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 (‘phonetic grounding’ after Archangeli and Pulleyblank 1994). As Cohn (1993a) points out, the (in)compatibility of segments with nasalization is judged on the basis of both articulatory/aerodynamic and acoustic/perceptual factors. For example, vowels are relatively compatible with nasalization from both phonetic perspectives: a lowered velum does not interfere with the production of a vowel, and both nasality and vowel quality are relatively well-perceived together in comparison to other nasalized continuants (although nasalization is well-known to have effects on perception of vowel quality; see, for example, Wright 1986; Padgett 1997; with foundation from Ruhlen 1975; Beddor 1983). In contrast, fricatives are poor on compatibility with nasalization. A nasalized fricative is problematic aerodynamically, because the lowered velum conflicts with the build-up of air pressure behind the constriction needed to produce turbulent airflow (J. Ohala 1975; Ohala and Ohala 1993; Ohala, Solé, and Ying 1998). It thus is difficult to produce audible frication and simultaneous audible nasalization. These phonetic considerations yield a relatively low placement for vowels in a scale of incompatibility with nasalization and a relatively high ranking for fricatives, corresponding to their patterning across languages.

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 nasal harmony. These crucial elements are the notions of constraint ranking and constraint violability. An optimality-theoretic grammar contains a language-particular hierarchy of universal constraints which simultaneously evaluate a set of possible output candidates. The candidate which is most harmonic with respect to the constraint hierarchy is the one which wins. Prince and Smolensky (1993: 84) note that language typologies will be derived by factorial constraint ranking, i.e. cross-linguistic variation is obtained by different rankings of the set of universal constraints, and the set of possible languages will be given by the set of possible rankings (factoring out fixed rankings, such as the nasalization constraint hierarchy). In the case of nasal harmony, I show that ranking of the constraint driving nasal spreading at all of the possible points in relation to the nasalization hierarchy achieves precisely the cross-linguistic variation which is attested. Importantly, the unified typology is obtained by positing *all* of the nasalization constraints as violable.

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 nasalization in nasal spreading) and should be regarded as belonging to this set of segments. The evidence for this claim is two-pronged. One point concerns a complementarity between systems with blocking segments (i.e. segments that remain oral and block nasal spreading) and those with transparent segments, identifying a complementary relationship between the sets of possible targets and transparent segments. 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 unexplained complementarity. The second point stems from the observation that transparent segments exhibit the same hierarchical implications as targets: if a segment behaves transparent, all more compatible segments will undergo nasal spreading. This co-patterning is explained under the analysis of transparent segments as targets. A consequence of this move is that segments behave in only one of two ways in nasal harmony, they either undergo [nasal] spreading or they block, so spreading never skips an intervening segment. This account thus offers new evidence for the strict segmental locality of feature spreading, that is, restricting feature spreading to taking place between strictly adjacent segments (after Ní Chiosáin and Padgett 1997; cf. Gafos 1996; foundational work includes Ní Chiosáin and Padgett 1993; McCarthy 1994; Flemming 1995b; Padgett 1995a; cf. also Allen 1951; Stampe 1979).

With descriptively transparent segments in nasal harmony analyzed as targets of nasal spreading, a new question emerges: what produces the surface transparent outcome for these segments? An acoustic study of ‘transparent’ voiceless stops in Guaraní verifies that this is indeed a question; voiceless stops are truly oral in nasal harmony spans in the language. Following early derivational analyses for transparent segments in vowel harmony proposed by Clements (1976) and Vago (1976), I propose to analyze segmental transparency as an instance of a derivational opacity effect (‘opacity’ in the sense of Kiparsky 1971, 1973), i.e. the kind of phonological outcome obtained in derivational frameworks through the opaque ordering of rules. This kind of approach to segmental transparency makes reference to a representation in which nasalization has spread to all target or transparent segments ([ãtata] → [ãt̃ãt̃ã]) with subsequent rule application or mapping to a form with nasalization of all segments except obstruents ([ãt̃ãt̃ã] → [ãtãtã]). 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 will be a (failed) 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 McCarthy (1997), I call on a faith relation between the sympathy candidate and the actual output to produce (derivational) opacity effects. This faith mapping will select the candidate most closely resembling the nasal character of the fully-spread sympathy form, while respecting a constraint prohibiting nasalized obstruents. The actual output will then be a form with nasalization of all segments except surface-transparent obstruents. Importantly, at no point will it be necessary to make use of a form with a gapped configuration, i.e. one with linkage of a feature across a skipped transparent segment, a representation which has been utilized solely for the purpose of analyzing segmental transparency (see Pulleyblank 1996 for a similar argument against using the gapped configuration, but with a different analysis of segmental transparency; cf. also Archangeli and Pulleyblank 1994; both of these accounts do not assume strict segmental locality and allow targetting of higher level structure, such as moras in vowel harmony). The need for parochial representations with the gapped configuration is thus eliminated, and segmental 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 descriptive 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 are those that that remain oral themselves but allow spreading to continue (2d).

(2) a. *Trigger segments:* Segments that initiate nasal spreading,
e.g. /na/ → [n̲ã].

b. *Target segments:* Segments that undergo nasal spreading,
e.g. /na/ → [nã̲].

c. *Blocking or opaque segments:* Segments that remain oral and block nasal spread, e.g. /nata/ → [nãt̲a].

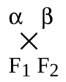
d. *Transparent segments:* Segments that remain oral but do not block nasal spreading, e.g. /nata/ → [nãt̲ã].

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 argued in a later chapter 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 to distinguish these segments. The present work places less focus on assumptions about representations, but before previewing this, I will briefly review the representational-derivational approach. In the representationally-driven kind of account, explanation of blocking makes use of the standard autosegmental assumption of the No Crossing Constraint, which forbids line crossing (Goldsmith 1976).

(3) No Crossing Constraint

*

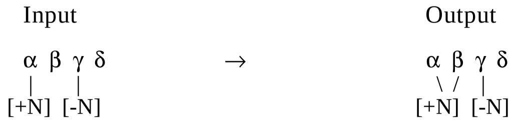


As various analysts have noted, the ill-formedness of line crossing can be understood in terms of contradictory precedence relations (see Sagey 1988; Hammond 1988; Scobbie 1991; Archangeli and Pulleyblank 1994). On the one hand, α precedes β on one tier, and F_1 precedes F_2 on another tier. However,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

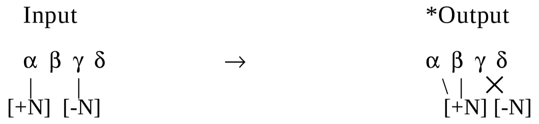
Using the No Crossing Constraint, many representationally-based accounts achieve blocking of spreading through the presence of structure. In nasal harmony, this could consist of the presence of a [-nasal] specification on the blocking segment. This is illustrated in (4). In (4a) the [+nasal] feature spreads up to the segment specified as [-nasal]. Spreading across the [-nasal] segment is ruled out by No Crossing (4b).

(4) Representational approach to segmental blocking

a.



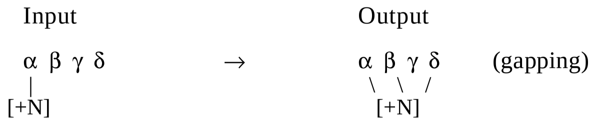
b.



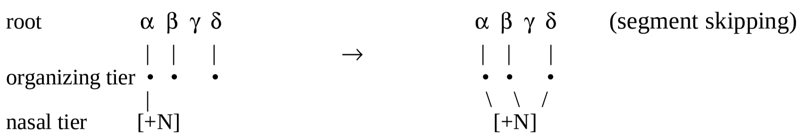
For segmental transparency, representational accounts make use of a configuration in which spreading takes place across an intervening segment. In some accounts, this may occur by simply skipping the target node, yielding a gapped configuration across the transparent segment (γ), as in (5a). Feature-geometric approaches avoid gapping across a target node by positing a more elaborated segment structure in which the spreading feature is dependent on an organizing tier (for example, a supralaryngeal tier). With this model, the skipping effect comes about by virtue of the absence of structure, i.e. when a segment lacks the target node for feature spreading in its representation. The standard assumption of locality in a feature geometric framework is that node adjacency is evaluated on its own tier, so locality is not violated in linking across an intervening segment provided that no target nodes themselves are skipped. An example of this kind of segmental skipping (of γ) is shown 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.

(5) Segmental transparency by gapping/skipping

a.



b.



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 foundational analyses see Ní Chiosáin and Padgett 1993; McCarthy 1994; Flemming 1995b; Padgett 1995a; more generally on disallowing gapping across targets see Kiparsky 1981; Levergood 1984; Archangeli and Pulleyblank 1994; Pulleyblank 1996). The ill-formedness of spreading across intervening segments is a formal theoretical issue which will be discussed in chapter 2. In addition to the formal dimension there is the question of motivation and explanatory adequacy. On the subject of motivation, it is matter of concern that this kind of skipping representation is utilized solely to obtain segmental transparency. Even with this neutrality-specific device, there are problems in the explanation provided. Given the representational assumptions concerning segmental blocking and transparency, no single feature-geometric structure can produce the blocking behavior of obstruents in some languages and their transparent behavior in others. This dilemma leads Piggott (1992), to propose that there are two kinds of nasal harmony which differ in the dependency of the feature [nasal] in the geometry: in harmony with a set of blocking consonants, [nasal] appears under a certain organizing node in (some) consonants, while in patterns with transparent obstruents, [nasal] is dependent on another organizing node present only in sonorants. While it offers the best available analysis under feature-geometric assumptions of segmental neutrality, the variable dependency account is unsatisfying in that it fails to find a commonality across all nasal harmony patterns. This is a result driven in part by the assumption that spreading takes place by skipping over transparent segments, which lack target structure.

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 has led us astray from perceiving a unified understanding of nasal harmony patterns, whether they exhibit examples of segmental blocking or transparency. The autosegmental representations I assume are minimal, consisting of features linked directly to root nodes. Generalizations concerning feature class behavior 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 should be regarded as undergoers of feature spreading, giving just two kinds of outcomes for segments with respect to spreading: they can be targets or blockers. Segmental transparency is analyzed as the result of the independently-motivated theoretical mechanism which obtains (derivational) opacity effects. To obtain blocking effects I do not assume input specification of [-nasal] on blocking segments, rather I call on optimality-theoretic, output-oriented feature cooccurrence constraints prohibiting the combination of [+nasal] with different segmental classes (with basis in the proposals of Kiparsky 1985; Pulleyblank 1989; Archangeli and Pulleyblank 1994). Analyzing blocking in this way has two important benefits. First, because the feature cooccurrence constraints are ranked, it provides a formal means of incorporating the hierarchical cross-linguistic variation in sets of blockers and targets across languages. Arraying the nasalization constraints according to phonetic compatibility gives a fixed nasalization constraint hierarchy, and then hierarchical variation comes out as differences in where languages make the cut between segments that are compatible enough with nasalization to undergo nasal spreading and those that are not. Second, positing nasal feature cooccurrence constraints as violable (in an optimality-theoretic model) rather than necessarily respected in the output of languages, yields not only the cross-linguistic variation, but it is also crucial to obtaining a unified account of nasal harmony. An insight of this study is that transparent segments pattern with targets; in order to achieve this, transparent segments must also be able to undergo nasal spreading, requiring a notion of all nasalization constraints as potentially violable in outputs. By turning the analytical focus away from representational explanation and towards outcomes of hierarchies 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 departs from generative frameworks in which a sequence of rules are applied to an input to carry it through various intermediate forms to a surface output. Optimality Theory instead conceives 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 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 select all and only those outputs which are well-formed in the language.

In an optimality-theoretic grammar there are three components: *Gen*, *Con*, and *Eval* (Prince and Smolensky 1993). Gen is a function which generates the range of candidate outputs for an input *i*. Gen includes the primitives of phonological structure and contains information about the inviolable elements of their organization. In generating the infinite set of candidate outputs for a given input, it is constrained by these inviolable primitives but otherwise posits strings and structures freely, which may or may not resemble the input form. Con is the set of universal constraints out of which grammars are constructed. The constraints belonging to Con are those that may be violated in the candidate outputs of a language. While the members of Con remain fixed across languages, language-particular orderings are imposed on the constraints; this ranking is the language-particular component of the grammar Γ. Selection of the optimal candidate from the infinite candidate set falls to Eval. Eval is a function that comparatively evaluates the set of output candidates with respect to a given constraint hierarchy, the ranking of Con that constitutes Γ. 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 Γ to select the optimal output, the actual output form for the input.

(6) Schema for an optimality-based grammar:

a. Gen (input_i) → $\{\text{cand}_1, \text{cand}_2, ...\}$

b. Eval (Γ, $\{\text{cand1}, \text{cand}_2, ...\}$) → $\{\text{cand}_{\text{real}}\}$

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 hierarchy of constraints heads successive columns with ranking descending from left to right. By convention, crucial constraint ranking is marked by solid lines separating constraint columns; if ranking of two constraints is undetermined, they are separated by a dotted line or no line at all. Rows tabulate the violations incurred by each candidate with respect to the hierarchy of constraints. The input here is /nar/, and Gen operates on this to give a set of candidates to evaluate as possible outputs for this input. Three of the more competitive candidates are shown here. 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 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 (SPREAD[+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 this constraint. The fatality is signalled by the exclamation mark and succeeding columns for this candidate are shaded. Moving on to the SPREAD[+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 a case of gradient constraint violation, where violations are computed incrementally on some basis (a formal expression of the spreading constraint and computation of its violations is discussed in chapter 2). Candidate (a), with spreading of [+nasal] to the vowel but not the liquid, is thus the winner of this candidate set, as signalled by the right-pointing hand.

(7) Constraint tableau: *NASLIQUID >> SPREAD[+nasal]

	Input /nar/	*NASLIQUID	SPREAD[+nasal]
☞	a. nãr (cand$_1$)		*
	b. nar (cand$_2$)		**!
	c. nãr̃ (cand$_3$)	*!	

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: 2). In this way, ranking expresses the precedence of one constraint over the other and satisfaction of a higher-ranked constraint can drive the violation of a lower-ranked one. As a result, the optimal output may actually violate many constraints. Constraints thus do not represent surface-true generalizations for the language, rather they express phonological demands which are ranked in their requirement for satisfaction. The demands expressed by constraints will be satisfied whenever possible, and they will be violated in an output only when compelled by higher-ranked and conflicting constraint demands.

As noted above, the universal constraints of Con are ranked on a language-particular basis. Variation across languages comes about as a consequence of permuting the rankings of constraints, and the set of possible grammars is given by the set of all of the possible rankings. Assuming that all rankings are possible, *n* constraints will give *n!* possible grammars, this is the notion of language typology as *factorial typology* discussed by Prince and Smolensky (1993: 84). Importantly, 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. A well-known example of this kind is the syllable peak and margin scales arraying segments according to their sonority (Prince and Smolensky 1993). A case to be discussed in this work is a nasalization scale ranking segments according to their compatibility with nasality.

1.3.2 Constraints and Correspondence theory

The constraints of Con fall into two main categories: *markedness constraints* and *faithfulness constraints.* Markedness constraints are all of those that 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 analysis. I assume that for every feature combination there is a cooccurrence constraint, although this is not crucial to the analysis. Some segments will obviously be more harmonic on phonetic grounds than others, for example, nasal sonorant stops, such as [n] are preferred to nasalized fricatives. This phonetic grounding underlies the tendency for constraints against nasal stops to be low-ranked across languages, explaining their occurrence in almost all every language.

Another important kind of markedness constraint is the family of alignment constraints, which require the nearest possible coincidence of edges of phonological and/or grammatical constituents (McCarthy and Prince 1993b). A general schema for alignment constraints is given in (8) (after McCarthy and Prince 1993b: 2).

(8) Alignment constraint schema

ALIGN(Cat_1, $Edge_1$, Cat_2, $Edge_2$) $=_{def}$
$\forall Cat_1\ \exists Cat_2$ such that $Edge_1$ of Cat_1 and $Edge_2$ of Cat_2 coincide.
Where
$Cat_1, Cat_2 \in PCat \cup GCat$
$Edge_1, Edge_2 \in \{right, left\}$

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 illustrated by their pivotal function in the analysis of Mbe discussed in chapter 6. In addition, building on a proposal of Kirchner (1993) alignment constraints have been used by many analysts to drive feature spreading (e.g. Pulleyblank 1993, 1996; Smolensky 1993; Akinlabi 1996, to appear; Itô and Mester 1994; Cole and Kisseberth 1994, 1995; Walker 1995; Beckman 1998; cf. also Ringen and Vago 1997). Following the work of Padgett (1995b) on nasal place assimilation, the nasal feature spreading constraint in this account (discussed in chapter 2) is not formulated strictly in terms of alignment, in order to emphasize the non-directional 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 constraints. Following McCarthy and Prince (1995), I adopt the Correspondence view of faithfulness. Faithfulness constraints in correspondence theory demand identity of structure and content in the input and output, or in the case of reduplication, between the base and reduplicant (reduplication will become relevant in the analysis of Mbe in chapter 6). An illustration of the systems of faithfulness relations holding in a form with a reduplicative affix is given in (9). This is the Basic Model of McCarthy and Prince (1995)

(9) The Basic Model

Input: $/Af_{RED} + Stem/$
$\uparrow\downarrow$ *I-O Faithfulness*
Output: $R \leftrightarrow B$
B-R Identity

Input-output faithfulness (Faith-IO) evaluates faith between input and output, and base-RED 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 S_1 refers to an element such as an input or base and S_2 refers to the output or reduplicant.

(10) Correspondence
Given two strings S_1 and S_2, correspondence is a relation R from the elements of S_1 to those of S_2. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as correspondents of one another when $\alpha R \beta$.

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 fully satisfying the array of faithfulness constraints. Three kinds of correspondence 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). IDENT constraints refer to the featural content of segments, requiring that correspondent segments be featurally identical to each other (11c). Importantly, IDENT constraints demand identity of featural properties of correspondent segments and do not evaluate correspondence between features themselves.[1] This characterization of featural faith will prove to be crucial in the analysis of segmental transparency as a (derivational) opacity effect. Following Pater (in press) and McCarthy and Prince (1995), I assume that IDENT constraints can be differentiated into [+F] and [-F] versions for the same feature.

(11) a. MAX
Every segment of S_1 has a correspondent in S_2. (No deletion of segments.)

b. DEP
Every segment of S_2 has a correspondent in S_1. (No insertion of segments.)

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[1] While an IDENT conception of featural faith can handle many kinds of featural phenomena and indeed is crucial for some, there are some cases where a correspondence view of features seems to be required. For discussion, see McCarthy and Prince (1995); Lombardi (1995a, 1998); Causley (1996); Walker (1997b); Yip (to appear) (cf. also Lamontagne and Rice 1995).

c. IDENT[F]
Let α be a segment in S_1 and β be any correspondent of α in S_2. If α is [γF], then β is [γF]. (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 hypothesizes that all inputs are possible. The constraints in Con evaluate outputs only (including their faithfulness to the input), and they do not hold of inputs. This gives us a universal set of inputs for all languages. The role of the constraint hierarchy component of the grammar is then to select only those outputs which conform to the phonological generalizations of the language. As a consequence, it is necessary for the analyst to ensure that the constraint rankings proposed for a given language will produce a grammatical outcome for any possible input, even if that input contains structures that never surface in the language.

In OT, a distinction may be drawn between inputs and underlying representations. Input forms belong to the universal set for all languages, and this is the set for which it is the task of the constraint hierarchy of the language to produce only grammatical outcomes. Because more possible inputs exist than actual outputs, there will be a many-to-one mapping from inputs to outputs. On the other hand, for a given output of an actual form in the language, it has been proposed that the learner posits a single underlying representation; this is not just a possible input but one which corresponds to the actual input posited for that lexical item (Prince and Smolensky 1993). In OT, selection of the underlying representation from the set of possible inputs for an output form follows the principle of Lexicon Optimization (Prince and Smolensky 1993: 192; Itô, Mester and Padgett 1995: 593; see also Inkelas 1994). Lexicon Optimization selects as the real input (i.e. the underlying representation), the one of all the potential inputs that is most harmonic with respect to the constraint hierarchy for the language. Thus, of all the possible inputs that map to a particular output, the one that will be selected as the optimal input or underlying form is the one that most closely resembles the output form.

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 the interaction of constraints in the hierarchy. I follow Prince and Smolensky (1993) in assuming that inventories and contrast are emergent properties of the ranking of 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 (*NASVOWEL) 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 output containing an oral vowel. This is illustrated in (12).

(12) *NASVOWEL >> IDENT-IO[±nasal]

/dã/	*NASVOWEL	IDENT-IO[±nasal]
☞ a. da		*
b. dã	*!	

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 des tableaux’ (after Itô, Mester, and Padgett 1995) in (13) which compares the harmonicity of the two possible inputs for the same output. Nasalized vowels will thus not occur in the general case in the underlying representations of the language.

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[2] Note that this assumption concerning contrast is not necessarily a crucial one to the analysis. Flemming (1995a) develops an optimality-theoretic approach called Dispersion Theory (extending ideas of Lindblom 1986, 1990; see Steriade 1995b for related ideas; also Padgett 1997). The Dispersion Theory approach offers some valuable explanation and may well be a preferable alternative, but this is a matter beyond the scope of the present study.

(13) Lexicon Optimization: selecting the underlying representation

Input	Output	*NASVOWEL	IDENT-IO[±nasal]
☞ a. da	☞ da		
b. dã	☞ da		*!

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 *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.

(14) SPREAD[+nasal] >> *NASVOWEL

/na/	SPREAD[+nasal]	*NASVOWEL	IDENT-IO[±nasal]
☞ a. nã		*	*
b. na	*!		

Another input that will map to the same output as in (14) is the one with nasalization of the vowel /nã/. 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:

(15) Lexicon Optimization

Input	Output	SPREAD[+nas]	*NASVOWEL	IDENT-IO[±nasal]
☞ a. nã	☞ nã		*	
b. na	☞ nã		*	*!

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 in the output; oral vowels will occur in underlying representations in the 'elsewhere' environment. As a consequence, the distinction between phonemic versus allophonic distributions does not correspond to a distinction in the possibility of occurring in inputs or even in the set of underlying representations, 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 typology of nasal harmony. In this chapter I exemplify the hierarchical variation in nasal harmony and present the cross-linguistic generalizations established by a comprehensive survey of nasal harmony patterns. I then go on to construct an optimality-theoretic analysis of the cross-linguistic variation in the sets of targets and blockers, making use of a hierarchy of nasalization constraints and exhausting the possible rankings of a nasal spreading constraint in relation to this hierarchy. The nasal harmony database and its findings are summarized in an appendix to the chapter.

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 'Sympathy' theory approach to opacity effects in OT (McCarthy 1997 with extensions by Itô and Mester 1997a, b). While adopting many of the core ideas of standard Sympathy theory, I propose a revised model for designating the sympathy candidate; this revised model is called *harmonic sympathy*. Tuyuca, a Tucanoan language of Colombia, forms a case study in this chapter for transparency and blocking in 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 the language are in fact surface-oral, verifying that there is truly a need to obtain transparency in the output. The chapter goes on to report on a comparison of other acoustic features of voiceless stops in oral versus nasal vocalic environments. It is discovered that while voiceless stops remain oral between nasal vowels, there are context-dependent differences in voice onset time and closure duration. These results signal the need for a distinction between phonological representations and phonetic outcomes, 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 feature spreading. A nasal agreement phenomenon in Mbe forms a case study. Phonological and morphological evidence from the language is assembled to support an analysis of the nasal agreement as a case of nasal copy, i.e. reduplication. The limitation of copy to a nasal segment is shown to fall out from independently-motivated rankings in the language and constraint rankings predicted by factorial typology. The chapter concludes with a brief examination of long-distance nasal agreement effects in some Bantu languages, and it is suggested that these are instances of cooccurrence effects. A direction for further pursuit of this approach is outlined.