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 impedence). 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 targetted by nasal spreading, all more compatible segments will also be targetted. 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. For example, Olfa and Olma (1993; Olfa, Salé, and Young, 1995) show that nasalization of nasal vowels does not arise in the production of a novel, and both nasality and vowel quality are relatively well perceived together in comparison to other nasalized systems (although nasalization is poorly understood). Olfa and Olma (1997; Olfa, 1995a; Padgett 1995) point out that the incompatibility of nasalization with acoustic/aesthetic criteria is also well-known from perception of nasal quality: see, for example, Wright 1986: Padgett 1997, on the basis of both articulatory/aerodynamic and acoustic/aesthetic criteria. 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Spreading across the [-nasal] segment is ruled out by No Crossing (4a). In (4a), [-nasal] feature spreads to the segment specified as [-nasal], according to the spreading prescription for the [-nasal] segment and blocking of spreading the [-nasal] segment. This is consistent with the spreading prescription for [-nasal] applying at the spreading of [-nasal] and blocking the spreading of [-nasal] in nasal harmony. This suggests that spreading through the spreading of [-nasal] in nasal harmony, the [-nasal] spreading of [-nasal] to [-nasal] is blocked, and the spreading of [-nasal] to [-nasal] is halted in nasal harmony. In nasal harmony, spreading through the spreading of [-nasal] in nasal harmony, the [-nasal] spreading of [-nasal] to [-nasal] is blocked, and the spreading of [-nasal] to [-nasal] is halted in nasal harmony.

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 but do not block nasal spreading (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 a].
   c. Blocking or opaque segments: Segments that remain oral and block nasal spreading, e.g. /nata/ [na-ta].
   d. Transparent segments: Segments that remain oral and 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 necessary to collapse some of these categories 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 of the spreading of [-nasal] to [-nasal], a spreading that is ruled out by No Crossing (4b).

The spreading of [-nasal] to [-nasal] is ruled out by No Crossing (4a). In (4a), [-nasal] feature spreads to the spreading of [-nasal] and blocking of spreading [-nasal] in nasal harmony. The spreading of [-nasal] to [-nasal] is blocked, and the spreading of [-nasal] to [-nasal] is halted in nasal harmony.

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For segmental transparency, representational accounts invoke configuration in which spreading takes place by skipping over transparent segments, which are minimal, consisting of features linked directly to root nodes. This 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 need for calling on segmental skipping configurations in feature linking to obtain transparency effects has been called into question (Ní Chiosáin and Padgett 1997; cf. also Gafos 1996; for an example). This kind of approach to nasal harmony is employed by Piggott (1992) in part by simply skipping the target node, yielding a gapped configuration across the transparent segment (gapping), as in (5a). Feature-geometric accounts of transparency include nasal harmony under a constraint that prohibits nasal harmony with a set of blocking configurations, namely nasal harmony with the target node itself (Ní Chiosáin and Padgett 1997; cf. also Gafos 1996; for an example). This kind of approach to nasal harmony is employed by Piggott (1992) in part by simply skipping the target node, yielding a gapped configuration across the transparent segment (gapping), as in (5a). Feature-geometric accounts of transparency include nasal harmony under a constraint that prohibits nasal harmony with a set of blocking configurations, namely nasal harmony with the target node itself (Ní Chiosáin and Padgett 1997; cf. also Gafos 1996; for an example).
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 are often interpreted as being generated by low-ranking constraint candidates where harmony is considered or as violations of ranked and violable constraints, the account brings new insight to the understanding 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 is based on the idea that 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 output forms selects the actual output by virtue of it being the most harmonic or optimal with respect to the constraint hierarchy.

The goal of constraint ranking is thus to set a hierarchy of constraints, often at the interface of the phonological and phonetic domains, which guides the selection of optimal candidates. The hierarchical structure of constraints is crucial in determining the order in which constraints are evaluated, and the ranking is determined by the input and the specific constraints involved. The ranking is also defined by the context in which the constraints are applied, and the optimal output is selected based on the highest ranking constraint violations.

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The evaluation of these candidates is performed in relation to the hierarchy of constraints of which I have shown a segment here, with a markedness constraint for forbidding nasalized liquids (*NASLIQUID, abbreviating a feature cooccurrence constraint) ranked over a constraint requiring that the feature [+nasal] spread to all segments in the word (SREAD [+nasal]). Evaluation is performed from left to right. First examining the column for *NASLIQUID, it is apparent that candidate (c) incurs a violation (marked by '*'). This violation is fatal for this candidate, since there are competitors which do not violate it. The fatality is signalled by the exclamation mark and succeeding columns for this candidate are shaded. Moving on to the SREAD [+nasal] constraint column, candidate (a) better satisfies the spreading constraint than (b), because (a) has failed to spread to only one segment, while (b) has failed to spread to two. This is because (a) only involves a [+nasal] feature change to the vowel but not the liquid, is thus the winner of this candidate set, as signalled by the right-pointing hand.

1.3.2 Constraints and Correspondence theory

Constraints according to their compatibility with each other: 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: 84). Important, factorial ranking of constraints may be modulated by fixed rankings of sets of related constraints given by phonetic or harmonic scales (Prince and Smolensky 1993). These fixed rankings will be factored out from the possible permutations. The constraints of Con fall into two main categories: markedness constraints and faithfulness constraints.
ALIGN(Cat1, Edge1, Cat2, Edge2) = def "Cat1 ∈ Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide."

Where Cat1, Cat2 ∈ PCat ∩ GCat

Edge1, Edge2 ∈ {right, left}

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 discussed in chapter 6. Analogous analysis of the nature of nasal spreading in languages like Tuyuca; however, this distinction is not crucial 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 between input and output, and between base and reduplicant, are given in (9). This is the Basic Model of McCarthy and Prince (1995).

(9) The Basic Model
Input: /Af + Stem/

Output: R

(a) MAX
Every segment of S1 has a correspondent in S2. (No deletion of segments.)

(b) DEP
Every segment of S1 is a correspondent of S2. (No addition of segments.)

Input-output faithfulness (Faith-IO) evaluates faith between input and output, and base-reduplicant faithfulness (Faith-BR) evaluates faith between a base and reduplicant. Focusing on the correspondence of strings, McCarthy and Prince (1995: 262) define correspondence as in (10) where S1 refers to an input or base and S2 refers to an output or reduplicant.

\[
\text{Correspondence: } S_1 \leftrightarrow S_2 \quad (10)
\]

Constraints on the correspondence of strings, McCarthy and Prince (1995: 262) define reduplicant faithfulness (Faith-REDBR) as being between a base and reduplicant. Reading from the left:

Input-output faithfulness (Faith-IO): correspondences between input and output and base-reduplicant faithfulness (Faith-BR): correspondences between base and reduplicant.

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Input-output faithfulness (Faith-IO): correspondences between input and output and base-reduplicant faithfulness (Faith-BR): correspondences between base and reduplicant.
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 plausibility of the output form. If an input were to map to a possible output, nasalized vowels will thus occur in the general case in the underspecified representation of the language. However, constraints hold on outputs and nasality properties are not assumed to hold of inputs.

In OT, a distinction may be drawn between inputs and underspecified representations of the language.

The underspecified case in the underspecified representation of the language:

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<tbody>
<tr>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>NASVOWEL</td>
<td>IDENT-[±nasal]</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 tableau below for a language with /da/ and /da/ as inputs. Constraints hold on outputs and nasality properties are not assumed to hold of inputs. In the general case, nasalized vowels are prohibited in the language.

The underspecified case in the underspecified representation of the language:

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<td>IDENT-[±nasal]</td>
</tr>
</tbody>
</table>

With the principle of Richness of the Base and constraints holding of outputs, nasalized vowels will be selected as the optimal input or underspecified form is the one that most closely resembles the optimal form.

In the underspecified case in the underspecified representation of the language, the constraint hierarchy is the one that most closely resembles the optimal form.
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 $SPREAD^{+nasal}$, 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, $SPREAD^{+nasal}$ must outrank $\ast NASVOWEL$. 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 /$\text{na}$/. Since this form is closer to the actual output than /$\text{na}$/, Lexicon Optimization will select the form with the nasalized vowel as underlying in this case:

\[
\begin{array}{c|c|c|c}
\text{Input} & \text{Output} & \text{Faith} & \text{Markedness} \\
\hline
SPREAD^{+nasal} & \ast NASVOWEL & + & + \\
\end{array}
\]

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.

1.4 Organization of the thesis

The organization of the thesis is as follows. Chapter 2 develops a description and analysis of a cross-linguistic database on nasal harmony and the corresponding analysis of harmonic sympathy. Chapter 3 turns to the matter of analysis of transparent segments. Here I propose that surface transparent outcomes be analyzed as a (derivational) opacity effect. I develop an analysis calling on the framework of Sympathy theory. Tuyuca, a Tucanoan language of Colombia, forms a case study in this chapter for transparency and nasal harmony. Chapter 4 presents an acoustic study of Guaraní, a Tupí language of Paraguay. This acoustic investigation first establishes that so-called 'transparent' voiceless stops in the nasal harmony of Guaraní show an allophonic distribution and they also have implications for the phonetic correspondents of phonological features.

In chapter 5 I consider other proposals for the analysis of transparent segments and the typology of nasal harmony. Finally, in chapter 6 I examine other phenomena that may be mistaken for nasal harmony but I argue are not instances of nasal features spreading. A nasal agreement phenomenon in Mbe forms a case study.
and morphological evidence from the language is assembled to support an analysis of nasal agreement as a case of nasal copy, i.e., reduplication. The limitation of copy to nasal segments is shown to fall out from independently motivated rankings in the language and constraint rankings predicted by constraint proliferation. The chapter concludes with a brief examination of long-distance nasal agreement effects in some languages, and constraint rankings predicted by constraint proliferation. The chapter concludes with a brief examination of long-distance nasal agreement effects in some languages, and constraint rankings predicted by constraint proliferation.