in the reduplicant. Then every place feature in the reduplicant correspondent of \(S\) has an output correspondent in the reduplicant.
nasal (i.e. [fun-fuel, [fun-fuen]), and for the moment I consider only candidates preserving onset place identity (as in (72), (74)) and maintaining root-final consonants. \( V \) represents a labio-dental approximant.

(76) Non-nasal codas are prohibited

\[
\begin{align*}
&\text{IDENT-IO/BR[OBS-Pl]} \\
&\text{IDENT-IO/BR[APR-Pl]} \\
&\text{MAX-IO} \\
&\text{MAX-BR} \\
&\text{C-PL/X MAX-IO} \\
&\text{+} \\
\end{align*}
\]

a. fu - fuel f, f, l

(76) Non-nasal codas are prohibited

b. ful - fuel f, l, f, l

c. fuVÉ - fuel *!(BR-APR-Pl) f, VÉf, l

In contrast to oral consonants, nasals are retained in codas, although they must be place-linked. To achieve this outcome, IDENT[NAS-Place] must be outranked by MAX, as shown in (77). The difference between nasal versus oral consonants is thus that nasal consonants in codas will share place identity, while oral consonants in codas will be lost rather than violate place-identity through assimilation.

(77) Nasal codas occur (place-linked)

\[
\begin{align*}
&\text{IDENT[OBS-Pl]} \\
&\text{IDENT[APR-Pl]} \\
&\text{MAX-IO} \\
&\text{MAX-BR} \\
&\text{IDENT-IO/BR[NAS-Pl]} \\
&\text{+} \\
\end{align*}
\]

a. pumÉ - puçni p, mÉp, n çi

(78a) R İGHT-ANCHOR-MAXROOT:

Any segment at the right edge of the root in the input has a correspondent at the right edge of the root in the output.

(78b) R İGHT-ANCHOR-IDENTROOT[Place]:

Let \( a \) be a segment at the right edge of the root in the input and \( b \) be a correspondent of \( a \) at the right edge of the root in the output. If \( a \) is [Place \( g \)], then \( b \) is [Place \( g \)].

Since MAX and IDENT higher-ranking constraints save consonants and their place features in root-final position, they must outrank C-PL/X. This is illustrated in (78).

(78) a. R İGHT-ANCHOR-MAXROOT

The final aspect of the Mbe CodaCond to be explained is the failure of coda restrictions to apply in root-final position. Recall that coda restrictions are lifted not only when root-final consonants are not released, but also when root-final consonants are moraic. If root-final consonants are not released, then with the rankings as they stand, saving \( +C-PL/X \) over MAX-IO would not be expected. This is illustrated in (79-80) for suffixed forms [ju$ab-kiÈ] 'be washing' and [jiÛEm-kiô] 'be singing'.

29 Note that even if root-final consonants are not released when the suffixes are attached, there is no independent evidence for this approach to date (or any independent evidence for peripheral segments, for that matter).

I add to this (78b), which enforces identity of featural properties for peripheral segments. In contrast to oral consonants, which are released through a peripheral featural projection (\( \text{RIGHT-ANCHOR-MAXROOT} \), peripheral segments for nasal consonants are not released. The ranking of Peripheral Segments (93) demands a correspondent for peripheral segments, as shown in (78b). The ranking of Peripheral Segments (93) requires the existence of a corresponding peripheral segment. The final aspect of the Mbe CodaCond to be explained is the failure of coda restrictions to apply in root-final position. Recall that coda restrictions are lifted not only when root-final consonants are not released, but also when root-final consonants are moraic. If root-final consonants are not released, then with the rankings as they stand, saving \( +C-PL/X \) over MAX-IO would not be expected. This is illustrated in (79-80) for suffixed forms [ju$ab-kiÈ] 'be washing' and [jiÛEm-kiô] 'be singing'.

Since MAX and IDENT higher-ranking constraints save consonants and their place features in root-final position, they must outrank C-PL/X. This is illustrated in (78).
(79) Codas without linked place can occur in root-final position.

juab-ki

R-ANCHOR-MAXROOT-ANCHOR-IDENTROOT[Pl] *C-PL/X

+ a. juab-ki
b. jua-ki

(80) Root-final nasals without linked place.

jiem-ki

R-ANCHOR-MAXROOT-ANCHOR-IDENTROOT[Pl] *C-PL/X

+ a. jiem-ki
b. jie-ki

c. jieNÉ-ki

We now have completed the rankings which obtain the Mbe CodaCond, which holds within roots and prefixes, including the reduplicative prefix in imperative verbs. The analysis draws on the identity constraint for nasals (after Padgett 1995b). The rankings for the coda restrictions are summarized in (81).

(81) Summary of rankings for CodaCond:

I DENTREL-IO/BR[Place], IDENT-IO/BR[OBS-Place], IDENT-IO/BR[APR-Place]

ONSET, HAVE PLACE, R-ANCHOR-MAXROOT, R-ANCHOR-IDENTROOT[Place]

* C-PLACE/X

MAX-IO, MAX-BR

IDENT-IO/BR[NAS-Place]

Before concluding this appendix, I briefly examine nasal copy in the formation of perfective verbs. This discussion is included for completeness, but the analysis should be considered as only tentative. The goal of this last segment is to outline how placemarkedness constraints already in the system can be used to offer explanation for an independent restriction in perfective nasal copy. Perfective verbs are formed with a prefix [-me] (82).

Perfective verb form
Gloss

a. me^ta@ 'has touched'
b. me^ju@bo$ 'has gone out'
c. me@m$-ba@mo$ 'has hidden'
d. me@n$-la@m 'has cooked'
e. me@¯$-jiêEm 'has sung'

Nasal copy in the perfective differs from the previous cases we have seen in an important way: the copied nasal in perfective formation is syllabic and transcribed as a tone bearing, while in diminutive, it is metrical and transcribed as a toneless. The nasal in perfective is the most alien among the nasals we have seen in Mbe.

30 It is particularly interesting to contrast the consistently full vowel of [-me] with the reduced quality of the vowel in the [-re]-inchoative prefix when followed by a nasal.

31 In discussing the coda status of copied nasals, Bamgbose (1971: 104-5) also raises the interesting and rather unexpected point that in imperative reduplicants closed by a nasal, the high vowels [i] and [u] occur instead of the expected [e].

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33 To offer explanation for an independent restriction in perfective nasal copy, the analysis should include how placemarkedness constraints already in the system can be used to do so.
The copied nasal that occurs in perfective formation is also exceptional in a second respect: it can copy a nasal in the verb stem in the usual way or it can copy asyllabic nasal pronoun to its left. Correspondence to a nasal pronoun is not possible in the other cases of nasal agreement (compare inchoative forms below).

<table>
<thead>
<tr>
<th>(83)</th>
<th>Perfective verb form</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>n$    me@n$</td>
<td>'I have touched'</td>
</tr>
<tr>
<td></td>
<td>o$    me^</td>
<td>'you have touched'</td>
</tr>
<tr>
<td>b.</td>
<td>n$    me@m$</td>
<td>'I have helped'</td>
</tr>
<tr>
<td></td>
<td>E$    me^</td>
<td>'he has helped'</td>
</tr>
<tr>
<td>c.</td>
<td>n$    me@n$</td>
<td>'I have slept'</td>
</tr>
<tr>
<td></td>
<td>e@    me^</td>
<td>'it has slept'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(84)</th>
<th>Inchoative verb form</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>d.</td>
<td>n$    re^lç^e$tÉsiê</td>
<td>'I have started to burn the tree'</td>
</tr>
<tr>
<td></td>
<td>*re$n@lç^e$tÉsiê</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>n$$    re^bç@ro$</td>
<td>'I have started to help the friend'</td>
</tr>
<tr>
<td></td>
<td>*re$m@bç@ro$</td>
<td></td>
</tr>
</tbody>
</table>

Although fascinating, the availability of copy of material in a preceding pronoun will not be analyzed here. I will simply note that it is possible that the syllabic status of the copied nasal in perfective forms may contribute to the availability of this alternative.

On the strength of the evidence from diminutive and inchoative prefixations for a separate RED affix in nasal segment/null copy, I assume that affixation in perfective verbs is complex, consisting of a prefix [me]- and a separate purely reduplicative prefix. I hypothesize that the syllabic status of the copied nasal in perfective prefixation is driven by a requirement that reduplicated perfective prefix material coincide with a tone. I will refer to this requirement as PERF/TONE, noting that this could perhaps be captured with an affix-to-tone alignment constraint. Because perfective reduplication adds a syllable in order to satisfy this constraint, PERF/TONE and REALIZEMORPHperf must outrank the size-restrictor ALLs:

(84)  PERF/TONE, REALIZEMORPHperf >> ALLs

Although this captures the evidence from diminutive and inchoative prefixation for a syllabic nasal in perfectives, it does not capture the evidence from perfectivized intransitive verbs.

The question is, if the perfective reduplicant can constitute a syllable, why is it not realized as V(N), which would better satisfy syllable peak markedness and MAX-BR? I suggest that the answer may be found in place markedness constraints. These prohibit the occurrence of place features, which must be satisfied by the perfective prefix. The copied nasal in perfectives will not be realized as V(N) unless it does not add a place feature.

### Tableau Illustration

<table>
<thead>
<tr>
<th>PERF/TONE, REALIZEMORPHperf</th>
<th>COPY</th>
<th>RED - REDUFFIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the syllabification of copy of material in perfective prefixation will not be addressed here, I will simply note that it is possible that the syllabic status of the copied nasal in perfective prefixation for a copred nasal in perfectives to come may contribute to the syllabification of this element.

On the strength of the evidence from diminutive and inchoative prefixation for a syllabic nasal in perfectives, it does not satisfy the evidence from perfectivized intransitive verbs.

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<td>b.</td>
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<tr>
<td>c.</td>
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<td></td>
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<tr>
<td>c.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The tableau in (87) shows an example where morpheme realization fails because there is no available nasal to copy and copying other material would necessitate adding a place feature:

(87) Copy fails when no nasal in stem

a. 

b. 

c.

The above rankings have shown that place markedness constraints outrank ALLs. Earlier it was established that ALLs dominated realization constraints for the diminutive and inchoative morphemes. This ranking is consistent with the position of C-P L/X, since realization of the diminutive and inchoative morphemes does not compel violations of place markedness constraints. It also has been determined that the realization constraint for the imperative dominates ALLs. Since imperative reduplication does introduce additional place features, the imperative realization constraint must also outrank C-P L/X and V-PL/X. The domination of MAX-BR by ALLs will keep reduplicant size down to a syllable. Similarly, in nominal affixation, whatever constraint forces some nominal class affix to appear will have to outrank place markedness constraints.

6.2 Cooccurrence effects in Bantu

In this section I examine a nasal agreement phenomenon occurring in certain Bantu languages (Johnson 1972; Howard 1973; Ao 1987), among others. This is similar to agreement phenomena occurring in certain other languages. The motivation for a cooccurrence analysis is sketched here and the details are left for further research.

33 Something further will be required to explain why the imperative reduplicant does not simply consist of a syllabic nasal when there is a nasal in the base to copy (which is predicted by C-PL/X >> MAX-BR if no more is said). This could be attributed to a prosodic constraint on the imperative reduplicant requiring that it match the canonical form of a verb root (e.g., m-a-) where a nasal is not copied.

Interestingly, there is no limitation on the distance between the alternating suffix and the nasal in the root. Also, intervening vowels and voiceless obstruents are unaffected, remaining oral. This is shown in many cases, e.g. Lamba, there is a requirement that no consonants intervene between the root nasal and suffix consonant. However, as seen in (88), this segment is realized as [d] before [i] (Bentley 1887: 624).
Ao (1991) gives the following examples from Kikongo to show that a nasal-obstruent sequence does not cause the suffix segment to become nasalized, nor does it prevent a preceding nasal from being realized. Another view is that the plain nasalization results from cooccurrence of a suffix consonant with a root nasal.

(89) a. 

<table>
<thead>
<tr>
<th>Stem</th>
<th>Suffix</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>tu-bing</td>
<td>idi</td>
<td>'we hunted'</td>
</tr>
<tr>
<td>tu-bing</td>
<td>ulu</td>
<td>'we were hunted'</td>
</tr>
<tr>
<td>tu-kong</td>
<td>idi</td>
<td>'we tied'</td>
</tr>
<tr>
<td>tu-kong</td>
<td>olo</td>
<td>'we were tied'</td>
</tr>
</tbody>
</table>

b. 

<table>
<thead>
<tr>
<th>Stem</th>
<th>Suffix</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>tu-meng</td>
<td>ini</td>
<td>'we hated'</td>
</tr>
<tr>
<td>tu-meng</td>
<td>ono</td>
<td>'we were hated'</td>
</tr>
<tr>
<td>tu-mant</td>
<td>ini</td>
<td>'we climbed'</td>
</tr>
<tr>
<td>wu-mant</td>
<td>unu</td>
<td>'it was climbed'</td>
</tr>
</tbody>
</table>

The data in (88-89) show the nasal agreement in suffix consonants. Nasal agreement does not induce oral/nasal alternations in root segments; however, as noted by Ao (1991: 195-96, n. 3) and Piggott (1996), the nasal segments are analyzed as prenasalized stops by Piggott (1996) (Hyman 1995 makes a similar assumption for Yaka).

(90) Kikongo consonant distribution:

Within a stem, a voiced consonant to the right of a nasal consonant is a nasal.

The first question for an analysis of this distribution is what phonological mechanism brings about the nasal distribution in (90)? In previous work, this nasal-agreement phenomenon has been analyzed as the result of spreading of [nasal] over the root vowel of a suffix consonant that is nasal, although some authors have noted that this may involve an affixation process.

35 Kikongo exhibits a height harmony in suffix vowels such that the high vowels \([i, u]\) lower to \([e, o]\) when the root vowel is \([e, o]\).

The important generalization established by the study of nasal harmony in chapter 2 that [+nasal] spreading occurs only between strictly adjacent segments. Second, the set of target segments does not obey the OCP, which bans adjacent [+nasal] segments. Within a stem, the nasal segment is a suffix consonant that is nasal, although some authors have noted that this may involve an affixation process.

With spreading and reduplication ruled out, I turn to another kind of phonological mechanism which has not yet been considered, namely, cooccurrence restrictions. Cooccurrence restrictions are a kind of spreading and reduplication that I turn to another kind of phonological mechanism which has not yet been considered. Odden (1994; 1996) points out that the Bantu nasalization effects along these lines explains both its non-locality and the kinds of segments targetted.

In the history of analysis of cooccurrence conditions, an important breakthrough was the discovery of many cooccurrence effects. Although the OCP serves to explain many cooccurrence effects, it is insufficient in explaining the broad range of phenomena in a work of other domains. I suggest that the basic facts of nasal harmony are a kind of spreading and reduplication that I turn to another kind of phonological mechanism which has not yet been considered. Odden (1994; 1996) points out that the Bantu nasalization effects along these lines explains both its non-locality and the kinds of segments targetted.
Mester 1986; Sagey 1986; Walker 1997c, Flemming 1998). An example of the latter kind comes from Ngbaka, a Niger-Congo language, reported by Thomas (1963) and discussed by Mester (1986) and Sagey (1986). Thus, nasal and prenasal are excluded together, also prenasal and voiced (oral), and voiceless with voiced (oral).

(91) voiceless obstruent - voiced obstruent - prenasalized voiced obstruent - nasal

e.g.     [p]          
     [b]     
     [mb]         
     [m]

Kera (Chadic) exhibits a similar restriction banning a mix of voiced and voiceless stops/affricates within the word (Ebert 1979; Odden 1994). This restriction induces voicing in affix stops when the stem contains a voiced obstruent (e.g. /ki-\dÉZir-ki/ [gi-\dÉZir-ki] 'colorful' (masc.); cf. /ki-sar-ki/ [gi-sar-ki] 'black' (masc.)). The cooccurrence restrictions in Ngbaka and Kera are strikingly similar to the nasal agreement phenomenon in Kikongo: two similar but conditionally different nasal inventories, one with segments matching in nasality or voicing in Kikongo, the other with segments matching in nasality or voicelessness in Ngbaka. The cooccurrence restrictions in Ngbaka and Kera are strikingly similar to the nasal agreement phenomenon in Kikongo: two similar but conditionally different nasal inventories, one with segments matching in nasality or voicing and the other with segments matching in voicelessness.

To review, although the Kikongo pattern of nasal agreement may at first appear to be a completely different type of nasal harmony (with [+nasal] feature spreading), the consonant distribution patterns of Ngbaka and Kera indicate that the cooccurrence restrictions in Ngbaka and Kera are strikingly similar to the nasal agreement phenomenon in Kikongo: two similar but conditionally different nasal inventories, one with segments matching in nasality or voicing and the other with segments matching in voicelessness.

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[\m
[\n[\n[\n
[\n[\n[\n[\n
[\n[\n[\n[\n
(16) nasal - prenasalized voiced obstruent - voiced obstruent - voiceless obstruent.

Kera (Chadic) exhibits a similar restriction banning a mix of voiced and voiceless stops/affricates within the word.
References


Bhat, D. N. S.  1975.  Two studies on nasalization.  In Ferguson, Hyman, and Ohala., eds., *pp. 27-47.


Frisch, Stefan, Michael Broe, and Janet Pierrehumbert. 1997. Similarity and phonotactics in Arabic. Ms., Indiana University and Northwestern University.


Hayes, Bruce, and Tanya Stivers. In progress. The phonetics of postnasal voicing. Ms., UCLA.


Lightner, Theodore M. 1965. On the description of vowel and consonant harmony. Word 21, 244-250.


