

Theoretical and Typological Issues
in Consonant Harmony

by

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Abstract

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The study of harmony processes, their phonological characteristics and parameters of typological variation, has played a major role in the development of current phonological theory. Consonant harmony is a much rarer phenomenon than other types of harmony, and its typological properties are far less well known. Since consonant harmony often appears to involve assimilation at considerable distances, a proper understanding of its nature is crucial for theories of locality in segmental interactions.

This dissertation presents a comprehensive cross-linguistic survey of consonant harmony systems. I show that the typology of such systems is quite varied as regards the properties that assimilate. In spite of this variation, they share a remarkably uniform typological profile. For example, the default directionality is anticipatory, with progressive harmony arising from stem-control effects. Furthermore, consonant harmony never displays segmental opacity, unlike other harmony types, and it is never influenced by prosodic factors or bounded by prosodic domains. Finally, consonant harmony is frequently sensitive to the relative similarity of the interacting consonants.

On the basis of these properties, I develop a generalized analysis of consonant harmony within Optimality Theory. A key ingredient is interpreting consonant harmony as agreement (rather than spreading), arising through syntagmatic correspondence motivated by such factors as relative similarity. I show that absolute directionality poses fundamental

problems which previous OT analyses have not dealt with, and propose solving them by appealing to the notion of targeted constraints. A wide range of cases is analyzed in detail, illustrating different directionality patterns as well as subtle interactions between harmony and phonotactics.

A further claim is that these agreement effects are based in the domain of speech planning. I show how consonant harmony systems share a number of characteristics with phonological speech errors. These include the bias towards anticipatory directionality, irrelevance of intervening segments, and similarity effects. A particularly striking parallel involves so-called Palatal Bias effects, robustly documented in research on speech errors, which also characterize coronal harmony processes. Parallels of this kind provide strong evidence in favor of analyzing consonant harmony as agreement at-a-distance, rather than spreading of features or articulatory gestures.

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CHAPTER 1

INTRODUCTION

Harmony is the widespread phenomenon whereby all phonological segments of a particular type within a particular domain (the morpheme, the stem, the word, etc.) are required to agree with respect to some phonological property. Within morphemes, harmony manifests itself as a static cooccurrence restriction, prohibiting disharmonic combinations but allowing harmonic ones, as shown schematically in (1a). When harmony reaches beyond the confines of individual morphemes, on the other hand, it can be directly observed ‘in action’, as it results in *assimilation*: A potentially disharmonic combination is made harmonic by forcing one segment to agree with another in the phonological feature in question, as shown in (1b).

(1) Surface manifestations of harmony in phonological feature [$\pm F$]

a. Harmony within morphemes (static restriction):

<i>Allowed</i>	<i>Prohibited</i>
$/\alpha F \dots \alpha F/$	$*/\alpha F \dots -\alpha F/$
$/-\alpha F \dots -\alpha F/$	$*/-\alpha F \dots \alpha F/$

b. Harmony across morphemes (active process):

<i>Input:</i>	$/\dots \alpha F \dots/ + / \dots -\alpha F \dots/$
	↓
<i>Output:</i>	$/\dots \alpha F \dots/ + / \dots \alpha F \dots/$ (or, alternatively: $/\dots -\alpha F \dots/ + / \dots -\alpha F \dots/$)

Vowel harmony, where the segments that are crucially required to agree in some features are vowels, is quite common cross-linguistically. It is well-attested on all continents, in all major language families, and examples are attested of vowel harmony involving just about every phonological feature that has been used to cross-classify the vowel space (backness,

rounding, height, tongue-root advancement or retraction, etc.). Likewise, vowels and consonants are frequently required to agree with each other in properties such as nasalization or pharyngealization ('emphasis'); we might refer to such harmony systems as 'vowel-consonant harmony'. The phonological and typological properties of vowel harmony and vowel-consonant harmony systems have been studied in great detail in the theoretical literature. A considerably much rarer kind of harmony phenomena is when consonants of a particular type are required to agree with each other in some property, often across a considerable stretch of intervening vowels and consonants – where these intervening segments do not appear to participate in the harmony in any obvious way. This phenomenon is what is referred to as *consonant harmony*. Because of its relative rarity in the world's languages, consonant harmony is not as well documented as other types of harmony. This in turn has stood in the way of developing a full understanding of the nature and characteristics of this phonological phenomenon.

Nevertheless, consonant harmony has figured quite prominently in the literature on phonological theory over the past two decades, especially as regards issues of *locality* in phonological interactions. However, the argumentation has tended to be based on a small number of well-known cases. Even the most ambitious survey-oriented studies to deal with consonant harmony systems, Shaw (1991) and Gafos (1996[1999]) are relatively limited in their scope and the number of cases surveyed (the same is true of Odden 1994, who also deserves mention here). The present study offers the most detailed typological study of consonant harmony phenomena in the world's languages to date, based on an extensive survey of attested consonant harmony systems.

The magnitude of the database that underlies this study allows several important typological generalizations to emerge, which have eluded previous researchers in this area, and which strongly suggest that consonant harmony is fundamentally different from most cases of vowel harmony as well as 'vowel-consonant harmony'. These generalizations in

turn from the basis of a generalized phonological analysis of consonant harmony systems, couched here in the framework of Optimality Theory (Prince and Smolensky 1993). Finally, the interpretation and analysis of this phenomenon that is developed here sheds new light on the relationship between the consonant harmony in the phonological grammars of (adult) languages and the consonant harmony processes that are frequently observed in child language.

1.1. Consonant harmony: A pre-theoretical definition

In a typological study of the kind undertaken here, it is important to adopt a carefully-phrased working definition of the phenomenon about to be surveyed. Firstly, the definition must be wide enough, as one must take care not to build one's expectations or pre-conceptions directly into the definition itself, in order to avoid circularity.

In the most extensive survey of consonant harmony to date, Gafos (1996[1999]) appears to fall into this trap by building the predictions of his theory of articulatory locality (see 1.2.3 below) into the working definition of consonant harmony that the survey is based on. As will be discussed below, an important corollary of articulatory locality is that consonant harmony can *only* involve articulatory parameters controlling the shape and orientation of the tongue tip-blade, since these alone can permeate intervening vowels and consonants without interfering significantly with their articulation or acoustic properties. These are, of course, precisely the parameters which define coronal-specific distinctions such as dental vs. alveolar vs. postalveolar, apical vs. laminal, etc., and the prediction of the theory is thus that coronal harmony is the only *possible* type of consonant harmony. The survey carried out by Gafos (1996[1999]) appears to confirm this prediction, but only because he seems to limit it a priori to coronal harmony systems! No mention is made of long-distance consonant assimilations which do *not* involve such coronal-specific

distinctions, some of which have been widely discussed in the literature, e.g., by Odden (1994).

The result is a circular argument, which seriously weakens Gafos' claim that the theory of articulatory locality is vindicated by the typology of consonant harmony systems. The theory predicts that non-coronal consonant harmony cannot exist, and those attested phenomena which might count as plausible examples of non-coronal consonant harmony are simply ignored in his survey.

In order to avoid such circularity, the present study adopts a simple pre-theoretical working definition of consonant harmony, as stated in (2):

(2) Consonant harmony (definition):

Any assimilatory effect of one consonant on another consonant, or assimilatory co-occurrence restriction holding between two consonants, where:

- a. the two consonants are separated by a string of segmental material consisting of at the very least a vowel; and
- b. intervening segments, in particular vowels, are not audibly affected by the assimilating property.

The definition in (2) is also designed to be narrow enough to exclude phenomena which may well be fundamentally different from consonant harmony as defined here. The restriction in (2a) separates the (apparent) long-distance assimilations involved in consonant harmony from the assimilations under adjacency found in consonant clusters, e.g., /rɪ/ → [l:] or /sdʒ/ → [ʃdʒ]. It should be emphasized that the definition in (2) does not necessarily imply that the two *are* distinct phenomena. However, it is quite *possible* that they are distinct, and collapsing long-distance assimilations and cluster assimilations could therefore

muddle the picture and prevent clear generalizations about one or the other from becoming apparent.

The restriction in (2b), which limits the scope of the study to those assimilations where the intervening vowels and consonants are not *audibly* affected, separates consonant harmony from what was referred to above as ‘vowel-consonant harmony’, i.e. such phenomena as nasal harmony or pharyngealization harmony. Again, the restriction in (2b) in itself does not constitute a claim that these two phenomena are distinct (although that claim will be made and argued for in this work). Indeed, several previous studies have made the claim that the two are essentially the same, and that the intervening segments *are* affected in consonant harmony, although without any readily audible result. The point in (2b) is that we cannot take it for granted that this is the case; consonant harmony *may* be different from vowel-consonant harmony in some fundamental respects, but these will only emerge if we study consonant harmony from the perspective that it is potentially a unique phenomenon.

Finally, another limitation built into the definition in (2) deserves mentioning.¹ This study equates harmony with *assimilatory* interactions; all phenomena involving long-distance *dissimilation* of consonants thus fall outside the scope of this dissertation. In this respect the present work differs from many earlier ones in this area, e.g., Shaw (1991) and Odden (1994). Again, it may well be the case that consonant assimilation and dissimilation are governed by the same principles and constrained in similar ways. But this cannot be taken for granted as an a priori assumption, and the inclusion of dissimilation cases in this study would have raised many additional questions beyond the ones examined here. For example, laterals and rhotics can interact in long-distance assimilation (harmony) as well as dissimilation (‘disharmony’) but the latter seems to be far more common cross-linguistically. Contrasting sibilants such as /s/ and /ʃ/, on the other hand, are that consonant type which is by far the most often involved in long-distance assimilation, whereas extremely few

¹ As regards the inclusion of ‘static’ cooccurrence restrictions alongside ‘active’ assimilations (resulting in alternations), see section 2.3 for justification.

cases of sibilant *dissimilation* are attested (yielding, e.g., /s...s/ → [ʃ...s]). The explanation for such asymmetries is an interesting and important issue in itself, but by excluding dissimilations from the present study, this is left to future investigations.

There is one area where the line between dissimilation and assimilation becomes difficult to draw in practice—that of static cooccurrence restrictions, which govern the permissible shapes of morphemes (typically roots) in many languages. In such cases, the evidence available tells us that certain combination of consonants are disallowed, but we frequently have no way of telling *how* a (hypothetical) input form with the disallowed combination would be ‘repaired’ in the output – by assimilation or by dissimilation. Imagine a language where the sibilants /s/ and /ʃ/ are not allowed to cooccur within morphemes, i.e. /s...s/ and /ʃ...ʃ/ are allowed but */s...ʃ/ and */ʃ...s/ are not. We might account for this by assuming that the language has consonant harmony, and that hypothetical inputs like /s...ʃ/ or /ʃ...s/ do not surface intact because they undergo *assimilation* to [ʃ...ʃ] or [s...s] (thus merging with the faithful outputs of underlying /ʃ...ʃ/ and /s...s/). But it is equally possible—though perhaps less plausible—that the gap is due to *dissimilation*. For example, we might assume instead that the hypothetical inputs /s...ʃ/ and /ʃ...s/ do not surface intact because they undergo dissimilation to, say, [t...ʃ] and [ʃ...t] (provided that such surface sequences are permitted in the language in question).

In the scenario just outlined, the dissimilation alternative may seem rather far-fetched. But the truth is that certain cases which might be analyzed as (morpheme-internal) consonant harmony have in fact been interpreted in this way. In a number of languages, ejective stops are not allowed to cooccur in morphemes unless they are identical (i.e. share the same place of articulation). Thus morpheme shapes like /tʰVk/ and /tʰVtʰ/ are allowed, but not */tʰVkʰ/. One way of stating the generalization is that if cooccurring stops differ in Place, then they may not both be [+constricted glottis]. This characterization is roughly equivalent to saying that a hypothetical input like /tʰVkʰ/ would surface as [tʰVk] (or [tVkʰ])

in the output, i.e. by *dissimilation*. In fact, this is exactly how cooccurrence restrictions of this type are treated in the OT analysis developed by MacEachern (1997[1999]). However, we might just as well paraphrase the generalization as ‘if cooccurring stops are both [+c.g.], then they must also *agree in place of articulation*’. This, then, would be equivalent to saying that an input like /tʰVkʰ/ gets repaired by ‘place harmony’, i.e. assimilation to [tʰVtʰ], rather than ‘laryngeal dissimilation’ to [tʰVk].²

Before proceeding to discuss previous approaches to the analysis of consonant harmony, it is useful to look at a straight-forward case of consonant harmony that fits the definition in (2) above. In the Athapaskan language Navajo, consonant harmony affects the sibilant sets /s, z, ts, tsʰ, dz/ vs. /ʃ, ʒ, tʃ, tʃʰ, dʒ/. Members of the two sets cannot cooccur morpheme-internally (a restriction which dates at least as far back as Proto-Athapaskan-Eyak, cf. Krauss 1964.) Moreover, when sibilants from the two sets are juxtaposed in heteromorphemic contexts, harmony is enforced in a right-to-left fashion, the rightmost sibilant determining the [±anterior] value of any and all preceding sibilants. This is illustrated in (3).

(3) Sibilant harmony in Navajo 1SgPoss prefix /ʃi-/ (data from Sapir & Hoijer 1967)

- | | | |
|----|-----------|-------------|
| a. | ʃi-lí:ʔ | ‘my horse’ |
| | ʃi-ta:ʔ | ‘my father’ |
| b. | ʃi-tʃíh | ‘my nose’ |
| c. | si-tsʰa:ʔ | ‘my basket’ |
| | si-zid | ‘my scar’ |

The forms in (3a) show that the underlying form of the 1Sg possessive prefix is /ʃi-/, and it surfaces as such also when the following stem contains one of the [-anterior] sibilants /ʃ/,

² Notice that this is entirely parallel to the s/ʃ case discussed above. In that case, the choice was between ‘[±anterior] harmony’ (/s...ʃ/ → [ʃ...ʃ]) and ‘[±continuant] dissimilation’ (/s...ʃ/ → [t...ʃ]).

/tʃ/, etc. (3b). However, if a [+anterior] sibilant occurs in the stem, the /ʃ/ of the prefix harmonizes with it (3c), surfacing as [si-] rather than the otherwise regular [ʃi-].

Although the examples in (3) show a prefix harmonizing with a following root, the harmony trigger need not belong to the root but may itself occur in an affix. Furthermore, the harmony is not sensitive to the number of sibilants occurring in the word; the underlying [±anterior] specification of the rightmost one determines the surface [±anterior] value of all preceding sibilants. This is shown in (4).

- (4) Navajo: Interaction of roots, perfective /-s-/ and ‘4th person’ /dʒi-/
 a. dʒi-di-bá:h /dʒi-di-bá:h/ ‘he (4th p.) starts off to war’
 b. dʒi-z-tí /dʒi-s-tí/ ‘he (4th p.) is lying’
 c. dʒi-ʒ-ʏiʃ /dʒi-s-ʏiʃ/ ‘he (4th p.) is stooped over’

The so-called ‘4th person’ (or deictic subject) prefix has the underlying form /dʒi-/, as is evident from forms like (4a), where no sibilant follows. When followed by the perfective prefix /-s-/ (which is voiced to [-z-] under conditions not relevant here), this prefix surfaces instead as [dʒi-] due to consonant harmony (4b). However, when this very same prefix sequence is followed by a root containing a sibilant, as in (4c), it is the root sibilant which determines the [±anterior] value of both preceding sibilants.

Before leaving this simple illustrative example, a few characteristics deserve to be pointed out, which will become relevant in the following chapters. First of all, the directionality is anticipatory (right-to-left), a property characterizing many consonant harmony systems. Secondly, the harmony is neutralizing and feature-changing, in the sense that the prefix sibilants targeted by the harmony are underlyingly specified as [+ant] or [-ant] and this underlying contrast is obliterated by harmony, which forces either [-ant] → [+ant] or [+ant] → [-ant] depending on the circumstances. This, again, is not an uncommon

state of affairs in consonant harmony systems, but is typically not true of vowel harmony systems.³ Finally, the harmony is oblivious to the intervening vowels and (non-sibilant) consonants intervening between the trigger and target sibilants. In (4c), the intervening [ɣ] has no effect on harmony, and the same is true of nonsibilant coronals such as [t] or [n], cf. [dʒi-ʒ-té:ʒ] ← /dʒi-s-té:ʒ/ ‘they two (4th p.) are lying’. As will be discussed at length below, the complete inertness of non-participating segments is a characteristic property of consonant harmony, whereas vowel harmony and ‘vowel-consonant harmony’ processes often display segmental *opacity*, whereby segments of a certain class block the propagation of harmony.

1.2. Previous research on consonant harmony

This section briefly summarizes the discussion and treatment of consonant harmony phenomena in earlier works, focusing on the analysis of consonant harmony within the tradition of generative phonology. Particularly important in this respect are analyses which rely on *spreading* of phonological features and/or articulatory gestures, since one of the major claims made in this thesis is that consonant harmony is in fact not to be construed as spreading at all.

1.2.1. Early sources

It appears that the first to explicitly discuss phenomena that fall under the definition of consonant harmony was the Danish linguist Otto Jespersen. In his textbook of phonetics,

³ Imagine a language with rounding harmony dependent on height (as in Turkish or Yowlumne), where a suffix high vowel agrees in rounding with a preceding high vowel, allowing only CiC+i and CuC+u, but not *CiC+u or *CuC+i. For this rounding harmony to be entirely analogous to Navajo sibilant harmony, it would have to be the case that the language contrasts /u/ and /i/ in suffixes. This contrast would be maintained after *non-high* vowels, where harmony is inapplicable, thus CaC+i would contrast with CaC+u, CoC+i with CoC+u, and so forth. After *high* vowels, on the other hand, the contrast would be neutralized, the suffix vowel taking on the [±rounded] specification of the preceding root vowel: CuC+i → CuC+u (merging with underlying CuC+u) and CiC+u → CiC+i (merging with underlying CiC+i). Vowel harmony systems with these characteristics are at best rare, if not unattested.

he discusses various examples of non-local assimilation, both between vowels and between consonants (Jespersen 1904:170-71). Jespersen argues that cases of assimilation at a distance (Assimilation auf Abstand) are often most appropriately characterized as ‘harmonization’ (Harmonisierung). Jespersen then lists a considerable number of examples of such harmonization, all of which seem to be sporadic diachronic sound changes. The same issue is also discussed in Jespersen (1922:279-80), where a partially overlapping list of examples is presented. Some of Jespersen’s examples of ‘consonant harmonization’ (Konsonanten-Harmonisierung) can be classified as coronal sibilant harmony, including Danish and German ‘vulgar’ [ʃerˈʃant] or [ʃerˈʒant] for *Sergeant* [serˈʃant] and French *chercher* < *cercher* (cf. English *search*) from Lat. *circare*. Interestingly, several of the other examples Jespersen cites appear to be classifiable as major-place harmony, involving labiality, viz. English *brimstone* < *brinstone*, *megrin* < *migraine*, as well as English *pilgrim* and German *Pfriem* from Italian *pellegrino*.

It is clear from the discussion surrounding these examples that Jespersen considers consonant-harmonization to be completely equivalent to the ‘vowel harmonization’ (Vokal-Harmonisierung) observed in other sporadic changes such as Italian *Braganza* < *Brigantia*, *uguale* < *eguale*, *maraviglia* < *miraviglia*, French *camarade* < *camerade*, and the common French pronunciations [ɔʒʁˈdɥi] for *aujourd’hui*, idiolectal [sɔlɔˈnɛl] *solennel*, [ʁɛˈzɛrv] *réserve*, [œʁœpɛˈɛ̃] *européen*, etc. Moreover, Jespersen appears to hold the view that such sporadic vowel harmonizations are in turn the diachronic source of those systematic phenomena that the term vowel harmony is nowadays usually reserved for: ‘[i]n Ugro-Finnic and Turkish this harmony of vowels has been raised to a principle pervading the whole structure of the language’ (Jespersen 1922: 280).

In the context of the present work, it is especially interesting to note that Jespersen appears to consider consonant-harmonization—and perhaps vowel harmonization as well—to have its origins in the domain of speech planning, i.e. in speech errors:

Each word is a succession of sounds, and for each of these a complicated set of orders has to be issued from the brain and to the various speech organs. Sometimes these get mixed up, and a command is sent down to one organ a moment too early or too late. The inclination to make mistakes naturally increases with the number of identical or similar sounds in close proximity. This is well known from those ‘jaw-breaking’ tongue-tests with which people amuse themselves in all countries [...]

(Jespersen 1922:279-80)

Jespersen then goes on to mention the well-known English tongue twister *she sells sea-shells by the seashore...*, and explicitly considers the sporadic change observed in French *chercher* < *cercher* to be equivalent to ‘when we lapse into *she shells* instead of *sea shells* or *she sells*’.

The exact same connection is made by the ethnographer-linguist J. P. Harrington in his posthumously published study of sibilant harmony in Ventureño Chumash (Harrington 1974; the study was written in the 1920s on the basis of data gathered in 1916). Unlike Jespersen, Harrington is here discussing a full-fledged consonant harmony system, rather than sporadic and isolated diachronic changes, but he cites the very same tongue twister as a direct parallel:

Reasons for this harmony are not difficult to discern. Everyone knows how hard it is to make the rapidly alternating adjustments in a sentence such as “she sells seashells” and how awkward the changing sibilants sound in such a sequence. It might therefore be expected that in a language full of sibilants of dull and sharp varieties some means would be devised for simplifying this alternation.

(Harrington 1974:5)

Both Jespersen and Harrington thus express the same general idea—that consonant harmony has its roots in the domain of articulatory planning, and that it is in some sense parallel to the interference effects observed in the production of difficult tongue-twisters (and presumably in speech errors in general). This notion is quite similar to the view of consonant harmony that will be argued for in this study. One should be careful, however, not to read too much significance into the fact that these linguists of the early 20th century appeal to articulatory planning to explain consonant harmony phenomena, since this may in part be due to the hegemony of articulatory rather than auditory (or acoustic) considerations in the field of phonetics at the time of Jespersen’s and Harrington’s writings. Nevertheless, it cannot be denied that the parallel between the ideas expressed by these scholars and the conclusions arrived at in the present study is striking.

Although Jespersen did use the term ‘consonant-harmonization’ (Konsonanten-Harmonisierung) in discussing sporadic sound changes, the currently conventional term ‘consonant harmony’ appears to have been first proposed by Karl V. Teeter in a short article on Wiyot and Cree (Teeter 1959). Teeter briefly mentions phenomena in a number of Native American languages—Wiyot, Cree, Navajo and Wishram—which have to do with consonant harmony (in the sense defined in 1.1 above) and/or sound symbolism. The distinction between consonant harmony, which by definition involves assimilation, and consonant *symbolism* is somewhat muddled, perhaps in part owing to the brevity of the article. However, Teeter does note that Navajo sibilant harmony is ‘purely morpho-phonemic’, in that it is phonologically rather than morphologically conditioned. In the other languages he cites, however, the alleged consonant harmony coexists (and largely overlaps) with elaborate systems of diminutive-augmentative sound symbolism. In Wiyot, for example, the coronals /t, s, l/ are changed to /tʃ, ʃ, r/ in augmentative forms (which also add the suffix /-atʃk/) and to /ts, ʃ, r/ in diminutive forms (which take the suffix /-o:ts/).

As Teeter notes, Wiyot *also* shows the very same alternations in contexts that more closely resemble consonant harmony, in that the conditioning environment is phonologically defined. When a stem contains a consonant of the ‘diminutive’ or ‘augmentative’ type, i.e. /ts/, /tʃ/, /ʃ/ or /r/, affixes with /t, s, l/ will change accordingly.⁴ Thus, for example, a suffixal /s/ is realized as [ʃ] after a stem containing /ʃ/, and a suffixal /l/ is realized as [r] after a stem containing /r/. As instances of consonant harmony, neither of these processes is particularly remarkable; sibilant harmony and liquid harmony is attested elsewhere (cf. the survey in chapter 2). The problem is that in the Wiyot case, the two are ‘collapsed’ into one: /s/ → [ʃ] also takes place after stems with /r/, and /l/ → [r] is likewise triggered by stems with /ʃ/. This makes it far less feasible to analyze the Wiyot phenomenon as consonant harmony in the strictest sense, i.e. as involving assimilation (but see Cole 1987[1991] for an attempt along those lines).

For this and other related reasons, Gafos (1996[1999]) rejects the idea that cases such as Wiyot, where sound symbolism is involved, should be considered examples of consonant harmony: ‘However systematic or interesting these phenomena may be, they cannot be coherently analyzed as instances of assimilation’ (Gafos 1999: 231). Although this is true of most reported cases of sound symbolism, the possibility should not be ruled out that sound symbolism phenomena might be involved in the diachronic development of individual consonant harmony systems; the pervasive identity patterns resulting from sound symbolism might be analogically reanalyzed as being bona fide cases of assimilation (i.e. consonant harmony) rather than global alternations in phonological shape (see section 6.3.3 for discussion).

⁴ Teeter notes a similar phenomenon in Cree, where /t/ → /ts/ in the formation of diminutives (with the addition of a suffix containing /s/), but where the same change is ‘carried over also to some non-diminutive forms with an /s/ near the end of the word’ (Hockett 1956:204). In the latter cases, which seem to be due to a kind of surface analogy, the morpho-semantic conditioning is absent and the /t...s/ → /ts...s/ change seems to be more akin with consonant harmony than sound symbolism.

1.2.2. Consonant harmony in generative phonology

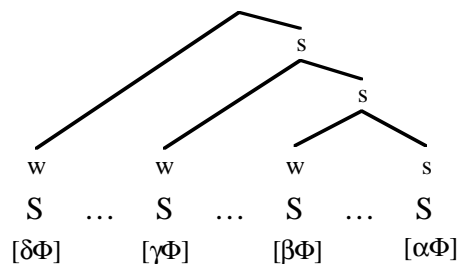
It is safe to say that harmony phenomena and their analysis have played a prominent role in the development of generative phonological theory over the past decades or so. The discussion has tended to focus on vowel harmony systems rather than consonant harmony systems—which is hardly surprising given the fact that the former are vastly more common cross-linguistically than the latter. Perhaps because of this ‘primacy’ of vowel harmony, those theoretical phonologists who have worked on harmony systems have consistently assumed that whatever (synchronic) mechanism or motivation which underlies vowel harmony is also the one operating in the case of consonant harmony systems. This was of course trivially true of classical generative phonology, where all processes of segmental phonology, including assimilation (and thereby harmony as well), were expressed using essentially the same notational scheme of feature-based rewrite rules. But the intuitive idea that consonant harmony and vowel harmony are manifestations of the same basic phenomenon—an a priori assumption which has always been taken for granted, rather than justified with any kind of explicit argumentation—has proven very long-lived, and has survived all the major theoretical innovations that have shaped the development of generative phonological theory over the years.

Halle & Vergnaud (1981) develop an analysis of harmony systems that in part makes use of the formal constructs of metrical phonology (see also the discussion in Poser 1982). Halle & Vergnaud distinguish between two classes of harmony systems. The first is what they refer to as *dominant* harmony—exemplified not only by systems traditionally known as dominant-recessive (e.g., Kalenjin ATR harmony) but also others, such as Akan ATR harmony, Finnish backness harmony and Capanahua nasal harmony. For these phenomena, Halle & Vergnaud adopt an analysis in terms of autosegmental feature spreading. The other class they recognize is that of *directional* harmony, which they exemplify

with rounding harmony in Turkish and Khalkha Mongolian, as well as sibilant harmony in Navajo.⁵

For directional harmony, Halle & Vergnaud suggest that ‘languages make use of a mechanism [...] which is an adaptation of the metrical structure mechanism that is otherwise employed in various stress and accent systems’ (1981:10). Under this view, harmony results from feature percolation by way of a branching metrical-tree structure erected over the participating segments. The trees are either uniquely right-branching, yielding consistent right-to-left harmony (as in Navajo), or uniquely left-branching, yielding left-to-right harmony. The feature specification of the designated terminal element (or ‘head’) of the tree—the one dominated exclusively by strong nodes rather than weak nodes—is copied onto the root of the tree, and percolates downward from there to all terminal nodes of the tree. This is illustrated schematically in (5) for the case of Navajo sibilant harmony; the right-branching tree is erected over any and all coronal sibilants in the word (indicated here by ‘S’). The harmonizing [\pm anterior] feature is denoted here as [Φ] for typographical reasons.

(5) Metrical analysis of right-to-left sibilant harmony (Halle & Vergnaud 1981):



⁵ Interestingly, Halle & Vergnaud (1981) also analyze voicing assimilation in Russian consonant clusters as a case of directional harmony.

The [αanterior] specification of the rightmost sibilant (the ‘designated terminal element’) is copied by rule onto the root of the tree, from whence it percolates down to each and every terminal node, overriding the specifications [βant], [γant], etc. of the preceding sibilants.

Although the metrical formalism developed by Halle & Vergnaud (1981) did not become widely accepted as a well-suited tool for analyzing harmony phenomena, it has certain interesting properties. For example, segments that do not constitute terminal nodes in the tree—nonsibilants in the case of sibilant harmony—are irrelevant to the harmony and thus cannot interfere with or block the propagation of the harmonic feature.

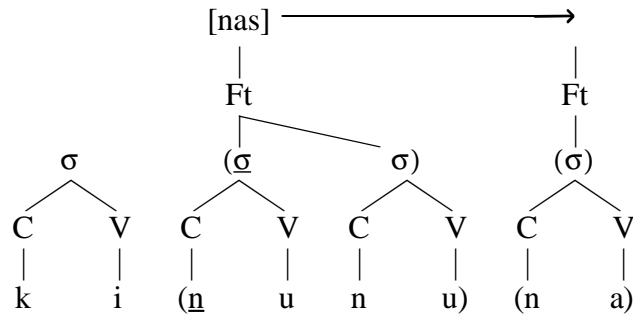
The approach to harmony developed by Piggott (1996, 1997) shares certain affinities with Halle & Vergnaud’s metrical analysis. Piggott’s analysis relies on the notion of prosodic licensing, and takes the view that harmony may hold as a relation either between segments or between suprasegmental units (syllables, feet). On this view, harmony is driven by a family of constraints on featural agreement between adjacent constituents, CONSTITUENT CONCORD or CONCORD for short (Piggott 1996). The constituent type licensing the harmonic feature may be specified parametrically as the segment, the syllable or the foot, and the directionality is also a matter of parametric variation, with CONCORD-R driving left-to-right harmony and CONCORD-L right-to-left harmony. Piggott (1996) uses this formalism to analyze both nasal harmony (e.g., in Malay and Barasano) and nasal consonant harmony (in various Bantu languages; cf. section 2.4.4 below). The latter is analyzed as harmony at the level of either the syllable (e.g., in Lamba) or the foot (e.g., in Kongo). The fact that intervening vowels are not realized as nasal is attributed to Structure Preservation (Kiparsky 1985), and obstruents are likewise unaffected because only sonorant consonants can be nasal-bearers in the languages in question.

The similarity to the metrical-tree analysis lies in the fact that harmony is propagated by way of nodes in a suprasegmental tree structure. Moreover, just as the metrical harmony trees of Halle & Vergnaud’s analyses are ad hoc structures that serve no other purpose than

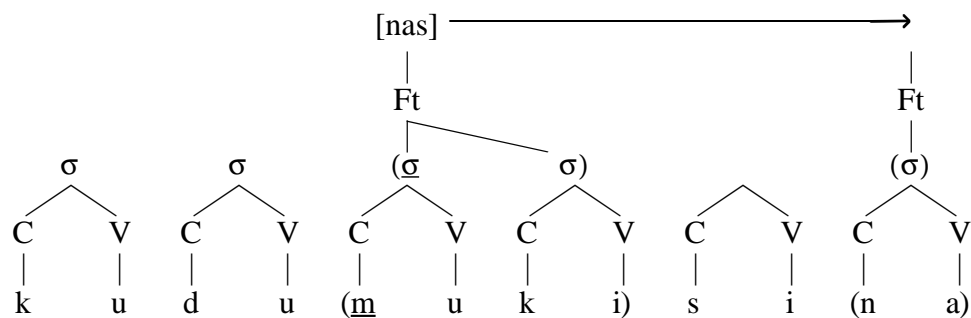
to account for harmony, so too is the suprasegmental ‘foot’ that Piggott (1996) uses to account for unbounded nasal consonant harmony in Kongo. The examples in (6) illustrate how this harmony is captured in Piggott’s analysis. The example in (6a) shows the derivation /-kin-ulul-a/ → [-kinununa] ‘to re-plant’ and (6b) shows /kudumuk-is-il-a/ → [kudumukisina] ‘to cause to jump for (s.o.)’; in both cases an /l/ in a suffix surfaces as [n], harmonizing with a nasal in the preceding verb stem.

(6) Kongo nasal consonant harmony as ‘foot-level’ nasal harmony (Piggott 1996)

a. Underlying representation: /-kin-ulul-a/



b. Underlying representation: /kudumuk-is-il-a/



As should be apparent from the structures in (6), the ‘feet’ which license the nasal feature, and between which nasal harmony is assumed to hold, are *not* the independently motivated metrical constituents that ordinarily govern stress patterns, etc., in most languages. Instead, these are independent constituents whose existence is assumed solely for the purpose of accounting for harmony: ‘[t]he foot that plays a role in harmony is an autonomous unit

called the Harmony Foot (H-Foot)’ (Piggott 1996:158). On Piggott’s analysis, an H-Foot is projected from a segment bearing the harmony feature [nasal] in the underlying representation, and this segment is associated with the *head* syllable of that foot. This is indicated by underlining in the above examples. H-Feet are maximally binary, and in Kongo they are assumed to be trochaic.

In (6a), the disyllabic foot encompasses the second and third syllables, and any and all ‘nasal-bearing’ segments within that foot surface as nasal—hence /lu/ → [nu] in the non-head syllable of that foot. In the disyllabic foot of (6b), on the other hand, the non-head syllable /ki/ contains no nasal-bearing segment and therefore surfaces intact. As for the final syllable in both (6a) and (6b), it is parsed into a (degenerate) H-Foot, to which the [nasal] feature is associated due to the constraint CONCORD-R, indicated by the arrow connecting the two H-Feet. The reason why the penultimate syllable [si] in (6b) is ‘skipped’ is that it contains no nasal-bearing—i.e. nasalizable—segment. Such a syllable can only be parsed into the dependent position of a (trochaic) H-Foot, as the syllable [ki] is, or else remain unparsed altogether, like [si].

It should be emphasized that Piggott’s licensing-based analysis, like all analyses of harmony phenomena to date, equates consonant harmony (as defined in 1.1 above) with vowel harmony and ‘vowel-consonant harmony’, in that all are taken to be manifestations of the same basic phenomenon. Piggott’s applies his analysis both to nasal consonant harmony and to nasal harmony. Furthermore, he suggests that transparency effects in vowel harmony systems indicate that the harmony operates between feet in the languages in question (e.g., Wolof ATR/RTR harmony and Khalkha Mongolian rounding harmony). In such systems, syllables containing a transparent vowel ‘are either assigned to the dependent position in H-Feet or remain unfooted’ (Piggott 1996:171), exactly like the syllables lacking nasal-bearing segments in Kongo.⁶

⁶ Piggott (1996:170) concludes that his theory ‘seems to allow for the occurrence of other cases of long-distance consonant agreement’, but refrains from taking a definitive position on ‘what is responsible for

Although they do allow for interesting possibilities, the full implications of which have yet to be explored fully, analyses in terms of metrical trees or ‘harmony feet’ have not been widely accepted as the preferred treatment of harmony phenomena in generative phonological theory. By far the most common mechanism used to account for harmony—including consonant harmony—is autosegmental feature spreading. The basic properties of this kind of analysis are well enough known that they do not need to be explained in detail. A schematic illustration is given in (7).

(7) Harmony as autosegmental spreading:



The elements X_i , X_j , X_k can be construed either as representing segments (i.e. as skeletal positions or root nodes) or as hierarchical nodes located lower in the feature-geometric tree—e.g., articulator nodes such as [Coronal] or [Labial]. Likewise, the elements here indicated as F, G, H represent either individual features (e.g., [anterior], [nasal]) or superordinate feature-geometric nodes such as [Laryngeal] or [Coronal]. In the scenario in (7a), harmony results in X_k assimilating to X_i by way of [F] spreading from the latter to the former. The intervening element X_j has no effect on this spreading in (7a), whereas in (7b) X_j *blocks* the harmony, since spreading of [F] would result in a line-crossing violation.

Locality is thus an extremely important issue in all spreading-based analyses of harmony. For each individual case, the class of target elements must be appropriately

restrictions on consonant harmony’. Nevertheless, he makes the interesting speculation that any feature which may be licensed by a higher prosodic category, such as the H-Foot, must be compatible (in principle) with *vowels*—given the fact that feet are headed by syllables, which in turn are headed by vowels. From this Piggott draws the conclusion that ‘[c]onsequently, syllable and foot harmonies may be restricted to those patterns in which harmonic features can be organized as vowel features.’ Interestingly, this seems to completely rule out the possibility of coronal harmony (e.g., sibilant harmony)—the most common type of long-distance consonant agreement by far—a corollary of which Piggott appears to be unaware.

defined—e.g., such that in (7a) [F] only spreads to X_k , rather than to *both* X_j and X_k . Secondly, any and all intervening segments that are transparent to the harmony must be unspecified on the tier which contains the spreading feature [F], since otherwise harmony would be blocked as in (7b). Given these assumptions, harmony can be construed as a local relation, in that the interacting segments are ‘adjacent’ on the relevant autosegmental tier (the one hosting F, G, H). This locality requirement has been expressed in slightly different ways in different works (see, e.g., Archangeli & Pulleyblank 1987; Steriade 1987; Shaw 1991; Odden 1994), although they all share the same fundamental idea. Two representative examples are given in (8).

(8) Conditions on locality in phonological interactions

a. Strict Adjacency (Shaw 1991):

The target of a phonological operation must be adjacent to the trigger on the relevant autosegmental tier.

b. Locality Condition (Odden 1994):⁷

In a relation involving A, B and the nodes α , β which they immediately dominate, nothing may separate α and β unless it is on a distinct plane from that of α and β .

Nowhere are the issues of locality and adjacency raised more acutely than in consonant harmony systems, where the trigger and target consonants are often separated by long stretches of intervening segmental material. Following the adjacency conditions expressed in (8), the fact that these intervening segments are *transparent* indicates that they are not

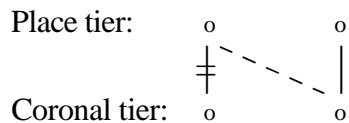
⁷ Odden further assumes that further adjacency conditions may be imposed on individual phonological rules, such as Syllable Adjacency (target and trigger must be in adjacent syllables) or Root Adjacency (the root nodes of target and trigger must be adjacent). Another such language-specific parameter is Transplanar Locality (nothing which separates the nodes dominating target and trigger may also dominate an element on the target tier), which effectively collapses planar distinctions. For example, Transplanar Locality allows intervening labial consonants to block rounding harmony in some languages—on Odden’s assumption that rounding harmony involves the spreading of [labial].

specified on the tier/plane on which the harmony is operating. Most autosegmental spreading-based analyses of consonant harmony phenomena thus rely quite heavily on the representational tools of feature geometry and underspecification.

Shaw's (1991) analysis of coronal harmony in Tahltan is a good example of this general approach. Tahltan has a three-way harmony system involving the fricatives and affricates of the following sets: dental /θ, ð, tθ, tθ', dð/ vs. alveolar /s, z, ts, ts', dz/ vs. postalveolar /ʃ, ʒ, tʃ, tʃ', dʒ/. The rightmost coronal of the /θ/, /s/ or /ʃ/ series triggers harmony on any and all preceding such coronals. Non-coronal consonants and all vowels are transparent to this harmony. More importantly, so are the plain coronal series /t, t', d, n/ as well as the lateral series /ɬ, l, tɬ, tɬ', dl/, as can be seen from such examples as /ja-s-tɬ'etʃ/ → [jaʃtɬ'etʃ] 'I splashed it' or /ni-θi(d)-t'a:ts/ → [nisi't'a:ts] 'we got up'.

Shaw (1991) analyzes Tahltan coronal harmony as resulting from the simple rule expressed in (9), which spreads the rightmost [Coronal] node leftward, with concomitant delinking of the previous [Coronal] specification of the target.

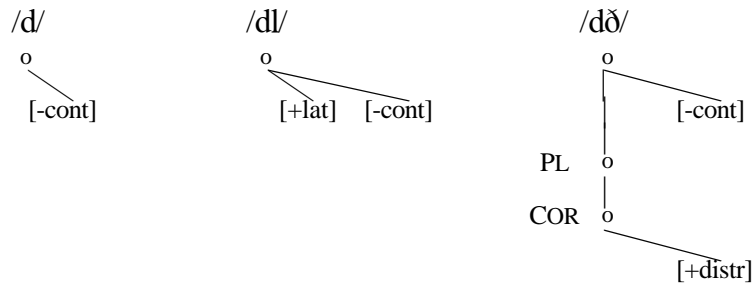
(9) Tahltan coronal harmony rule (Shaw 1991):



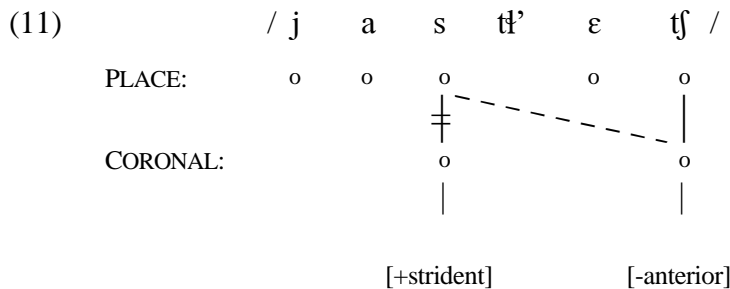
On this analysis, the transparency of vowels and non-coronal consonants falls out straightforwardly from feature geometry: these segments are not specified on the [Coronal] tier, and do thus not constitute potential targets. However, the same must also be true of the plain coronal series /t, t', d, n/ and the lateral series /ɬ, l, tɬ, tɬ', dl/, in spite of the fact that these consonants are all (phonetically) coronal. Here Shaw appeals to *underspecification*; she assumes that both series completely lack a [Place] node (and therefore also a [Coronal] node). Furthermore, the locality condition entails that the feature [±lateral] must be located

relatively high in the feature-geometric tree. The representations Shaw assumes are as shown in (10) for the /d/, /dl/ and /dð/ series. (The internal structure of /dz/- and /dʒ/-series consonants is like that of the /dð/ series, but with the sub-Coronal feature specifications being [+strident] and [-anterior], respectively.)

(10) Underspecification-based representations of Tahltan coronals (Shaw 1991):



Given these representational assumptions, the transparent behavior of the plain coronal series and the lateral series is accounted for, as shown by the example in (11), which represents the derivation /ja-s-tʃ'εtʃ/ → [jaʃtʃ'εtʃ] 'I splashed it'. Note that the lateral affricate /tʃ'/ lacks a Place node altogether; this allows the [Coronal] specification to spread uninterrupted from the trigger /tʃ/ to the target /s/ by the rule stated in (9) above.⁸



⁸ Blevins (1994) suggests an alternative to the feature geometry and specifications assumed by Shaw (1991). Blevins suggests that the feature [lateral] is in fact dominated by the [Coronal] node, just like [±anterior] and [±distributed] are, but that the latter are embedded under an intermediate node [Central], rather than being direct dependents on [Coronal]. Tahltan coronal harmony can then be reinterpreted as leftward spreading of the [Central] node; the rule is identical to Shaw's rule in (9) above, but with [Coronal] replacing [Place], and [Central] replacing [Coronal].

With the advent of output-oriented frameworks of phonological analysis, in particular Optimality Theory (Prince & Smolensky 1993), the tool of underspecification cannot be used as liberally as in previous derivational frameworks. Most analyses along the lines of the one by Shaw (1991) exemplified above assume that although a consonant like /tʃ/ can be ‘placeless’ at the level of underlying (i.e. lexical) representation, it is nevertheless specified as coronal in the eventual *output*. If the assumption of full output specification is carried over into Optimality Theory—where assimilations such as those involved in harmony processes are necessarily driven by constraints on output representations—then underspecification is of no help whatsoever. If coronal harmony is a restriction on output forms, then any segment which is coronal in the output (regardless of what its *input* specifications are) will participate in the harmony, either as a trigger, target, or blocker.

In recent years an alternative approach has emerged which gets around this problem by radically revising the interpretation of transparency effects such as those observed in Tahltan coronal harmony. Instead of being transparent, i.e. ‘skipped’ by the spreading property, the intervening segments are construed as in fact being *targeted* by the harmony, but with little or no phonetic/phonological effect on their realization. This alternative, referred to here simply as the *strict locality* approach, is discussed in the following section.⁹

1.2.3. Consonant harmony and the notion of strict locality

As outlined above, most non-linear analyses of harmony as autosegmental feature spreading have attempted to preserve a principled and constrained definition of locality by relativizing it to some particular class of ‘legitimate targets’. As long as no legitimate target is skipped,

⁹ It should be pointed out that some analyses of harmony phenomena in Optimality Theory *do* make use of underspecified (output) representations. For example, this is how transparent vowels are treated in Hungarian vowel harmony by Ringen & Vago (1998) and in Finnish vowel harmony by Ringen & Heinämäki (1999); the assumption is that vowels unspecified for backness in the output are *interpreted* phonetically as front.

locality is obeyed (even when segments that do not constitute legitimate targets are skipped). In many cases, maintaining locality in this manner requires that underspecification be invoked—a notion which is difficult to reconcile with output-oriented frameworks such as Optimality Theory.

A series of recent works argues for an alternative view of locality which is *not* relativized in this manner; instead, spreading is seen as strictly, segmentally local (e.g., Fleming 1995b; Padgett 1995b; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997; Walker 1998[2000]). According to this view, all segments within a spreading domain are participants, i.e. targeted by the spreading feature. Spreading thus respects *segmental* adjacency (on the root tier); in short, there is no transparency or skipping whatsoever. In most cases, proponents of the strict locality approach also advocate a very concrete interpretation of phonological features, equating them with actual phonetic parameters, such as *articulatory gestures* (along the lines of Articulatory Phonology as developed by Browman & Goldstein 1986, 1989, 1992 et passim). For example, this is the interpretation underlying the theory of articulatory locality developed by Gafos (1996[1999]).

Findings from a large number of phonetic studies of vowel-to-vowel coarticulation (reaching back to Öhman 1966) suggest that in a string VC₀V, the vocalic place gestures are articulatorily contiguous across the intervening consonant(s). The articulatory gestures of the intervening consonants are superimposed on these vocalic gestures and thus coarticulated with them. This is cited by proponents of the strict locality approach as evidence that intervening consonants in vowel harmony are in fact not ‘skipped’ by the spreading vocalic gesture (lip rounding, tongue-root retraction, etc.) but *permeated* by it. Thus they constitute harmony targets no less than the vowels. The difference is that the effect that the spreading vocalic gesture has on consonantal targets have no phonological repercussions. Strictly speaking, the surface realization of /t/ in a [-back] harmony span like /iti/ or a [+round] harmony span like /ɔtu/ is [t^h] and [t^w], respectively. However, as long as con-

sonant palatalization or labialization is not contrastive in the language in question, this fact has no impact on the phonology of the language.

The implications of the strict locality hypothesis for consonant harmony systems have been explored most thoroughly by Gafos (1996[1999]). Gafos assumes a one-to-one correspondence between phonological features and articulatory gestures. This entails that spreading involves the real-time temporal extension of a single continuous articulatory gesture. Skipping of intervening segments is thereby impossible by definition, and all segments that give the *appearance* of being transparent must thus be construed as being permeated by the spreading gesture. Gafos (1996[1999]) argues that the cross-linguistic typology of consonant harmony systems supports this view. Based on a survey of coronal harmony systems, he notes that the features involved are correlated with gestures carried out by the tongue-tip/blade. The relevant gestural parameters are defined as Tongue-Tip Constriction Orientation (TTCO) and Tongue-Tip Constriction Area (TTCA). As a semi-independent articulator, the tongue tip/blade is not actively employed in the articulation of other consonants or vowels, and the superimposition of tongue-tip gestures on such segments has little noticeable effect on their acoustic realization. Therefore, TTCO and TTCA settings are precisely the kinds of properties that would be expected to be involved in consonant harmony, since they are able to spread undisturbed (and largely unnoticed) through intervening segments.

In support of this interpretation of coronal harmony (argued for by Flemming 1995b and Ní Chiosáin 1997 as well), a study on consonant-to-consonant coarticulation by Bladon & Nolan (1977) is frequently cited as evidence for the plausibility of the analysis. This study found that in words such as *sat*, *does*, *sedan* and *deserve*, the stops [t, d] show a slight coarticulatory shift in tip-blade configuration towards that of the neighboring [s] or [z] (which were found to be consistently laminal). This can be taken as confirmation that tip-blade gestures *can* extend across vowels, and thus that coronal consonants can interact

articulatorily in CVC contexts.¹⁰ However, none of the findings reported by Bladon & Nolan (1977) bear on the question whether tip-blade gestures can extend across non-coronal consonants, e.g. in CVCVC, CCVC or CVCC contexts (where the middle consonant is a non-coronal one, such as [m] or [k]). That this is also the case is crucial for the gesture-spreading analysis of coronal harmony, since such harmony is never blocked by non-coronal consonants. Moreover, it should be emphasized that the local gesture-spreading analysis of coronal harmony has never been *directly* corroborated by instrumental studies of any actual languages displaying coronal harmony (such as Navajo, Tahltan, Basque or Kinyarwanda, to name a few examples). All the evidence that has been adduced so far is purely conjectural, suggesting that it is *in principle* possible that coronal harmony involves the spreading of an uninterrupted gesture of the tongue tip/blade.

Given that the strict locality hypothesis emerged in the constraint-based context of Optimality Theory, proponents of the local gesture-spreading approach to coronal harmony phenomena typically formalize their analyses of such phenomena within that theory. As such, these analyses will be discussed in section 4.1.1 below, where other OT-based analyses are also outlined. In that section, various empirical flaws of the gesture-spreading approach are discussed in far greater detail than is possible here. The main arguments are the following. Firstly, Gafos (1996[1999]) is incorrect in claiming that ‘consonant harmony is *attested only* for coronal consonants’ and that the features which assimilate ‘are *limited to* those which describe the mid-sagittal or cross-sectional shape of the tongue tip-blade’ (p. 125-25; emphasis added). If consonant harmony is defined descriptively—and free of

¹⁰ Interestingly, the stops /t, d/ were precisely the ones whose articulation (in non-coarticulation contexts) was the least uniform across the pool of subjects in Bladon & Nolan’s study. Whereas /l, n/ were consistently apical, and /s, z/ consistently laminal, individual speakers varied much more in the articulation of /t/ and /d/. Unfortunately, the study gathered no data on possible coarticulatory effects on /l, n/ across vowels. Note, however, that in the fricative-stop and stop-fricative CVC sequences, the fricatives /s, z/ remained laminal. Unlike the stops, the fricatives were thus unaffected by coarticulation; this may well be connected to the fact that they were consistently laminal across subjects as well. In short, the study by Bladon & Nolan (1977) raise a number of additional questions which may have a bearing on the validity of the gesture-spreading analysis of coronal harmony.

theoretical preconceptions—as in (2) above, then non-coronal harmony most certainly does exist, as amply documented in the survey in chapter 2. To categorize such phenomena as something *other* than consonant harmony, in order to rescue the predictions of the strict locality hypothesis, introduces a circularity which renders these predictions vacuous and unfalsifiable in principle.

Secondly, the gesture-spreading analysis of coronal harmony phenomena advocated by Gafos (1996[1999]) requires one to call into question a number of clear and unequivocal statements about the phonetics and phonology of individual coronal harmony languages in the descriptive literature. According to the strict locality hypothesis, those coronals which were previously assumed to be non-targets (e.g., the plain stops and laterals in the Tahltan case examined in the previous section) are in fact permeated by the spreading tongue-tip gesture. They should thus be ‘allophonically’ affected, often in a way that ought to be noticeable (e.g., an /n/ should be realized as dental [n̥] if dentality is the spreading property). However, the descriptive sources are consistently and conspicuously silent about such allophonic differences, even when they are at least as detailed otherwise—and sometimes even mention the occurrence of the very same allophone (e.g., dental [n̥]) in other contexts unrelated to the harmony! This casts serious doubt on the empirical validity of the predictions made by gesture-spreading analyses.

Finally, the strict locality approach predicts segmental opacity effects to occur in at least some coronal harmony systems. A particular type of intervening segment may be incompatible with the spreading feature in the language in question—to use our earlier example, dental [n̥] may be disallowed for some reason, and /n/ thus blocks the spreading of dentality. However, segmental opacity effects do not seem to be attested at all in the cross-linguistic typology of consonant harmony systems, as discussed at length in section 3.2 below (where potential counterexamples are also dealt with).¹¹

¹¹ It should be noted that (genuinely) transparent vowels in vowel harmony systems remain a genuine problem for most versions of the strict locality approach (as acknowledged explicitly by Ní Chiosáin &

This concludes our brief survey of previous approaches to consonant harmony in the phonological literature. All of the alternative analyses that have been discussed here have been based on the same fundamental premise—that the same ‘machinery’ is responsible for consonant harmony as for vowel harmony (and vowel-consonant harmony). To my knowledge, no pre-OT works on harmony phenomena (and very few OT ones) have even addressed the possibility that consonant harmony might in fact be a distinct phenomenon, governed by principles potentially different from those seen to hold for other types of harmony.

1.3. Central claims

A major claim made here is that consonant harmony is *not* restricted to coronal harmony, involving coronal-specific articulatory gestures, in spite of the claim made by Gafos (1996[1999]) to that effect. Long-distance consonant assimilations frequently involve various other phonetic/phonological properties, such as voicing, stricture, nasality, uvularity (among dorsals), secondary articulations, rhoticity, and so on. In terms of their typological profile, coronal harmony systems do not stand out in any way that might suggest that these (unlike other types of consonant harmony) *are* due to strictly local-spreading along the lines argued for by Gafos (1996[1999]) and others. With respect to their typological characteristics, all the subtypes of consonant harmony surveyed here—coronal and non-coronal alike—form one coherent class.

What is more, the typology of consonant harmony systems differs from that of vowel harmony in several striking respects which have not been noted by previous researchers. For example, consonant harmony is never sensitive to prosodic factors in any way (stress, syllable weight, length, foot structure, etc.), whereas this is quite common not

Padgett 1997). Various special devices have been proposed to deal with such phenomena, e.g., nested feature domains or reference to a separate level of representation—the latter roughly equivalent to intermediate representations in previous derivational frameworks (see, e.g., Smolensky 1993; Cole & Kisseberth 1994; Walker 1998[2000]).

only in vowel harmony systems but also in those involving ‘vowel-consonant harmony’ such as nasal harmony or pharyngealization harmony, where the harmony trigger is often a consonant. If nasal harmony and, say, sibilant harmony are both due to spreading of articulatory gestures, and if the spreading gesture targets vowels in sibilant harmony no less than it does in nasal harmony, then there is no obvious reason why the former could not be constrained (or otherwise affected) by prosodic factors, just as the latter can.

Another glaring difference that emerges from the typology of consonant harmony systems is the fact that consonant harmony is consistently oblivious to the nature of the segments intervening between the trigger and target consonants.¹² Any and all segments which do not participate directly in the harmony are always ‘transparent’, in the sense that they are completely inert to the point of being *irrelevant* to the harmony. By contrast, both vowel harmony and vowel-consonant harmony systems very frequently display segmental *opacity* effects, whereby a particular set of non-participating segments *blocks* the propagation of the harmonizing property. This difference is highly surprising if consonant harmony is due to the exact same mechanism as the other types of harmony phenomena—i.e. local spreading of features or articulatory gestures.

Based on these considerations, another major claim made here is that consonant harmony—including coronal harmony—is in fact not to be understood as involving spreading at all. Instead, consonant harmony is a matter of long-distance *agreement* between consonants of a particular type. In the Optimality Theory analysis of consonant harmony developed in chapter 4, this agreement is formalized in terms of syntagmatic correspondence. The analysis builds in part on proposals by Walker (2000ab, to appear), but extends Walker’s model to coronal harmony systems in addition to non-coronal ones. Since consonant harmony is not due to spreading, but instead to agreement under correspondence, it is not bound by the strict locality requirement commonly assumed to govern spreading. The

¹² For discussion of a well-known phenomenon which is an apparent counterexample to this generalization (*n*-retroflexion in Vedic Sanskrit), see section 3.2.3 below.

correspondence-based analysis also explains the complete absence of segmental opacity effects in consonant harmony, since the only segments that participate in the harmony are the ones that are linked by a correspondence relation. Intervening vowels and consonants cannot possibly block the agreement between these segments; strictly speaking, they are not ‘transparent’ so much as they are *irrelevant*, and thus ignored altogether.

Following Walker (2000ab, to appear), the main factor driving the correspondence relation responsible for consonant harmony is taken to be the relative *similarity* of the two consonants (as well as their relative proximity).¹³ The more similar two consonants are, the stronger the drive towards agreement in the feature or features that distinguish them. The role of similarity—which has also been found to be involved in dissimilatory cooccurrence restrictions on place of articulation (Frisch et al. 1997)—strongly suggests that consonant harmony is connected to the domain of *speech planning*. Similarity plays a clear role in facilitating the occurrence of slips of the tongue: the more alike two cooccurring consonants are, the more likely they are to interfere with each other during the process of phonological encoding in language production. The interpretation of consonant harmony argued for in this work can indeed be paraphrased (rather liberally) as ‘phonologized speech errors’.

In support of this view, several additional parallels between speech errors and consonant harmony processes are adduced throughout this study, most of which have gone unnoticed by previous works on consonant harmony. Perhaps the most obvious one is the fact that the segment contrasts most often involved in consonant harmony systems, sibilant distinctions like /s/ vs. /ʃ/, are also the ones most typically employed in conventional tongue-twisters in many languages (a fact noted already by such linguists as Jespersen and Harrington, cf. section 1.2.1 above). Another indication is the prevalence of anticipatory (right-to-left) directionality in consonant harmony systems, which has not been noted

¹³ Rose & Walker (2001) further develop the same idea; however, this manuscript did not become available to me until a few days before finishing this thesis. There is considerable overlap between their proposals and those of the present study. Various parts of this work would no doubt have been slightly different, had there been time to respond to the suggestions and claims made in Rose & Walker’s manuscript.

before. As pointed out by Dell et al. (1997), a crucial property of any well-designed serial-order production system is that it must prepare to activate upcoming elements at the same time as the current element is being produced, whereas past elements must be promptly deactivated once they have been produced. As a result, interference effects are more likely to be anticipatory (the future influencing the present) than perseveratory (the past influencing the present); this asymmetry is indeed found to hold quite robustly in speech error data. A third parallel is the curious phenomenon referred to by Stemberger (1991) as the ‘palatal bias’ effect: alveolars like /s/ are far more susceptible to interference from (= assimilation to) ‘palatals’ like /ʃ/ than vice versa. An important finding of the present study is that the very same asymmetry characterizes the cross-linguistic typology of coronal harmony systems. This is true not only of sibilant harmony effects (involving the /s/ vs. /ʃ/ distinction), but also of the much rarer phenomenon whereby alveolar stops and ‘palatal’ affricates interact (/t, d/ vs. /tʃ, dʒ/).

Taken together, such parallels between phonological speech errors and consonant harmony systems constitute strong evidence for the view that consonant harmony has its roots in the domain of speech planning—which in turn underlies the correspondence-based analysis of consonant harmony developed in chapter 4. This applies to such non-coronal phenomena as nasal consonant harmony, where intervening segments are quite obviously transparent to the ‘propagation’ of nasality. More importantly, the same is equally true of coronal harmony systems, where it is in principle *conceivable* that the intervening vowels and consonants are permeated by the harmonizing gesture (as claimed by Gafos 1996[1999]). In the absence of any concrete evidence to the contrary—and no such non-conjectural evidence has ever been offered by the proponents of the strict locality approach to coronal harmony phenomena—it seems safe to conclude that coronal harmony is due to agreement at-a-distance, not spreading under adjacency.

Note that this conclusion is not tantamount to rejecting the strict locality hypothesis as such. The view that all spreading respects segmental adjacency is in no way incompatible with the claim that consonant harmony effects are due to something *other* than spreading (i.e. agreement). The general validity of the strict locality hypothesis is thus mostly irrelevant in this context and will not be addressed in the present study. Likewise, the conclusion that consonant harmony is due to agreement rather than spreading invites the possibility that some vowel harmony phenomena might be properly analyzed as agreement as well. Just as [\pm nasal] can define harmony either by spreading (= nasal harmony) or by agreement (= nasal consonant harmony), is it possible that some vowel harmony systems are ‘non-local’ and agreement-based, rather than local and spreading-based? This is an intriguing question, but one which will be left to future research.¹⁴

1.4. Organization of the dissertation

The dissertation is organized as follows. Chapter 2 presents a typological overview of attested consonant harmony systems, classified by the phonological/phonetic property involved in the harmony. This overview summarizes the findings of a detailed cross-linguistic survey, cataloguing well over a hundred documented examples of phenomena that fit the definition of consonant harmony given in section 1.1 above. Chapter 3 discusses several striking generalizations that emerge from the cross-linguistic survey, and which set consonant harmony apart from both vowel harmony and vowel-consonant harmony with respect to the typological profile of these phonological phenomena. Chapters 2 and 3 thus form the empirical backbone of this work. Because they are based on the most extensive

¹⁴ In his OT analysis of vowel harmony systems, Baković (2000) proposes to eliminate autosegmental spreading altogether. The work previously accomplished by spreading—which is essentially a *representational* device—is instead shifted to the domain of constraint *evaluation*. Under this view, all assimilation is in fact construed as agreement; the strict locality hypothesis translates into the restriction that agreement is evaluated between adjacent segments. This brings the analysis of vowel harmony phenomena much closer to that developed for consonant harmony in this study. The full implications of the differences and their significance remain as a matter of future investigation.

survey of consonant harmony phenomena to date, it is my hope that they will serve as a useful resource for future research in this area. As such, the findings reported in chapters 2 and 3 are independent of any particular framework of phonological analysis. Chapters 4 and 5 develop a generalized phonological analysis of consonant harmony phenomena, cast in the form of Optimality Theory (Prince & Smolensky 1993). As mentioned above, the analysis borrows heavily from proposals developed by Walker (2000ab, to appear), but is here extended to all types of consonant harmony, including coronal harmony. Furthermore, the analysis developed in this work relies crucially on the notion of targeted constraints (Wilson 2000, in progress; cf. also Baković & Wilson 2000), which are used in a novel way to account for fixed-directionality effects. The OT analysis proposed in chapters 4 and 5 interprets consonant harmony as agreement under correspondence. This is based on the idea that consonant harmony has its roots in the domain of speech planning and has considerable affinities with phonological speech errors. Chapter 6 reviews the arguments for this connection between consonant harmony and speech errors, and adduces yet another such parallelism: the existence of so-called ‘palatal bias’ effects in the cross-linguistic typology of coronal harmony systems. Finally, chapter 7 summarizes the conclusions of this study and briefly addresses the relationship between consonant harmony processes in child language and the (adult) consonant harmony phenomena surveyed here.

CHAPTER 2

A CROSS-LINGUISTIC TYPOLOGY OF CONSONANT HARMONY

The study of consonant harmony as a phonological phenomenon in its own right has been hampered by the lack of a truly comprehensive and detailed cross-linguistic survey of consonant harmony systems in the world's languages. Only on the basis of a large-scale typological study can valid empirical generalizations about consonant harmony systems be made. Among the relevant issues are a) which phonetic/phonological properties can define consonant harmony; b) segmental transparency and opacity; c) directionality; d) interaction with morphological structure; e) relevance of prosodic domains. The typological generalizations that emerge are in turn what must constitute the foundation of any theoretical analysis of consonant harmony, as well as shedding light on its motivations (articulatory, perceptual, cognitive), the historical origins and evolution of consonant harmony systems, etc. The need for an empirical survey, as unbiased as possible by analytical and theoretical preconceptions, is rendered even more acute by the fact that consonant harmony is a much less well known phenomenon than vowel harmony, and has traditionally been interpreted and analyzed in the exact same terms as the latter without much independent justification.

The typological overview presented in this and the following chapter aims to fill this gap. It constitutes by far the most thorough and extensive survey to date of consonant harmony systems in the world's languages, their parameters of variation and shared typological characteristics. The most notable finding to emerge from this survey is that consonant harmony displays a typological profile which is markedly different on several counts from that of vowel harmony, as well as those harmony systems that are sometimes referred to as vowel-consonant harmony (nasal harmony, pharyngealization harmony, etc.). Some of these typological asymmetries, and their implications for our understanding of the nature of consonant harmony, are discussed in chapter 3. The data uncovered in this cross-linguistic

survey thus provides the basis of the phonological analysis of consonant harmony presented in subsequent chapters.

The structure of the chapter is as follows. Section 2.1 discusses the findings of previous survey-oriented works concerning consonant harmony phenomena. The nature of the database underlying this survey is described in section 2.2. A considerable number of cases in the database are static cooccurrence restrictions (morpheme structure constraints). Section 2.3 compares such static restrictions with harmony in the more conventional sense (i.e. as manifested in alternations), and justifies including the former as valid examples of consonant harmony. The bulk of the chapter is made up by section 2.4, which lists the various types of consonant harmony systems that are exemplified in the database, classified according to the phonetic and/or phonological property involved in the assimilation (or assimilatory cooccurrence restriction). Since many of the types of consonant harmony are virtually unknown, a point has been made of including a wide range of illustrative examples, especially of the relatively rare types (e.g., liquid harmony, dorsal harmony, stricture harmony), with pointers to the relevant descriptive sources. As a result, the overview is quite lengthy, but it is hoped that it will prove valuable as a source of data and references for future research on consonant harmony. Finally, section 2.5 summarizes the main findings and discusses some problematic issues regarding the classification and its formalization in terms of distinctive features.

2.1. Previous surveys of consonant harmony

Although the present survey of consonant harmony systems is the first truly comprehensive one to have been carried out, it is not without predecessors. A few previous works deserve mentioning which make somewhat more limited attempts at addressing the typology of consonant harmony systems. The first of these is the groundbreaking study by Shaw (1991). Shaw's survey is based on a somewhat wider definition of consonant harmony than

that used in this study: ‘phonological assimilation *or dissimilation* between consonants that are not necessarily adjacent in the surface string and where, crucially, other intervening vocalic or consonant segments do not interact with the harmony in any way’ (Shaw 1991:125; emphasis added). In addition, Shaw also counts what she refers to as ‘morphological harmony’ (following Cole 1987[1991]). These are cases ‘where the harmony instantiates or signifies a particular morpheme’ (Shaw 1991:128), i.e. the phenomenon also known as ‘featural morphology’ or ‘featural affixation’ (Akinlabi 1996). It is true that consonant harmony in the strictest sense—i.e. assimilatory interaction between consonants within a string—may potentially be involved in *some* such cases (viz. those where the floating feature docks onto multiple consonants in the string; cf. the discussion of Harari palatalization in 2.4.1.2 below). However, this is by no means certain, and one should be wary of putting ‘morphological harmony’ on a par with purely phonological consonant-to-consonant interactions, at least from the synchronic perspective (a point made already by Cole 1987[1991] and acknowledged explicitly by Shaw 1991).

When all dissimilatory effects are left out (including dissimilatory morpheme-structure constraints), as well as those instances of ‘morphological harmony’ that do not involve multiple targets, the cases covered by Shaw’s cross-linguistic survey are reduced to the list in (1). The somewhat suspect status of the ‘morphological’ cases is indicated by enclosing these in brackets. For cases that are discussed elsewhere in this study, references have been omitted.

(1) Shaw’s (1991) cross-linguistic survey of consonant harmony (abridged)

a. LARYNGEAL HARMONY

- [Salish diminutive glottalization] (Reichard 1938; Mattina 1973; Cole 1987)
- [Nisga’a ʔ-spread] (Shaw et al. 1989, cited by Shaw 1991)

b. PLACE HARMONY

CORONAL HARMONY

- Chumash sibilant harmony
- Navajo sibilant harmony
- Tahltan coronal harmony
- (Southern Peruvian) Quechua sibilant harmony
- Kinyarwanda sibilant fricative harmony
- Wiyot coronal harmony
- Sanskrit *n*-retroflexion
- [Harari dental palatalization]

LABIAL HARMONY

not attested

DORSAL HARMONY

not attested

PHARYNGEAL HARMONY

not attested

Aside from the cases that involve featural morphology, then, Shaw (1991) only finds 7 examples of consonant harmony in the strictest sense. All of these involve coronal consonants, typically sibilants (even in Wiyot and Tahltan, sibilant contrasts such as [s] vs. [ʃ] are among those involved in the harmony). Furthermore, one of the cases Shaw lists, Sanskrit *n*-retroflexion, is highly suspect as an instance of consonant harmony, as will be argued in more detail in section 3.2.3 of the next chapter.

A more ambitious survey is presented by Gafos (1996[1999]), who expands on Shaw's findings and makes the somewhat stronger claim that coronal harmony is only attested type of consonant harmony. In fact, Gafos suggests that it is the only *possible* type,

inasmuch as it involves the spreading of articulatory tongue-tip/blade gestures that do not interact with the articulation of intervening vowels or consonants. Given the nature of this hypothesis, it is curious to note that Gafos (1996[1999]) appears to deliberately limit the scope of his cross-linguistic survey to coronal harmony systems—rather than bringing up apparent cases of consonant harmony involving *non*-coronal features/gestures, and explaining these away (based on criteria independent of the hypothesis) as involving something other than ‘harmony’. This is all the more surprising since many of the prime candidates—such as nasal consonant harmony, voicing harmony, and liquid harmony—are explicitly discussed in some of the works Gafos cites (e.g., Odden 1994). Be that as it may, the cross-linguistic investigation by Gafos (1996[1999]) is quite valuable as a source on the typology of *coronal* harmony systems specifically.

The coronal harmony systems mentioned by Gafos (1996[1999]) are listed in (2). The cases are grouped according to the gestural parameter that Gafos argues to be involved in the harmony. Those in (2a) involve Tongue-Tip Constriction Area (‘tip-up’ vs. ‘tip-down’), which is assumed to underly not only the apical/laminal contrast in Chumash but also the retroflex/dental contrast in Sanskrit and the Northern Australian languages Gooniyandi and Gaagudju. The other parameter, Tongue-Tip Constriction Area (which can potentially have three values, ‘wide’ vs. ‘mid’ vs. ‘narrow’) is taken to be the basis of coronal harmony in Tahltan—involving threefold contrasts such as [θ] vs. [s] vs. [ʃ] (2b). Finally, for the systems listed here under (2c), Gafos does not explicitly discuss whether the precise parameter involved is TTCA or TTCO. The first four cases are Athapaskan languages, whose harmony systems are cognate with the Tahltan one. With the exception of Kinyarwanda, the other languages in (2c) are simply listed without further discussion of their phonetic/phonological nature, except for the fact that harmony in these languages is confined to coronal fricatives and affricates, all other segments being transparent. In some cases it seems clear that TTCO rather than (or in addition to) TTCA is involved, for example

in Basque, where the relevant contrast is an apical vs. laminal one (Hualde 1991; Trask 1997).

- (2) Coronal harmony systems surveyed by Gafos (1996[1999])
- a. ARTICULATORY PARAMETER: TONGUE-TIP CONSTRICTION ORIENTATION
 - Chumash sibilant harmony
 - Sanskrit *n*-retroflexion
 - Gooniyandi retroflexion harmony
 - Gaagudju retroflexion harmony
 - b. ARTICULATORY PARAMETER: TONGUE-TIP CONSTRICTION AREA
 - Tahltan coronal harmony (dental/alveolar/postalveolar fricatives and affricates)
 - c. ARTICULATORY PARAMETER UNCERTAIN OR NOT DISCUSSED
 - Chilcotin sibilant harmony
 - Navajo sibilant harmony
 - Chiricahua Apache sibilant harmony
 - Kiowa-Apache sibilant harmony
 - Kinyarwanda sibilant (fricative) harmony
 - Moroccan Arabic sibilant harmony
 - Basque sibilant harmony
 - Imdlawn Berber sibilant harmony
 - Ntifa Berber sibilant harmony
 - Southern Paiute sibilant harmony
 - Tzeltal sibilant harmony

Gafos (1996[1999]) thus finds 16 attested cases of consonant harmony, all of them involving coronal consonants. Of these, 5 were among the 7 cases mentioned earlier by

Shaw (1991). The two remaining ones are (Southern Peruvian) Quechua and Wiyot, the latter of which Gafos rejects as a plausible case of consonant harmony. Instead, the Wiyot phenomenon is interpreted as a case of ‘consonant symbolism’, on a par with other sound symbolism systems found throughout North America, especially along the Pacific coast (cf. Haas 1970; Nichols 1971). Gafos is certainly right in drawing a distinction between consonantal sound symbolism and consonant harmony, and in pointing out that ‘some cases of consonant symbolism have been misinterpreted as examples of consonant harmony’ (Gafos 1999: 230-31). However, the Wiyot case turns out to be somewhat more complicated, involving *both* symbolism and harmony, which partially overlap in their effects and the segments involved (cf. Teeter 1959, 1964).¹ In sum, the combined surveys of Shaw (1991) and Gafos (1996[1999]) thus cover 18 consonant harmony systems, all involving coronal harmony.

Although Shaw (1991) and Gafos (1996[1999]) are the only explicit attempts at general cross-linguistic surveys of consonant harmony, other works of more limited scope are worth mentioning here as well. Odden (1994) is concerned with the general issue of locality and adjacency in phonological processes, and thus covers a wide range of assimilatory and dissimilatory phenomena, both local and at-a-distance. Many of these involve consonant-consonant interactions, and the article thus contains a wealth of examples of long-distance assimilations that count as consonant harmony for the purposes of the present study. MacEachern (1997[1999]) gives a thorough and valuable survey of cooccurrence restrictions involving laryngeal features. Although most of the effects

¹ In fact, there is a considerable number of languages where sound symbolism and consonant harmony (in the sense of long-distance assimilation between consonants) coexist and affect the same segment types. Although the two are clearly distinct phenomena synchronically, this fact perhaps suggests that consonant harmony may be *diachronically* related to sound symbolism in some cases. One possibility is that the pervasive ‘agreement’ effects that result from across-the-board sound symbolism may become analogically reinterpreted as evidence of phonological assimilation, which then becomes generalized to new, non-sound-symbolic contexts. Although this is an interesting topic of investigation, especially as regards potential sources of consonant harmony systems, it will be left outside the scope of this study.

MacEachern discusses are dissimilatory in nature, some can be interpreted as assimilatory (requiring identity in one or more features under certain conditions) and can thus be counted as instances of consonant harmony.

The survey presented in this chapter, and the database of consonant harmony systems on which it is based, is radically different in both size and scope from those reported in previous studies. Instead of covering a mere handful of cases (in the 10-20 range, as in Shaw 1991 or Gafos 1996[1999]), this typological survey reports on a database containing nearly 100 separate cases of consonant harmony. These are quite diverse, not merely in terms of geographic distribution and genetic affiliation, but also with respect to their phonological characteristics. The resulting picture of the ‘universe’ of consonant harmony systems in the world’s languages is quite different from the one suggested by earlier surveys. Not only is it considerably richer, and much more varied, but some striking consistencies emerge that seem to indicate that consonant harmony is significantly different typologically (and thus phonologically) from other better-known types of harmony interactions.

2.2. Description of consonant harmony database

As noted above, the typological survey presented in this chapter is based on an extensive database of attested cases of consonant harmony. For the purposes of determining whether a particular phenomenon should be included in the database, the working definition of consonant harmony in (3) was followed (repeated from 1.1 above).

(3) Consonant harmony—a working definition

Any assimilatory effect of one consonant on another consonant, or assimilatory co-occurrence restriction holding between two consonants, where:

- a. the two consonants are separated by a string of segmental material consisting of at the very least a vowel; and
- b. intervening segments, in particular vowels, are not audibly affected by the assimilating property.

The restriction in (3b) that intervening segments must not be ‘audibly affected’ is crucial, since it is what differentiates consonant harmony from phenomena such as nasal harmony or pharyngealization (‘emphasis’) harmony, where intervening vowels and consonants are quite obviously affected, i.e. nasalized or pharyngealized, respectively. Based on his thesis of strict articulatory locality, Gafos (1996[1999]) equates coronal harmony systems with these, in that he assumes that intervening vowels and consonants *are* affected—i.e. that they are permeated by the spreading articulatory gesture—but that this simply does not yield a noticeable acoustic effect (cf. also Flemming 1995b; Ní Chiosáin & Padgett 1997). However, it cannot be emphasized enough that, as a claim about the articulatory ‘mechanics’ of consonant harmony, this is no more than a conjecture. It is based not on direct investigation of the temporal dynamics of coronal gestures in languages with consonant harmony, but on the observation that coronal harmony by and large involves features/gestures that *would* be able to permeate intervening segments with little or no acoustic-perceptual effect. It is an empirical fact that many long-distance assimilations that fit the definition in (3) are of such a nature that they cannot possibly involve strictly-local spreading of articulatory gestures (e.g., nasal consonant harmony, where intervening vowels are not nasalized). In the absence of direct positive evidence (e.g., from much-needed articulatory studies) that coronal harmony in languages like Navajo, Basque or

Kinyarwanda does indeed permeate intervening vowels and consonants, a more appropriate null hypothesis is therefore that these segments are in fact not affected in consonant harmony systems of *any* kind.

The database on which this typological survey is based consists of any and all phenomena fitting the definition in (3) which I have been able to find in descriptive and analytical sources. The languages and dialects included in the database represent a broad cross-linguistic spectrum, both as regards geographic areas and genetic groupings. Given that consonant harmony is a relatively rare phenomenon—at least as compared to vowel harmony—no attempt was made to design the database as an areally and genetically balanced sample. Instead, all attested cases known to the author were included; this entails that the database is not very suitable for making statistical inferences about, e.g., the relative predominance of particular typological traits, areal skewings in their geographic distribution, etc. However, since the present database is an attempt at an exhaustive catalogue of attested consonant harmony systems, it would follow that any statistically balanced sample of such systems would constitute a subset of this database (barring, of course, any gross shortcomings in the coverage of the latter).

All in all, the database contains around 120 separate cases of consonant harmony. The contents of the database are listed in an extremely condensed version in the Appendix. The use of the term ‘separate case’ deserves some qualification here. As the reader will notice, closely related languages with the same type of harmony systems are often given as separate entries, even though the consonant harmony phenomena they exhibit are presumably cognate and sometimes (near-)identical. As an example, over 15 cases of nasal consonant harmony in Bantu languages are listed individually (and more could no doubt be added). Although this may seem odd, it is a sound and well motivated strategy. The main goal of this survey is to gather enough empirical data to uncover generalizations about consonant harmony phenomena as manifested within the synchronic phonologies of the

world's languages. One and the same harmony phenomenon, when attested in two closely related languages, may nevertheless differ in crucial details that are potentially relevant to the typology of consonant harmony. Regardless of their common historical source, cognate harmony systems in related languages thus deserve being listed individually simply because they are *potentially* different.

Nasal consonant harmony in Bantu languages is a case in point. The trigger and target are usually required to be separated by no more than a single vowel (Bemba, Lamba, Luba, Ndonga, etc.), but a few languages place no maximum distance requirement on the trigger-target pair (Kongo, Mbundu, Yaka). Some cases are intermediate between the two (Suku) in that 'long-distance' harmony—across an intervening -VC- suffix—is optional. In yet others, nasal consonant harmony is confined to the root (Ganda), or is restricted to the C₂ and C₃ positions in a CVCVC stem template (Teke, Tiene). In most cases, nasal consonant harmony gives rise to alternations between [l] and [n] (and/or [d] and [n]), but in some languages, the alternation is between [r] and [n] (Herero). In yet others, nasal consonant harmony targets velar [k], [g] or [x] as well (e.g., Pangwa, Tiene). The effect of the harmony is generally nasalization (/l/ → /n/ etc.), but may result in denasalization (e.g., /m/ → /b/) in at least one language (Tiene). Finally, although the directionality of Bantu nasal consonant harmony is usually left-to-right (or 'inside-out'), right-to-left harmony from reciprocal /-an-/ to the preceding stem systematically occurs in one language (Pangwa).

In fact, the all-inclusive strategy employed here is no different from that used in the previous consonant harmony surveys discussed earlier. For example, of the 16 coronal harmony systems listed by Gafos (1996[1999]), five are from Athapaskan languages, whose harmony systems are almost certainly cognate (and can be reconstructed as a morpheme-structure constraint for Proto-Athapaskan-Eyak; see Krauss 1964). Likewise, the two Australian languages Gafos cites (Gooniyandi and Gaagudju) display virtually identical

phenomena and are undoubtedly connected historically or areally. Finally, the sibilant harmonies found in the two Berber dialects listed (Imdlawn and Ntifa) are presumably cognate, and may well be areally connected to Moroccan Arabic sibilant harmony as well.

The point here is not to accuse others of the same misdeed, but to emphasize that inclusiveness is entirely appropriate for surveys of this type. Indeed, it would be a grave mistake to equate all coronal harmony systems within Athapaskan, since they often differ significantly in their synchronic properties. In Tahltan, three obstruent series are involved (dental, alveolar, postalveolar), whereas harmony typically affects only two series in the other languages. These two series are usually either alveolar vs. dental or alveolar vs. postalveolar, but in Tsilhqot'in (Chilcotin), they are instead pharyngealized vs. non-pharyngealized alveolars. The languages also differ in subtle ways with respect to how harmony interacts with morphological structure: although Athapaskan coronal harmony generally propagates from right to left, Navajo has left-to-right harmony between the Perfective /si-/ and 1SgSubj /ʃ-/ prefixes under certain conditions (see, e.g., McDonough 1991). In sum, the instantiations of coronal harmony in different Athapaskan languages, although related diachronically, must be counted as separate cases from a synchronic standpoint, and thus also for the purposes of a survey of consonant harmony systems and their parameters of typological variation.

The strategy of listing harmony systems in closely related languages as separate entries even when (apparently) identical can of course be pushed to the absurd. What about cases where the same harmony is found in different dialects of the same language? In this database, dialects have only been listed separately if they differ significantly in the properties of the consonant harmony phenomenon in question. As for the inherently problematic and arbitrary dichotomy between 'language' and 'dialect', an attempt was made to follow the same practice as recent descriptive sources on the family in question and to avoid the ubiquitous and overly general use of the term 'dialect' found in many early 20th

century works (and older). For example, the Chumashan family is treated as a group of several closely related languages (Barbareño, Ineseño, Ventureño, etc.) rather than as dialects of the same language, ‘Chumash’.

It should also be noted that one and the same language may often exhibit more than one type of consonant harmony. These are listed as separate entries even in those cases where it is quite likely that the two types of harmony are connected (synchronically and/or historically). For example, Ngbaka places several cooccurrence restrictions on homorganic consonants, the disallowed combinations being: voiced vs. voiceless obstruents (laryngeal harmony), voiced oral vs. prenasalized obstruents (nasal consonant harmony), and prenasalized obstruents vs. full nasals (nasal consonant harmony). As another example, Hausa requires tautomorphemic homorganic stops to agree in [\pm constricted glottis] (laryngeal harmony); conversely, it also requires two tautomorphemic [+constr. glottis] stops to be identical, i.e. to agree in both place and voicing as well. In cases such as the Hausa or Ngbaka ones, an adequate phonological analysis must of course account for all of the harmony effects at once, perhaps even triggered by the same constraint. At the risk of obscuring such language-internal connections, phenomena involving agreement in different types of features have been classified as separate instances of consonant harmony in the database.

Finally, it should be emphasized that the main purpose of this study is to investigate the typological characteristics of consonant harmony *systems*. For this reason, reported instances of sporadic sound changes fitting the definition in (3) were not looked for. (Recall, for example, the interpretation of such examples by Jespersen 1904, 1922 as cases of ‘Konsonant-Harmonisierung’, as discussed in 1.2.1 above.) This is not to say that such sporadic phenomena are taken to be essentially different from those where harmony manifests itself as a more general and systematic sound pattern. Presumably the sporadic cases are due to the same phonetic and/or cognitive factors, but have failed to become

phonologized as anything more than an arbitrary property of individual segments in individual lexemes. The decision not to look for sporadic cases of consonant-harmonizing sound change was simply a matter of practical necessity—a systematic and near-exhaustive search for such phenomena would have been impossible within the scope of a dissertation like the present one. Although sound changes as such were not systematically included, a few that turned up have nevertheless been incorporated into the database. These are the coronal-harmony-like changes reported for several Formosan languages (including at least Paiwan, Saisiyat, Thao) by Blust (1995). These pervasive and recurrent sound changes are of interest, in part, because they show the participation of lateral [ɬ] (in Thao) in what otherwise looks like a typical example of sibilant harmony.

2.3. Root-internal harmony: the status of morpheme structure constraints

In determining what kinds of phenomena to include in the database of consonant harmony systems, another important methodological decision was made: that ‘static’ cooccurrence restrictions should be counted, as long as they are assimilatory (i.e. require agreement in some property). In the literature on consonant harmony, the cases that are cited typically involve alternations driven by harmony operating across morpheme boundaries (e.g., sibilant harmony in Navajo /sì-ts’à:ʔ/ ‘my basket’, cf. /ʃi-tà:ʔ/ ‘my father’). Although assimilatory cooccurrence restrictions are often mentioned in the general literature on morpheme-structure constraints (cf. Yip 1989, who mentions coronal harmony in Nilotic), the connection to consonant harmony in the more conventional sense is rarely made, at least not explicitly.

The decision to include ‘static’ cooccurrence restrictions alongside ‘dynamic’ sound patterns (yielding alternations) is in part motivated by purely formal considerations. It does not seem that an ad hoc stipulation that ‘static’ and ‘dynamic’ patterns would have any principled foundation. Even the latter types of consonant harmony are often confined to

a particular morphological domain (a ‘stem’, involving, e.g., derivational affixes to the exclusion of inflectional ones, or suffixes to the exclusion of prefixes)—and the same is frequently true of vowel harmony systems as well. There is no a priori reason why consonant harmony could not in some cases be confined to the most restrictive domain possible—i.e. the root. Such a severe limitation usually entails that the harmony is manifested only ‘statically’, but this limited manifestation is simply a consequence of the narrow morphological domain, not a sign that we are dealing with an essentially different phonological phenomenon.

Furthermore, the ‘static’ vs. ‘dynamic’ labels are somewhat misleading, because morpheme-internal cooccurrence restrictions may occasionally have ‘dynamic’ effects, i.e. yield alternations. One situation where this may occur is when roots display ablaut-like alternations. For example, many of the Western Nilotic languages have root-internal coronal harmony—a cooccurrence restriction on dental vs. alveolar obstruents and nasals, as illustrated by the Pāri examples in (4). Note that no dental vs. alveolar contrast exists for /l, r/, which thus freely cooccur with both series. (Morpheme-final ‘`’ in the examples in (4-5) indicates a floating low tone.)

(4) Root-internal coronal harmony in Pāri (Andersen 1988)

a. Well-formed roots with multiple (non-‘palatal’) coronals

ɬ̀ɔ̀ŋ̀	‘male’
ɲ̀ɬ̀	‘sucking’
ɖ́á:ɲ̀-é̀	‘person (ergative)’
àtwá:t̀	‘adult male elephant’
àdú:nd-ó̀	‘heart’

b. Disallowed root-internal combinations

*d...n *d...nd *d...t *t...n *t...nd (etc.)

*d...ŋ *d...nd̩ *d...t̩ *t...ŋ *t...nd̩ (etc.)

c. Alveolar /l, r/ are neutral (dental /l̪, r̪/ absent from inventory)

t̪el ‘legs’

-t̪ò:l̪-ì ‘ropes’

rò:t ‘grind’

rwà:t̪ ‘chief’

Independently of this assimilatory morpheme-structure constraint, Western Nilotic languages make extensive use of root-final consonant alternations in their derivational and inflectional morphology (see, e.g., Andersen 1988, 1999; Tucker 1994; Reh 1996). Among the patterns observed, a root-final /l/ may change to /t/ or /nd/, and vowel-final roots may have alternate realizations with final /n(:)/. This is illustrated by the Pãri forms in (5). In those cases where the alternation would be expected to yield disharmonic alveolar-dental sequences, coronal harmony prevails, and the alternant root allomorphs instead have dental /l̪/, /nd̩/, etc.

(5) Root consonant alternations feed root-internal harmony in Pãri (Andersen 1988)

a. *Completive 3Sg* *Completive 3Pl*

á-gò:l-é á-gò:nd-é ‘he scratched it’ vs. ‘they scratched it’

á-tè:l-é á-tè:nd-é ‘he pulled it’ vs. ‘they pulled it’

á-tá:l̪-é á-tá:nd̩-é ‘he cooked it’ vs. ‘they cooked it’

b. <i>Unpossessed</i>	<i>Possessed (1Sg)</i>	
bò:l-ì	bò:t-â	‘handles’ vs. ‘my handles’
àbí-î	àbí:n`-á	‘cloth’ vs. ‘my cloth’
dè:l	dè:nd-á	‘skin’ vs. ‘my skin’
tà-à	tà:n:-á	‘pancreas’ vs. ‘my pancreas’
tùol	tùonḡd-à	‘snake’ vs. ‘my snake’
ùtò`-ó	ùtò:n`-á	‘fox’ vs. ‘my fox’

The Pãri case serves to illustrate that even root-internal cooccurrence restrictions may be manifested ‘dynamically’, by driving alternations. A similar example in Tlachichilco Tepehua is discussed in 2.4.2 below; here, a phonological phenomenon of coda dorsalization (yielding /t/ → /k/, etc.) feeds dorsal consonant harmony, which harmonizes the resulting /k/ to any uvular found elsewhere in the root.

In fact, a great number of the consonant harmony systems included in the database are restricted to the root-domain. In fact, treating these as yet another instantiation of harmony brings to light what appears to be a typological asymmetry between vowel harmony and consonant harmony systems. Vowel harmony frequently applies only (or primarily) in derived contexts, operating across morpheme boundaries, whereas disharmony is rampant within roots. In consonant harmony systems, on the other hand, roots are rarely exceptional in this manner; indeed, the root is quite often the only domain where harmony applies. Some of the types of consonant harmony surveyed here are almost exclusively attested as root-internal cooccurrence restrictions (e.g., laryngeal harmony). But even in the case of sibilant harmony—arguably the most canonical type of consonant harmony—a considerable number of the attested cases involve ‘static’ morpheme-structure constraints.

A final argument for equating root-internal cooccurrence restrictions with alternation-yielding consonant harmony comes from the comparative-historical domain. In a

number of cases where a particular consonant harmony is attested in several related languages, some languages restrict the harmony to the root domain whereas in others, it extends across the root-affix boundary. Returning to Western Nilotic coronal harmony, we find that in many of the languages it is strictly root-internal, as in Pāri (e.g., Alur, Luo, Shilluk), but in at least one language, Mayak, it extends to suffixes as well (Andersen 1999). Another example is sibilant harmony in Omotic languages, where root-internal harmony can be reconstructed for Proto-Omotic (Hayward 1988). Whereas most daughter languages show no trace of sibilant harmony beyond the root, several have extended it to suffixes, resulting in alternations (Aari, Gimira, Koyra, Zayse). In Zayse, harmony in suffixes is merely optional (Hayward 1990b). According to Hayward (1988:297 n. 38), optionality of harmony is particularly characteristic of inflectional suffixes, both in Koyra and in Aari. In Gimira, certain suffixes undergo harmony but not others (e.g., out of the two causative suffixes, /-s/ and /-as/, only the former harmonizes).

To sum up, then, one of the claims implicit in the design of the database is that the distinction between assimilatory morpheme-structure constraints and ‘dynamic’ (alternation-yielding) harmony patterns is purely epiphenomenal. Rather than reflecting a fundamental difference in the nature of the phonological phenomenon involved, the distinction simply translates into a difference in the morphological domain within which harmony is enforced. Root-internal harmony is merely at one end of the scale, with word-level or ‘across-the-board’ harmony at the other end (e.g., sibilant harmony in Chumashan languages). Intermediate between the two are cases where consonant harmony is limited to a (derivational) stem of some kind, usually affecting derivational affixes but not inflectional ones. The sensitivity of consonant harmony to morphological domains is briefly addressed in section 5.3 below.

2.4. Classification by harmonizing property

This section presents a fairly detailed survey of the consonant harmony systems that make up the database, classified in terms of the types of segments involved and the phonetic/phonological property defining the harmony. Each type and subtype has been illustrated with several examples, especially in the case of less well-known harmony types. Needless to say, space does not permit all of the systems in the database (about 120 in all) to be illustrated, though nearly all of them are at least mentioned. However, an attempt has been made to include, for each harmony type, examples involving alternations (if attested) as well as ones involving ‘static’ cooccurrence restrictions, i.e. root-internal harmony.

The classification which has been followed is primarily intended to serve expository purposes, rather than having any theoretical or analytical significance as such. Indeed, some individual cases may well turn out to be more properly classified in a different category from the one specified here. One problem is the frequent lack of detailed and exact phonetic descriptions in the sources cited. Given the size and scope of this survey, it was often deemed infeasible to follow up by searching for other sources on the language in question; it is thus inevitable that a certain amount of important detail has been overlooked or misinterpreted. Another recurring dilemma has to do with the ambiguity inherent in much traditional usage of descriptive-phonetic terminology—the terms ‘palatal’ and ‘palatalized’ being the most extreme examples. Whereas ‘palatalization’ in the strictest sense refers to the superimposition of an essentially vocalic articulatory gesture onto a consonant (yielding pairs such as [s]/[s^h], [t]/[t^h]), it is frequently used to refer to alternations such as [s] → [ʃ], [d] → [dʒ] or [dz] → [dʒ], and the resulting postalveolar fricatives/affricates are often labeled ‘palatals’. Indeed, when a descriptive source refers to a ‘palatal stop’, perhaps rendering it semi-orthographically as ‘j’, it is often nearly impossible to determine whether the segment in question is truly a palatal stop, [j], or instead a (lamino-)postalveolar affricate [dʒ].

The descriptive terminology used for sibilants is even more confusing: a segment transcribed as /ʃ/ (or ‘š’) may be described alternatively as ‘alveo-palatal’, ‘palato-alveolar’, ‘blade-alveolar’, ‘groove-alveolar’, ‘lamino-palatal’, ‘dorso-palatal’, or simply ‘palatal’, where it is far from clear what exactly is meant by any of these terms. The problem becomes even more thorny when the sources consulted are phonological-analytical rather than purely descriptive, since phonological analysis usually involves interpreting the raw data in terms of more abstract features or feature classes. To take an example, Humbert (1995) even treats Chumash sibilant harmony—which appears to involve either an alveolar-postalveolar [s]/[ʃ] or laminal-apical [ɕ]/[ʑ] contrast—as *secondary-articulation* harmony.

Keeping in mind the above caveat that the classification presented here may at times be somewhat arbitrary, consonant harmony systems attested in the database have been grouped into the following classes. Coronal harmony (2.4.1), by far the most common type of consonant harmony, is broken down into sibilant harmony (2.4.1.1) and the somewhat heterogeneous category of ‘non-sibilant’ coronal harmony systems (2.4.1.2). Those relatively rare cases that involve distinctions subordinate to major articulators other than [coronal] are discussed in a separate section on dorsal and labial consonant harmony (2.4.2). Section 2.4.3 discusses consonant harmony involving secondary articulations such as pharyngealization, labialization, palatalization, etc. Nasal consonant harmony, which enforces agreement in [±nasal] between consonants without nasalizing intervening vowels, is discussed in section 2.4.4. The relatively uncommon phenomenon of liquid harmony (2.4.5) covers harmony between liquids, e.g., in terms of [±lateral], as well as harmony between liquids and non-liquids (typically glides). An even rarer phenomenon is what is classified here as stricture harmony (2.4.6), which involves distinctions such as fricative vs. stop, fricative vs. affricate or stop vs. affricate. Consonant harmony in terms of laryngeal features (voicing, aspiration, ejection, etc.)—which is almost unattested outside the root domain—is covered in a separate section on laryngeal harmony (2.4.7). Finally, section

2.4.8 takes a fresh look at the oft-repeated claim that major-place consonant harmony does not exist in adult language, in contrast to child language, where place harmony is rampant. As it turns out, a sizable number of attested sound patterns (all of them root-internal cooccurrence restrictions) are characterizable either as major-place consonant harmony or as an independent category of ‘total’ consonant harmony.

2.4.1. Coronal harmony

Of all the different types of consonant harmony surveyed here, one stands out as exceptionally common. This is the class of phenomena conventionally referred to as coronal harmony. In this respect, the present survey confirms previous claims (e.g., by Shaw 1991) to the effect that coronal harmony is the predominant type of consonant harmony—though it contradicts the stronger claim made by Gafos (1996[1999]) that coronal harmony is the *only* attested type of consonant harmony. Although the term ‘coronal harmony’ may seem self-explanatory, it is nevertheless worth discussing briefly what does and does not fall under this term, especially since many of the other types of harmony often involve interactions between consonants that happen to be coronals (e.g., stricture harmony, liquid harmony, etc.).

In the sense used here, ‘coronal harmony’ refers to assimilatory interactions between coronals where the property involved is what is sometimes referred to as ‘minor place of articulation’ specifications. These are coronal-specific distinctions that have to do with the configuration of the coronal articulator and the location of the constriction; roughly speaking, the parameters involved are tongue posture (apical vs. laminal) and target region (dental vs. alveolar vs. postalveolar).² Coronal harmony systems are attested for various

² Gafos (1997, 1999) suggests that, at least in the case of fricative (or affricate) contrasts such as /θ/ vs. /s/ vs. /ʃ/, the latter parameter should be reinterpreted as involving (cross-sectional) constriction *area*. As for languages with dental vs. alveolar stop contrasts, Gafos argues that the laminal vs. apical parameter is in fact the phonologically relevant one. To avoid confusion, the more traditional phonetic terminology involving ‘target region’ is used here (see, e.g., Ladefoged & Maddieson 1996).

combinations of such ‘minor-place’ specifications. Some examples of the contrasts involved are lamino-dental vs. alveolar (/t̪/ – /t/; /θ/ – /s/ etc.), apico-alveolar vs. lamino-alveolar (/ʃ/ – /s/, etc.), alveolar vs. apico-postalveolar (/t/ – /t̪/; /s/ – /ʃ/, etc.), and alveolar vs. lamino-postalveolar (/t/ – /t̪/ etc.; /s/ – /ʃ/ etc.). Note that apico-postalveolar and lamino-postalveolar articulations are equivalent to the more traditional terms ‘retroflex’ and ‘palato-alveolar’, respectively (the latter sometimes also referred to as ‘alveo-palatal’ or simply ‘palatal’).

As for the potential relevance of manner distinctions ([±continuant] and the like), coronal harmony effects are attested for a wide range of segment types, including stops, affricates, fricatives, nasals and liquids. Nevertheless, the most frequently encountered kind of coronal harmony is sibilant harmony, where the harmonizing segments are fricatives and/or affricates (usually strident ones). Because it is such a salient subtype of coronal harmony, sibilant harmony is here treated in a separate section (2.4.1.1), followed by a section on coronal harmony systems involving non-sibilant coronals (2.4.1.2).

2.4.1.1. Sibilant harmony

It is safe to say that the prototypical consonant harmony is one which involves the interaction of sibilants, such as alveolar /ts, s, z/ vs. postalveolar /tʃ, ʃ, ʒ/. In fact, it is more accurate to say that it is *sibilant* harmony, rather than coronal harmony in general, which is the cross-linguistically predominant type of consonant harmony. Indeed, *non-sibilant* coronal harmony systems (see 2.4.1.2) are relatively uncommon—about as rare as little-known harmony types like dorsal harmony or liquid harmony. Sibilant harmony systems, by contrast, make up about one-third of all the entries in the database surveyed here. The

languages in question belong to about 15 different families, distributed over at least four continents (North and South America, Africa, Europe).³

Among the various possible kinds of sibilant harmony, the most common involves the alveolar vs. lamino-postalveolar distinction, i.e. /s, z, ts, dz/ vs. /ʃ, ʒ, tʃ, dʒ/. (The latter will henceforth be referred to simply as ‘postalveolar’, although it should be remembered that, strictly speaking, this term also covers retroflex consonants.) The predominance of this kind of sibilant harmony is no doubt due to the fact that the alveolar/postalveolar distinction appears to be the one most commonly utilized for phonological contrast among sibilants cross-linguistically. One of the best-known examples of consonant harmony is of exactly this type: Navajo sibilant harmony (see, e.g., Sapir & Hoijer 1967; Kari 1976; Halle & Vergnaud 1981; McDonough 1990, 1991; Faltz 1998).

As was illustrated briefly in section 1.1 above, sibilant harmony in Navajo involves the alveolar and postalveolar series, /tsʰ, ts, dz, s, z/ vs. /tʃʰ, tʃ, dʒ, ʃ, ʒ/. It applies in a right-to-left fashion (with certain exceptions, discussed in 3.1.2 below) throughout a domain comprising the stem and so-called ‘conjunct’ prefixes. A sibilant in the root will thus trigger assimilation in prefixes, and a prefix sibilant will likewise trigger assimilation in any preceding prefixes.

³ The linguistic-geographic distribution of attested sibilant harmony systems is of necessity limited by certain areal-typological trends in inventories. For example, most aboriginal languages of Australia and New Guinea lack fricatives altogether, or have only /s/, and a great number of Austronesian languages also have no more than one sibilant.

(6) Sibilant harmony in Navajo (data from McDonough 1991)

jismas	/j-iʃ-mas/	‘I’m rolling along’
sisná	/ʃ-is-ná/	‘he carried me’
ʃidzé:ʔ	/si-dzé:ʔ/	‘they lie (slender stiff objects)’
dziʃta:l	/dz-iʃ-l-ta:l/	‘I kick him [below the belt]’
dzists’in	/dz-iʃ-l-ts’in/	‘I hit him [below the belt]’

The same kind of sibilant harmony is found elsewhere in Southern Athapaskan languages, e.g., in Chiricahua Apache (Hoijer 1939, 1946) and Kiowa-Apache (Bittle 1963). In the Northern branch of Athapaskan languages, consonant harmony involving alveolar and post-alveolar sibilants is also attested in Tahltan (Hardwick 1984; Nater 1989; Shaw 1991), Beaver (Doig River dialect; Story 1989), Sarcee (Cook 1979; 1984), Slave (Bearlake dialect; Rice 1989) and Tanana (Tuttle 1998). In the third branch of the Athapaskan family, the Pacific Coast subgroup, sibilant harmony of the same type has been reported for Tututni (Golla 1976) and Hupa (Golla 1970), although it occurs only in a very restricted morphological contexts.⁴ In fact, sibilant harmony can be reconstructed as a root-internal cooccurrence restriction as far back as Proto-Athapaskan-Eyak (Krauss 1964), where it ruled out combinations of the three *ts, *tʃ and *tʃ^w series.⁵

Sibilant harmony of the alveolar vs. postalveolar type is found in many other native languages of North America. Another well-known example is found in several of the

⁴ Beyond the confines of the root, harmony in Hupa appears to affect only the human deictic subject prefix /tʃ^ʔɪ-/ , when it immediately precedes an /s/ (usually belonging to the /s-/ perfective prefix), thus /tʃ^ʔɪ-s-tatʃ^ʔ/ ‘he tattooed s.o.’ → [ts’ɪstatʃ^ʔ]. In Tututni, harmony appears to affect only the combination of conjugation marker /sə-/ and 1SgSubj prefix /ʃ-/ , and only in so-called neuter verb themes (resulting in /sə-ʃ-/ → [sə-s-]; see 3.1.2 below for a similar phenomenon in Navajo). Tututni also has sibilant assimilation under absolute adjacency, though this is arguably distinct from sibilant harmony.

⁵ The interaction of morphological structure with sibilant harmony in Navajo (cf. McDonough 1991) is discussed in section 3.1.2 below. Note also that the peculiar sibilant *pharyngealization* harmony found in Tsilhqot’in (Chilcotin; Krauss 1975; Cook 1983, 1987, 1993; Hansson 2000), described briefly in 2.4.3, is cognate with the coronal harmony found in Navajo, Apache, etc.; the series involved there are the direct historical reflexes of the Proto-Athapaskan *ts vs. *tʃ/*tʃ^w series.

Chumashan languages (Yu to appear), such as Ineseño (Applegate 1972; see also Poser 1982; Steriade 1987; Shaw 1991), Barbareño (Beeler 1970; Mithun 1998) and Ventureño (Harrington 1974). It should be noted, however, that it is not entirely clear whether the sibilant distinctions involved were primarily a matter of alveolar vs. postalveolar ([s] vs. [ʃ], etc.) or, alternatively, laminal vs. apical ([s] vs. [s̺], etc.)—sibilant harmony systems of the latter type will be discussed below.

As in Athapaskan, sibilant harmony in the Chumashan languages is anticipatory, the rightmost sibilant in the word determining the value of all preceding sibilants. This is illustrated by the Ineseño examples in (7a-b) Because of the exclusively prefixing character of Athapaskan morphology, the right-to-left directionality in languages such as Navajo or Tahltan goes hand in hand with the layering of morphological constituents—in other words, it applies in an ‘inside-out’ fashion from stem to affix (but see section 3.1.2 for some necessary qualifications of this view). However, the same is not true of Chumashan sibilant harmony, where the right-to-left directionality is clearly independent of morphological structure (cf. Poser 1982). As shown by examples such as those in (7b), even suffixes will trigger harmony in a preceding root (as well as in prefixes), resulting in an ‘outside-in’ effect.

(7) Sibilant harmony in Ineseño Chumash (data from Applegate 1972)

a. Unbounded right-to-left harmony (caus. /su-/; 3Subj /s-/)

kʃufojin	/k-su-fojin/	‘I darken it’
ʃapitʃ ^h olit	/s-api-tʃ ^h o-it/	‘I have a stroke of good luck’

b. Directionality independent of morphological structure (past /-waʃ/, 3Obj /-us/)

sapits ^h olus	/s-api-tʃ ^h o-us/	‘he has a stroke of good luck’
ʃapitʃ ^h oluʃwaʃ	/s-api-tʃ ^h o-us-waʃ/	‘he had a stroke of good luck’
haʃxintilawaʃ	/ha-s-xintila-waʃ/	‘his former Indian name’
sistisijepus	/s-iʃ-tiʃi-jep-us/	‘they (2) show him’

c. Harmony overridden (and fed) by pre-coronal /s/ → /ʃ/ change

ʃtijepus	/s-ti-jep-us/	‘he tells him’
ʃiʃlusisin	/s-iʃ-lu-sisin/	‘they (2) are gone awry’
ʃiʃtiʔi	/s-is-tiʔi/	‘he finds it’

The apparently disharmonic forms in (7c) illustrate the interaction between sibilant harmony and an independent constraint enforcing /s/ → /ʃ/ (etc.) before the coronals /t, l, n/. This pre-coronal effect is restricted to derived environments (cf. /wastu/ ‘pleat’). It overrides sibilant harmony, in that the resulting sibilants are consistently postalveolar, regardless of the quality of any following sibilants in the word.⁶ As shown by the last example in (7c), however, the pre-coronal effect also *feeds* sibilant harmony, in that the /ʃ/ in question will itself trigger harmony on any preceding sibilants. See Poser (1982) for further discussion of the interaction between sibilant harmony and precoronal /s/ → /ʃ/ in Chumash.

According to Mithun’s (1998) characterization of the precoronal effect, it was essentially a matter of *apicalization* before (apical) /t/, /n/, etc.—thus resulting in [s] > [ʃ] or [ʃ] (allophonic) rather than [s] > [ʃ] (merging with /ʃ/). Mithun does not mention the interaction of this allophonic apicalization with sibilant harmony—i.e. that the apical allophone of /s/ has come to trigger the same harmony effect as postalveolar /ʃ/. One possible

⁶ Notice that even an underlying /ʃ/ can be disharmonic in this way (cf. the second example in 7c), as long as it is in a derived __{t, l, n} environment. The generalization that pre-coronal /ʃ/ is immune to sibilant harmony is not without exceptions in Ineseño; it occasionally does undergo harmony (cf. the last example in 7b), just as /ʃ/ in underived pre-coronal environments does. In the closely related Ventureño, on the other hand, Harrington (1974) describes derived /ʃ/ as being consistently unaffected by sibilant harmony.

diachronic scenario is perhaps that the [s̥] (or [s̥]) allophone merged with /ʃ/—giving rise to surface exceptions to sibilant harmony—and that sibilant harmony was then enforced in any preceding prefixes (roughly: [s-i̥s̥-lu-sisin] > [s-iʃ-lu-sisin] > [ʃ-iʃ-lu-sisin], etc.). The interplay of apicalization and harmony is a topic which merits further investigation as regards its diachronic-philological aspects. A preliminary analysis of the interaction of sibilant harmony with the precoronal effect in Ineseño is presented in section 5.1.1.

In addition to the various Athapaskan and Chumashan languages mentioned so far, harmony between what appear to be alveolar and (lamino-)postalveolar sibilant series is also found in many other native languages of the Americas. The ones spoken in North and Central America are at least the following: Southern Paiute (Uto-Aztecan; Sapir 1931; Harms 1966; Lovins 1972); Wiyot (Algic; Teeter 1959, 1964); Rumsen (Costanoan; Garrett 1999, based on Miller to appear); various Mayan languages such as Tzeltal (Kaufman 1971), Tzotzil (Cowan 1969), Tzutujil (Dayley 1985), classical and modern Yucatec (Straight 1976; Lombardi 1990), and Ixil (Nebaj dialect; Ayres 1991); the Totonacan languages, e.g., Misantla Totonac (MacKay 1999) and Tepehua (Tlachichilco dialect; Watters 1988). In South America, this type of sibilant harmony is found at least in Capanahua (Panoan; Loos 1969) and some of the Quechuan languages, such as Wanka Quechua (Cerrón-Palomino 1967, 1977; Mannheim 1988) and Southern Peruvian Quechua (as spoken in the colonial period; Mannheim 1988, 1991). In virtually all of these languages, the harmony either exhibits right-to-left directionality or is manifested merely as a root-internal cooccurrence restriction. The sole examples involving left-to-right directionality are Wiyot and Rumsen; here, it seems that the directionality may be derivable from morphological constituent structure, i.e. reducible to an ‘inside-out’ effect (although this is less clear in the Wiyot case).⁷

⁷ The Wiyot case is remarkable in that it appears to be a combination of sibilant (fricative) harmony, yielding /s/ → /ʃ/, and liquid harmony, yielding /l/ → /r/. Neither is particularly remarkable as such, but Wiyot appears to combine the two, such that /r/ also triggers /s/ → /ʃ/, and /ʃ/ also triggers /l/ → /r/. This

Outside of the Americas, sibilant harmony involving the alveolar-postalveolar distinction is also attested in a number of African languages, belonging to various branches of the Niger-Congo and Afro-Asiatic macro-families. Within the Bantu family, for example, this kind of harmony is attested in Shambaa (Roehl 1911), Izere (Blench 2000), and several languages of the Lacustrine ('Zone J') subgroup, notably Rwanda (Kimenyi 1979; Coupey 1980), Rundi (Meeussen 1959; Ntahirageza 1993) and Nkore/Kiga. No published sources on Nkore/Kiga explicitly discuss the existence of sibilant harmony effects, but Hyman (1999b) finds it robustly manifested in Taylor's (1957) dictionary (computerized as part of the CBOLD database). In all of these cases, harmony is manifested in alternations in roots and/or affixes. In Izere, a /-s-/ plural infix harmonizes with a preceding root-initial sibilant: /sɔnɔŋ/ 'to insert' vs. plural /sɔ́=s=ɔ̀ŋ/, but /ʃínìn/ 'to fill up' vs. plural /ʃí=ʃ=ìn/, /tʃánàŋ/ 'defeat in wrestling; argument' vs. plural /tʃá=ʃ=àŋ/.⁸ In all of the other languages, the directionality is uniformly right-to-left, often from suffix to root.

Within Afro-Asiatic, sibilant harmony is independently attested in at least three branches. In Coptic, several dialects (Sahidic, Akhmimic, Assiutic) underwent a sound change whereby /s/ > /ʃ/ by assimilating to a tautomorphic /ʃ, tʃ/ (Chaine 1933; Till 1961; Westendorf 1977). There is much variation as regards directionality and the possible effects of distance between trigger and target; however, the harmony appears to have been strictly confined to root-internal sibilant sequences. In these dialects, /ʃ/ of secondary origin, a reflex of earlier /x/ (perhaps by a later sound change), does not trigger harmony. By

is possibly connected to the fact that Wiyot also has a systematic pattern of diminutive/augmentative consonant symbolism, whereby /s/ → /ʃ/, /l/ → /r/ and /t/ → /tʃ/ or /ts/ (see 6.3.3 for discussion of such possible links between sound symbolism and harmony in other languages).

⁸ The morphology of Izere plural formation as described by Blench (2000) is very complex and does not appear to follow any one productive pattern. In most cases a 'replacive morph' of some kind is involved, often containing an /s/, and this /s/ always harmonizes with a /ʃ/ or /tʃ/ elsewhere in the word. Other singular/plural alternations that illustrate sibilant harmony, but which hardly fit under the rubric of infixation, are sg. /ʃé:r/ ↔ pl. /ʃéʃèk/ 'to hang up', sg. /tʃér/ ↔ pl. /tʃéʃèk/ 'to carry' (cf. /re:r/ ↔ /résék/ 'to cook', /tár/ ↔ /tásàk/ 'to shout; yell'), as well as sg. /ʃán/ ↔ pl. /ʃâ:ʃ/ 'to buy, receive' (cf. /gaŋ/ ↔ /gá:s/ 'to push').

contrast, in certain other dialects (Bohairic, Fayyoumic) harmony appears to be almost exclusively triggered by this secondary /ʃ/ < /x/, although descriptions are sketchy.

The same kind of sibilant harmony is attested in different Berber dialects, e.g., Ntifa Berber (Laoust 1918) and Imdlawn Berber (Elmedlaoui 1992), where it manifests itself both root-internally and across morpheme boundaries. The directionality is consistently right-to-left. Virtually identical harmony assimilations are found in Moroccan Arabic (Harris 1944; Harrell 1962; Heath 1987). Although the latter belongs to a different branch (Semitic), its sibilant harmony is very likely to be areally (and sociolinguistically) directly connected to the Berber one. It is worth pointing out that in Berber sibilant harmony, only the non-pharyngealized sibilants interact with each other, i.e. /s, z/ vs. /ʃ, ʒ/, whereas pharyngealized /s^h/ does not appear to participate in the harmony in any way. The same does not appear to be true in Moroccan Arabic; according to Heath (1987), /ʃ, ʒ/ do not cooccur either with plain /s, z/ or with pharyngealized /s^h, z^h/.

Finally, sibilant harmony is quite widespread in the Omotic languages of southern Ethiopia, as mentioned briefly in 2.3 above. These include Aari (Hayward 1990a), Gimira (Benchnon dialect; Breeze 1990), Koyra (Hayward (1990b) and Zayse (Hayward 1990c); cf. also Hayward (1988), who discusses the phonological development of sibilants across the Omotic languages. In fact, sibilant harmony can be reconstructed as a root-internal cooccurrence restriction in Proto-Omotic (Hayward 1988). In all of the daughter languages that retain sibilant harmony, it involves at least an alveolar vs. lamino-postalveolar distinction, /ts', ts, s, z/ vs. /tʃ', tʃ, ʃ, ʒ/. In addition to holding root-internally, Omotic sibilant harmony also gives rise to alternations in affixes, whereby /s, z/ → /ʃ, ʒ/. This is illustrated by the Koyra examples in (8).

(8) Sibilant harmony in Koyra (data from Hayward 1982)

a. Root-internal harmony

<i>Well-formed roots</i>		<i>Disallowed sequences</i>	
su:ts'-	'blood'	*s...ʃ	*ʃ...s
zu:s-	'creeper'	*s...tʃ	*tʃ...s
ts'ugunts-	'fingernail'	*s...dʒ	*dʒ...s
ʃo:ʃ-	'snake'	*ts...ʃ	*ʃ...ts
dʒaʃ-	'fear'	(etc.)	
ʔitʃ:ʔtʃ:e	'five'		

b. Harmony in suffixes (causative /-(u)s/, 3MSg.perf. /-os:o/, 3MSg.juss. /-es:e/)

dʒaʃ-uʃ-	'cause to fear'
go:tʃ-uʃ-	'cause to pull'
ʔordʒ-uʃ-	'make big, increase (tr.)'
ʃaj-ʃ-	'cause to urinate'
patʃ:-oʃ:o	'it became less'
ʔordʒ-oʃ:o	'he/they got big'
gi:ʒ:-oʃ:o	'it suppurated'
dʒaʃ-uʃ-ef:e	'let him/them frighten (s.o.)!'

c. Harmony is strictly transvocalic; no harmony at greater distances

ʃod-us-	'cause to uproot'	(*ʃod-uʃ-)
ʃoh-us-	'wash (tr.)'	(*ʃoh-uʃ-)
tʃ'a:n-us-	'cause to load'	(*tʃ'a:n-uʃ-)
ʃod:-os:o	'he uprooted'	(*ʃodd-oʃ:o)
ʔatʃ-ut:-os:o	'he (polite) reaped'	(*ʔatʃut:-oʃ:o)

In Koyra sibilant harmony, the trigger and target sibilants may at most be separated by a vowel (Hayward 1982; Ford 1990); the same is true in Zayse as well (Hayward 1990b). In Aari and Gimira, on the other hand, there is no limit on the distance between the trigger and target consonants (Hayward 1988, 1990a; Breeze 1990). This is shown by the Aari forms in (9).

(9) Across-the-board sibilant harmony in Aari (data from Hayward 1988, 1990a)

a. Harmony in causative /-sis/)

nɛʃ-ʃiʃ-	‘cause to love’
ʔuʃ-ʃiʃ-	‘cause to cook’
qɑʒ-ʒiʃ-	‘make cold’
ʃa:n-ʃiʃ-	‘cause to urinate’
ʒɑq-ʃiʃ-	‘cause to throw’
tʃʰɑ:q-ʃiʃ-	‘cause to swear (oath)’

b. Harmony in perfective /-s/

ʔuʃ-ʃ-it	‘I cooked’
qɑʒ-ʒ-it	‘I got cold’
tʃʰɑ:q-ʃ-it	‘I swore’
ʒaʔ-ʃ-it	‘I arrived’
baʃ-er-ʃ-it	‘I was overcome’
ʃed-er-ʃ-it	‘I was seen’
ʒɑ:g-er-ʃ-e	‘it was sewn’

Sibilant harmony in Koyra and Aari can be characterized as ‘transvocalic’ and ‘unbounded’, respectively. The exact same dichotomy is attested for at least one other harmony type: nasal consonant harmony in Bantu languages (see section 2.4.4). There, as

in the Omotic case, closely related languages display different versions of the same harmony, differing only in whether the trigger and target consonants may be separated by more segmental material than a single vowel.

Although the directionality is clearly left-to-right in the Koyra and Aari examples shown above—and indeed in all sibilant harmony alternations in Omotic—there is reason to believe that this is an epiphenomenon of morphological structure. The more appropriate generalization, instead, is that harmony applies ‘inside-out’, i.e. from base to affix. Note that all alternating suffixes have alveolar /s/, and the harmony effect is thus always /s/ → /ʃ/. Within roots, there is diachronic evidence that this harmony applies bidirectionally, as noted by Hayward (1988). In Zayse loanword adaptation, Amharic /tʰ/ is usually rendered with Zayse /tsʰ/; however, /tʃʰadʒ:e/ ‘mead’ (from Amharic /tʰädʒ:/) and /tʃʰilo:ʃa/ ‘brideprice’ (from Amharic /tʰiloʃ/) appear to have undergone a change of *right-to-left* sibilant harmony from earlier */tsʰadʒ:e/, */tsʰilo:ʃa/.

Proto-Omotic had a third series of sibilants, retroflex (i.e. *apico*-postalveolar) */tʃʰ/, */ʃ/, */zʰ/; this series was also within the scope of the (root-internal) harmony, which then ruled out the cooccurrence of alveolar, lamino-postalveolar and apico-postalveolar sibilants (Hayward 1988). At least one of the daughter languages, Gimira (Benchnon dialect), retains all three series. Here, as in Proto-Omotic, the sibilant harmony is a three-way one, even as regards suffix alternations; this is illustrated in (10).

(10) Three-way sibilant harmony in Benchnon Gimira (data from Hayward 1988)

a. Root-internal harmony

<i>Well-formed roots</i>		<i>Disallowed sequences</i>
sis	‘fir tree’	*s...ʃ, *s...ʂ, *ʃ...s, *ʃ...ʂ, etc.
zos	‘neighbor’	*s...tʃ, *s...tʂ, *ʃ...ts, *ʃ...tʂ, etc.
ts’ots’-	‘centre’	*ts...ʃ, *ts...ʂ, *tʃ...s, *tʃ...ʂ, etc.
ʃaʃkn	‘green tree-snake’	*ts...tʃ, *ts...tʂ, *tʃ...ts, *tʃ...tʂ, etc.
tʃiʃkn	‘bile’	*ts’...ʃ, *ts’...ʂ, *tʃ’...s, *tʃ’...ʂ, etc.
ʒatʃu	‘maize flower’	*ts’...tʃ, *ts’...tʂ, *tʃ’...ts, *tʃ’...tʂ, etc.
ʂetʂ’	‘type of cabbage’	*z...ʃ, *z...ʂ, *ʒ...s, *ʒ...ʂ, etc.
zɛz-	‘become red’	(and so forth)
tʂ’ontʂ’-	‘fill (tr.)’	

b. Harmony alternation in causative /-s/

s ^h ap-s-	‘make wet’
ʃir-f-	‘bring near’
tʃ’ob-f-	‘make light’
ʂup-ʂ-	‘make soft’

In fact, several of the languages mentioned earlier have similar three-way harmony systems, involving not only alveolar and lamino-postalveolar (‘palatal’) sibilants, but also a third series of apico-postalveolar (‘retroflex’). These include Capanahua (Loos 1969) and the Nebaj dialect of Ixil (Ayres 1991), and possibly Proto-Athapaskan-Eyak as well (Krauss 1964).⁹ The same is also true of Rumsen sibilant harmony (Garrett 1999, based on Miller to appear), but here the three series do not play an equal part in the harmony. Whereas

⁹ Reconstructions of the Proto-Athapaskan consonant inventory vary as to whether the *tʃ^w series was labialized or instead a retroflex *tʂ series (as is found in several Northern Athapaskan languages).

alveolar /s, ts/ assimilate to apico-postalveolar /ʃ, tʃ/, and vice versa, the participation of lamino-postalveolar /ʒ, tʒ/ in the harmony is quite marginal; cf. section 5.3.3 for discussion. In the morpheme-internal harmony found in Wanka Quechua (Cerrón-Palomino 1967, 1977), only retroflex and ‘palatal’ sibilants interact, whereas the alveolar /s/ does not participate in the harmony.¹⁰

In many of the sibilant harmony systems discussed so far, it is difficult to determine exactly what the nature of the phonetic distinction between the harmonizing sibilant series is. In some cases, it is quite possible that the relevant parameter is not so much alveolar vs. postalveolar, as has been assumed here, but rather an apical vs. laminal distinction (‘tip-up’ vs. ‘tip-down’, in gestural terms, cf. Gafos 1996[1999]). One case where it is quite clear that a pure apical/laminal opposition is involved is Basque, where sibilant harmony applies as a root-internal cooccurrence restriction (Hualde 1991; Trask 1997).

Basque has a three-way contrast between apico-alveolar, lamino-alveolar and lamino-postalveolar (‘palatal’) sibilants: /ʃ, tʃ/, /s, ts/ and /ʒ, tʒ/—represented in the orthography as <s, ts>, <z, tz> and <x, tx>, respectively. (Bizkaian dialects, and some Gipuzkoan dialects, have merged the two alveolar series.) According to Hualde (1991), sibilants of any of the three series do not cooccur within morphemes. Hualde bases his characterization of Basque sibilant harmony on Salaburu’s (1984) description of the Baztan dialect; the latter claims that no counterexamples are found. If true, this means that Basque displays a three-way sibilant harmony, at least dialectally, which is similar to that found in Gimira, Ixil, Capanahua, etc. In all cases, the harmony involves a (lamino-)alveolar series, a lamino-postalveolar one (‘palatals’) and a third, apical series. Whereas this third series appears to be apico-*postalveolar* (‘retroflex’) in Gimira, Ixil, etc., it is clearly apico-alveolar in Basque.

¹⁰ Interestingly, the palatal sonorants /ʎ, ɲ/ appear also to participate in the Wanka Quechua harmony, in that these do not cooccur with the retroflex affricate /tʃ/ (Cerrón-Palomino 1977:62).

Other descriptions of Basque sibilant harmony make no mention of the postalveolar series being involved (Michelena 1985, 1995; Trask 1997). Instead, the harmony is merely said to prohibit the cooccurrence of the apico-alveolar and lamino-alveolar series, /ʃ, tʃ/ vs. /s, ts/. Indeed, forms combining ‘palatal’ sibilants with alveolars are attested, at least in some dialects (e.g., /tʃimiʃta/ ‘lightning’, /tʃoʃten/ ‘report’). The root-internal harmony involving apical vs. laminal alveolars, by contrast, is a very robust generalization. Indeed, it asserts itself as an active constraint on Basque phonology, for example, in loanword adaptation (e.g., /fran(t)ʃeʃ/ ‘French’ < /fran(t)seʃ/, from Spanish *francés*). The same effect can be seen in the reanalysis of compounds (e.g., /ʃinetʃi/ ‘believe’ < /sin-etʃi/, cf. /sin/ ‘truth’, /(h)etʃi/ ‘consider’; /eʃetʃi/ ‘persist’ < /es/ ‘no’ + /(h)etʃi/, etc.). In general, the directionality of assimilation is right-to-left, but interestingly, the apical series tends to be the ‘dominant’ one. Thus, left-to-right harmony is observed in /ʃatʃuri/ ‘mole’ (17th century) < */ʃat-suri/ and in /ʃaʃoi(n)/ < */ʃasoi(n)/ (from Spanish *sazón*). Some dialects have right-to-left assimilation even here, e.g., Isaba /sasoi/, Vidángoz /sasoĩ/ (Michelena 1985).

The sibilant harmony systems examined so far have all involved alveolar vs. post-alveolar and/or apical vs. laminal distinctions. It is far less common for sibilant harmony to involve a dental vs. alveolar contrast; nevertheless, a few such cases are attested in the database; all of these belong to the Athapaskan family.¹¹ It may appear odd to discuss these under the heading ‘sibilant harmony’, given that (inter)dental fricatives and affricates are not usually included in the class of ‘sibilants’ as that term is conventionally used (cf. Ladefoged & Maddieson 1996). Nevertheless, the cases in question clearly belong in this category. Two of these are three-way harmony systems that also involve *bona fide* sibilant distinctions; furthermore, all are cognate with the sibilant harmony systems found in Navajo, etc. (cf. above discussion).

¹¹ A point that may be relevant in this context is the fact that (inter)dental affricates are extremely rare cross-linguistically. Athapaskan is one of the few families where such segments are widespread.

One of the Athapaskan languages in question is Tahltan (Hardwick 1984; Nater 1989; Shaw 1991), where a three-way harmony holds between the dental /tθ, tθ', dð, θ, ð/, alveolar /ts, ts', dz, s, z/ and (lamino-)postalveolar /tʃ, tʃ', dʒ, ʃ, ʒ/ series.¹² As in other Athapaskan sibilant harmony systems, the directionality is right-to-left in Tahltan, applying from root to prefix or from prefix to earlier prefix. In fact, the dental (/θ/) and alveolar (/s/) series of Tahltan are cognate with the alveolar (/s/) and postalveolar (/ʃ/) series, respectively, in languages such as Navajo and Apache. Both are reflexes of the Proto-Athapaskan *s and *ʃ/*ʃʷ series, respectively (note that all of the relevant languages have merged the PA *ʃ and *ʃʷ series). Indeed, the data reported by Hardwick (1984) suggests that the third series (Tahltan /ʃ/ etc., from PA front velars) plays a more marginal role in the sibilant harmony system in Tahltan, and is likely to be a later addition to what originally was a two-way harmony.

The Doig River dialect of Beaver, as described by Story (1989), also displays three-way sibilant harmony involving a dental, alveolar and postalveolar series, although it is much less systematic than its Tahltan counterpart. As in Tahltan, the Beaver dental and alveolar series go back to the Proto-Athapaskan *s and *ʃ/*ʃʷ series, respectively.¹³ Story (1989) describes the dental series as ‘postdental’, which may indicate that these are indeed true sibilants, i.e. [tʃ, tʃ', dʒ, ʃ, ʒ] rather than [tθ, tθ', dð, θ, ð].

A third Athapaskan language (also spoken in the southwestern part of the Northern Athapaskan area) is relevant in this context, even though its consonant harmony system does not conform to the definition of sibilant harmony. This is Tsilhqot'in (Chilcotin), whose sibilant pharyngealization harmony is described briefly in 2.4.2 below. The (two-

¹² Technically the /θ/-series consonants do not qualify as sibilants, but given the comparative Athapaskan context—as well as the fact that a /s/ vs. /ʃ/ sibilant opposition is *also* involved in Tahltan—it is appropriate to include Tahltan here.

¹³ The Halfway River dialect of Beaver, described by Randoja (1989), has merged these two sibilant series, and displays no sibilant harmony. In this respect it closely resembles Sekani (Hargus 1988); indeed, Randoja states that the Halfway River dialect might more appropriately be counted as a dialect of Sekani, if it were not for the fact that the speakers refer to themselves as speakers of ‘Beaver’.

way) sibilant distinction on which Tsilhqot'in consonant harmony is synchronically a matter of pharyngealized vs. non-pharyngealized alveolars. Nevertheless, there is little doubt that this reflects an earlier dental vs. alveolar contrast (and ultimately the PA *s vs. */*^w series). In his brief sketch of Tsilhqot'in phonemics in King (1979) describes the 'flat' (i.e. pharyngealized) series as 'post-dental', and even transcribes them with [θ] etc.

In the neighboring language Dakelh (Carrier), the corresponding two series are realized as dental [ʃ] vs. alveolar [s], and so on, although this opposition is fast disappearing—or has already been lost—in most dialects (William Poser, pers. comm.). In fact, though none of the Carrier dialects have been reported to have sibilant harmony, there are some facts which might suggest that it did have harmony at some point in the past. The Proto-Athapaskan 'conjugation marker' prefix *se-, which should have yielded /ʃ-/ in Carrier, has two different reflexes, /ʃ-/ and /s-/. The relative distribution of the two reflexes is not phonologically defined; instead, /ʃ-/ and /s-/ reflect the two main morphological functions that *se- has in many Northern Athapaskan languages (including the neighboring Tsilhqot'in), namely perfective and negative. As a perfective marker, *se- has the expected reflex /ʃe-; as a negative marker, it shows up as /se-/ instead. One conceivable explanation is that what was once a harmony alternation between /ʃ-/ and /s-/ became levelled out in different directions in different morphological contexts: the /ʃ-/ variant was generalized in perfective paradigms, whereas in negative paradigms /s-/ was generalized.

Before moving on to coronal harmony involving non-sibilants, a final example of sibilant harmony deserves mentioning, one that has some rather peculiar properties. Several of the Formosan languages—the Austronesian languages of Taiwan—have undergone various sound changes, to some extent sporadic, which all appear to be instances of sibilant harmony (Blust 1995). As conventionally reconstructed, Proto-Austronesian had three sibilants, *S, *s and *C, which may have been /ʃ/, /s/ and /ts/, respectively (or perhaps /s/, /ʃ/ and /tʃ/). In Formosan languages, these segments often show unexpected reflexes, typically

through assimilation to another sibilant elsewhere in the world. Thus, in Paiwan (SE Taiwan), we find the following: *liseqeS > *liSeqeS > /liseqes/ ‘nit, egg of a louse’, *Sasaq > *SaSaqa > /tataq/ ‘to whet (on large stone)’, and *Cangis > *tsangis > /tsangits/. Note that the last example appears to involve assimilation between /s/ and /ts/—a process which would belong under stricture harmony (section 2.4.6) in the typological classification presented here.

In Saisiyat (NW Taiwan), the following are some of the attested assimilations: *liseqeS > *liSeqeS > /Liʔʃij/ ‘nit, egg of a louse’, *Sajek > *Sazek > /sazek/ ‘smell’, *CingaS > *SingaS > /ʃingaʃ/ ‘food particles caught between teeth’, *Cangis > *sangis > /h-...-angih/ ‘to cry, weep’ (the last one attested only with a -VC- infix). Again, assimilation appears to sometimes involve stricture (affricate vs. fricative) rather than ‘minor-place’. However, this is less clear in Saisiyat than in Paiwan, since *C has the regular reflex /s/; it is thus possible that *C, though originally an affricate, did not undergo assimilation until after it had become a fricative.

The third language Blust (1995) discusses, Thao (central Taiwan), has developed an exceptionally large inventory of fricatives, including at least /f, v, θ, ð, s, ʃ, ʎ, h/. Thao shows evidence of various assimilations that are similar to the ones described above for Paiwan and Saisiyat, e.g., *CaqiS > /ʃaqiʃ/ (perhaps via */θaqiʃ/) ‘sew’, *dakeS > *sakeS > /ʃakiʃ/ ‘camphor laurel’, *Sidi > *Sisi > /sisi/ ‘goat’. Interestingly, these sibilant assimilations affect the lateral fricative /ʎ/ as well; thus, e.g., *daRa > *saʎa > /ʎaʎa/ ‘Formosan maple’, *zaRum > *saʎum > /ʎaʎum/ ‘needle’. The inclusion of /ʎ/ is rather remarkable, given that lateral fricatives are not generally counted as ‘sibilants’. Moreover, lateral fricatives and affricates do not participate in sibilant harmony in any of the Athapaskan languages, and this fact has been interpreted as evidence bearing on the location of [±lateral] in various feature-geometric models. This interpretation has always been based on the assumption that consonant harmony respects locality, and that particular feature specifications on intervening

segments would inevitably result in blocking. However, this comprehensive survey finds that blocking *never* occurs in consonant harmony systems, regardless of the nature of the intervening material (see section 3.2 below). Therefore, the transparency of lateral obstruents in Athapaskan sibilant harmony can hardly be used as evidence for a particular version of feature geometry. The existence of long-distance assimilations between /ʃ/ and /s/ in Thao casts further doubt on the validity of such argumentation.

2.4.1.2. Non-sibilant coronal harmony

Although the vast majority of coronal harmony systems involve sibilants, consonant harmony may also be defined over other types of coronals—stops, nasals, liquids, etc.—provided that an appropriate ‘minor place’ contrast exists for such segments in the language in question (e.g., dental vs. alveolar, retroflex vs. dental, etc.). It should be stressed that the cases mentioned in this section form a somewhat heterogeneous class; the only thing they have in common is that non-sibilants take part in the harmony interaction. In some of the examples, the harmony exclusively involves non-sibilants, whereas in others, stops appear to be interacting with sibilant affricates. In this latter case, it is sometimes difficult to determine whether stricture harmony (see section 2.4.6) would be a more appropriate classification.

One example of non-sibilant coronal harmony has already been mentioned in section 2.3 above—the root-internal dental vs. alveolar harmony found in many Western Nilotic languages. This was illustrated for Pāri in (4)-(5); some of the relevant examples are repeated in (11) for ease of reference.

(11) Root-internal coronal harmony in Pãri (Andersen 1988)

a. Well-formed roots with multiple coronals

n̥t̥	‘sucking’
d̥á:n̥-é̃`	‘person (ergative)’
àtwá:t̥`	‘adult male elephant’
àdú:nd-ó̃`	‘heart’

b. Disallowed root-internal combinations

*d̥...n	*d̥...nd	*d̥...t	*t̥...n	*t̥...nd (etc.)
*d...n̥	*d...n̥d̥	*d...t̥	*t...n̥	*t...n̥d̥ (etc.)

c. Root-final consonant alternations feed coronal harmony

<i>Unpossessed</i>	<i>Possessed (1Sg)</i>	
dè:l	dè:nd-á	‘skin’ vs. ‘my skin’
t̥ùol	t̥úon̥d-à	‘snake’ vs. ‘my snake’
tà-à	tà:n:-á	‘pancreas’ vs. ‘my pancreas’
ùt̥ó̃`-ó	ùt̥ó̃:n̥`-á	‘fox’ vs. ‘my fox’

In Pãri, the dental vs. alveolar contrast exists for stops and nasals, and these are precisely the segments that interact in the consonant harmony. The same is also true of Anywa (Reh 1996), which shows alternations of the same kind as in the Pãri examples in (5) and (11) above.¹⁴ The liquids /l, r/, by contrast, are always alveolar; for the purposes of harmony, they are neutral, and thus cooccur freely both with dentals and with other alveolars. Root-

¹⁴ Although Anywa has both dental and alveolar nasals, Reh (1996) states that dental [n̥] is only found in words which also contain a dental stop, which suggests that it is a mere allophone of /n/. Nevertheless, [n̥] also appears through the kind of root-final consonant alternations shown in (11c) for Pãri, as in /p̥ò:n̥:ò/ ‘become smooth’ (from /p̥ò:d̥/ ‘be smooth’). Although the dentality of [n̥] is thus mostly *predictable*, it is not strictly speaking allophonic. This is somewhat analogous to the case of Nkore-Kiga sibilant harmony, discussed in 5.1.2 below, where the [s] vs. [ʃ] distribution is *mostly* predictable based on the following vowel, but where a surface contrast between [...ʃa] vs. [...sa] nevertheless exists (the latter arising from /...S-ɨ-a/).

internal coronal harmony seems to operate almost identically in Shilluk (Gilley 1992); here, too, both nasals and stops participate in the harmony, cf. /t̥ɪ̃n̥/ ‘small’, /t̥ɪ̃n̥/ ‘today’ (underlining indicates [+ATR], or ‘expanded pharynx’). In Shilluk, just as in Pāri, harmony is fed by the various alternations exhibited by root-final consonants, cf. the Pāri forms in (11c). However, in Shilluk, the derived root-final alveolar *triggers* harmony rather than undergoing it. Thus, when the final /l/ of Shilluk /t̥al/ ‘cook (trans.)’ changes to /t/ or /d/ in certain morphological contexts, it is the root-initial /t̥/ that yields to the harmony: antipassive /t̥a:t̥/, instrumental /t̥ā:d̥-ā/.

Both Pāri and Shilluk belong to the Northern division of the Luo branch of Western Nilotic languages. Various languages in the Southern Luo subbranch, on the other hand, lack a dental vs. alveolar contrast in nasals, but nevertheless maintain the same root-internal coronal harmony restriction on stops. These include Alur (Bursens 1969; Tucker 1969; cf. Mester 1986[1988]) and Dholuo (Tucker 1994; cf. also Yip 1989; Padgett 1995a). In these languages, the nasal /n/ acts as neutral, just as the other alveolar sonorants /l, r/ do in all of the languages mentioned so far. Tucker (1994) does not explicitly discuss the interaction of root-final consonant alternations (such as /l/ → /t/) with coronal harmony in Dholuo. However, pairs such as /t̥uo:l/ ‘snake’ vs. Plur. /t̥úó:nd̥/ and /t̥uo:n/ ‘male, brave man’ vs. Plur. /t̥uo:nd̥i/ suggest that these alternations do *not* feed coronal harmony in Dholuo, unlike Pāri, Anywa and Shilluk.¹⁵

In addition to the Luo languages, Western Nilotic contains two other branches, Dinka-Nuer and Burun. According to Tucker (1994:31, fn. 30), coronal harmony does not hold in the Dinka-Nuer languages, ‘where dental/alveolar sequences occur’. However, it is unclear whether this is true of roots in general, or merely of those root allomorphs derived through final-consonant alternations, e.g., in /t̥at̥/, antipassive of /t̥a:l/ ‘cook’ (cited from

¹⁵ Note that dental [nd̥] clusters do occur morpheme-internally in Dholuo; what these examples show is that a root-final derived nasal-stop cluster remains alveolar [nd̥] rather than being realized as [nd̥] due to harmony with a root-initial dental.

Andersen 1999). The final-/t/ antipassive formation—widespread in Western Nilotic—arguably goes back to what originally was a separate antipassive suffix (Hall & Hall 1996). Therefore, such examples may simply indicate that Dinka-Nuer languages have not extended the root-internal harmony to derived contexts.

In the third branch of Western Nilotic, the sparsely documented Burun languages, coronal harmony is found. What is more, it may even give rise to harmony alternations beyond the root. This is attested in Mayak, one of the Northern Burun languages (Andersen 1999). In the Mayak consonant inventory, a dental vs. alveolar contrast exists among stops. As for nasals, dental [ɲ̥] does occur, but only as an allomorph of alveolar /n/ and only in the clusters [ɲ̥ɲ̥], [ɲ̥t̥]. According to Andersen's (1999) analysis, the phonemic dental vs. alveolar contrast is between /ɲ̥, ɲ̥/ and /t, d/. However, in certain predictable contexts, /ɲ̥/ is realized as fricative [ð̥] and /d/ as implosive [d̥], and thus the surface contrast between dentals and alveolars is [ɲ̥, ɲ̥, ð̥] vs. [t, d, d̥].

Andersen (1999) does not discuss whether dentals and alveolars cooccur root-internally in Mayak, but the only potential counterexample found in the data he cites is the form [pɪd̥aɲ̥] 'shell'. This is likely to be bimorphemic /pɪd̥-aɲ̥/; as in other Western Nilotic languages, Mayak roots generally have the shape CV(V)C, and several other nouns Andersen cites end in [...aɲ̥].

Beyond the root, however, coronal harmony optionally extends to various -Vɲ̥ suffixes, especially in nouns. When a suffix such as singulative /-ɛɲ̥/, /-ʌɲ̥/ or /-iɲ̥/ is attached to a root containing alveolar /t/ or /d/ (the latter realized as either [d] or [d̥]), the suffixal /ɲ̥/ optionally becomes alveolar, as shown in (12a). The triggering alveolar may be either root-final or root-initial. Note that only the *contrastively* alveolar consonants trigger harmony, not the redundantly alveolar sonorants like /n/ or /l/ (12b).

(12) Coronal harmony (optional) in Mayak -Vɿ suffixes (data from Andersen 1999)

a. Harmony triggered by [t, d, d̥] in root

leɣ-ɿ	‘tooth’
gim-ɿ	‘cheek’
wʌð-ɿ	‘buttock’
tid-ʌɿ ~ tid-ʌt	‘doctor’
tuy-ɿ ~ tuy-it	‘back of head’

b. Alveolar [l, r, n] do not trigger harmony

bɛ:l-ɛɿ	‘cane’
riŋ-ɿ	‘meat’
?in-ʌɿ	‘intestine’
kan-ɿ	‘torch’

c. Harmony triggered *across* alveolar [n]

ɖɪ:n-ɛɿ ~ ɖɪ:n-ɛt	‘bird’
kɛt-m-ɛɿ ~ kɛt-m-ɛt	‘star’

An important point to note is that not only does alveolar /n/ not trigger harmony, but it also does not block it. Alveolar /n/ is thus both neutral and transparent, allowing harmony to apply across itself, as in the examples in (12c). The same is presumably also true of /l, r/, although Andersen cites no forms that bear on this issue.

Before leaving the Western Nilotic coronal harmony systems, it is worth emphasizing a point made in previous analyses of the cooccurrence restrictions (Yip 1989; Padgett 1995a). In most of the languages in question, dental and alveolar stops (and nasals, where applicable) freely cooccur with other obstruents that also seem to be coronals, such as /s/ (in Dholuo) and the ‘palatals’ /c, ʃ/. In virtually all of the languages, the ‘palatals’ are either optionally or consistently realized as postalveolar affricates, [tʃ, dʒ], according to

descriptive sources; Andersen (1999) even gives [ʃ] as a possible realization of /c/ in Mayak. As for Dholuo /s/, Yip (1989) and Padgett (1995a) analyze it as being [-anterior] and therefore exempt from the harmony (which is assumed to hold only for coronals that agree in [\pm ant]). Nevertheless, Tucker (1994) quite explicitly classifies Dholuo /s/ as alveolar, along with /t, d, n, l, r/, and does not mention any alternative realizations of this segment that might suggest that it belongs with the ‘palatals’. It seems more appropriate to conclude that /s/ fails to participate because the consonant harmony involves only those segments that are contrastively dental or alveolar. Dholuo alveolar /s/ is then neutral for the same reason that alveolar /n/ is neutral in Dholuo (unlike in Pāri or Shilluk): because no dental/alveolar contrast exists for fricatives or sonorants.

In Western Nilotic, coronal harmony involves the dental vs. alveolar opposition (or [\pm distributed], in terms of traditional distinctive features). Another opposition over which harmony is often defined is retroflex vs. non-retroflex (dental or alveolar). For example, dental /t/ and retroflex /ʈ/ are not allowed to cooccur within roots in Pohnpeian (Rehg 1981). In another Austronesian language, Javanese, dental and retroflex stops are also not allowed to cooccur in roots, especially in C₁ vs. C₂ position (Uhlenbeck 1949; Mester 1986[1988]; see also Yip 1989). However, in the Javanese case, this is merely part of a more general restriction against non-identical consonants with the same place and/or manner of articulation. Thus, none of the labials /p, b, m, w/ cooccur with each other, nor do the ‘palatals’ /c, ʃ, s, ɲ/, the coronal stops /t, d, ʈ, ɖ/, the liquids /l, r/, and so forth.¹⁶ What is important in this context is simply that retroflex and dental stops are above the similarity threshold beyond which the cooccurrence restrictions take effect in Javanese.

Another example of coronal harmony where retroflex and non-retroflex segments interact with each other is found in certain languages of Northern Australia, such as

¹⁶ The so-called ‘palatal’ obstruents of Javanese are in fact alveolar, although they behave phonologically as palatals to some extent; thus /c, ʃ/ = [ts, dz] (see Ladefoged & Maddieson 1996 and references cited therein).

Gooniyandi (McGregor 1990; Steriade 1995ab; see Gafos 1996[1999]) and Gaagudju (Hamilton 1993, cited by Gafos 1996[1999]); see also Evans (1995) on Mayali. The discussion here is based mainly on the description in Gafos (1996[1999]). Languages of this area typically have a four-way contrast among coronal stops, nasals and laterals: lamino-dental /t̪, d̪, n̪, l̪/, apico-alveolar /t, d, n, l/, apico-postalveolar (= retroflex) /t̠, d̠, n̠, l̠/, and lamino-postalveolar (= ‘palato-alveolar’) /t̟, d̟, n̟, l̟/ (cf. also Ladefoged & Maddieson 1996). In addition, there is usually an apico-alveolar vs. apico-postalveolar contrast in rhotics as well, thus between (tap/trill) /r/ and (approximant) /ɻ/ or (flap) /ɾ/.

In a great number of languages, the apico-alveolar vs. apico-postalveolar contrast is maintained only postvocally, and is thus neutralized in word-initial position—not surprisingly, given that the perceptual cues for retroflexion are primarily present in VC transitions (Steriade 1995b). In Gooniyandi, word-initial neutralization results in variation between alveolar and retroflex articulations, as shown in (13a). In Gaagudju, on the other hand, word-initial apicals are consistently realized as alveolar, e.g., [na:wu] ‘he’ (Gafos 1996[1999]). In both languages, however, the generalizations about the realization of initial apicals are overridden by consonant harmony. When followed by another apical, the initial consonant consistently agrees with it; this is shown for Gooniyandi in (13b). Finally, consonant harmony only governs the realization of apicals in positions of neutralization, i.e. word-initially; as shown in (13c), it never tampers with the contrastive specifications of apicals in postvocalic positions.

(13) Coronal harmony in Gooniyandi apicals (McGregor 1990 apud Steriade 1995a).

a. Neutralization with free variation in word-initial position (alveolar ~ retroflex)

tu:wu ~ t̠u:wu ‘cave’

na:gʌ ~ n̠a:gʌ ‘dress’

- b. Word-initial apical harmonizes with following apical
- | | | |
|--------------|--------------|------------------------------|
| tili | ‘light’ | (*t̪ili) |
| t̪iɾipp̪ɪndi | ‘he entered’ | (~ t̪iɾipp̪ɪndi only rarely) |
- c. No harmony (or free variation) in non-initial positions
- | | | |
|------------|----------------|---------------|
| kiliŋi | ‘grass’ | (*kiliŋi) |
| wad̪guluna | ‘I bring them’ | (*wad̪guluna) |

Outside of the languages of Australia, a very similar phenomenon is found in some Dravidian languages, where phonological retroflex vs. non-retroflex contrasts are quite common among stops. One such example is the Northern Dravidian language Malto (Mahapatra 1979), which contrasts dental /t, d/ with retroflex /t̪, d̪/. In Malto, dentals and retroflex stops cannot cooccur as C₁ and C₂ in morpheme-internal CV(C)C sequences. In all the forms that Mahapatra (1979) cites in support of this generalization, C₁ is root-initial, e.g., /t̪u:d̪/ ‘tiger’, /d̪and̪a/ ‘staff’, /dudu/ ‘mother’, /to:totri/ ‘quickly’. This is significant, because retroflex stops did not occur root-initially in Proto-Dravidian. Malto roots like /d̪and̪a/ ‘staff’ are the direct result of a sound change enforcing right-to-left retroflexion harmony (Subrahmanyam 1983), cf. cognates such as Kannada /daɖi, daɖɖi/ ‘staff, cudgel’, Tamil /taɻi/ ‘stick’ (Burrow & Emeneau 1984). Coronal harmony in Malto is thus virtually identical to that found in the Northern Australian languages, especially the one in Gaagudju, where non-harmonized initial apicals are consistently non-retroflex. Finally, note that, just as in the Western Nilotic languages discussed earlier, the only consonants affected by the harmony are the ones which are contrastively dental vs. retroflex, i.e. the stops. For example, the retroflex flap /t̪/ does not trigger coronal harmony (/taɻe/ ‘grinding stone’), and consonants like /s, n, l/ do not undergo it. Furthermore, the ‘palatals’ /c, ɟ/ do not interact with the harmony either. It is not quite clear whether these are true (dorso-)palatals or

coronals, although the former does seem likely; Mahapatra describes both as ‘alveo-palatal affricates’, but transcribes them as $[\text{c}\text{c}']$ and $[\text{j}\text{j}']$.

Recall from section 2.4.1.1 that a retroflex vs. non-retroflex contrast is quite frequently involved in sibilant harmony systems as well, such as in Rumsen, Gimira, Capanahua and Ixil (note that, interestingly, all of these are three-way harmony systems). In these systems, there is no retroflex vs. non-retroflex contrast among nonsibilants, such as stops or nasals, and these segment types are thus neutral and do not interact with the harmony in any way, either as triggers, targets or blockers.

One last case involving long-distance retroflexion assimilation deserves mentioning, if only for the fact that it has been widely cited in the theoretical literature on consonant harmony. This is the *n*-retroflexion (also known as ‘*ṅati*’) found in Vedic Sanskrit (Wackernagel 1896; Whitney 1889; Macdonell 1910; Allen 1951; Schein & Steriade 1986; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997). It will be argued below (section 3.2.3) that this phenomenon is in fact *not* a case of consonant harmony, in that it displays properties radically different from the other cases of long-distance assimilation surveyed in this chapter. Nevertheless, the most important characteristics of *n*-retroflexion are worth outlining in the present context, since this is one of the best-known (alleged) examples of consonant harmony.

In the Vedic Sanskrit phoneme inventory, dental /t, t^h, d, d^h, s, n, l/ contrasted with retroflex /ṭ, ṭ^h, ḍ, ḍ^h, ṣ, ṇ, ṛ/, where /r/ was quite likely an approximant [ɹ] (and able to head a syllable). In addition, there was a third series of ‘palatals’, traditionally transcribed <c, ch, j, jh, Ê, ñ>, which were likely coronals as well, rather than true (dorso-)palatals. The ‘*ṅati*’ or *n*-retroflexion phenomenon is this: when a postvocalic /n/ is preceded by a retroflex continuant (/ṣ/ or /r/), it assimilates to it, becoming /ṅ/. If there is more than one potential target, only the first /n/ assimilates: /praṅṅiná:ja/ ‘lead forth’ (from /ni:-/ ‘lead’). Any intervening coronal—whether dental, retroflex or ‘palatal’—blocks the assimilation; thus /kṣub-a:ṅa/

‘quake’, but /kṣved-a:na/ ‘hum’ (both with middle participle suffix /-a:na-/). This *n*-retroflexion also applies in compounds, though with some exceptions, and occasionally even across word boundaries.

Although it has long been celebrated as an example of coronal harmony, Vedic Sanskrit *n*-retroflexion is in fact highly suspect as such, as will be discussed in detail in 3.2.3 below. In the context of the 120 or so long-distance assimilations surveyed here, it stands out as a sore thumb, showing properties that are otherwise unattested in the database (but common in ‘vowel-consonant’ harmonies where entire spans of vowels and consonants are demonstrably affected, e.g., nasal harmony). One crucial point is segmental opacity: if *n*-retroflexion is an instance of consonant harmony, it is the only case where assimilation is blocked by particular segments which themselves do not participate in the harmony as triggers or targets. Another point is the trigger vs. target asymmetry: whereas /ṣ, r/ trigger the assimilation, it is only /n/ which undergoes it. A clear generalization to emerge from this typological survey is that consonant harmony always involves ‘agreement’ between segments that are above a certain similarity threshold; the more similar the consonants, the more likely (or stringent) the harmony requirement. In light of this generalization, it is highly surprising that /ŋ/ and /n/ do not interact (i.e. /ŋ/ is not a trigger)—surely /ŋ/ is more similar to /n/ than are either of /ṣ, r/! A third point, related to the previous one, is the non-iterative character of *n*-retroflexion: a /ṣ, r/ will only trigger retroflexion in the closest following /n/, not on any additional /n/’s further away. No other consonant harmony systems in the database have anything resembling this characteristic. This restriction is clearly not a matter of relative distance, in that the second /n/ in an underlying string like /ṣVCVnV/ would undergo retroflexion if the intervening C were a non-coronal consonant. Further restrictions on Vedic Sanskrit *n*-retroflexion, which likewise distinguish it from other consonant harmony phenomena, include the fact that the target /n/ must be released into a (nonliquid) sonorant, and that retroflexion is blocked (in

compounds) if the target /n/ is also *followed* by an /ʃ/ or /r/ later in the word. See section 3.2.3 for further discussion of these unusual properties, and their implications for the analysis of *n*-retroflexion—and of consonant harmony in general.

The final class of coronal harmony phenomena to be covered in this section consists of cases where alveolar (or dental) stops interact with postalveolar affricates like /tʃ/—i.e. the kind of segments that are often described as ‘alveo-palatal’, ‘palato-alveolar’ or just ‘palatal’. Because this kind of harmony crosses the stop/affricate boundary, it may perhaps more appropriately belong in the category of stricture harmony (section 2.4.6). However, the cases that fit this description are classified here as coronal harmony for two reasons. Firstly, the ‘minor-place’ contrast involved (/t/ vs. /tʃ/, etc.) is essentially the same as the alveolar vs. postalveolar opposition which is so often the basis of *sibilant* coronal harmony systems (/s/ vs. /ʃ/, /ts/ vs. /tʃ/, etc.). Secondly, both the /t/ vs. /tʃ/ harmonies examined here and sibilant harmonies of the /s/ vs. /ʃ/ type share important characteristics with alveolar-postalveolar interactions in phonological speech errors; see chapter 6 for extensive discussion of such parallels between consonant harmony and slips of the tongue.

In the dialect of Aymara described in De Lucca (1987), tentatively labelled ‘Bolivian’ Aymara by MacEachern (1997[1999]), the root-internal cooccurrence of alveolar /t, t^h, tʔ/ and ‘alveo-palatal’ /tʃ, tʃ^h, tʃʔ/ is quite limited.¹⁷ As MacEachern points out, roots with /t^h...tʃ^h/, /tʃ^h...t^h/, /tʔ...tʃ^h/ or /tʃʔ...t^h/ are not attested in Bolivian Aymara. (Certain other conceivable combinations are independently ruled out by various laryngeal cooccurrence restrictions, such as /t^h...tʃʔ/, /tʃ^h...tʔ/, /tʔ...tʃʔ/, /tʃʔ...tʔ/; see MacEachern 1997[1999] for detailed discussion.) These lexical gaps suggest that, at least as regards laryngeally specified coronals—ejectives and aspirates—alveolars and postalveolars are not allowed to cooccur root-internally in Bolivian Aymara.

¹⁷ Aside from these, Bolivian Aymara also has alveolar /s/, which does not appear to interact with the ‘alveo-palatals’ in roots.

Since MacEachern (1997[1999]) does not mention the behavior of the plain plosives /t, tʃ/ in this respect, the dictionary entries in De Lucca (1987) were searched for any word-initial /TVČ/ or /ČVT/ sequences, where T = {t, t^h, tʰ} and Č = {tʃ, tʃ^h, tʃʰ}. The results were quite interesting: although /ČVt/ sequences are quite common (14a), not a single example of /TVtʃ/ was found. It thus seems that, when plain (laryngeally unspecified) stops/affricates are involved, the cooccurrence restriction is directional, disallowing only postalveolar-alveolar sequences (14b).

(14) Root-internal coronal harmony in Bolivian Aymara (data from De Lucca 1987)

a. Well-formed roots mixing alveolars and postalveolars

tʃatu	‘jug, small vessel of clay’
tʃitu	‘minute, tiny (dial.)’
tʃ ^h ita	‘string, row of objects put on a thread’
tʃʰuta	‘collision of two round objects’

b. Disallowed root-internal sequences¹⁸

*/t...tʃ/, */t^h...tʃ/, */tʰ...tʃ/

(also */t^h...tʃ^h/, */tʃ^h...t^h/, */tʰ...tʃ^h/, */tʃʰ...t^h/, etc.; cf. discussion above)

In the West Chadic language Kera (Ebert 1979), a similarly directional assimilation between /t/ and /tʃ/ is found. In this language, an original /t/ sometimes is sometimes realized as /tʃ/, either optionally or obligatorily (Ebert 1979:7). Furthermore, the feminine prefix—otherwise /t-/ in presonorant contexts—is systematically realized as /tʃ-/ if another /tʃ/ follows in the stem (Ebert 1979:146-47). This is illustrated in (15).

¹⁸ Due to a ‘leftness effect’, an aspirated or ejective stop always occurs earlier in the morpheme than a voiceless unaspirated stop, hence */t...tʃʰ/, */t...tʃ^h/, etc. (MacEachern 1997[1999]).

(15) Coronal harmony effects in Kera (data from Ebert 1979)

- a. Root-internal assimilation of /t/ to following /tʃ/ (sporadic?)

tutʃi ~ tʃutʃi	‘tamarind’	
tʃətʃerkó	‘backbone’	(cf. Tupuri /tʃtʃèrè/)

- b. Alternations in feminine prefix /t-/

tó:já	‘dog (fem.)’	(cf. masc. /kó:já/)
te:ŋa	‘dry (fem.)’	(cf. masc. /ke:ŋe/)
tʃə:tʃó	‘small (fem.)’	(cf. masc. /ko:tʃé/)

Thus in Kera, as in Bolivian Aymara, sequences with the order alveolar...postalveolar are ruled out: */t...tʃ/, but /tʃ...t/ is allowed (cf. /tʃérté/ ‘split’). Whereas the harmony effect in Aymara is evident only as a static cooccurrence restriction, its Kera counterpart shows explicit evidence, both synchronic and diachronic, of harmony being enforced by means of assimilation, /t...tʃ/ → /tʃ...tʃ/.

Another case which involves ‘palatals’—which may or may not in fact be postalveolar affricates—is found in certain South-Central Dravidian languages, such as Pengo (Burrow & Bhattacharya 1970). In Pengo, a root-initial dental stop /t, d/ assimilates to a root-final ‘palatal’ (rendered with <c, j> by Burrow & Bhattacharya 1970). Although the description is not explicit about the phonetic realization of <c, j>, I will assume for the present purposes that they are (lamino-)postalveolar affricates, henceforth transcribed with /tʃ, dʒ/. As the forms in (16a) show, the evidence for the harmony is not merely comparative-historical, but also synchronic, in that morphologically-driven alternations in root-final position may trigger harmony effects in root-initial position, as in the first example.¹⁹ The facts are thus somewhat reminiscent of root-internal coronal harmony in

¹⁹ It is hard to tell how significant this example is, and whether this type of alternation is at all productive in Pengo morphology. This may therefore be a matter of suppletion, synchronically, even though it clearly arose through harmony diachronically.

Western Nilotic, cf. the Pāri examples in (4)-(5) above. Pengo harmony is optional to some extent, although harmonized forms appear to be more common than their non-harmonized variants.

(16) Root-internal coronal harmony in Pengo (data from Burrow & Bhattacharya 1970)

- a. Dental harmonizes (optionally) to following postalveolar

tiʃ- ~ tʃiʃ- ‘to eat (past stem)’ (derived from /tin-/ ‘eat’)

to:ʃ- ~ tʃo:ʃ- ‘to show’

ta:ndʒ- ~ tʃa:ndʒ- ‘to weave (a garland)’

dʒo:ʃ- ‘to carry on the head’ (cf. Gondi /to:ʃa:na:/)

tʃo:ndʒ- ‘to appear’ (cf. Kuvi /to:ndʒ-/)

- b. Root-internal postalveolar...dental sequences are allowed

tʃeta man- ‘to be awake’

tʃinta ki- ‘to think; to worry, be anxious’

dʒa:ti ‘caste’

dʒunda ‘spinning top’

No harmony applies to retroflex...postalveolar sequences (e.g., /d̪andʒ-/ ‘to stick to’), and the harmony in (16) is virtually without exception. If it is valid to equate the Pengo ‘palatals’ with the Aymara postalveolar affricates, as has been done here, then both display the very same directionality effect: coronal harmony rules out sequences like /t...tʃ/, but leaves /tʃ...t/ untouched.

The asymmetric harmony effect exhibited by these languages bears a striking resemblance to the so-called ‘palatal bias’ which is robustly attested in speech error studies (Shattuck-Hufnagel & Klatt 1979; Stemberger 1991; see chapter 6 for discussion of this phenomenon). Several studies have found that in speech errors, /tʃ/ is more likely to be

substituted for /t/ than vice versa, and the same holds true of /ʃ/ and /s/, respectively. When one combines this with the right-to-left directionality so predominant both in consonant harmony systems (cf. section 3.1) and in speech errors (see section 6.1), the combined effect is exactly what is found in Kera, Aymara and Pengo: there is a much stronger tendency for /t...tʃ/ → /tʃ...tʃ/ than there is for /tʃ...t/ → /t...t/.

Finally, there is one more case which might belong in the same category, although its status as an instance of consonant harmony is somewhat dubious. This involves the ‘mobile palatalization’ found in certain Ethio-Semitic languages—more specifically, the optional double-palatalization effect that can be seen in Harari (Leslau 1958; Rose 1997). For detailed discussion of the Harari case, the reader is referred to section 2.4.3 below. The general phenomenon is essentially a matter of featural morphology, whereby a suffix /-i/ triggers ‘palatalization’ of alveolar consonants in the preceding stem—the target consonant not necessarily being adjacent to the triggering /-i/. Because the Harari phenomenon is conventionally described as involving ‘palatalization’—and does in some cases yield true palatals, e.g., /n/ → /ɲ/ and /l/ → /ʎ/—it is classified here as a matter of secondary-articulation harmony (2.4.3) rather than coronal harmony. Nevertheless, it should be noted that in the case where the target is an obstruent, the effect is /t, tʰ, d, s/ → /tʃ, tʃʰ, dʒ, ʃ/.

The double-palatalization effect, which may potentially involve consonant harmony, is seen in variants such as /tʰimädʒ-i ~ tʃʰimädʒ-i/ ‘put the yoke! (2SgFem)’ and /bitʃʰäʃ-i ~ bitʃʰäʃ-i/ ‘rip! (2SgFem)’ (cf. the corresponding 2SgMasc imperatives /tʰimäd/, /bitʰäs/). Note that the effect can potentially be interpreted as involving harmony of essentially the same kind as that observed in Kera, Aymara and Pengo: anticipatory assimilation of a dental/alveolar stop (or fricative) to a following postalveolar affricate (or fricative). Whether this parallel is more than mere coincidence remains to be seen—for example, the right-to-left directionality is likely to be connected with the simple fact that the triggering /-i/ is a suffix.

2.4.2. Dorsal and labial consonant harmony

The preceding section illustrated how consonant harmony is frequently defined over parameters that can be collectively labelled as defining ‘minor place of articulation’. These parameters are all specific to coronals. But what about the other major places of articulation, dorsal and labial? It is true that the coronal articulator (the tongue tip/blade) allows for a particularly rich inventory of possible ‘minor-place’ contrasts. But there are dorsal- and labial-specific parameters that can be conceived of in the same way, such as labiodental vs. bilabial for labial consonants, and velar vs. uvular (perhaps also velar vs. palatal) for dorsal consonants. The question then arises whether consonant harmony is ever defined over such *non*-coronal ‘minor-place-of articulation’ parameters. On analogy with the term ‘coronal harmony’, these could then be referred to as ‘dorsal harmony’ and ‘labial harmony’—although the latter is frequently used as a synonym of ‘rounding harmony’, i.e. a particular type of *vowel* harmony. To avoid confusion, these will be referred to here as dorsal and labial *consonant* harmony, respectively.

Such types of consonant harmony appear to be quite rare. The best examples of dorsal consonant harmony are found in the Totonacan language family, where it is attested in both branches of the family, Totonac and Tepehua. For example, MacKay (1999) describes what she refers to as ‘uvular assimilation’ in Misantla Totonac, whereby heteromorphemic /k...q/ sequences are harmonized to /q...q/.²⁰ Although MacKay does not address the *tautomorphemic* cooccurrence of /k/ and /q/, a tentative search for morpheme-internal /k...q/ or /q...k/ sequences in her grammar yielded no results. It can thus be concluded that Misantla Totonac dorsal consonant harmony holds (non-directionally) as a root-level cooccurrence restriction as well. In the heteromorphemic cases, where the

²⁰ Due to an independent (and optional) phenomenon of postvocalic spirantization of /q/, such a harmonized /q...q/ sequence can be realized as [q...q], [q...χ], [χ...q] or [χ...χ] depending on the context.

harmony results in [k]/[q] alternations (or [k]/[χ]; see footnote), the target is always in a derivational prefix and the trigger in the root; this is illustrated in (17a-b). As MacKay (1999) points out, the domain in which dorsal consonant harmony applies is morphologically defined: it consists of the *stem*, which comprises the root and derivational prefixes (such as body-part prefixes or valence-changing prefixes). Inflectional prefixes, by contrast, are outside the scope of the harmony, as shown by the examples in (17c). Finally, forms such as that in (17d) show that the harmony operates strictly from right to left, in that derived /q...k/ sequences remain disharmonic.

(17) Dorsal consonant harmony in Misantla Totonac (data from MacKay 1999)

a. Harmony alternation in body-part prefixes /-kə:k-/ , /maka-/

mínqá:qpaχéʔ	/min-kə:k-paqaʔ/	‘your shoulder’
mínká:ktʃa:n	/min-kə:k-tʃa:-ni/	‘your shoulder’ [sic!]
ʔút maqáʃqét	/ut maka-ʃqat/	‘s/he scratches X (with hand)’
ʔút makapáʃ	/ut maka-paʃ/	‘s/he bathes his/her hand’

b. Harmony in other derivational prefixes /maka-/ , /lak-/:

maqáʃqwaʃ	/maka-ʃuqwan-la(ʃ)/	‘s/he tired X’
láχtʃánχʃ	/lak-tʃanqʃ/	‘s/he chops (bones)’

c. No harmony in inflectional prefixes (1Subj /ik-/ , 1Obj /kin-/:

ʔíkláqtsaqa	/ik-lak-tsaqa/	‘I chew X’	(*ʔíqláqtsaqa)
kísqojúniʃ	/kin-squ-jan-ni-la(ʃ)/	‘s/he smokes X for me’	(*qísqojúniʃ)

d. No left-to-right harmony (i.e. /q...k/ not affected):

sqokóhəʃ	/squ-kuhu-la(ʃ)/	‘it was smoked’	(*sqoqóhəʃ)
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Although there are morphological limitations on dorsal consonant harmony in Misantla Totonac, it is clear from MacKay’s description that the harmony interaction is not *phono-*

logically bounded in any way. There are no particular segments—whether consonants or vowels—that are opaque, i.e. capable of blocking the propagation of harmony if they intervene. Nevertheless, the possibility must be entertained that the harmonizing [RTR] (or [-high]) feature is transmitted from trigger to target by strictly local spreading, i.e. that any and all intervening segments are affected as well. At first glance, this seems plausible in light of the fact that /q/ does trigger lowering of adjacent high vowels (as does /h/); this is shown in (18a). However, this effect is quite limited in its temporal scope. Firstly, a vowel is only affected if it is immediately adjacent to /q/, but not if another consonant intervenes (18b).²¹ Secondly, when the vowel is a long /i:/, the lowering frequently affects only that part of it which is adjacent to the /q/, resulting in diphthongization rather than lowering throughout (18c).

(18) Vowel lowering in Misantla Totonac (data from MacKay 1999)

a. Lowering of /i, u/ before or after /q/ ([q, χ]):

ʃá:qɛł	/ʃa:qił/	‘buzzard’
θʃutóχʃ	/tʃutuqʃ/	‘lame’
stəχənuʔ	/stuqu-nʋʔ/	‘old woman’

b. No lowering across another consonant:

kíłqó:NGnán	/kił-łqu:nq-nan/	‘s/he (mouth) snores’	(*kéłqó:NGnán)
míłáqtʃíʃit	/min-laq-tʃíʃit/	‘your eyelashes’	(*míłáqtʃéʃit)
páqʃú:tah	/paq-ʃu:tał/	‘left-handed’	(*páqʃó:tah)
ʔíʃmá:ʔóχʃu:t	/iʃ-ma:-uqʃu:-Vt/	‘her/his name’	(*ʔíʃmá:ʔóχʃó:t)

²¹ In the closely related Papantla Totonac, it appears that an intervening consonant will not necessarily block the vowel lowering effect that uvulars trigger. Elorrieta (1996, based on Levy 1987 and cited by Bessell 1998) states that in Papantla Totonac, the vowel lowering effect propagates through a sonorant (= voiced?) lateral, but that it decreases in effect the further the vowel is from the uvular.

c. Lowering of long /i:/ often partial ([e̞] after /q/, [iə] before /q/):

mínqéjɲĩlt	/min-qi:n-ʃili-Vt/	‘your mucus’
hón má:χéĩtá:náʔ	/hun maa-qi:ta:nVʔ/	‘DET bossy one’
ʔiklíəqáwəʔ	/ik-li:-qəwə-la(ʔ)/	‘I spoke for/of X’

As is evident from the data in (17) above, no comparable limitations apply in the case of the /k...q/ → /q...q/ harmony effect. Although it is by no means impossible that coarticulatory effects of /q/ on nearby segments were somehow involved in the historical appearance of the /k/ > /q/ assimilation, they are clearly *not* involved in the resulting synchronic pattern, which has been phonologized strictly as a (non-local) consonant harmony interaction.²²

Dorsal consonant harmony applies in a very similar way in the Tepehua branch of the Totonacan family. In his description of the phonology of Tlachichilco Tepehua, Watters (1988) discusses what he refers to as ‘k-q assimilation’ under the explicit heading ‘consonant harmony’ (which covers an independently occurring sibilant harmony as well). As in Misantla Totonac, the assimilation is strictly right-to-left, assimilating a prefixal /k/ to a /q/ or /qʔ/ in the root.²³ This is illustrated in (19a). Note that the harmony is rendered opaque by the unconditioned debuccalization of /qʔ/ (yielding [ʔ]); as a result, the prefix /k/ appears at first glance to be ‘harmonizing’ with a glottal stop. As in Misantla Totonac, only

²² A similar argument is made by Bessell (1998) for Interior Salish faucal harmony—an unbounded right-to-left vowel retraction harmony triggered by uvular and pharyngeal consonants (and thus an example of vowel-consonant harmony, as that term has been used in this study). She argues based on instrumental phonetic data that intervening consonants do not participate in the harmony, and that vowels do so in a categorical manner. If Totonacan dorsal consonant harmony originates in a phonologization of local coarticulatory effects, Interior Salish may provide an interesting diachronic parallel. But the synchronic differences are fundamental, especially in that the Totonacan phenomenon is a *consonant-consonant* interaction. Totonacan vowel lowering has all the hallmarks of a local, coarticulatory effect (following the criteria used by Bessell 1998). As will be seen in the Tlachichilco Tepehua case below, the consonant assimilation is independent of this effect and may apply across a span of segments where not even (all) the intervening vowels are affected in any way.

²³ Watters (1988) finds two exceptions where harmony is rightward (/q...k/ → /q...q/) from prefix to root, both involving the body-part prefix /ʔaq-/ ‘head’: [ʔaqloqoti] ‘horn’ (/ʔaq-lukut/, where /lukut/ = ‘bone’) and [ʔaqlaqawa:nan] ‘dream’ (from /lakaw/ ‘see’). These exceptions are clearly of a sporadic nature, cf. counterexamples such as [ʔaqʃkaviʔ] ‘curly-headed’ (/ʃkaviʔ/ ‘curly’).

certain prefixes fall within the domain of dorsal consonant harmony in Tlachichilco Tepehua; the ones that *do not* are all inflectional (19b). However, it is less obvious that the prefixes that *do* harmonize can all be classified as belonging to ‘derivational’ morphology, the locative pre-clitic /laka:-/ being a case in point (19c). Another potential counterexample is /lak-/, glossed by Watters (1988) as ‘3PIObj’, which would suggest that it is inflectional. However, ‘distributive’ may be a more appropriate characterization, in which case /lak-/ may well qualify as derivational.

(19) Dorsal consonant harmony in Tlachichilco Tepehua (data from Watters 1988)

a. Harmony alternations in derivational prefixes:

maqʃaʔa:j	/mak-tʃaqʔa:-j/	‘X washes hands (impf.)’
maktʃa:j	/mak-tʃa:-j/	‘X claps; X cooks [tortillas] (impf.)’
ʔoqslaqtsʔin	/ʔuks-laqtsʔin/	‘look at Y across surface’
ʔukskʔatsa:	/ʔuks-kʔatsa:/	‘feel, experience sensation’
laqtʃeʔeʃ	/lak-tʃiqʔi-ʃ/	‘X broke them (perf.)’
lakhuni:ʃ	/lak-huni:-ʃ/	‘X told them (perf.)’

b. No harmony in inflectional prefixes (1Subj /k-/, 1Obj /kin-/, /ki:-/ ‘return’):

kʔaqtajniʃ (*qʔaqtajniʃ)	/k-ʔaqtaj-ni-ʃ/	‘I began (perf.)’
kiʔaqs-a (*qiʔaqs-a)	/kin-ʔaqs-a/	‘it’s tight on me’
ki:laqtsʔiʃ (*qi:laqtsʔiʃ)	/ki:-laqtsʔi(n)-ʃ/	‘X went, saw Y and returned (perf.)’

c. Harmony in locative proclitic /laka:-/:

laqa:-tʃaqa:	/laka:-tʃaqa:/	[no gloss] (‘PREP-house’)
laka:-kʔiw	/laka:-kʔiw/	[no gloss] (‘PREP-tree’)

The examples in (19) all illustrate the workings of dorsal consonant harmony in heteromorphemic /k...q/ sequences, resulting in [k]/[q] alternations. Although Watters (1988)

makes no explicit mention of whether the harmony holds within morphemes as well, it does appear to do so. In fact, certain contexts exist which allow us to observe dorsal harmony as an active constraint on roots. Syllable structure in the Tlachichilco dialect is subject to strict constraints, one of which requires a coda stop to be dorsal. As a result, when underlying /t/ or /p/ occur in coda position, they surface instead as [k] and [wk], respectively (the latter yielding a diphthongal nucleus, i.e. [CVwk]), a process which Watters refers to as ‘consonant backing’. When a root such as /q’ut-/ ‘drink’ occurs before a consonant, such that the /t/ is syllabified as a coda, coda dorsalization should result in the disharmonic sequence /q’uk-/, other things being equal. But instead, it *feeds* consonant harmony: the derived /k/ surfaces instead as [q], assimilating to the root-initial /q’/. This is illustrated by the pairs in (20). (Note that, again, harmony is rendered opaque by the debuccalization of /q’/.) It should be noted that in this case, harmony appears to be progressing from left to right, since it is the derived dorsal that harmonizes, rather than the underlying one.

(20) Coda dorsalization feeds root-internal consonant harmony (Watters 1988)

a. Underlying /p, t/ dorsalize to [(w)k] in coda position:

ʃa.p’a /ʃap-ʔa/ ‘X pants (imperf.)’

ʃawk.ʔi /ʃap-ʔi/ ‘X panted (perf.)’

b. Dorsalized /p, t/ harmonizes with uvular /q, q’/ elsewhere in root:

ʔo.t’a /q’ut-ʔa/ ‘X drinks it (imperf.)’

ʔoq.ʔi (*ʔokʔi) /q’ut-ʔi/ ‘X drank it (perf.)’

As in Totonac, the uvular consonants of Tepehua have a lowering effect on neighboring high vowels, resulting in /i, u/ → [e, o], as illustrated in (21). (This lowering, just like the consonant harmony, is made opaque by the debuccalization of /q’/ to [ʔ], with the result that /i, u/ appear to lower in the vicinity of some [ʔ] but not others.)

(21) Vowel lowering before/after uvular /q, q'/ (data from Watters 1988)

a. Lowering of /i, u/ by non-ejective /q/:

qent'uj /qin-t'uj/ 'two (people)'

maqawe:qni /maqawi:qni/ 'swing (n.)'

?aqtʃoq /?aq(-)tʃuq/ 'pot'

?oqʃtama:ti /?uqʃtama:-ti/ 'hired worker'

b. Lowering of /i, u/ by ejective /q'/ (realized as [ʔ]):

laqtʃeʔej /lak-tʃiq'i-j/ 'X shatters Y (perf.)'

(cf. laqts'iʔi:j 'X takes Y as an example' = /laqts'in-ʔi:-j/)

ʃʔe:rw /ʃq'i:rw/ 'yuca' (cf. ʃʔi:rw 'we (incl.) bought it')

?oʃi /q'uʃ(i)/ 'good' (cf. ?uʃ 'bee')

tsoʔo /tsuq'u/ 'bird' (cf. Huehuetla Tepehua [tsoq'o])

The fact that the quality of nearby vowels is affected by uvulars raises the same question as before: Is it possible that the dorsal consonant harmony in fact involves strictly local spreading of the relevant feature/gesture, affecting all intervening segments as well? As with the cognate harmony in Misantla Totonac, the answer is no. The counterevidence against a local-spreading analysis is even stronger in the case of Tlachichilco Tepehua. Vowel lowering only affects an *immediately* adjacent /i, u/, just as in Totonac; any intervening consonant blocks the effect. Moreover, in cases where the triggering uvular and targeted velar are separated by more than one syllable, intervening (*nonadjacent*) vowels are unaffected by lowering, as illustrated in (22).

(22) Dorsal consonant harmony is not local spreading (data from Watters 1988)

laqpu:teʔenij /lak-pu:tiq'i-ni-j/ 'X recounted it to them'

(3PObj-recount-Dat-Impf)

ʔaqpiteʔej /ʔak-pitiq'i-j/ 'X folds it over'²⁴

(head-fold-Impf)

The examples in (22) clearly show that dorsal consonant harmony violates strict locality, in that it enforces agreement in [RTR] (or [-high]) *across* an intervening string of consonants and vowels, without spreading the feature to those intervening segments. If the consonant harmony involved local spreading, the expected surface forms in (22) would instead be *[laqpu:teʔenij] and *[ʔaqpiteʔej], respectively.

In addition to the Totonacan languages, another unambiguous example of dorsal harmony is found in the dialect of Aymara that MacEachern (1997[1999]) tentatively labels 'Bolivian' Aymara. Unlike its Totonacan counterpart, dorsal consonant harmony in Aymara seems to hold only as a morpheme-internal cooccurrence restriction. As pointed out by MacEachern (1997[1999]), velars and uvulars are not allowed to cooccur within roots, although each may combine freely with segments at other places of articulation. MacEachern's somewhat tentative observations, which are based on a search of dictionary entries in De Lucca (1987), are limited to a few very specific types of disharmonic sequences—/k^h...q^h/, /q^h...k^h/, /q^h...k'/ and /k'...q^h/—all of which are absent from roots. A more detailed follow-up search of the same dictionary has revealed that other combinations of velar and uvular stops (as well as fricatives; see below) are likewise prohibited or strongly disfavored in roots. The effect of dorsal consonant harmony in Bolivian Aymara is illustrated in (23). Note that, in addition to the dorsal harmony require-

²⁴ Elsewhere Watters (1988) analyzes the body-part prefix for 'head' as having underlying /q/: /ʔaq-/ (cf. footnote 16 above). The second form in (22) may thus turn out to be irrelevant in the present context; however, this in no way affects the validity of the evidence that the first form provides.

ment, Aymara roots are also subject to somewhat intricate laryngeal cooccurrence restrictions (see 2.4.7 for further discussion).

(23) Root-level dorsal harmony in ‘Bolivian’ Aymara

a. Well-formed sequences (data from De Lucca 1987)

qelqa	‘document’
q ^h atʃq ^h a	‘rough to the touch’
q’enq’o	‘rough (ground); crooked’
q ^h apaqa	‘wealthy, rich person’
kiki	‘similar, identical’
k ^h usk ^h a	‘common’
k’ask’a	‘acid to the taste’
k’iku	‘wise’ (obsolete)

b. Unattested combinations in roots²⁵

*k ^h ...q ^h	*k’...q’	*k...q	*k’...q ^h	*k’...q (etc.)
*q ^h ...k ^h	*q’...k’	*q...k	*q ^h ...k’	*q’...k (etc.)

As the examples in (23) show, the harmony requirement is blind to the nature of the intervening segmental material. No members of the segmental inventory—consonants or vowels—act as opaque, blocking the agreement in ‘uvularity’ or ‘velarity’ between the two dorsal consonants. If this were the case, roots combining uvulars and velars *would* be allowed, as long as these were separated by one or more intervening opaque segment.

Dorsal harmony in Bolivian Aymara appears to extend to fricatives as well. The only dorsal fricative in the inventory is uvular /χ/, which has a somewhat limited distribution in

²⁵ De Lucca (1987) contains a few entries where (plain) /q/ and /k/ cooccur, but most of these appear to be polymorphemic. Significantly, some have variant forms that obey the dorsal harmony, such as /kamqota/ ~ /qamqota/ ‘beautiful’.

that it is only found in medial position. A search for word-initial /KVχ.../ and /QVχ.../ in De Lucca (1987)—where ‘K’ and ‘Q’ stand for any velar and uvular stop, respectively—revealed a great number of entries with /QVχ.../ (e.g., /qoχo/ ‘elbow’, /q’axaŋa/ ‘dig’), but not a single entry with /KVχ.../. A few examples were found with /K...χ.../ where the velar and uvular are separated by more than just a vowel, but most seem likely to be polymorphemic.

Although the above description pertains only to the ‘Bolivian’ dialect of Aymara as described in De Lucca (1987), it is quite possible that the cooccurrence restriction on velars and uvulars is a pan-Aymaran phenomenon. This could be verified by conducting similar searches of dictionary entries in Ayala Loayza (1988) or Deza Galindo (1989), both of which describe dialects that MacEachern (1997[1999]) labels ‘Peruvian’ Aymara.²⁶ Finally, it is also worth pointing out that Quechua (or, at least, some of the Quechua languages) appears to have the same kind of root-internal dorsal consonant harmony as does (Bolivian) Aymara. Mannheim (1991:173) points out that in modern Southern Peruvian Quechua, ‘a morpheme may have two velar stops or two uvular stops, but not one of each.’ Mannheim does not mention whether the same harmony is found elsewhere in the Quechua language family, e.g., in the Central Quechua branch.²⁷ Be that as it may, it is interesting to note in this context that the Aymaran and Quechua languages have been in close contact for a

²⁶ As pointed out in 2.4.7 below, the ‘Bolivian’ and ‘Peruvian’ dialects differ slightly in the precise nature of the laryngeal harmony restrictions they display (see MacEachern 1997[1999]). Unlike its Bolivian counterpart, Peruvian Aymara lacks /χ/ (and thus has no dorsal fricatives at all); a cross-dialectal comparison might shed light on the sources (or reflexes) of /χ/ and its participation in dorsal consonant harmony in Bolivian Aymara.

²⁷ Although Mannheim (1991) is concerned primarily with the Cuzco-Collao dialect of Southern Peruvian Quechua, there is no reason to doubt that his statement applies to the Ayacucho-Chanka dialect as well, where */q/ > /χ/ in all positions, such that the velar-uvular contrast is now realized as /k/ vs. /χ/. Southern Peruvian Quechua belongs to the ‘Peripheral Quechua’ branch of the family (a.k.a. ‘Quechua A’ or ‘Quechua II’). As for languages of the Central branch (‘Quechua B’/‘Quechua I’), Cerrón-Palomino (1977) makes no mention of cooccurrence restrictions on dorsal consonants in Wanka/Shausa, one of the subgroups of Central Quechua. This is hardly surprising, since */q/ yields /ʔ/ in some dialects (Wanka), and /h/ ~ /x/ in others (Shausa), such that any inherited uvular/velar harmony would now be a matter of the cooccurrence of /k/ vs. /ʔ/ or /k/ vs. /h ~ x/.

millennium or more. It has even been suggested that the two are not isolates but genetically related to each other (Orr & Longacre 1968), though this ‘Quechumaran’ hypothesis remains controversial. It is thus quite possible that the root-internal dorsal consonant harmonies of (Bolivian) Aymara and (Southern Peruvian) Quechua are connected, whether by shared retention from a common proto-language or by areal diffusion through extensive contact.

Based on the description of Ineseño Chumash by Applegate (1972), it appears that this language may at an earlier stage have had a morpheme-internal dorsal consonant harmony similar to that found in Aymara and Quechua. Applegate notes that velar /k/ and uvular /q, χ/ do not cooccur in the same CVC sequence (1972:35). He points out that velars and uvulars do frequently cooccur in what are synchronically single morphemes, but adds that ‘[i]t is tempting to regard these forms [...] as having at one time been morphologically complex’, noting that many appear to contain ‘the ubiquitous formatives’ /aq-/, /ax-/. If Applegate’s speculation is valid, then an earlier stage of Ineseño, or perhaps even Proto-Chumashan, appears to have had morpheme-internal dorsal consonant harmony.

Finally, morpheme-internal dorsal consonant harmony is found in the Dravidian language Malto. According to the description in Mahapatra (1979), velar /k, g/ and uvular /q, ɣ/ do not cooccur in CVC sequences—whether tauto- or heterosyllabic—except where a morpheme boundary intervenes. Interestingly, the restriction is limited to dorsal obstruents; Mahapatra clearly states that velar /ŋ/ is free to cooccur with uvular /q, ɣ/; Malto has no uvular sonorants). Although the description does not mention whether velars and uvulars cooccur at greater distances, I was unable to find any such ‘disharmonic’ sequences in what are plausibly single morphemes.

To sum up, dorsal consonant harmony thus does seem to exist, although it is cross-linguistically relatively rare. As for labial consonant harmony, on the other hand, no cases appear to be attested in adult language. Note that this term would apply to harmony

interactions defined over some labial-specific distinction, the prime candidate being that between bilabial vs. labiodental segments.²⁸ The absence of labial consonant harmony may well have something to do with the fact that the bilabial vs. labiodental distinction is rarely utilized for phonological *contrast* in the world's languages. Labiodental articulation is typically restricted to fricatives, and even among fricatives, labiodental-bilabial contrasts are extremely rare (see Ladefoged & Maddieson 1996:16-18 for discussion). The labiodental nasal [ɱ] is reasonably frequent, but is almost always allophonic, i.e. the result of coarticulation of a bilabial nasal with a neighboring labiodental fricative. It appears to be a valid generalization that consonant harmony systems typically involve distinctions that are phonologically contrastive. This fact, combined with the inherent aerodynamic problems involved in the articulation of labiodental stops (and to some extent nasals), makes it less surprising that no language appears to base a consonant harmony system on the labiodental vs. bilabial parameter.

However, one apparent case of labial consonant harmony has been reported in child language by Stemberger (1988, 1993). In the speech of Gwendolyn (age 4;3-4;6), an otherwise bilabial /m/ assimilated to a nearby labiodental [f] or [v], as illustrated in (24). The examples in (24b) show that the 'spreading' of labiodentality was bidirectional, and that it operated across any number of intervening vowels (as well as across word boundaries).

²⁸ Another conceivable distinction would be that between (bi)labial and *linguolabial* segments, but given the extreme cross-linguistic rarity of the latter (Ladefoged & Maddieson 1996), it is hardly surprising that no consonant harmony involving this contrast has been reported.

(24) ‘Labial harmony’ in the speech of Gwendolyn (4;3-4;6)

- | | | | |
|----|------------------|------------------|--|
| a. | [ɭv ɲais] | ‘love mice’ | |
| | [snɪf ɲais] | ‘sniff mice’ | |
| b. | [fɲɛu ɲais] | ‘smell mice’ | |
| | [fɲɛu ɪŋ] | ‘smell him’ | |
| | [ɲai fɲɛui ɲais] | ‘my smelly mice’ | |

Furthermore, the labiodental harmony displayed by Gwendolyn held across an intervening glottal segment, such as [h] (25a), but was blocked by any other consonant, whether dorsal or coronal (25b).

(25) Transparency of glottals; opacity of non-glottal consonants

- | | | | |
|----|---------------------------|-----------------|------------------------------|
| a. | [fɲau houŋ] | ‘small home’ | |
| b. | [fɲau k ^h ouŋ] | ‘small comb’ | (*[fɲau k ^h ouŋ]) |
| | [fɲaut mais] | ‘smart mice’ | (*[fɲaut ɲais]) |
| | [fɲɛuz mais] | ‘smells mice’ | (*[fɲɛuz ɲais]) |
| | [fɲɛum mais] | ‘smelling mice’ | (*[fɲɛum ɲais]) |

Glottal consonants, as well as vowels, are thus transparent to the harmony—and possibly glides as well, depending on how one interprets vocoid sequences like [ɛu], [ou], [ɛui], etc. On the other hand, all buccal (= non-glottal) consonants are *opaque*. In this respect, Gwendolyn’s labiodental harmony behaves unlike any of the adult-language consonant harmony systems in the database surveyed here. As will be discussed in greater detail in section 3.2 below, segmental opacity of any kind is unattested for consonant harmony systems; where intervening consonants appear to be blocking the propagation of harmony,

the crucial factor seems instead to be trigger-target *distance*, not the nature of the intervening segments.

By contrast, the labiodental harmony displayed by Gwendolyn is typologically much closer to attested adult-language systems of pharyngealization (‘emphasis’) harmony or nasal harmony. For example, in several of the nasal harmony systems surveyed by Walker (1998[2000]), nasalization spreads through vowels and glottals, but is blocked by all other consonants (e.g., Barasano, Mixtec, Sundanese). In an even larger number of languages, nasalization propagates through glides as well (e.g., Acehnese, Capanahua, Malay, Maxakali, Seneca, Urdu). In contrast to the generalizations that will be claimed to hold for consonant harmony systems in this work, it seems clear that Gwendolyn’s labiodental harmony does in fact involve *spreading* of a phonological feature and/or articulatory gesture.

2.4.3. Secondary-articulation harmony

In the preceding sections, the term ‘minor place of articulation’ has been used very informally to refer to finer-grained distinctions within each of the major places of articulation, such as dental vs. alveolar vs. postalveolar under Coronal, labiodental vs. bilabial under Labial, or velar vs. uvular under Dorsal (without any commitment as to how exactly these distinctions should be expressed in featural or gestural terms). But the label ‘minor place of articulation’ is also applicable—and perhaps more appropriately so—to secondary articulations (see Sagey 1986[1990], 1988, who uses the terms ‘minor articulator’ in roughly this way). The class of secondary articulations is conventionally assumed to include at least labialization, palatalization, velarization and pharyngealization. In most cases, a secondary articulation can be seen as the superimposition of essentially *vocalic* features onto a consonant; thus a labialized /k^w/ is a velar stop with superimposed lip rounding, and so on. How best to capture this notion representationally in formal terms is a

matter of some controversy in the theoretical literature (see Clements & Hume 1995 and references cited therein). However, the precise phonological status of secondary-articulation features will not be of direct relevance in the present context. What matters here is simply whether there are any attested cases of consonant harmony that involve agreement with respect to some secondary-articulation feature.

The only attested case that is manifested in the form of actual harmony alternations is the curious sibilant harmony system of the Northern Athapaskan language Tsilhqot'in (a.k.a. Chilcotin), which involves a pharyngealized vs. non-pharyngealized distinction on alveolar sibilants (Krauss 1975; Cook 1983, 1993). The full intricacies of this rather remarkable case—especially as regards its interaction with a synchronically independent phenomenon of ‘vowel flattening’ (essentially a general pharyngealization harmony)—are beyond the scope of this section, and only the basic characteristics will be outlined here. In the Tsilhqot'in consonant inventory, a pharyngealization contrast exists for alveolar sibilants: /s^ɸ, z^ɸ, ts^ɸ, ts'^ɸ, dz^ɸ/ vs. /s, z, ts, ts', dz/.²⁹ The contrast is generally not clearly perceptible on the sibilants themselves, but is easily detectable through the effect that pharyngealized sibilants have on neighboring vowels (Krauss 1975; Cook 1993). In the vicinity of a pharyngealized sibilant, vowels are systematically lowered and/or backed, e.g., /i/ → [Λi ~ e], /ɛ/ → [Λ], /æ/ → [ɑ]. In addition to the two series of alveolar sibilants, Tsilhqot'in also has a third sibilant series, lamino-postalveolar /ʃ, tʃ, tʃ', dʒ/ (phonetically more or less identical to their English counterparts).³⁰ The postalveolar sibilants do not have

²⁹ The former are represented as ‘ŝ, ž, tŝ, tŝ', dŝ' in the native orthography, as well as in most works on Tsilhqot'in phonology. Based on second-hand descriptions, Gafos (1996[1999]) interprets the contrast as a dental vs. alveolar one. Although the segments in question can sometimes be realized as dental—in particular the voiced fricative, and especially in coda position—this is true of *both* series; thus, both /z/ and /z^ɸ/ are frequently realized phonetically as [ʒ].

³⁰ Gafos (1996[1999]) interprets these—mostly through conjecture—as phonetically dorso-palatal, i.e. as true (non-coronal) palatals. Although it is true that /ʃ/ is realized as palatal [ç] in absolute word-final position, the other postalveolars are never phonetically dorso-palatal (and neither is /ʃ/ in non-final position).

any effect on nearby vowels; they also do not interact with the sibilant pharyngealization harmony in any way.

The pharyngealization contrast among sibilants, and the allophonic alternations it triggers in neighboring vowels, is readily interpretable in terms of the phonological feature $[\pm\text{RTR}]$. Synchronically, sibilant pharyngealization harmony in Tsihqot'in is obscured by a separate pharyngealization harmony, which spreads leftwards from a $[\text{+RTR}]$ sibilant, affecting every preceding vowel in the word (and perhaps intervening consonants as well, although this is harder to detect). This phenomenon is illustrated in (26). Here and in all following examples, underlining is used to highlight those vowels which are realized as $[\text{+RTR}]$. (Note that tone is not marked; the underlying representations are somewhat abstract, mostly following the analysis of Tsihqot'in verb morphology presented in Cook 1989.)

(26) Right-to-left $[\text{RTR}]$ vowel-consonant harmony

$\dot{g}^w \underline{\Delta n \Delta n t^h} \underline{q z^s} \underline{\Delta t}$	/ $g^w \varepsilon\text{-}n\varepsilon\text{-}t\varepsilon\text{-}k\varepsilon\text{-}z^s \varepsilon t$ /	'it's going to get warm'
$\text{ʔ} \underline{q n q t^h} \underline{\Delta z^s} \underline{\Delta i t}$ 'in	/ $\text{ʔ} \varepsilon\text{-}n \varepsilon\text{-}t \varepsilon\text{-}s^s \varepsilon\text{-}i d\text{-}t$ 'in/	'we started working'
(cf. $\text{ʔ} \varepsilon n \varepsilon d \text{ʒ} \varepsilon t$ 'in	/ $\text{ʔ} \varepsilon\text{-}n \varepsilon\text{-}d \text{ʒ} \varepsilon\text{-}t$ 'in/	'they're working')

Sibilant pharyngealization harmony, by contrast, simply enforces agreement in $[\pm\text{RTR}]$ between all alveolar sibilants in a word. The harmony is anticipatory: the rightmost sibilant determines the $[\pm\text{RTR}]$ value of any preceding (alveolar) sibilant in the word. When the harmonizing feature value is $[\text{+RTR}]$ —i.e. when the rightmost sibilant is pharyngealized—the effect of this consonant harmony is rendered invisible by the general right-to-left $[\text{RTR}]$ harmony in (27). This is shown in (27a). However, the *depharyngealizing* version of the consonant harmony—where the harmonizing feature value is $[\text{-RTR}]$ —is readily detectable. In the forms in (27b), sibilant harmony depharyngealizes the $[s^s]$ (or $[z^s]$) of the con-

jugation marker /s^ʰε-/ , and thus has the effect of *bleeding* the spread of [+RTR] from that sibilant to nearby vowels.

(27) Sibilant pharyngealization harmony in Tsilhqot'in

- a. Pharyngealizing ([+RTR]) version — obscured by vowel-consonant harmony

nq̄s^ʰ Δnq̄B Δl̄ts^ʰ Δs^ʰ /næ-sε-næ-Bε-nε-l-ts^ʰεns^ʰ/ 'you're hitting me' (Cook 1993)

nq̄n Δdq̄s^ʰ Bq̄s^ʰ /næ-nε-dε-Bε-s-ʰ-bæss^ʰ/ 'I'm turning you around'

(cf. nænεdq̄æsḡæʰ /næ-nε-dε-Bε-s-ʰ-gæʰ/ 'I'm spinning you [around]')

- b. Depharyngealizing ([-RTR]) version

nætezes̄bin /næ-tε-s^ʰε-s-d-bin/ 'I'm swimming away'

(cf. nq̄tΔz^ʰ Δl̄bin /næ-tε-s^ʰε-id-d-bin/ 'we're swimming away')

sitt^ʰæz /s^ʰε-i-ʰ-tʃæz/ 'I barbequed it'

(cf. jq̄s^ʰ Δilt^ʰiq̄ /jæ-s^ʰε-id-ʰ-tiq̄/ 'we're not talking')

The second example in (27b) also illustrates that intervening postalveolar sibilants do not block the harmony, nor interact with it in any way. In fact, all intervening segmental material is transparent to the sibilant pharyngealization harmony. That this consonant harmony is not a matter of strictly-local spreading of articulatory gestures and/or phonological features is shown by forms such as those in (28). Here, right-to-left agreement in [-RTR] holds across a span which includes vowels that are realized as [+RTR], due to assimilation to an immediately adjacent uvular fricative /ʁ/.

(28) Non-local character of Tsilhqot'in sibilant [RTR] harmony³¹

ʔæ jɛtʰɛzʌʔqɔʔzɛz /jɛ-tɛ-sʰɛ-ʔæ-id-jɛz/ 'we're not g. to get the hiccups'

ʔæ næʰɛzʌʔqɔʔkʰɛs /næ-tɛ-sʰɛ-ʔæ-id-l-kʰɛs/ 'we're not g. to be stiff' (spkr A)

ʔæ næʰɛzqɔʔkʰɛs /næ-tɛ-sʰɛ-ʔæ-id-l-kʰɛs/ 'we're not g. to be stiff' (spkr B)

Were it not for sibilant harmony, the forms in (28) should surface as [jʌtʰɛzʰʌʔqɔʔzɛz] and [næʰɛzʰʌʔqɔʔkʰɛs] ~ [næʰɛzʰqɔʔkʰɛs], respectively—with the [zʰ] of the /sʰɛ-/ prefix remaining pharyngealized, and in turn spreading [+RTR] of all preceding (and adjacent) vowels. That [-RTR] sibilant harmony is able to apply across [+RTR] vowels is clear evidence that Tsilhqot'in sibilant harmony is a matter of [\pm RTR] *agreement*, rather than spreading.³²

Another example of secondary-articulation consonant harmony is the case of velarization in Pohnpeian (Rehg 1981; Mester 1986[1988], 1988), which is manifested as a static cooccurrence restriction on roots. In Pohnpeian, the velarized vs. non-velarized contrast exists only for labial consonants; thus plain /p, m/ contrast with velarized /pʷ, mʷ/. (Note that the latter are usually represented with 'p^w', 'm^w' in the literature. Although it is true that these segments are phonetically *labio*velarized in most positions, the labialization component appears to be a matter of secondary phonetic enhancement; for example, it is

³¹ I follow Cook's (1989) suggestion to analyze the progressive prefix (normally /-ʔæ-/) as having the allomorph /-ʔæ-/ in certain forms of the future, or 'inceptive-progressive', paradigm. Speaker B appears to contract the entire /...ɛʔæ.../ sequence to a single [ɑ] instead of the expected [ʌʔɑ]; note that even though /ʔ/ is deleted in this case, its underlying [+RTR] specification is preserved, and realized on the remaining vowel. See Cook (1989) for further discussion of verb prefix phonology and morphology in Tsilhqot'in.

³² Shahin (1997) argues that *uvulization* and *pharyngealization* are distinct phenomena, with different (though somewhat overlapping) phonetic manifestations. It might therefore be argued that sibilant pharyngealization harmony could potentially hold across a uvularization span. There are two reasons for rejecting this idea. One is the fact that uvulars and pharyngealized sibilants seem to have the exact same categorical effects on vowels (e.g., [æ] → [ɑ], [i] → [ɪ]). The second objection is that in (28), it is *depharyngealization* which is taking place across the uvularization span. Even though pharyngealization and uvularization may be distinct and to some extent independent from each other, it seems obvious that active depharyngealization and active uvularization are inherently incompatible.

absent in word-final position.) In any given Pohnpeian morpheme, plain and velarized labials are not allowed to cooccur, as shown in (29):³³

(29) Root-level velarization harmony in Pohnpeian

a. Well-formed roots (data from Rehg 1981)

pirap	‘steal; be stolen’
mem	‘sweet’
parem	‘nipa palm’
matep	‘species of sea cucumber’
p ^y up ^y	‘fall down’
m ^y aam ^y	‘fish’
m ^y op ^y	‘out of breath’

b. Unattested combinations in roots

*p...p ^y	*m...m ^y	*p...m ^y	*m...p ^y
*p ^y ...p	*m ^y ...m	*p ^y ...m	*m ^y ...p

As illustrated by examples such as /matep/ and /parem/, and the absence of morphemes such as */p^yarem/, */matep^y/, etc., the harmony requirement is not in any way sensitive to the segmental material which intervenes between the two labials. There are no segments (consonants or vowels) which are opaque, blocking the propagation of harmony, and thus allowing velarized and non-velarized labials on either side to cooccur within a morpheme.

³³ Mester attributes this generalization to Rehg (1981:44-46), but notes that the latter only discuss the incompatibility of /m/ with /m^y/ and of /p/ with /p^y/; as Mester points out, the other combinations in (29b) also appear to be unattested as well (Mester 1988:21, fn. 2). McCarthy (1989:79)—who refers to the Pohnpeian phenomenon as *rounding* harmony on labials—finds the same cooccurrence restrictions in the closely related language Mokilese as well. Rehg (1981) also notes the morpheme-level incompatibility (or near-incompatibility) of various other ‘front’ vs. ‘back’ consonant pairs in Pohnpeian: the liquids /l/ vs. /r/, dental vs. retroflex stops, and dental vs. velar nasals. In the survey of attested consonant harmony types presented in this chapter, these are noted separately, each in the relevant section.

No attested cases of consonant labialization harmony appear to exist—unless the Pohnpeian cooccurrence restriction just discussed is interpreted as such. As for consonant palatalization harmony, evidence for its existence is tentative at best. One language, Karaim, is sometimes cited as having ‘transphonologized’ the palatal vowel harmony typical of Turkic languages into a palatalization harmony on consonants (Jakobson, Fant & Halle 1963; Lightner 1965; Hamp 1976)—possibly due to contact with surrounding Baltic and Slavic languages where consonant palatalization is rampant. However, this claim seems to depend on a particular structuralist-phonemic analysis, whereby the palatal feature is assumed to be *distinctive* on consonants only, rather than on vowels (or on both). Such an analysis ignores the issue of whether the relevant feature/gesture is also present *phonetically* on the intervening vowels—since this would be a matter of mere allophonic detail. For the purpose of this survey, on the other hand, it is absolutely crucial to know whether palatalization does indeed ‘jump’ from consonant to consonant without affecting intervening vowels. In the absence of the kind of detailed phonetic evidence that could determine this, it seems safer to assume that the palatal harmony in Karaim is more akin to, e.g., nasal harmony, which is quite often triggered by consonants but which demonstrably (and audibly) affects all segments in its domain, vowels and consonants alike.

Another, even more tentative case of consonant palatalization harmony is that of Zoque (Wonderly 1951). When discussing various local palatalization effects of the glide /j/ on neighboring consonants, Wonderly (1951:117) cites, among others, the forms /sohs-jah/ → [ʃohʃahu] ‘they cooked it’ (from /sohs-/ ‘cook’) and /meʔts-jah/ → [m^heʔtʃahu] ‘they sought it’ (from /meʔts-/ ‘seek’).³⁴ He does not comment on the double ‘palatalization’ in these forms. Other similar forms do not show the same effect, e.g., /ken-jah/ → [keɲahu]

³⁴ Wonderly writes a cluster (‘my’) in the latter case, but I follow Sagey (1986[1990]) and Humbert (1995) in interpreting such combinations as palatalized. However, Wonderly is very explicit about the ‘palatalized’ counterparts of /s/, /ts/, etc. being ‘alveopalatal’ [ʃ], [tʃ], etc., and definitely not [s^h], [ts^h] (pace Humbert 1995).

‘they looked’ (from /ken-/ ‘see’) and /wiht-jah/ → [wihcahu] ‘they walked’ (from /wiht-/ ‘walk’), even though /k/ and /w/ regularly undergo palatalization when immediately adjacent to /j/. In the absence of more data it is thus impossible to know how the Zoque facts are to be interpreted. It should also be noted that even if the Zoque data are in fact due to consonant harmony, more information would be needed to determine whether this should be classified as true *palatalization* harmony or, instead, as yet another case of coronal harmony (involving the alveolar vs. postalveolar contrast)—or perhaps a combination of the two.

Finally, consonant palatalization harmony may play a part in the complex patterns displayed by the mobile or ‘featural’ morphology of some of the Ethio-Semitic languages (see, e.g., McCarthy 1983; Akinlabi 1996; Zoll 1996; Rose 1997). In particular, harmony may be involved in the palatalization patterns found in Harari (Leslau 1958; Rose 1997). In Harari, the 2SgF subject suffix /-i/ triggers palatalization of a stem-final coronal, as shown in (30a). If the stem-final consonant is not coronal, palatalization may instead target a coronal in stem-medial position (30b) or even stem-initial position (30c). All forms in (30) are cited from Rose (1997:40-55); note that the representation of consonants have been altered to conform to the IPA transcription system.

(30) Palatalization with 2SgFem subject suffix /-i/ in Harari

	<i>2SgMasc</i>	<i>2SgFem</i>	
a.	kifät	kifätʃ-i	‘open!’
	zimäd	zimädʒ-i	‘drag!’
	libäs	libäʃ-i	‘dress!’
	kifäl	kifäj-i	‘pay!’ ³⁵

³⁵ Harari lacks a palatal lateral [ɬ] (or a palatalized [lʲ]); thus /l/ surfaces as the glide [j] when palatalized.

b.	kitāb	kitʃäb-i	‘write!’	
	sidäb	sidʒäb-i	‘insult!’	(see also 32b below)
c.	tʻiräg	tʃʻiräg-i	‘sweep!’	
	sixär	ʃixär-i	‘be drunk!’	
	diräq	dʒiräq-i	‘be dry!’	

In each of the cases above, only one consonant is singled out as a target; such forms are thus not evidence of harmony of any kind. However, when the stem contains more than one coronal, multiple palatalization may occur. If the stem-final consonant is a coronal sonorant, i.e. /l/ or /n/ (/r/ is not a target for palatalization), then palatalization will also target a stem-medial obstruent, in addition to the stem-final sonorant, as shown in (31). Rose (1997) treats this as an obligatory process, but doublets such as [gidʒäj-i] ~ [gidäj-i] reported by Leslau (1958) suggest that, at least for some speakers, double palatalization is optional here (just as in final-obstruent cases to be discussed below).

(31) Double palatalization in multiple-coronal stems with final sonorant

	<i>2SgMasc</i>	<i>2SgFem</i>		
	fitʻän	fitʃʻäj-i	‘hurry!’	
	xidän	xidʒäj-i	‘cover!’	
	nidäl	nidʒäj-i	‘make a hole!’	
	gidäl	gidʒäj-i	‘kill!’	[~ gidäj-i (Leslau 1958)]

If the stem-final consonant is a coronal obstruent, on the other hand, a stem-medial coronal is affected only optionally (32a). According to Leslau (1958), a stem-initial coronal may optionally be affected as well, in addition to the final (or medial) one (32b), but Rose’s consultant rejected such pronunciations (Rose 1997: 42).

(32) Double palatalization in multiple-coronal stems with final obstruent (optional)

	<i>2SgMasc</i>	<i>2SgFem</i>		
a.	bit'äs	bit'äƷ-i ~ bitʃ'äƷ-i	'rip!'	
	sidäd	sidädʒ-i ~ sidʒädʒ-i	'chase away!'	
	kisäs	kisäƷ-i ~ kiʃäƷ-i	'take to court!'	
b.	nixäs	nixäƷ-i	'bite!'	[~ nixäƷ-i, (Leslau 1958)]
	t'imäd	t'imädʒ-i	'put the yoke!'	[~ tʃ'imädʒ-i (ibid.)]
	sidäb	sidʒäb-i	'insult!'	[~ ʃidʒäb-i (ibid.)]
	diläg	dijäg-i	'work!'	[~ dʒijäg-i (ibid.)]

As Rose (1997) argues, it would be inappropriate to analyze the Harari palatalization facts as a whole as consonant harmony—in the sense of contiguous spreading of articulatory gestures (but note that this is precisely the notion that is being argued against in this work). On the other hand, as Rose points out, the (optional) double palatalization does bear the hallmarks of consonant harmony: 'If optional palatalization were triggered not by the vowel but by the consonant required to be palatalized, then it would count as an instance of consonant harmony' (Rose 1997: 45).³⁶ She does not dwell on this point, and her Optimality Theory analysis focuses on the obligatory palatalization. Rose takes this to include double palatalization only in the sonorant-final cases in (31), but doublet forms cited by Leslau (1958), such as [gidʒäj-i] ~ [gidäj-i] 'kill!', suggest that these should perhaps be

³⁶ Rose voices some reservations about this interpretation because of the fact that in Harari, *stops* like /t', t, d/ would then be harmonizing with affricates and fricatives like [tʃ', tʃ, dʒ, ʃ], in sharp contrast to attested coronal harmonies in languages such as Chumash or Tahltan, where stops are neutral and transparent (Shaw 1991). However, the more extensive cross-linguistic survey reported on here reveals the existence of coronal harmony systems where stops do participate; see section 2.4.1.2 above for examples of this type. Furthermore coronal stop-sibilant alternations are found in Yabem stricture harmony (see section 2.4.6), where a prefixal /s/ assimilates in [±continuant] with a [t] or [d] in the following root.

grouped together with the obstruent-final cases; if so, *all* instances of double palatalization would potentially count as examples of consonant harmony.

Rose (1997) accounts for double palatalization in sonorant-final stems by appealing to a Palatalization Hierarchy, which encodes (among other things) a preference for palatalizing obstruents over sonorants. She then stipulates that a PALATALIZATION MARKEDNESS constraint is violated only if the most optimal palatalization anchor in the domain is not palatalized, but is not sensitive to whether an inferior anchor is *also* palatalized at the same time. For the input /xidän-i/, MARKEDNESS thus rules out the candidate *[xidäŋ-i], but leaves the alternatives *[xidzän-i] and [xidzäŋ-i] tied. The preference of [xidzäŋ-i] over *[xidzän-i] is made with reference to an ADJACENCY constraint (see Rose 1997: 45-55 for the full details of the analysis).

As a final note, it should be pointed out that, since the target consonants involved are always coronals, the Harari double-palatalization case might perhaps more appropriately be classified as an instance of coronal harmony rather than secondary-articulation harmony. Although mobile ‘palatalization’ in Harari (and other Ethio-Semitic languages) conventionally goes by this name, this constitutes a rather loose usage of the term ‘palatalization’, at least from a phonetic point of view. When they undergo this ‘palatalization’, alveolar (or perhaps dental) obstruents become postalveolars, strictly speaking ([tʃ], tʃ, dʒ, ʃ]), whereas the sonorants /l, n/ become true palatals ([j, ɲ]). In neither case is the resulting segment a *palatalized* alveolar (or dental), in the strictest sense. The ‘palatal’ component of the resulting segments does thus not qualify as a secondary articulation in the phonetic sense of that term. To what extent ‘consonant palatalization harmony’ or ‘secondary-articulation harmony’ is the appropriate interpretation of the Harari facts from a *phonological* perspective largely depends on how one chooses to analyze palatals and palatalization—particularly that of coronals—in terms of features (or gestures) and their interplay. At the present time, there does not seem to be a clear

consensus on this rather intricate issue within the theoretical-phonological literature (but see, e.g., Sagey 1986[1990], 1988; Broselow & Niyondagara 1989; Lahiri & Evers 1991; Ní Chiosáin 1991; Hume 1992; Clements & Hume 1995, for a variety of feature-geometric proposals and analyses).

2.4.4. Nasal consonant harmony

Another phonetic parameter along which consonant harmony may operate is nasality. This is referred to here as ‘nasal consonant harmony’ (following, e.g., Hyman 1995 *et passim*) in contradistinction to the more familiar notion of ‘nasal harmony’. The latter phenomenon would perhaps be more aptly named ‘*nasalization* harmony’, in that it is generally characterized by the nasalization of any and all segments that fall within its span. As such, it shares more affinities with vowel harmony than with consonant harmony, and clearly patterns with the former with respect to the asymmetries discussed in chapter 3. For a recent survey of nasal harmony systems, see Walker (1998[2000]).

Nasal harmony—i.e. nasalization harmony—is illustrated by the forms in (33) which are from the Johore dialect of Malay (Onn 1980, cited from Walker 1998[2000]). In Johore Malay, nasalization spreads rightwards from a nasal consonant, affecting vowels and glides. Harmony is blocked by all supralaryngeal consonants (liquids and obstruents), whereas glottals are transparent. (In the examples in (33), the permeability of glottals is indicated by marking them as nasalized as well.)

(33) Nasal harmony in Johore Malay (Onn 1980, cited from Walker 1998[2000])

mãjãŋ	‘stalk (palm)’
mõnãwãñ	‘to capture (active)’
mãʔãp	‘pardon’
pønõŋãhãñ	‘central focus’
põŋãwãsan	‘supervision’
mõratappi	‘to cause to cry’

Nasal consonant harmony, by contrast, does not affect intervening segments in any phonetically detectable way—it does not result in the nasalization of any vowels (or consonants) separating the trigger and target consonant. Cross-linguistically, nasal consonant harmony appears to be relatively rare—certainly much rarer than nasal harmony—but it is quite widely attested within one language family: the Bantu languages. In those Bantu languages that have nasal consonant harmony, it is typically manifested in suffix alternations between [l]/[d] and [n] (see, e.g., Greenberg 1951; Johnson 1972; Howard 1973; Ao 1991; Odden 1994; Hyman 1995; Piggott 1996; Walker 1998[2000], 2000b). A suffixal [l]/[d] will come out as [n] if preceded by a nasal earlier in the stem.³⁷ The most dramatic instantiation of Bantu nasal consonant harmony is that found in languages such as Mbundu (Chatelain 1888-89), Kongo (Ao 1991; Odden 1994; Piggott 1996) and Yaka (Hyman 1995), where harmony holds regardless of the distance between the trigger and target consonants.³⁸ This is illustrated by the Yaka forms in (34); note that

³⁷ In Bantu, [l] and [d] are often in complementary distribution. In Yaka, for example, the phoneme in question appears as [d] before [i], as well as after a nasal, but as [l] otherwise (Hyman 1995). Many Bantu languages have /r/ instead of /l/; thus, in Herero (Booysen 1982), nasal consonant harmony results in an alternation between /r/ and /n/ rather than /l/ and /n/.

³⁸ Note that ‘Mbundu’ here refers to KiMbundu rather than the closely related UMBundu. The latter also has a phenomenon closely resembling—and presumably cognate with—nasal consonant harmony in other Bantu languages, except for the fact that intervening vowels *are* nasalized. Furthermore, ‘harmonization’ of /l/ yields not [n] but a segment transcribed as [ĩ], and /k/ is also nasalized, yielding [h̃]. See Schadeberg (1982) for detailed discussion of the complex nasalization patterns found in UMBundu. A conjectural

the transcription has been translated into IPA. In (34a), the harmony can be seen operating across a vowel; in (34b), longer stretches of segmental material separate trigger and target.

(34) Nasal consonant harmony in Yaka (Hyman 1995)

a. Harmony alternations in perfective suffix [-idi]/[-ele]³⁹

són-ene	‘color’	cf.	sól-ele	‘deforest’
kém-ene	‘moan’	cf.	kéb-ele	‘be careful’
ján-ini	‘cry out in pain’	cf.	jád-idi	‘spread’
tsúm-ini	‘sew’	cf.	tsúb-idi	‘wander’

b. Interaction at a distance:

mák-ini	‘climb’
ɲé:k-ene	‘bend down’
hámúk-ini	‘break (intr)’
nútúk-ini	‘bow’
mítuk-ini	‘sulk’

As the forms in (34b) clearly show, intervening consonants do not interfere with the harmony ‘agreement’ in nasality in any way. Interestingly enough, this is even true of intervening NC contours (which may be analyzed as prenasalized stops rather than clusters). As shown in (35a), prenasalized stops do not trigger harmony on a following /l ~ d/; moreover, forms such as those in (35b) show that nasal consonant harmony holds *across* a prenasalized stop. As in (34) above, all forms contain the perfective suffix.

scenario linking UMbundu nasalization harmony and the nasal consonant harmony found elsewhere in Bantu is presented in Dolbey & Hansson (1999).

³⁹ The [i]/[e] suffix alternations are due to an independent vowel height harmony (see, e.g., Hyman 1998).

(35) Inertness of prenasalized stops in Yaka harmony (Hyman 1995)

a. NCs are non-triggers

bí:mb-idi	‘embrace’	(*bí:mb-ini)
kú:nd-idi	‘bury’	(*kú:nd-ini)
hé:ng-ele	‘sift’	(*hé:ng-ene)

b. NCs are transparent

ná:ng-ini	‘last’	
nú:ng-ini	‘win’	
mé:ng-ene	‘hate’	

Many other Bantu languages have a more restrictive version of nasal consonant harmony than do Yaka and Kongo, in that it is strictly transvocalic. In such systems, harmony only applies when the triggering nasal is separated from the target by no more than a single vowel. Given the general CV syllable structure of the languages in question, another possible formulation would be that the trigger and target must be in adjacent syllables (cf. Odden 1994; Piggott 1996; Walker 2000b; see also section 3.2.2 for discussion). As illustrated in (36), nasal consonant harmony is limited to transvocalic contexts in Lamba (Doke 1938; Odden 1994).

(36) Transvocalic nasal consonant harmony in Lamba (Odden 1994)

a. Perfective suffix [-ile]/[-ele]

pat-ile	‘scold (perf.)’	(cited from Piggott 1996:142)
uum-ine	‘dry (perf.)’	
nw-iine	‘drink (perf.)’	
mas-ile	‘plaster (perf.)’	(*mas-ine)

- b. Transitive reversive suffix [-ulul-]/[-olol-]
- fis-ulul-a ‘reveal’
- min-unun-a ‘unswallow’
- mas-ulul-a ‘unplaster’ (*mas-unun-a)
- c. Intransitive reversive suffix [-uluk-]/[-olok-]
- fis-uluk-a ‘get revealed’
- min-unuk-a ‘get unswallowed’
- mas-uluk-a ‘get unplastered’ (*mas-unuk-a)

As the last example in each of (36a-c) shows, the root-initial /m/ of /mas-/ ‘plaster’ does not trigger assimilation in a suffixal /l/, unlike the root-initial /n/ of /nw-/ ‘drink’ in (36a). The harmony requirement holds only when the trigger and target consonants are separated by no more segmental material than a vowel.

Other languages where the harmony is strictly transvocalic are Ila (Greenberg 1951), Bemba (Hyman 1995), Luba (Johnson 1972; Howard 1973), Ndonga (Viljoen 1973; Tirronen 1986; cf. Walker 2000b), Tonga (Collins 1975), Herero (Booyesen 1982) and Kwanyama (Meinhof 1932). According to Larry Hyman (pers. comm.), Pende, Punu and Ruund can be added to this list—although Ruund appears to be in the progress of levelling out harmony alternations in favor of the /-Vn(V)-/ allomorph.⁴⁰ Yet another language, Suku, is somewhat intermediate between the ‘transvocalic’ and ‘unbounded’ types; here, a /-VI(V)/ suffix may optionally harmonize to a root-final nasal when another -VC- suffix intervenes (Piper 1977).

It should be noted that in languages like the ones mentioned above, where nasal consonant harmony is manifested directly in the form of alternations, harmony holds root-

⁴⁰ If the description in Greenberg (1951) is accurate, the nasal allomorphs have also been generalized in the northwestern language Fang; thus the applicative suffix is /-in-/ regardless of context, and reversive is /-un-/.

internally as well (as a cooccurrence restriction). In fact, Hyman (1995) reduces the Yaka facts to a general constraint which bars (non-prenasalized) voiced oral consonants from occurring if preceded by a nasal anywhere within the stem—the term ‘stem’ referring to the root+suffix domain. Piggott (1996) makes a similar observation about Kongo, based on a search of the dictionary listings of Bentley (1887) and Laman (1936). The same appears to be true of the strictly transvocalic harmony in Lamba as well. Other Bantu languages may have an even more limited version of nasal consonant harmony, in that it exists *only* in the form of a root-level cooccurrence restriction, such that Proto-Bantu **-mid-* ‘swallow’ > *-min-*, but **-túm-id-* ‘send for (appl.)’ > *-túm-il-* (Hyman 1995:23).

It should be noted that among roots, only the ones with the structure -NV(V)D- harmonize consistently (to -NV(V)N-), whereas -DV(V)N- roots, such as /-lim-/ or /-dim-/ ‘cultivate’ usually do not harmonize to -NV(V)N-. Rather than attributing this to consistent left-to-right directionality, the asymmetric effect can be accounted for by assuming relatively high-ranked faithfulness to root-initial consonants, such that a /d/:/n/ contrast is preserved intact in initial position but may be neutralized by consonant harmony elsewhere. In fact, diachronic evidence suggests that nasal consonant harmony may apply bidirectionally in the root domain, though perhaps not quite consistently so. The Proto-Bantu root **-bon-* ‘see’ becomes /-mon-/ in a large area that coincides almost perfectly with the area where (left-to-right) nasal consonant harmony between root and suffixes is found.⁴¹ The systematicity of the correlation suggests that this case of right-to-left directionality is more than a sporadic quirk. In addition, right-to-left directionality holds between suffix and stem in at least one language, Pangwa (Stirnemann 1983). Here, reciprocal /-an-/ triggers nasalization of a stem-

⁴¹ I am grateful to Larry Hyman (pers. comm.) for bringing this correlation to my attention. The only exception I have come across is Tonga (Collins 1975), which shows (transvocalic) harmony in suffixes as well as root-internally in /-men-/ ‘swallow’ (< **-mid-*) and the like, but nevertheless retains unharmonized /-bon-/ ‘see’.

final velar (e.g., /pulix-/ ‘listen to’, /puliŋ-an-/ ‘listen to each other’). Issues of directionality, stem control, etc., are discussed in greater detail in section 3.1 below.

Ganda, another Bantu language, seems to have root-level nasal consonant harmony that is to some extent dependent (or ‘parasitic’) on place of articulation (Katamba & Hyman 1991). In canonical roots of the C_1VC_2 shape, C_1 and C_2 must agree in nasality if they are homorganic and voiced (i.e. *NV(V)D and *DV(V)N are disallowed if N and D are homorganic). In addition, however, there is a marked dispreference for *NV(V)D sequences in general, even when N and D are *non*-homorganic, although the picture is somewhat complicated. The only robustly occurring combinations of this type are mVD and ɲVg (both across a short vowel only); by contrast, *ɲVD ($D \neq /g/$), *nVD and *NVVD are all disallowed. According to Katamba & Hyman (1991:201), the cooccurrence restrictions on nasality found in Ganda may probably be reconstructed for Proto-Bantu as well. The protolanguage does not seem to have had any morpheme-internal **d...n* sequences, and few, if any, **b...m* sequences. Nonhomorganic sequences like **d...m* or **b...n*, on the other hand, were quite frequent. In fact, according to Larry Hyman (pers. comm.), at least one Proto-Bantu **n...n* root (*-*nun*- ‘old person’) has /*d...n*/ cognates in some of the Grassfields languages.

Returning to those languages where nasal consonant harmony is manifested in alternations, it should be pointed out that all the relatively well-known cases (Kongo, Yaka, Lamba, etc.) involve *nasalization* rather than *denasalization*. In other words, an input /*d*/ (or /*l*/) surfaces as [n] due to harmony; an input /*n*/, on the other hand—in the reciprocal suffix /-an-/, for example—does not harmonize with a preceding (voiced) oral consonant to surface as [d] or [l]. This asymmetry can straightforwardly be captured in an Optimality Theory analysis by assuming the relative faithfulness ranking MAX[nasal] >> DEP[nasal] (or, if nasality is assumed to be binary, IDENT[+nasal] >> IDENT[-nasal]). As long as the

constraint that ultimately drives harmony is ranked between the two faithfulness constraint, it can only have the effect of nasalization, never denasalization.⁴²

There does, however, exist an example of nasal consonant harmony which has the effect of either nasalization or denasalization ('oralization'), depending on circumstances.⁴³ This is the case of Tiene, another language of the Bantu family (Ellington 1977; Hyman 1996; Hyman & Inkelas 1997), where nasal consonant harmony plays part in an intricate system of prosodic stem templates. In Tiene verbs, the so-called D-stem (derivational stem, i.e. root + derivational suffix) must be exactly bimoraic, i.e. either CVVC or CVCVC. Further restrictions apply to D-stems of the CVCVC variety: not only must C₂ be coronal, and C₃ non-coronal (labial or velar), but C₂ and C₃ must also agree in nasality. (A similar templatic restriction limiting nasal consonant harmony to C₂ and C₃ is also found in various Teke dialects, such as Kukuya.)

Because of the strict restriction on place of articulation (C₂ = coronal, C₃ ≠ coronal), the addition of derivational affixes to CV(V)C roots results in a remarkable interplay between infixation and suffixation, depending on the place of articulation of the root-final consonant, as well as that of the affix consonant (Hyman & Inkelas 1997). What is of importance in the present context, however, is merely the agreement in nasality between C₂ and C₃; suffice it to say that (coronal) C₂ may belong either to the verb root or an infix, whereas (non-coronal) C₃ may belong either to a suffix or the verb root. The harmony effects are illustrated by the forms in (37); the CVCVC stem is enclosed in brackets, with all infixed material indicated by '=' boundaries. In each case, the affix itself consists only of a

⁴² The left-to-right (or 'inside-out') directionality does not fall out automatically, however; see section 3.1 for further discussion of directionality and its relationship to stem control, dominance, etc.

⁴³ In addition to the Tiene case, denasalization is also found in the Austronesian language Sawai (Whistler 1992). Here the /n/ of the possessive classifiers /nɔ-/ (edibles) and /ni-/ (non-edibles) becomes denasalized before a pronominal suffix containing /r/ (= [r]), e.g., /nɔ-ri/ → [rɔ-ri] 'their edible' and /ni-r/ → [rɔ-r] 'our (incl.) edible'.

single consonant; the additional vowel (V₂) results from the bimoraic template requirement, and its quality is entirely predictable from context (Hyman & Inkelas 1997).

(37) Nasal consonant harmony in the Tiene CVCVC template (data from Hyman 1996)

a. Alternation in infixed applicative /-l-/ (< Proto-Bantu *-ed-)

bák-a	‘reach’	[bá=la=k]-a	‘reach for’
jók-a	‘hear’	[jó=le=k]-ε	‘listen to’
dum-a	‘run fast’	[du=ne=m]-ε	‘run fast for’
lɔŋ-ɔ	‘load’	[lɔ=nɔ=ŋ]-ɔ	‘load for’

b. Alternation in suffixed stative /-k-/ (< Proto-Bantu *-ek-)

jaat-a	‘split’	[jat-ak]-a	‘be split’
ból-a	‘break’	[ból-ek]-ε	‘be broken’
vwuj-a	‘mix’	[vwuj-εŋ]-ε	‘be mixed’
sɔn-ɔ	‘write’	[sɔn-ɔŋ]-ɔ	‘be written’

Note that the harmony effects in (37) are bidirectional—regressive in (37a), progressive in (37b)—and in both cases an oral consonant assimilates to a nasal (cf. the asymmetry in Yaka, Lamba, etc. discussed above). Since none of the relevant derivational suffixes happen to contain an underlying nasal, in both cases it is the suffix consonant which assimilates, rather than the root consonant. (Note, furthermore, that nasal consonant harmony is enforced regardless of differences in voicing: suffixal /k/ surfaces as [ŋ] after a root-final nasal.)

However, when the oral consonant is one that cannot undergo nasalization, such as the fricative /s/, it is instead the *nasal* that yields, undergoing denasalization to become a (voiced) oral stop. This happens when causative /-s-/ is infixed into a nasal-final root, as

shown in (38b). Note also that, in this case, a root consonant is harmonizing with an affix consonant, rather than vice versa.

(38) Alternation in root ('oralization') with infixable causative /-s-/ (< Proto-Bantu *-es-):

a.	lab-a	'walk'	[la=sa=b]-a	'cause to walk'
	lók-a	'vomit'	[ló=se=k]-ε	'cause to vomit'
b.	tóm-a	'send'	[tó=se=b]-ε	'cause to send'
	dím-a	'get extinguished'	[dí=se=b]-ε	'extinguish'
	suom-ɔ	'borrow'	[sɔ=sɔ=b]-ɔ	'lend'

Recall from (37) that Tiene nasal consonant harmony triggers nasalization not only of /l/, as in most other languages, but also of the (redundantly) voiceless velar stop /k/. The same is attested elsewhere in Bantu; for example, in various languages of the Teke group the stative suffix /-Vg-/ harmonizes with a root-final nasal, yielding /-Vŋ-/ instead (Greenberg 1951). Greenberg (1951) claims that the same happens in Basaa with respect to 'continuative and imperative' formation in /-k/, which harmonizes to /-ŋ/ when the last preceding consonant is a nasal (imper. /lobok/ from /lob/ 'bite', but /tamaŋ/ from /tam/ 'wish', /hanaŋ/ from /han/ 'choose'), but I have not been able to confirm this observation with other sources on Basaa. Finally, the regressive nasal consonant harmony triggered by reciprocal /-an-/ in Pangwa (Stirnimann 1983) converts velar /x/ to /ŋ/, cf. /anuŋ-an-/ 'receive from each other' (from /anux-/ 'receive').

In the Tiene case, nasal consonant harmony defines a cooccurrence restriction on nasals vs. any oral consonants, regardless of voicing, continuancy, etc. In the other Bantu cases considered so far, the harmony specifically targets *voiced* oral consonants—usually liquids or stops. The same is also true of the root-level cooccurrence restrictions in Ganda

discussed above.⁴⁴ A further case of root-internal nasal consonant harmony, which specifically targets liquids, is Hausa. According to Newman (2000:410), /l/ and /n/ cannot cooccur root-internally ‘in normal CVCV sequences’ within roots. As for the root-internal cooccurrence of /n/ and /l/ (a retroflex flap), the restriction is directional: whereas /l...n/ is well attested, */n...l/ is not allowed in Hausa.⁴⁵

In all of the languages that have been mentioned so far in this section, the nasal consonant harmony in question concerns the cooccurrence of *fully* nasal and *fully* oral consonants. It does not place any limitation on the cooccurrence of nasal contour segments—prenasalized obstruents—with either fully nasal or fully oral consonants. Such harmony requirements do exist, however. For example, in Ganda, roots are subject to an additional restriction that disallows the cooccurrence of full nasals and voiced prenasalized stops (Katamba & Hyman 1991). Roots with the structure NV(V)N are allowed, but neither *NV(V)ND nor *NDV(V)N are (an independent constraint rules out *NDV(V)ND as well). Note that this harmony is not place-dependent, unlike the one governing the cooccurrence of N and D, as discussed above; it applies to non-homorganic pairs as well as homorganic ones. It should also be emphasized that it is only *voiced* prenasalized *stops* that are barred from cooccurring with full nasals; combinations such as NVNT, NVNS, NVNZ are allowed (where T = voiceless stop, S = voiceless fricative, Z = voiced fricative).

Another example of consonant harmony involving nasal contour segments is that of the Adamawa-Ubangi language Ngbaka (Thomas 1963; Mester 1986[1988]; Sagey 1986[1990]; Walker 1998[2000], 2000b). In Ngbaka roots, prenasalized (voiced) stops

⁴⁴ According to Katamba & Hyman (1991), Ganda also has a place-dependent cooccurrence restriction on nasals and *voiceless* stops, although this is asymmetric: a homorganic *NV(V)T sequence is excluded, but TV(V)N is allowed.

⁴⁵ According to Newman (2000), the apical /r/—realized either as a trill [r] or tap [ɾ]—is a more recent addition to the Hausa inventory (the retroflex flap /l/ being ‘the native Hausa R’). Apical /r/ does not appear to be subject to any of the cooccurrence restrictions that apply to /l/.

may not cooccur with homorganic full nasals or with homorganic voiced oral obstruents.⁴⁶ This is illustrated in (39). Homorganic combinations of full nasals and fully oral stops are allowed (as are non-homorganic combinations of any kind).

(39) Place-dependent root-level nasal consonant harmony in Ngbaka

a. Well-formed roots (cited from Walker 2000b)

nanè	‘today’
ᵑᵐḡbaᵑᵐḡbḶ	‘species of caterpillar’
bàbā̄	‘companion’
boma	‘how’
màᵑgà	‘net’
báᵑgá	‘jaw’

b. Disallowed combinations in roots

*m...ᵐb	*n...ᵑd, *n...ᵑz	*ᵑ...ᵑg	*ᵑᵐ...ᵑᵐḡb
*ᵐb...m	*ᵑd...n, *ᵑz...n	*ᵑg...ᵑ	*ᵑᵐḡb...ᵑᵐ
*b...ᵐb	*d...ᵑd, *z...ᵑz	*g...ᵑg	*ḡb...ᵑᵐḡb
*ᵐb...b	*ᵑd...ᵑd, *ᵑz...ᵑz	*ᵑg...g	*ᵑᵐḡb...ḡb

Note that this harmony requirement is place-dependent—as was the case with some of the Ganda restrictions—in that it holds only between segments that share the same place of articulation.

Another potential case of harmony involving prenasalized vs. oral stops—albeit a somewhat tentative one—is found in the Oceanic language Yabem (Dempwolff 1939;

⁴⁶ In fact, homorganic voiced and voiceless (oral) stops are not allowed to co-occur either. The totality of the cooccurrence patterns can be captured by a relative-similarity scale, T – D – ND – N, whereby consonant types adjacent on the scale may not cooccur in roots if they also share the same place of articulation (Mester 1986[1988]; Walker 1998[2000]).

Bradshaw 1979; Ross 1993, 1995). In Yabem, the irrealis mood is marked by a ‘floating’ [+nasal] feature which docks onto any and all prenasalizable consonants in the verb root. Etymologically this prenasalization goes back to an irrealis prefix *n- (< *na-), which coalesced with a root-initial obstruent (Bradshaw 1979:203). The class of consonants that count as prenasalizable, and can thus host the floating feature, consists of all voiced obstruents, as well as /s/ in low-tone contexts.⁴⁷ The irrealis prenasalization pattern is illustrated by the forms in (40). In (40a) the root contains no legitimate host, and the [+nasal] feature fails to surface. In (40b), a root-initial obstruent is targeted, in (40c) a root-internal one, and (40d) shows multiple prenasalization. All tones are indicated (high tone = ‘ˀ’, low tone = ‘̀’) and the transcription is altered to conform to IPA transcription (thus ‘j’ instead of ‘y’, etc.).

(40) Irrealis marking as ‘floating’ prenasalization in Yabem (data from Ross 1993)⁴⁸

	<i>Realis</i>	<i>Irrealis</i>	
a.	ká-létí	já-létí	‘run (1sg)’
	ká-kátón	já-kátón	‘make a heap (1sg)’
b.	ká-dám ^{wè}	já- ⁿ dám ^{wè}	‘lick (1sg)’
	ká-sàì?	já- ⁿ sàì?	‘pull off, snap (1sg)’

⁴⁷ Historically, /s/ in low-tone contexts goes back to voiced */z/ at an earlier stage, and thus also [ʰs] < *[ʰz] (Ross 1995). See section 3.3.2 for detailed discussion of tone-voicing interaction in Yabem.

⁴⁸ Ross gives these forms with /ká-/ as the 1sg prefix in irrealis and realis alike, rather than /ká-/ in realis and /já-/ in irrealis forms (Ross 1993:140; the same list reappears in Ross 1995:711). This is almost certainly a mistake: the realis/irrealis distinction is signaled by complementary sets of person-number prefixes in the singular (though not in the plural), with realis having 1sg /ka-/ , 2sg /ko-/ , 3sg /ke-/ and irrealis 1sg /ja-/ , 2sg /o-/ , 3sg /e-/ . According to the description in Dempwolff (1939), this is true of disyllabic roots no less than monosyllabic ones; although Dempwolff happens not to cite any 1sg irrealis forms of such verbs, he has 2sg /o-/ and 3sg /e-/ . (Note also that elsewhere Ross 1993:135 cites the 3sg irrealis form /é-tólón/ ‘he will carry’, with /e-/ as distinct from its realis counterpart /ke-/).

- | | | | |
|----|------------------------|--|----------------------|
| c. | ká-màdòm | já-mà ⁿ dòm | ‘break in two (1sg)’ |
| | ká-lèsù | já-le ⁿ sù | ‘poke, stir (1sg)’ |
| d. | ká-dàbìŋ | já- ⁿ dà ^m bìŋ | ‘approach (1sg)’ |
| | ká-gàb ^w à? | já- ^ɰ ga ^m b ^w à? | ‘untie (1sg)’ |

In (40a-c) where prenasalization surfaces on no more than a single segment, there can of course be no question of consonant harmony being involved in any way. The case that is of relevance in the present context is the phenomenon of *multiple* prenasalization, as in (40d). It is quite possible to derive this effect as resulting from a root-level harmony requirement that rules out the combinations *ND...D and *N...ND but allows ND...ND as well as D...D. From this perspective, irrealis prenasalization in Yabem is then entirely analogous to the case of ‘mobile’ palatalization in Harari discussed in section 2.4.3 above. As potential instances of consonant harmony, the two are equally tentative. The issue of how to interpret them reduces to a more general question: What is the most appropriate analysis of multiple docking in featural or ‘mobile’ morphology as a general phenomenon? This question will be left unanswered in this study.

2.4.5. Liquid harmony

The class of consonant harmony phenomena covered in this section comprises all assimilatory interactions either among liquids or between liquids and non-liquids. Although liquid harmony seems to be relatively rare in the world’s languages, it is nevertheless solidly attested, both as a static cooccurrence restriction on root morphemes and in the form of alternations in morphologically complex words.

The natural class of liquids is made up by two segment types: laterals and rhotics, which in most phonological frameworks are distinguished by means of the feature [±lateral]. A handful of cases exist where consonant harmony triggers precisely the lateral

vs. rhotic distinction, thus prohibiting the cooccurrence of /l/ and /r/—segments that agree in all features except [\pm lateral]—within some domain. In fact, at least two cases of /l/ vs. /r/ harmony *alternations* are attested. One of these is the Bantu language Bukusu, where a suffixal /l/ is realized as [r] when preceded by an [r] in the stem (cf. de Blois 1975; Odden 1994). This is illustrated in (41), where the applicative suffix /-il-/ surfaces as [-il-] or [-ir-] depending on liquid harmony with the root-final consonant. Except where stated otherwise, the forms in (41) are from the Bukusu files of the Comparative Bantu On-Line Dictionary database (CBOLD; searchable on-line at <http://linguistics.berkeley.edu/CBOLD>).

(41) Transvocalic liquid harmony alternations in Bukusu applicative /-il-/

- | | | |
|----|-----------|---------------------------|
| a. | xam-il-a | ‘milk for’ |
| | but-il-a | ‘pick/gather for’ |
| | te:x-el-a | ‘cook for’ |
| | i:l-il-a | ‘send thing’ (Odden 1994) |
| b. | bir-ir-a | ‘pass for’ |
| | ir-ir-a | ‘die for’ |
| | kar-ir-a | ‘twist’ (Odden 1994) |

The forms in (41a) clearly establish that the basic form of the suffix is [-il-], which occurs not only after /l/-final roots but also after non-liquid-final ones. After /r/-final roots, on the other hand, the suffix surfaces as [-ir-] (41b), thus showing that the liquid of the suffix must agree in [\pm lateral] with a preceding liquid. In (41b), the trigger and target are separated only by a vowel, but in fact the harmony also holds at greater distances, as the forms in (42) illustrate. Odden (1994) states the assimilation as applying ‘across unbounded strings’, and thus gives only forms with [-ir-] after roots with initial /r/ (e.g., /rum-ir-a/ ‘send someone’).

According to the CBOLD database, on the other hand, the ‘long-distance’ version of liquid harmony appears to be optional in Bukusu.

(42) Long-distance liquid harmony in Bukusu applicative /-il-/ (optional?)

ruk-ir-a ~ ruk-il-a ‘plait for’ (CBOLD)

rum-ir-a ~ rum-il-a ‘send for’ (CBOLD)

re:b-er-a ‘ask for’ (Odden 1994)

resj-er-a ‘retrieve for’ (Odden 1994)

It thus seems that strictly-transvocalic and across-the-board liquid harmony coexist in Bukusu—the former obligatory, the latter optional. This is somewhat analogous to nasal consonant harmony in the Bantu family as a whole, where transvocalic and unbounded versions of the harmony coexist in different, closely related languages.

Bukusu liquid harmony can also be observed as a static cooccurrence restriction on liquids within morphemes, although a great deal of [r] ~ [l] variability in roots renders the picture somewhat unclear, at least from the synchronic perspective. One type of evidence for the existence of root-internal liquid harmony is loanwords, such as /ee-loli/ ~ /ee-roori/ ‘truck’ (from English *lorry*). The examples in (43) show how the harmony is also manifested diachronically. Bukusu /l/ and /r/ are the regular reflexes of Proto-Bantu **d* and **t*, respectively, but **d* may surface as /r/ by virtue of harmonizing with another /r/ (< **t*) in the same morpheme. The doublet forms in (43a) indicate optionality and/or variability—whether inter- or intradialectal—in the application of liquid harmony.⁴⁹

⁴⁹ In fact, it appears that the [r] ~ [l] variability in Bukusu can sometimes give rise to reflexes that are the exact opposite of what is expected from **d* > /l/ and **t* > /r/. For example, CBOLD also lists an alternative form with /-rool-/ for ‘dream’!

(43) Root-internal liquid harmony in Bukusu roots (from CBOLD database)

a. -rare	‘iron/copper ore’	< Proto-Bantu * <i>tade</i>
-re:r-a ~ -le:r-a	‘bring’	< Proto-Bantu * <i>deet-a</i>
-ro:r-a ~ -lo:r-a	‘dream (v)’	< Proto-Bantu * <i>doot-a</i>
b. -lilo-	‘fire’	< Proto-Bantu * <i>dido</i>
-lol-a	‘look at’	< Proto-Bantu * <i>dod-a</i>
-lul-a	‘be bitter’	< Proto-Bantu * <i>dud-a</i>

The diachronic correspondences in (43a) seem to suggest an asymmetry in the application of harmony, whereby /l/ assimilates to a nearby /r/, but not vice versa. Diachronically, at least, liquid harmony appears to result in /r...r/ regardless of whether the ‘input’ is /r...l/ or /l...r/. This is somewhat reminiscent of the workings of dominant-recessive vowel harmony systems. Synchronically, /l...l/ sequences exist as well, but these are virtually always reflexes of Proto-Bantu **d...d*—in other words /l...l/, unlike /r...r/, is never the result of liquid harmony.⁵⁰

Furthermore, although the examples in (43a) suggest that liquid harmony applies ambidirectionally within roots, there are some indications that the tendency towards anticipatory harmony (/l...r/ → /r...r/) may be stronger than that of perseverative harmony (/r...l/ → /r...r/) in Bukusu. A search for disharmonic sequences in the CBOLD database yielded only 5 examples of /lV(V)r/, whereas 28 examples of /rV(V)l/ were found. Although these results are suggestive, it should be noted that in some of the /rV(V)l/ cases, the /l/ is actually suffixal. A greater dispreference for /l...r/ than /r...l/ may perhaps also lie behind

⁵⁰ Counterexamples are rare; one such case is ‘bring’ which has /-leel-a/ as a third alternative to the /-reer-a/ ~ /-leer-a/ forms listed in (43a). Note, finally, that for entirely independent reasons, Proto-Bantu **t...t* never results in /r...r/. Instead, due to the dissimilatory sound change known to as Dahl’s Law, such sequences instead end up as Bukusu /t...r/: **t...t* > **d...t* (after **d* > *l*), followed by **t* > *r* and **d* > *t*.

the fact that English *lorry* gets harmonized (/roori/ ~ /-loli/ ‘truck’), whereas Swahili *-rodi* (~ *-lodi*; from Eng. *lord*) does not (/roli/ ‘fighter, a person who enjoys fighting’).

Whereas Bukusu constitutes a case of liquid harmony resulting in ‘delateralization’ of /r/, i.e. agreement in [-lateral] among liquids, the opposite effect is found in the Malayo-Polynesian language Sundanese (see, e.g., Robins 1959; Cohn 1992; Holton 1995; Suzuki 1998, 1999). In Sundanese, the plural (or distributive) marker /-ar-/, like many other affixes with -VC- shape, is infixated after a root-initial onset consonant, as shown in (44a-b). However, when that consonant is /l/, the /r/ of the infix assimilates to it, surfacing instead as [-al-] (44c). Infixated material is demarcated by ‘=’ boundaries in the plural forms cited.

(44) Liquid harmony alternations in Sundanese plural /-ar-/ (data from Cohn 1992)

<i>Singular</i>	<i>Plural</i>	
a. kusut	k=ar=usut	‘messy’
poho	p=ar=oho	‘forget’
di-visualisasi-kin	di-v=ar=isualisasi-kin	‘visualized’
b. riwat	r=ar=iwat	‘startled’
rahit	r=ar=ahit	‘wounded’
c. litik	l=al=itik	‘little’
ləga	l=al=əga	‘wide’

It should be noted that as an illustration of the [-ar-]/[-al-] alternation in Sundanese, (44) is a vast simplification; the full range of facts is much more intricate. Most importantly, the liquid harmony operating in (44c)—and in (44b), though less obviously so—interacts in a complex manner with a *dissimilatory* restriction against /r...r/ sequences (Cohn 1992; Holton 1995; Suzuki 1998, 1999). For example, /pərceka/ ‘handsome (sg.)’ becomes /p=al=ərceka/, whereas /curiga/ ‘suspicious (sg.)’ becomes /c=ar=uriga/ (rather than

*/c=al=uriga/). Sundanese liquid harmony and its implications will be discussed in greater detail in section 4.3.3 below. At this point, it will suffice to point out that Sundanese liquid harmony has the effect of ‘lateralizing’ an affixal /r/ (44c), whereas liquid harmony in Bukusu counterpart resulted in the delateralization (or ‘rhotacization’) of an affixal /l/. Note that although in both cases liquid harmony appears to apply in a left-to-right fashion, it is also true that in both cases an affix consonant is harmonizing with a consonant in the root/stem. The general issue of directionality vs. stem control will be taken up in section 3.1 of the following chapter.

There are also attested cases of liquid harmony manifested solely as a cooccurrence restriction on roots, i.e. a prohibition on *tautomorphic* /l...r/ or /r...l/ sequences. In Pohnpeian, for example, the alveolar trill /r/ and dental /l/ make up one of the segment pairs that ‘are almost never found within the same morpheme’ (Rehg 1981:46; other such disfavored pairs are plain vs. velarized labials, dental vs. retroflex plosives, and dental vs. velar nasals). Thus, roots with /r...r/ or /l...l/ combinations are relatively numerous, as in (45a-b), whereas disharmonic /r...l/ or /l...r/ sequences, as in (45c) seem to be extremely rare. In fact, the examples in (45c) may turn out to be either polymorphemic or loanwords of recent origin.

(45) Liquid harmony in Pohnpeian roots (data from Rehg 1981)

a. Harmonic /r...r/

rar	‘finger coral’
rere	‘skin, peel (v)’
rer	‘tremble’

- b. Harmonic /l...l/
- | | |
|-----|--------------|
| lel | ‘be wounded’ |
| lul | ‘flame (v)’ |
| lɔl | ‘deep’ |
- c. Disharmonic /l...r/, /r...l/ hardly attested
- | | |
|---------|-------------|
| rija:la | ‘be cursed’ |
| lirop | ‘mat’ |

Morpheme-internal cooccurrence restrictions on /l/ vs. /r/—both assimilatory (i.e. harmony) and dissimilatory ones—appear to be widespread in Austronesian languages, such as in Javanese (Uhlenbeck 1949, 1950; Mester 1986[1988]; Yip 1989) or Sundanese (Cohn 1992). In Javanese, for example, the disharmonic sequence /l...r/ is permitted (and many morphemes with original /r...r/ have in fact undergone dissimilation to /l...r/, historically), whereas the reverse sequence, /r...l/, is prohibited.⁵¹ As an additional complication, harmonic liquid sequences /l...l, r...r/ are only allowed as the C₁-C₂ pair in C₁VC₂VC₃ roots. Many of these can presumably be explained away as cases of initial CV reduplication—if not synchronically, then at least historically (cf. Cohn 1992 for discussion of the same problem regarding /r...r/ sequences in the closely related Sundanese).

Outside of Austronesian, root-internal liquid harmony is also attested in Hausa, where /l/ and the retroflex flap /ɭ/ cannot cooccur ‘in normal CVCV sequences’ within the root (Newman 2000). (The same is true of /l/ vs. /n/, as was briefly mentioned in section 2.4.4 above.) On the other hand, Hausa places no such restrictions on the cooccurrence of /l/ and the other rhotic phoneme, apical /r/ (realized as trilled [r̥] or tap [r̥]). As Newman (2000) points out, /r/ is in fact a comparatively recent addition to the segment inventory.

⁵¹ Counterexamples exist, but are typically dialect borrowings or loans from Arabic, Dutch, Portuguese, etc. (Uhlenbeck 1949; Mester 1986[1988]).

All the cases examined so far have been examples of what might be called ‘inter-liquid’ harmony, i.e. harmony between liquid segments (typically laterals vs. rhotics). There also exists a different type of liquid harmony, namely where liquids and non-liquids harmonize with each other. If the feature $[\pm\text{liquid}]$ is what singles out laterals and rhotics as a natural class (see Walsh Dickey 1997 for a proposal along these lines), then liquid harmony of this type can be analyzed as agreement in terms of $[\pm\text{liquid}]$. However, since both of the two attested cases involve the glide /j/ vs. the liquids /r, l/, the harmony could equally well be defined as involving $[\pm\text{consonantal}]$ (see 2.5 for discussion).

In Basaa (Bantu), the applicative suffix allomorph /-VI/, which attaches to monosyllabic roots, surfaces instead as [-Vj] after CVj roots. This is illustrated in (46a-b). Interestingly, in CV roots with initial /j/, harmony is not triggered by the root-initial glide, as in (46c). Furthermore, harmony does not hold morpheme-internally, as evidenced by roots with the shape /jVI/ as in (46d). Harmony is thus only triggered by a root-final /j/, and targets only the /l/ of the immediately following applicative suffix.

(46) Liquid harmony in Basaa applicative /-VI/ (data from Lemb & de Gastines 1973)

a.	tɪŋ-ɪl	‘tie for/with’	(root = /tɛŋ-/)
	ʃém-ɛl	‘wait with/for’	(root = /ʃám-/)
	ʃòl-òl	‘go bad for/because of’	(root = /ʃòl-/)
b.	tóŋ-òŋ	‘drip for’	(root = /tòŋ-/)
	ʃèj-èj	‘shine on/for’	(root = /ʃàj-/)
	ɲóŋ-òŋ	‘disappear for’	(root = /ɲòŋ-/)
c.	jê-l	‘appear to/for’	(root = /jê-/)
	jò-l	‘steal wine at’	(root = /jò-/)
d.	jɪla	‘become, transform’	
	jéli	‘be revealed’	

In terms of the phonological/phonetic properties of the segments involved, the Basaa [l]/[j] alternation involves not merely [±liquid] (or the equivalent) but also [±lateral]. Since Basaa lacks rhotics in its surface inventory, this fact invites the possibility of analyzing the [l]-to-[j] assimilation in Basaa as a matter of [±lateral] harmony—just as in Bukusu, Sundanese, etc. However, glide vs. liquid harmony is attested in at least one other language, where such a reinterpretation is not an option. This is the Bantu language Pare (or Asu), where a suffixal /j/ optionally harmonizes with a root-final /l/ or /r/ (Odden 1994). The harmony alternations are exhibited by applicative /-ij-/ (47a-b) as well as perfective /-ije/ (48a-b). As the forms in (47c) and (48c) show, the harmony is strictly transvocalic, in that it does not hold between segments that are separated by an additional syllable.

(47) Liquid harmony in Pare applicative /-ij-/ (data from Odden 1994)

- a. -tet-ij-a ‘say for’
- big-ij-a ‘beat for’
- b. -tal-il-a ~ -tal-ij-a ‘count for’
- zor-ir-a ~ -zor-ij-a ‘buy for’
- c. -rumb-ij-a ‘make pots’ (*-rumb-ir-a)

(48) Liquid harmony in Pare perfective /-ije/ (data from Odden 1994)

- a. -kund-ije ‘like (perf.)’
- dik-ije ‘cook (perf.)’
- von-ije ‘see (perf.)’
- b. -tal-ile ~ -tal-ije ‘wash (perf.)’
- zor-ire ~ -zor-ije ‘heal (perf.)’
- c. -ronḡ-ije ‘make (perf.)’ (*-ronḡ-ire)

In fact, the /j/ of these two suffixes is also subject to a separate alternation which appears—at least superficially—to qualify as stricture harmony ([j]/[ɟ]). This alternation, as well as other similar phenomena elsewhere in Bantu languages, is discussed in more detail in the section on stricture harmony (2.4.6).

Recall that in Basaa, it was possible to account for the [j]/[l] alternation in terms of [±lateral] alone. In Pare, on the other hand, this option is obviously not available, since /j/ assimilates to /r/ as well as /l/. Instead, the harmony must be based on whatever feature is taken to encode the glide vs. liquid distinction (e.g., [±liquid] or [±consonantal]). In addition, however, the suffix consonant *also* obeys harmony with respect to [±lateral], surfacing as [r] after [r] but [l] after [l]. Liquid harmony in Pare thus seems to be a combination of ‘inter-liquid’ (lateral vs. rhotic) harmony and liquid vs. non-liquid harmony.

In both Basaa and Pare, the ‘non-liquid’ consonant interacting with the liquid(s) is the palatal glide [j]. Assuming that relative similarity plays a fundamental role in motivating consonant harmony interactions (see chapters 4 thru 6), it thus appears that of all non-liquid consonants, glides are more similar to liquids than are any other consonant.⁵² As for the possibility of harmony involving liquids and other types of non-liquid consonants, note that in most cases of nasal consonant harmony in Bantu languages (see section 2.4.4), the alternations do involve a liquid: [l]/[n] (as well as [d]/[n]). Based on the informal definition of liquid harmony stated at the beginning of this section, such alternations would in fact count as liquid harmony as well. In these cases, however, the assimilatory interaction clearly involves agreement in nasality ([+nasal]), whereas any additional changes in [±lateral], [±sonorant], etc. must be considered to be secondary. (Note that in the languages in question, [+lateral, +sonorant] [l] and [-lateral, -sonorant] [d] are typically allophones in

⁵² This is probably true of [j] in particular, rather than the class of glides as a whole. If [j] is classified as having the Place feature [coronal], then it is homorganic with /l, r/, since the latter are coronals as well—at least in most languages.

complementary distribution.) It would thus be misleading to interpret Bantu nasal consonant harmony as involving liquid vs. nonliquid harmony. The Basaa and Pare examples on the other hand, where liquids and glides interact, do appear to be true cases of liquid harmony. As for the possibility of ‘static’ manifestations liquid vs. glide harmony—i.e. assimilatory cooccurrence restrictions on liquids vs. glides within roots—such patterns do not seem to have been reported in the descriptive or analytical literature so far.

Finally, yet another potential case of liquid harmony deserves mentioning, although its interpretation as involving consonant harmony (and liquid harmony more specifically) is somewhat dubious. This is a curious alternation between two different types of alveolar laterals in the Bantu language Mwiini. The two are represented with ‘l’ and ‘ɺ’ by Kisseberth & Abasheikh (1975); judging from their phonetic description, the latter can most accurately be described as a lateral tap.⁵³ In what follows, I will transcribe the tap ‘ɺ’ as /ɺ/, which then contrast with /l/, a ‘normal’ lateral. (Strictly speaking, the IPA symbol [ɺ] refers to a lateral *flap*, but will be used here for lack of a better alternative; on the tap vs. flap distinction, see Ladefoged & Maddieson 1996, who also document the existence of lateral taps in other languages.)

The relevant facts have to do with the surface realization of the perfective suffix, which has a bipartite structure and is realized as /-i:l-e/ or /-e:l-e/ depending on vowel height harmony. The basic surface shape of the perfective suffix is seen in the forms in (49a). When the preceding root ends in a non-tap liquid—i.e. [l] or [r]—the lateral tap of the suffix changes to its non-tap counterpart, [l] (49b). Furthermore, when the root ends in another tap, the tap of the suffix likewise changes to the non-tap [l] (49c). According to

⁵³ Kisseberth & Abasheikh (1975:250-51) describe the articulatory difference between Mwiini ‘ɺ’ and ‘l’ as follows: ‘Preliminary instrumental investigation suggests that in the articulation of *ɺ*, the tip of the tongue strikes lightly against a small area to the front of the alveolar ridge without any lateral contact. The area of contact in the case of *l*, on the other hand, is larger, and there is lateral contact. The duration of *l* is longer than the duration of *ɺ*.’

Kisseberth & Abasheikh (1975), the same alternation is also found in the applicative suffix /-i:l-/, the only other suffix containing /l/ in Mwiini.

(49) Alternations in Mwiini perfective /-i:l-e/ (data from Kisseberth & Abasheikh 1975)

- a. kun-i:l-e 'he scratched'
- som-e:l-e 'he read'
- haḍ-i:l-e 'he said'
- sameh-i:l-e 'he forgave'
- b. sul-i:l-e 'he wanted'
- owel-e:l-e 'he swam'
- gir-i:l-e 'he moved'
- mer-e:l-e 'he turned about'
- c. faḍil-e:l-e 'he preferred'⁵⁴
- gulgul-i:l-e 'he did'

The examples in (50a) show that the liquid-to-liquid interactions in Mwiini are limited to suffixal /l/; within roots or across a prefix-root boundary, the assimilatory and dissimilatory requirements do not hold. Furthermore, the interactions are strictly transvocalic, since suffixal /l/ remains unchanged if the preceding liquid is separated from it by a greater distance (50b).

⁵⁴ In most /l/-final roots, the /l/ changes to [z] before the perfective suffix (by so-called Consonant Mutation). The only cases where the dissimilation in (49c) can be observed are thus those roots that are lexical exceptions to Consonant Mutation. According to Kisseberth & Abasheikh (1975:257), there are in fact a fair number of such exceptions, all of which are loans from either Arabic or Somali. However, since Mutation is not triggered by applicative /-i:l-/, the /l...l/ → [l...l] dissimilation should be robustly manifested after native /l/-final roots as well. Kisseberth & Abasheikh (1975) cite no data that pertains to this issue.

(50) Limitations of [l]/[l̥] alternations in Mwiini (Kisseberth & Abasheikh 1975)

- a. -la:l-a ‘be sick’
- li-le ‘tall’ (/li-/ is a prefix)
- ja:l-a ‘sleep’
- .le:lo ‘today’
- b. laz-i:l-e ‘he went out’
- rag-i:l-e ‘he was late’
- .lim-i:l-e ‘he cultivated’

Kisseberth & Abasheikh (1975) refer to the [l̥] → [l] change as ‘lateralization’, but this term is hardly appropriate if /l/ is already lateral, as their articulatory description implies (it is articulated ‘without any lateral contact’). Instead, the crucial difference between [l̥] and the resulting [l] seems to be in the ‘tappedness’ of the former. It is far from clear how the phonetic distinction between taps and their non-tap counterparts (e.g., stops, trills, etc.) should be encoded in terms of phonological features, and an in-depth discussion of the issues involved would take us too far afield from the purpose of this section.

For the sake of the argument, suppose that taps (and flaps) are characterized by a feature like [+ballistic]. Within the class of Mwiini liquids, then, /l, r/ are [-ballistic] and /l̥/ [+ballistic], whereas /l, l̥/ are both [+lateral] as opposed to [-lateral] /r/. The alternations in (49a-c) can then be interpreted as being driven by a combination of harmony and dissimilation. Firstly, a [+ballistic] liquid (/l̥/) harmonizes with a preceding [-ballistic] liquid (/l, r/), without changing its [+lateral] specification: thus /l...l̥/ → [l...l] and /r...l̥/ → [r...l]. As with so many other cases of consonant harmony, this one is dependent on identity in other features (the relevant segments must both be coronal, both must be liquids, etc.). Secondly, in sequences of two [+ballistic] segments, the second one dissimilates, becoming [-ballistic]—again, preserving its [+lateral] specification: thus /l...l̥/ → [l...l]. The same

kind of dissimilation in tap...tap sequences is attested elsewhere: in the Papuan language Yimas, for example, a /rVr/ sequence dissimilates to [rVt] (Foley 1991:54; cf. Odden 1994).⁵⁵

To conclude, the relevant empirical facts regarding liquid harmony can be summarized as follows. Harmony interactions may hold between liquids and non-liquids; more specifically, between (coronal) liquids and ‘coronal’ (i.e. palatal) glides. When resulting in alternations, the effect may either be liquid → glide (Basaa) or glide → liquid (Pare). Harmony may also hold between (coronal) liquids that differ in some crucial property. This is most robustly attested in the case of [±lateral], resulting in lateral → rhotic (Bukusu) or rhotic → lateral (Sundanese); the Pare case also involves agreement in [±lateral], in addition to glide → liquid. An additional possibility for harmony in terms of a liquid-specific contrast involves [±ballistic] (or whatever feature is used to single out taps/flaps as a separate segment type), if the Mwiini [l]/[l̥] alternations are in fact to be interpreted as involving consonant harmony.

2.4.6. Stricture harmony

For the purposes of this descriptive survey of consonant harmony types, the term ‘stricture’ is used in the sense ‘degree of constriction’, and is relevant in that it defines the relative scale *stop–(affricate)–fricative–approximant*. Stricture harmony involves any kind of assimilatory cooccurrence restriction—whether manifested statically within morphemes or in the form of alternations—which holds over segment types that are contiguous on the stricture scale.

Stricture harmony appears to be a quite rare type of consonant harmony. However, a small number of clear cases do exist, even ones resulting in alternations. The best example

⁵⁵ Odden (1994) chooses to interpret this dissimilation as involving [±lateral] instead, based on Foley’s observation that the segment represented here as /r/ varies freely between [r] and an apical [l]. Odden thus interprets /r/ as being phonologically [+lateral].

of this involves the stop vs. fricative contrast, and is found in the Oceanic language Yabem (Bradshaw 1979; Ross 1995). The segmental inventory of Yabem contains only one fricative, [s], which occurs in the 3pl prefix /se-/, as well as in roots. The [s] of the /se-/ prefix assimilates to a root-initial alveolar stop, as illustrated in (51) below (Dempwolff 1939). Ross (1995) notes that stricture harmony is optional in present-day Yabem, but argues that the optionality is a relatively recent development.

(51) Stricture harmony in Yabem 3pl /se-/ prefix (data from Ross 1995)

a.	sé-líʔ	‘see (3pl realis/irrealis)’	
	sé-gàb ^w àʔ	‘untie (3pl realis)’	[inferred from disc.]
	sé-kátón	‘make a heap (3pl realis/irrealis)’	[inferred from disc.]
b.	té-táŋ	‘weep (3pl realis/Irrealis)’	(~ sé-táŋ)
	té-téŋ	‘ask, beg (3pl realis/irrealis)’	(~ sé-téŋ)
	dè-dèŋ	‘move towards (3pl realis)’	(~ sè-dèŋ)
	dè- ⁿ dèŋ	‘move towards (3pl irrealis)’	(~ sè- ⁿ dèŋ)

Dempwolff (1939), Bradshaw (1979) and Ross (1995) all clearly state that the /s/ of the /se-/ prefix only assimilates to a following stop in case it is alveolar. Yabem stricture harmony can thus be interpreted as place-dependent, applying only to combinations of *homorganic* fricatives and stops. (Recall that /s/ is the only fricative in Yabem). Note also that Yabem stricture harmony is strictly transvocalic, applying across no more than a single vowel: only root-initial stops trigger harmony, not root-internal ones (as in /-létí/ ‘run’). Finally, it should also be pointed out that the harmony requirement is asymmetric, in that a prefixal /t/ or /d/ does not assimilate to a root-initial /s/. For example, the 1pl (inclusive) prefix /ta-/ is always realized as either /tá-/ or /dà-/, never as /sá-/ (or /sà-/), cf. /dà-sùŋ/ ‘we (incl.) push’, /tá-sèlèŋ/ ‘we (incl.) wander’.

Although Yabem stricture harmony usually results in total identity (/s/ becomes /t/ before /t/, /d/ before /d/), this is a mere accident—a by-product of the independent tone-and-voicing harmony that holds throughout the word-final disyllabic foot (the latter is described in detail in 3.3.2 below). When the prefix attaches to a disyllabic root, and thus falls outside the domain in which tone/voicing harmony applies, the /s/ of 3pl /se-/ harmonizes to [t] regardless of whether the harmony trigger is /t/ or /d/. This is shown by examples such as /té-táké/ (3Pl realis/irrealis of /-táké/ ‘frighten’) and /té-dàgùʔ/ (3pl realis of /-dàgùʔ/ ‘follow’; both examples from Dempwolff 1939). Interestingly, the descriptions by Dempwolff (1939) and Ross (1995) differ with respect to the interaction of stricture harmony and the prenasalization which marks irrealis mood. According to Ross (1995), prenasalized [ʰd] triggers stricture harmony no less than non-prenasalized [d]; cf. the last two forms in (51b) above. However, Dempwolff (1939) is quite explicit that stricture harmony is *not* triggered by a prenasalized stop. The last two forms in (51b) are thus given as 3pl realis /dè-dèŋ/ vs. 3pl irrealis /sè-ⁿdèŋ/ (not /dè-ⁿdèŋ/) by Dempwolff. He also cites other similar pairs: 3pl realis /dè-dèʔ/ vs. 3pl irrealis /sè-ⁿdèʔ/ (from /-dèʔ/ ‘dislike’), 3pl realis /té-dàgùʔ/ vs. 3pl irrealis /sé-ⁿdà^ʰgùʔ/ (from /-dàgùʔ/ ‘follow’). Between the descriptions of Dempwolff (1939) and Ross (1995), it thus seems that stricture harmony has been extended to apply before prenasalized stops as well—perhaps through paradigm levelling (generalizing the [dè-] allomorph to both moods).

In addition to giving rise to stop/fricative alternations, Yabem stricture harmony is also manifested root-internally as a static cooccurrence restriction: native Yabem morphemes do not contain /s...t/ or /s...d/ sequences (Dempwolff 1939; Bradshaw 1979; Ross 1995). Again, the cooccurrence restriction is place-dependent; non-homorganic fricative...stop sequences are allowed (e.g., /sákíŋ/ ‘service’, /sàgìŋ/ ‘house partition’, /sàb^wàʔ/ ‘potsherd; spleen’).

Another apparent case of stricture harmony that also results in alternations involves the fricative vs. approximant distinction and is found in the Bantu language Shambaa (or Shambala). According to Besha (1989:194), the near-past tense suffix /-ije/ becomes /-ize/ after ‘stems which end in fricatives’, as illustrated by the examples in (52a-b).⁵⁶ Although it is clear from the context that Besha is referring to fricatives in general, the few examples she cites all have stem-final *coronal* fricatives, i.e. /s, z, ʃ/ (Shambaa lacks /ʒ/); these are shown in (52b). Odden (1994) alludes to the Shambaa facts as involving assimilation between a stem-final consonant and a suffixal glide /j/. However, it is far from clear that this interpretation of the facts is justified. As the examples in (52c-d) show, not only does [j] fail to change to [z] after certain non-coronal stem-final fricatives, but even after certain stems with final /z/, where harmony would above all be expected to apply.

(52) Stricture harmony in Shambaa perfective /-ije/? (data from Besha 1989)

- | | | |
|----|-----------|--|
| a. | -kant-ije | ‘wear (past)’ |
| | -ʃind-ije | ‘during the whole day (past)’ [aspectual auxiliary verb] |
| | -dik-ije | ‘cook (past)’ |
| b. | -goʃ-ize | ‘sleep (past)’ |
| | -gwiʃ-ize | ‘drop (past)’ |
| | -kas-ize | ‘roast (past)’ |
| | -toz-ize | ‘hold (past)’ |
| c. | -aɣ-ije | ‘get lost (past)’ |
| | -iv-ije | ‘hear (past)’ |
| d. | -iz-ije | ‘come (past)’ |

⁵⁶ Besha (1989) refers to this as the ‘near past’ suffix. However, it is clearly cognate with the perfective suffix which occurs in other Bantu languages as /-ile/, /-ire/, etc.

In order to gain a better understanding of what motivates the [j]/[z] alternation in Shambaa, it is helpful to examine similar alternations in the same perfective suffix (< Proto-Bantu *-*id-e*) in other Bantu languages. Odden (1994) cites Pare—a language closely related to Shambaa—as displaying consonant-consonant assimilations which could potentially count as an example of stricture harmony. In Pare, as in Shambaa, the perfective suffix has the shape /-ije/. According to Odden’s description, the [j] of the suffix optionally becomes [ʒ] (or [dʒ]; Odden describes it as ‘a palatal stop’) just in case the preceding stem ends in any of the palatal segments /ʃ/ (or /dʒ/), /ʃ/, /ɲ/. This is illustrated in (53). Odden (1994) cites the forms in (53c) as evidence that the assimilation—if that is what it is—is strictly transvocalic in that it is not triggered by a root-internal or root-initial palatal.

(53) Stricture harmony in Pare perfective /-ije/ (Odden 1994)?

- | | | | |
|----|-----------|------------------------|---------------|
| a. | -tet-ije | ‘say (perf.)’ | |
| | -kund-ije | ‘like (perf.)’ | |
| | -dik-ije | ‘cook (perf.)’ | |
| | -von-ije | ‘see (perf.)’ | |
| b. | -oɟ-ije | ‘wash (perf.)’ | (~ -oɟ-ije) |
| | -banɟ-ije | ‘heal (perf.)’ | (~ -banɟ-ije) |
| | -vuʃ-ije | ‘put up (perf.)’ | (~ -vuʃ-ije) |
| | -maɲ-ije | ‘know (perf.)’ | (~ -maɲ-ije) |
| c. | -jeng-ije | ‘build (perf.)’ | (*-jeng-ije) |
| | -ʃig-ije | ‘leave behind (perf.)’ | (*-ʃig-ije) |

The [j]/[ʒ] alternation can be interpreted as stricture harmony based on the following assumptions: a) with respect to the stricture scale, nasals count as stops rather than approximants (i.e. the scale refers to degree of *oral* constriction); b) Pare does not allow [ʒ]

in its surface inventory (ruling out /j/ → [ʒ]); c) faithfulness to voicing is high-ranked in Pare (ruling out /j/ → [ʃ]). Provided that all assumptions are justified, it is possible to state the [j]/[ʃ] alternation as place-dependent stricture harmony along the following lines: a palatal approximant [j] assimilates in stricture (i.e. becomes an obstruent) when preceded by a homorganic (i.e. palatal) obstruent.

Pare also shows the exact same alternation, triggered by the very same root-final segments, in the applicative suffix /-iy-/, as shown in (54).

(54) Stricture harmony in Pare applicative /-ij-/ (Odden 1994)?

- | | | | |
|----|-------------|----------------|----------------|
| a. | -tet-ij-a | ‘say for’ | |
| | -big-ij-a | ‘beat for’ | |
| | -dik-ij-a | ‘cook for’ | |
| b. | -oj-ij-a | ‘wash for’ | (~ -oj-ij-a) |
| | -mij-ij-a | ‘press for’ | (~ -mij-ij-a) |
| c. | -jɪŋk-ij-a | ‘run away for’ | (*-jɪŋk-ij-a) |
| | -ʃukum-ij-a | ‘push for’ | (*-ʃukum-ij-a) |

Yet another example of a similar alternation involving the perfective suffix is found in a third Bantu language, Mwiini (Kisseberth & Abasheikh 1975; Kenstowicz & Kisseberth 1979; Hyman 1993). The Mwiini case can hardly be argued to be an instance of stricture harmony, though; it is mentioned here only because it may help shed light on the somewhat puzzling Shambaa and Pare facts. In Mwiini, the perfective suffix has a bipartite structure and surfaces as /-ii.l-e/ or /-ee.l-e/ depending on vowel height harmony. (The suffix also shows a vowel length alternation which will be ignored here.) The consonant transcribed here as [l] is the ‘ɸ’ of Kisseberth & Abasheikh (1975), which appears to be a lateral tap

(see 2.4.5 above for discussion of the phonetic nature of this segment and its phonological interaction with other liquids).

As in Shambaa, the perfective suffix shows up with a [z] when the root ends in a certain class of consonants; in Mwiini, this class consists of the fricatives /s, z, ʃ/ and the palatal nasal /ɲ/. This is illustrated by the forms in (55a-b). Kisseberth & Abasheikh (1975) formalize the alternation in terms of a rule whereby the consonants in question trigger ‘stridentization’ of a following /l/. A further complication is caused by the fact that only *underived* /s, z, ʃ/ trigger stridentization. Fricatives that are derived from stops by so-called ‘consonant mutation’ (triggered by the perfective suffix) do not cause [l] → [z], as the forms in (55c) show.⁵⁷ In addition, there are a handful of exceptional roots with underlying /s, z/ that unexpectedly fail to trigger stridentization (e.g., *-asis-* ‘found an organization’, *-bariz-* ‘attend a meeting’).

(55) Alternations in Mwiini perfective /-i:l-e/ (Kisseberth & Abasheikh 1975)

- | | | |
|----|-----------|---------------------|
| a. | kun-i:l-e | ‘he scratched’ |
| | rag-i:l-e | ‘he was late’ |
| | tij-i:l-e | ‘he feared’ |
| | ḍoḍ-e:l-e | ‘he complained’ |
| b. | kos-e:z-e | ‘he made a mistake’ |
| | anz-i:z-e | ‘he began’ |
| | toʃ-e:z-e | ‘he thought’ |
| | fəɲ-i:z-e | ‘he did’ |

⁵⁷ These forms also show an independent vowel length alternation, which is irrelevant in the present context (for discussion of vowel shortening and its problematic interaction with Consonant Mutation, see Kisseberth & Abasheikh 1975; Hyman 1993).

c. gi:s-il-e	‘he pulled’	(cf. -gi:t- ‘pull’)
lo:nz-il-e	‘he begged’	(cf. -loomb- ‘beg’)
po:nz-e.l-e	‘he pounded’	(cf. -poond- ‘pound’)
piʃ-il-e	‘he cooked’	(cf. -pik- ‘cook’)

The sensitivity to underlying vs. derived segments, combined with the peculiar nature of the class of triggering segments (/s, z, ʃ, ɲ/), casts some doubt on the interpretation that the [ɹ]/[z] alternation is due to assimilation, i.e. consonant harmony. It is far from clear what the harmonizing phonological feature (or articulatory gesture) could be.

Hyman (1993:222, n. 14) offers an alternative explanation of the Mwiini facts, suggesting that ‘[i]t is likely that verb roots that end in /s, z, ʃ, ɲ/ actually involve an underlying final *-i-* that combines with the perfective to form *CVC-*it-i-e** sequences’ (see also Hyman 1994:86, n. 8). The implication is that this *-i-* would then be the trigger of the [ɹ] → [z] change. The infixation or ‘imbrication’ of the /-iC-/ portion of the perfective suffix (/ -il-/, / -id-/, / -ir-/, / -ij-/, etc. in other languages) is a well known phenomenon in Bantu (see, e.g., Bastin 1983). In many languages, ‘imbrication’ into a *CVC-i-* sequence results in the *-i-* triggering mutation of both the root-final consonant and the suffix consonant. This is illustrated by the Bemba examples in (56); the symbol ‘i’ indicates a mutation-triggering vowel.⁵⁸

⁵⁸ In the interest of exposition, the forms in (56) are presented in somewhat abstract terms, following Hyman (1994). The alveolar fricative /s/ becomes [ʃ] before high front vowels; furthermore, before a vowel, the mutating *-i-* surfaces as a glide [j], but merges with a preceding /s/ to yield [ʃ]. A form like *-buus-is-i-e* is thus actually pronounced [bu:ʃiʃe].

(56) Multiple consonant mutation in Bemba (Hyman 1994)

- a. -bu:k- ‘get up’
 -bu:s-ɨ- ‘get s.o. up’ (CAUS.)
- b. -bu:k-il- ‘get up for/at’ (APPLIC.)
 -bu:s-is-ɨ- ‘get s.o. up for/at’ (APPLIC. + CAUS.)
- c. [-bu:k-il-e ‘got up’ (inferred from discussion)]
 -bu:s-is-ɨ-e ‘got s.o. up’ (CAUS.)

The forms in (56b) illustrate that when the applicative suffix /-il-/ is ‘imbricated’ into a causative verb stem, the causative /-ɨ-/ causes mutation in the root as well as in the suffix; (56c) shows that the same occurs with perfective /-il-e/, where the /-il-/ portion is infixated in a similar manner. Hyman (1994) points out that forms with such double mutation may *superficially* seem to be due to assimilation—i.e. consonant harmony—but notes that this interpretation is ruled out by forms like /-las-il-/ ‘wound for/at’ (with underlying root-final /s/). Hyman analyzes the double mutation in terms of cyclic rule application (in the sense of morphology-phonology interleaving). An equally viable alternative would be output-output correspondence (e.g., Benua 1995, 1997), whereby the root-final /s/ in the applicativized causative /-bu:s-is-ɨ-/ or the perfective causative /-bu:s-is-ɨ-e/ is due to faithfulness to the plain causative /-bu:s-ɨ-/.

Hyman’s suggestion, then, is that ‘imbrication’ with double mutation is the source of the [l]/[z] alternation in the Mwiini perfective as well.⁵⁹ The question that this raises is whether the same reinterpretation can also be extended to the putative cases of stricture harmony in Shambaa and Pare. Although the question cannot be answered confidently at

⁵⁹ Although this is no doubt the diachronic source of the [l]/[z] alternation in Mwiini, a potential problem for a synchronic analysis along these lines is the fact that *all* verb roots with underlying /s, z, ʃ, j/ trigger the [l] → [z] change, even borrowings such as /-bus-/ ‘kiss’, /-xus-/ ‘be concerned’, /-his-/ ‘feel cold’ (all from Arabic).

this point, the facts in (56) suggest that this alternative analysis does seem quite plausible in the case of Shambaa. The Pare [j]/[ʝ] alternation (or possibly [j]/[dʒ]), on the other hand, remains a strong contender for counting as a true example of stricture harmony. The main reason is that the [j] of the relevant verbal suffixes in Pare is subject to other assimilatory alternations as well, surfacing as [l] and [r] after root-final [l] and [r], respectively. This [j]/[l]/[r] alternation can only be accounted for as transvocalic consonant harmony (liquid harmony, more specifically) and was treated as such in 2.4.5 above. The fact that [j] does display consonant harmony alternations in these cases lends support to the view that the [j]/[ʝ] alternation is also due to harmony. Furthermore, the latter patterns with the [j]/[l]/[r] alternation in that both are optional, with non-harmonized [j] being acceptable in all cases. In sum, it seems quite plausible that Pare does in fact exhibit (place-dependent) stricture harmony involving the approximant vs. obstruent distinction.

Regardless of the tentative nature of the Pare case, the existence of stricture harmony as a possible type of consonant harmony is solidly confirmed by the Yabem [s]/[t] and [s]/[d] prefix alternations discussed at the beginning of this section. Recall that in the Yabem case, the alternation was mirrored by a static cooccurrence restriction on */s...t/ or */s...d/ sequences morpheme-internally. Is it possible that other languages exist where stricture harmony is manifested solely in this static manner, as a morpheme structure constraint—as is true of so many cases of sibilant harmony, for example?

One potential example of such a language is Modern Yucatec (Straight 1976; Lombardi 1990) which has a root-level stricture harmony involving the fricative vs. affricate contrast. Modern Yucatec has inherited from Classical Yucatec a root-level *coronal* harmony, which rules out morpheme-internal combinations of alveolar and postalveolar sibilants, such as */s...ʃ/, */tʃ...s/, */ts'...tʃ/, etc. (Lombardi 1990:389-91). (This type of sibilant harmony appears to be quite widespread in the Mayan language family.) In addition, Modern Yucatec roots are subject to a stricture harmony, such that root-internally, affricates

and fricatives may not cooccur, as shown in (57). Non-permissible root shapes ruled out by the coronal harmony restriction are not listed.

(57) Stricture harmony in Modern Yucatec roots (Straight 1976; Lombardi 1990)

a. Permissible root shapes with non-ejective sibilants

s...s ʃ...ʃ ts...ts tʃ...tʃ

b. Non-permissible root shapes with non-ejective sibilants

*s...ts *ʃ...tʃ *ts...s *tʃ...ʃ

c. Permissible root shapes mixing ejective and non-ejective sibilants

s...ts' ʃ...tʃ' ts'...s tʃ'...ʃ

Note that the stricture harmony is dependent on identity in laryngeal features, in that glottalized affricates may freely combine with (non-glottalized) fricatives, as the forms in (57c) illustrate. (As for */ts...ts'/, */tʃ'...tʃ'/, etc., these are independently excluded by a laryngeal harmony prohibiting the cooccurrence of homorganic ejective and non-ejective plosives; thus also */k'...k'/, */t...t'/, and so forth.)

It appears that the absolute cooccurrence restriction on Modern Yucatec sibilants in (57) constitutes a generalization of what was merely an *ordering* restriction in Classical Yucatec. Lombardi (1990) observes that in Classical Yucatec roots, homorganic affricates and fricatives must occur in a specific order: /s...ts/, /ʃ...tʃ/ are allowed, but not */ts...s/, */tʃ'...ʃ/.⁶⁰ Interestingly enough, the exact same ordering restriction holds for homorganic affricates and stops: /t...ts/, /t...tʃ/, are allowed, but not */ts...t/, */tʃ'...t/. Just as its Modern Yucatec descendant, the Classical Yucatec ordering restriction is parasitic not only on place

⁶⁰ Lombardi bases her observations on McQuown's (1967) charts of roots from the late-16th-century *Diccionario Motul*, checked against various other lexicographic sources on Classical Yucatec.

identity but also identity in laryngeal features, in that roots of the type /ts'...s/, /ts'...t/, /tʃ'...ʃ/, /tʃ'...t/ are allowed.

It is not entirely clear whether it is appropriate to view even the order-specific restrictions of Classical Yucatec as a case of stricture harmony, but this is certainly a possible interpretation. Under such an analysis, the root-level stricture harmony is strictly anticipatory (cf. the discussion of directionality in section 3.1), is dependent on identity in place and laryngeal features, and prohibits the cooccurrence of affricates with segments adjacent to them on the stricture scale, i.e. stops as well as fricatives. Hypothetical input roots like /ts...s/, /tʃ'...t/ then surface as harmonic [s...s], [t...t], etc. The fact that disharmonic root shapes like /t...ts/, /ʃ'...tʃ/, etc. surface intact, rather than harmonizing to [ts...ts], [tʃ'...tʃ], etc. can be accounted for by assuming that contour segments (affricates) are more marked than non-contour ones (stops, fricatives), such that Classical Yucatec allows ‘deaffrication’ (/ts, tʃ/ → [t], /ts/ → [s] or /tʃ/ → [ʃ]), but not ‘affrication’ (/s, t/ → [ts] or /ʃ, t/ → [tʃ]). This would be somewhat analogous to the alveolar vs. postalveolar asymmetry observed in various sibilant harmony systems, whereby alveolar-postalveolar sequences like /s...ʃ/ harmonize to [ʃ...ʃ], but postalveolar-alveolar sequences like /ʃ...s/ fail to harmonize to [s...s] (see chapter 6 for detailed discussion of this ‘palatal bias’).

Thus, whereas Modern Yucatec shows stricture harmony governing affricates vs. fricatives, Classical Yucatec may be interpreted to have stricture harmony involving both affricate vs. fricative and stop vs. affricate contrasts. Another potential case of stricture harmony involving homorganic stops and affricates is Bolivian Aymara. Based on a search of dictionary entries in De Lucca (1987), MacEachern (1997[1999]) observes that roots of the form /t^h...tʃ^h/, /tʃ^h...t^h/, /t'...tʃ^h/, /tʃ'...t^h/—which are otherwise well-formed, according to laryngeal cooccurrence restrictions operative in the language—do not occur. Based on this fact, and the apparent lack of roots combining velars and uvulars (cf. section 2.4.2 above), she tentatively suggests that morphemes in Bolivian Aymara may be governed by

‘prohibitions on the cooccurrence of similar, but non-identical coronal and back lingual articulations’ (MacEachern 1999:48). If it is true that the cooccurrence of coronal stops and affricates is ruled out by a consonant harmony requirement in Bolivian Aymara, it is still not clear whether this should be classified as *stricture* harmony, rather than a subtype of coronal harmony, given that the stops and affricates also differ along the alveolar (or dental?) vs. postalveolar dimension. It should be noted, though, that if the constraint against combinations like /tʰ...tʰ/ is indeed a case of coronal harmony, it is a relatively untypical one, in that it straddles the stop/affricate (or ‘stop/sibilant’) boundary.

Finally, another case deserves mentioning which presents the same problem as Bolivian Aymara. This is a root-internal harmony found in the Dravidian language Pengo (as well as certain other South-Central Dravidian languages), whereby root-initial dental stops become ‘palatals’—i.e. postalveolar affricates—when a ‘palatal’ (affricate) occurs later in the same morpheme. The triggering affricate may itself be derived, and thus the root-internal harmony can actually manifest itself in the form of alternations (as in /tʃitʃ-/ , past stem of /tin-/ ‘eat’). For further discussion of the Pengo stop vs. affricate (or dental vs. ‘palatal’) harmony, see section 2.4.1.2 above.

2.4.7. Laryngeal harmony

Another set of features/gestures that may be involved in consonant harmony are those pertaining to laryngeal properties, such as voicing, aspiration, ‘glottalic’ airstream mechanisms (characterizing ejectives and implosives), and the like. Laryngeal consonant harmony is a relatively robustly attested phenomenon, but most of the reported cases involve static cooccurrence restrictions on root morphemes, rather than alternations. For a recent study of (static) assimilatory and dissimilatory laryngeal cooccurrence restrictions, see MacEachern (1997[1999]), which is the source of much of the information reported here. It should be noted that the treatment of individual cases in this section often differs to a greater

or lesser extent from that in MacEachern’s work. This is mostly due to the fact that the present study is limited to those cooccurrence restrictions that are *assimilatory*, and thus may count as instances of consonant harmony. Also, the overview in this section is exclusively concerned with restrictions on the cooccurrence of segments that differ specifically in *laryngeal* features. On top of this kind of harmony effect, many of the languages mentioned here and in MacEachern (1997[1999]) have additional assimilatory requirements, whereby segments that agree in some laryngeal feature must be completely identical—i.e. must have the same place of articulation. This issue will be ignored here, but is taken up again in section 2.4.8 below.

In fact, only two cases of laryngeal harmony resulting in alternations appear to be attested in the world’s languages. One of these, Yabem (Oceanic), is discussed in detail in section 3.3.2 below (for other types of consonant harmony also found in Yabem, see sections 2.4.4 and 2.4.6 above). The only other example I am aware of is the East Chadic language Kera (Ebert 1979; Odden 1994; Walker 2000a, to appear). In Kera, voiced and voiceless plosives do not cooccur in a word; if the root contains a voiced plosive (stop or affricate), plosives in affixes surface voiced as well. As (58) clearly illustrates, this voicing agreement is bidirectional, in that prefixes and suffixes alike are affected.

(58) Laryngeal harmony alternations in Kera (Ebert 1979)

a. Voicing harmony in nominal prefix /k-/⁶¹

- | | |
|-------------|-----------------------|
| kə-màanə | ‘woman’ |
| kə-taatá-w | ‘cooking pot (plur.)’ |
| kə-kámná-w | ‘chief (plur.)’ |
| gə-dàarə | ‘friend’ |
| gə-dàjgá-w | ‘jug (plur.)’ |

⁶¹ The vowel surfacing in this prefix is epenthetic, its quality determined by vowel harmony.

b. Voicing harmony in feminine suffix /-ká/

sár-ká ‘black (fem.)’

dʒàr-gá ‘colorful (fem.)’

c. Bidirectional voicing harmony (collective /-káŋ/, masculine /-kí/)

kə-sár-káŋ ‘black (coll.)’

ki-sír-kí ‘black (masc.)’

gə-dʒàr-gáŋ ‘colorful (coll.)’

gi-dʒír-gí ‘colorful (masc.)’

Kera laryngeal harmony is parasitic on identity in stricture, in that both trigger and target must be plosives; fricatives and plosives do not interact, as is evidenced by forms like /fèrgé/ ‘itch’, /dèfé/ ‘make (a sauce)’ (Ebert 1979:9).⁶² Neither, of course, do sonorants and plosives harmonize in voicing. Although it is clear that the voicing agreement goes beyond being strictly transvocalic—it can cross an intervening sonorant consonant as well—Ebert (1979) does not seem to contain any forms that would determine whether trigger and target must be in adjacent syllables, or whether the domain of voicing harmony is unbounded, spanning the entire word. Note also that Kera laryngeal harmony is asymmetric, in that voiceless plosives become voiced, but not vice versa: there does not seem to be any evidence that *voicelessness* can ‘spread’ from root to affix consonants.

Elsewhere within the Chadic language family, root-level laryngeal harmony is attested. For example, the West Chadic language Ngizim (Schuh 1978, 1997) has undergone a sound change whereby a voiceless obstruent becomes voiced when followed by a voiced obstruent, as shown in (59a). Note that laryngeal harmony in Ngizim, unlike its Kera counterpart, is not sensitive to differences in stricture between obstruents; fricatives

⁶² The failure of fricatives to participate in voicing harmony seems to be due to the general shift of voiced continuants to voiceless, thus fèrgé < *vèrgé, dèfé < *dèvé.

and stops alike are affected. However, the Ngizim harmony is dependent on identity in (other) laryngeal features, in that voiced *implosives* fail to trigger voicing in a preceding obstruent (59b). Finally, a handful of disharmonic words exist, as in (59c); these are all loanwords, presumably of relatively recent origin.⁶³ The data in (59) are cited from Schuh (1997), unless stated otherwise.

(59) Root-level laryngeal harmony in Ngizim (data from Schuh 1997)

a. Voicing harmony between non-implosive obstruents

kùtór	‘tail’	
ḥèpú	‘clap’	(Schuh 1978:260)
tàsáú	‘find’	
sètú	‘sharpen to point’	(Schuh 1978:260)
gâazá	‘chicken’	(< *k...z, cf. Hausa /kàazáa/)
dóbâ	‘woven tray’	(< *t...b, cf. Hausa /tàafii/ ‘palm’)
zàbìjú	‘clear field’	(< *s...b, cf. Hausa /sáàsàbée/)
zèdù	‘six’	(< *s...d, cf. Hausa /ǰídà/)

b. Voiced implosives do not trigger voicing harmony

páǰǰk	‘morning’	
kùǰǰú	‘eat (meat)’	
fǰǰú	‘four’	(Schuh 1978:260)
sàǰǰú	‘pound (v)’	

⁶³ Interestingly, Bade, the language most closely related to Ngizim, displays an anticipatory voicing *dissimilation* under the exact same conditions (Schuh 1978, 1997). A non-implosive voiced obstruent becomes voiceless when followed by another non-implosive voiced obstruent (e.g., /kádùwáan/ ‘duiker’, cf. Ngizim /gádùwà/, Hausa /gàdàa/). Unlike Ngizim voicing harmony, Bade voicing dissimilation does give rise to voicing alternations in prefixes dialectally: /dè-ḥávà/ ‘pierced’, but /tè-ḥàwí/ ‘seated’ (Schuh 1978: 267, n. 17).

c. Disharmony in loanwords (lexical exceptions)

tàabâ ‘tobacco’ (source: Hausa /táabàa/)

kàrgûn ‘medicine’ (source: Kanuri /kùrgûn/)

Disharmonic forms with /D...T/ sequences, such as those in (60), constitute evidence that Ngizim voicing harmony is asymmetric in two ways. Firstly, as in Kera, the harmony relation itself is asymmetric in that voiceless obstruents assimilate to voiced ones, but not vice versa (i.e. /bàkú/ ‘roast’ does not change to *[pàkú]). Secondly, the assimilation is unidirectional—i.e. strictly anticipatory or right-to-left—in that the target has to *precede* the trigger (i.e. /bàkú/ does not change to *[bàgú]).

(60) Asymmetric character of Ngizim voicing harmony (D...T, but no *T...D)

bàkú ‘roast’ (Schuh 1997)
 zàpènú ‘churn’ (Schuh 1978:254)
 gùmtǎí ‘chin’ (Schuh 1997)
 dùkǎí ‘heavy’ (Schuh 1978: 251)
 zùktú ‘pierce’ (Schuh 1978:273)
 mbàsú ‘sit’ (Schuh 1978:262)
 ŋgàs ‘spear’ (Schuh 1978: 263)

As regards locality issues and the maximum distance between trigger and target consonant, Schuh (1997) states the voicing assimilation rule as holding between onsets of adjacent syllables. This implies that a coda consonant may intervene between the two (...TVC.DV... → ...DVC.DV...), and furthermore that voicing harmony will *not* hold between onset and coda consonants in the same syllable (...TVD.C...). Moreover, it implies that voicing assimilation will fail to apply if another syllable intervenes between the two consonants

(...TVCVD...). Unfortunately, Schuh (1978, 1997) does not cite any forms that could be brought to bear on the question of locality.⁶⁴ There are no disharmonic sequences of the type /T...D/ at all in the Ngizim data (/T, D/ = any non-implosive obstruents). Regardless of the nature or amount of intervening segmental material, the only attested combinations are /T...T/, /D...D/ and /D...T/. The evidence Schuh cites would thus be consistent with the alternative interpretation that Ngizim is not sensitive to distance at all.

An additional possible (though somewhat suspect) case of voicing harmony is found in the Dravidian language Malto, where it seems to be restricted to homorganic combinations of velar or palatal plosives. Mahapatra (1979:39-40) states that if a CVC syllable has a voiced velar onset, it cannot have a voiceless velar coda. The same applies to palatal onset-coda combinations. As a result, syllables of the type */gV_k/ and */jV_c/ are not allowed, while the reverse sequences /kV_g/ and /cV_j/ appear to be permissible syllables (e.g., in /kag.te/ ‘paper’). Although Mahapatra (1979) states this cooccurrence restriction as applying specifically to *tautosyllabic* dorsal stops, it is possible that it holds for heterosyllabic (morpheme-internal) ones as well. I have not been able to determine this conclusively, but a brief search of Mahapatra (1979) did not reveal any counterexamples in CV.CV sequences either. For example, although same-voicing cases like /kake/ ‘comb’ and /goga/ ‘stone’ seem common, I did not find any /gV_kV/ or /jV_cV/ sequences.

In all the cases of laryngeal harmony mentioned so far, the parameter involved has been voicing vs. voicelessness among obstruents. Recall also that in Ngizim, voicing harmony is restricted to *pulmonic* obstruents: voiced implosives do not trigger harmony. Another West Chadic language, Hausa, displays a variety of root-level laryngeal harmony

⁶⁴ Note, though, that Schuh (1997) uses the same adjacent-syllable-onset restriction in his formalization of the Bade voicing dissimilation rule (cf. note 53 above). The existence of pairs such as Ngizim /gúmbàk/, Bade /kûmbáan/ ‘lake’—with uncertain etymology, i.e. either < *g...b or *k...b—entails that either Ngizim voicing harmony or Bade voicing dissimilation can apply across a coda sonorant (i.e. is not strictly transvocalic). However, such forms are of course also consistent with one of the two phenomena (or both) being unbounded, i.e. able to apply across *any* stretch of intervening segmental material.

restrictions that, among other things, prohibit the cooccurrence of ejective and implosive stops (Parsons 1970; MacEachern 1997[1999]). As a natural class, ejectives and implosives are characterized by the glottalic airstream mechanism; they differ phonologically only in the feature [\pm voiced]. Thus, the prohibition against their cooccurrence can be viewed as an instance of voicing harmony—one which, in the Hausa case, is limited to the class of glottalic (or [+constricted glottis]) obstruents.

Other cases of laryngeal harmony exist that specifically target the pulmonic vs. glottalic distinction. An ‘implosive harmony’ of this kind seems to be a characteristic of most Ijoid languages. For example, in the Kalabari dialect of (Eastern) Ijo roots, voiced implosives and voiced pulmonic stops are not allowed to cooccur (Jenewari 1989; note that Ijo has no ejectives). This is shown in (61).

(61) Root-level laryngeal harmony in Kalabari Ijo (data from Jenewari 1989)

a. Well-formed roots containing multiple voiced stops

bábā	‘cut’
ébébé	‘talk while sleeping’
badara	‘be(come) very wide’
ɓɪɓɪ	‘mouth’
dǎbá	‘lake’
dǔbári	‘stone’

b. Disallowed morpheme-internal combinations

*ɓ...b	*b...ɓ	*d...d	*d...d
*ɓ...d	*b...d	*d...b	*d...ɓ

Other examples of this type of harmony are found in other Ijoid languages. In his description of the Bumo dialect of Izon, Efere (2001) discusses this phenomenon, stating

clearly that it is restricted specifically to labials and alveolars, where pulmonic /b, d/ and implosive /ɓ, ɗ/ contrast, just as in the Kalabari Ijo examples above. On the other hand, velar /g/ is redundantly pulmonic (no /g̊/ exists), and labial-velar /ɡ̊b̊/ is redundantly implosive (no /ɡ̊b̊/ exists). These freely cooccur with labial and alveolar stops, regardless of whether the latter are implosive or pulmonic (e.g., *ɗúgó* ‘to pursue’, *ɡ̊b̊ódaɡ̊b̊oda* ‘(rain) hard’). The Bumo Izon case is discussed again in section 5.3 below.

Hausa has a similar restriction against the cooccurrence of implosives and plain voiced stops within morphemes, but in Hausa, this harmony requirement is dependent on identity in place of articulation (Parsons 1970; MacEachern 1997[1999]). If two root-internal voiced stops are homorganic, then they must also agree along the pulmonic/glottalic dimension; thus sequences like /d...g/, /ɓ...d/, etc. are allowed (e.g., *ɗiga* ‘poured out in drops’), whereas */d...d/, */ɓ...ɓ/, etc. are disallowed.⁶⁵

The pulmonic vs. glottalic distinction can also be the basis of harmony between voiceless obstruents. In fact, Hausa roots do not contain combinations of voiceless pulmonic stops and ejectives either. The harmony generalization for Hausa can thus be stated in more general terms, as being parasitic on both place and voicing: pulmonic and glottalic stops may not cooccur if they are homorganic and agree in voicing (MacEachern 1997[1999]).⁶⁶ A very similar harmony pattern occurs in the Mayan language Tzutujil (Dayley 1985; MacEachern 1997[1999]). As in many other languages of the Mayan family, only two series of plosives are differentiated in Tzutujil—voiceless unaspirated and ‘glottalic’ ones (broadly speaking). In Tzutujil, the glottalic consonants are implosive at the labial and coronal places of articulation, but ejective otherwise (glottalic coronal affricates

⁶⁵ There are several exceptions to this generalization in Hausa, virtually all of them containing the sequence /d...d/. MacEachern (1999:57-58) takes note of this unexpected occurrence of /d...d/, but does not attempt to incorporate it into her analysis of laryngeal cooccurrence restrictions in Hausa.

⁶⁶ MacEachern (1997[1999]) decides to treat the ‘plain’ voiceless stops in Hausa as aspirated (based on voice onset time measurements by Ladefoged 1964). This issue is irrelevant in the present context.

are ejective as well, not surprisingly).⁶⁷ Based on Dayley (1985), MacEachern (1997[1999]) interprets the Tzutujil cooccurrence restriction against homorganic glottalic vs. pulmonic plosives in roots as holding only for ejectives, not implosives. Thus, sequences like */k'...k/ or */ts...ts'/ are ruled out, whereas /b...p/ or /t...d/ is allowed.⁶⁸ If this is the right characterization of the Tzutujil facts, the pattern can easily be accounted for by analyzing the pulmonic/glottalic harmony as being parasitic on voicing as well place of articulation, just like its Hausa counterpart.

Elsewhere in the Mayan language family, laryngeal harmony preventing the cooccurrence of homorganic pulmonic and glottalic plosives (in effect, plain vs. ejective voiceless stops) is also attested. One example is Modern Yucatec (Straight 1976). As was the case with Modern Yucatec stricture harmony, discussed in section 2.4.6 above, this absolute cooccurrence restriction appears to be a generalized version of what was merely an *ordering* restriction in the Classical Yucatec language (Lombardi 1990). Whereas the latter permitted homorganic ejective-plain combinations, /T'...T/ (but not plain-ejective, */T...T'/), Modern Yucatec allows neither */T'...T/ nor */T...T'/ as homorganic root-internal sequences.

Finally, Old Georgian (Kartvelian) might be added to the list of languages displaying place-and-voicing-dependent harmony involving pulmonic vs. glottalic obstruents. The segmental inventory of Old Georgian contained three series of plosives: voiced (/b/, /d/, etc.), voiceless aspirated (/p^h/, /t^h/, etc.) and ejective (/p'/, /t'/, etc.). MacEachern (1997[1999]) notes that homorganic stops from the latter two classes do not seem to have been able to cooccur in roots (she notes that this is apparently no longer true

⁶⁷ According to Dayley (1985), /b/ and /d/ are in fact realized as ejective [p', t'] in coda position. Note furthermore that the pulmonic voiced stops /b, d, g/ do occur, but only in relatively recent borrowings from Spanish.

⁶⁸ The rarity of implosive /d/ and the paucity of relevant data in Dayley (1985) makes it hard to determine if sequences like /b...p/ or /t...d/ are prohibited as well. In her analysis of Tzutujil, MacEachern (1997[1999]) allows for this alternative possibility as well.

in Modern Georgian). In other words, root-internal stops that agree in place of articulation and voicing must also agree with respect to the pulmonic vs. glottalic parameter. However, the fact that the pulmonic voiceless stops are phonetically aspirated may indicate that Old Georgian laryngeal harmony in fact targeted the cooccurrence of homorganic stops with *conflicting* glottal features/gestures (i.e. [+spread glottis] vs. [+constricted glottis]).

Harmony requirements to precisely that effect are attested elsewhere, for example in Aymara (isolate), whose plosive inventory contains ejectives, aspirates and plain *voiceless* stops.⁶⁹ Aymara prohibits the root-internal cooccurrence of ejectives and aspirates, but dialects differ in the scope of this restriction (MacEachern 1997[1999]). With only a handful of exceptions, the dialect that MacEachern labels ‘Peruvian’ Aymara (based on dictionary data from Ayala Loayza 1988 and Deza Galindo 1989) does not allow any root-internal combinations of ejectives and aspirates, regardless of place of articulation. In the dialect she refers to as ‘Bolivian’ Aymara (based on data from De Lucca 1987), on the other hand, this harmony requirement is more limited, in that it is parasitic on place: heterorganic sequences like /t’...p^h/ or /p^h...k’/ are allowed, but not homorganic ones like */t’...t^h/, */p^h...p’/, etc. Although this dialect does allow heterorganic ejective-aspirate combinations, these are subject to certain ordering restrictions: if the first plosive is coronal or dorsal, it must be ejective (and the second one is thus aspirated); see MacEachern 1997[1999] for further discussion.

In addition, both varieties of Aymaran appear to disfavor the cooccurrence of plain voiceless stops with either ejectives or aspirates at the same place of articulation. In other words, homorganic sequences of the type /T’...T/, /T...T’/, /T^h...T/ and /T...T^h/ are extremely rare (MacEachern 1997[1999]). Thus, in addition to prohibiting combinations of otherwise-identical pulmonic vs. glottalic stops, Aymara prohibits the cooccurrence of

⁶⁹ Although Aymara is usually assumed to be an isolate, there have been proposals of a genetic affiliation between Aymara and Quechua (see, e.g., Orr & Longacre 1968).

aspirated and unaspirated versions of the same consonant. This type of place-dependent ‘aspiration harmony’ is attested elsewhere, for example in the Indo-Aryan language Gojri, whose plosive inventory comprises voiced, voiceless unaspirated and voiceless aspirated stops. Based on a search of Sharma (1979), MacEachern (1997[1999]) finds that in Gojri, homorganic voiceless stops differing only in aspiration are not allowed to cooccur within a morpheme. (MacEachern finds only three exceptions to this generalization in Sharma 1979.) Gojri thus allows words with homorganic voiceless stops that agree in aspiration (/c^hɪc^hl̥əp/ ‘cobra’, /pəɾpəɾt̥o/ ‘blunt’), as well as homorganic aspirated and unaspirated stops which differ in voicing (/bap^həŋ/ ‘eyelash’), but sequences like */t^h...t/, */k...k^h/, etc. are prohibited. The Gojri cooccurrence restriction can therefore be analyzed as a root-level aspiration harmony which is parasitic on identity in both place of articulation and voicing.

It should be noted that none of the attested cases of laryngeal harmony—whether manifested in alternations or as mere static cooccurrence restrictions—display any sort of phonological blocking effects. In other words, it is never the case that some subset of the segment inventory is *opaque* to the laryngeal harmony, such that a disharmonic segment pair is allowed to cooccur if and only if such an opaque segment intervenes. Instead, intervening segments that do not participate in the harmony are always *transparent*. At first glance, this observation may seem unsurprising, but cases do exist where an intervening segment would *a priori* seem equally likely to display opaque and transparent behavior. This can be illustrated with an interesting three-way laryngeal harmony found in the Nguni subgroup of Bantu languages (comprising Zulu, Xhosa, Ndebele and Swati). For example, Khumalo (1987) notes the existence in Zulu of a laryngeal consonant harmony governing the cooccurrence of (non-click) stops within morphemes: ‘they will either all be [+aspirated] or all will be [+depressed] or all will be unspecified’. The stops Khumalo analyzes as [+depressed] are fully voiced stops, whereas the phonetic realization of the segments treated as laryngeally unspecified stops seems to vary between ejectives and

voiced fricatives, depending on their position in the word. The laryngeal harmony is illustrated in (62).

(62) Root-level laryngeal harmony in Zulu (data from Khumalo 1987)

a. Well-formed verb stems with multiple stops

ukú-peta	‘to dig up’	(T...T)
úku-tápa	‘to collect (honey, etc.)’	(T...T)
ukú-k ^h et ^h a	‘to choose’	(T ^h ...T ^h)
úku-p ^h át ^h a	‘to hold’	(T ^h ...T ^h)
ukú-guba	‘to dig’	(D...D)

b. Disallowed morpheme-internal combinations

*p...t ^h	*p ^h ...t	*p...d	*b...t	*p ^h ...d	*b...t ^h
(etc.)					

c. Laryngeal harmony in loans from English

í-k ^h ô ^t o	‘court’	(T ^h ...T ^h)
úm-bídi	‘conductor’ (< English <i>beat</i>)	(D...D)

Khumalo (1987) finds no counterexamples to Zulu laryngeal harmony among regular disyllabic roots. The phonological reality of the harmony is also supported by borrowings from English, where word-final /t/ is rendered as aspirated or voiced in Zulu depending on the laryngeal features of the initial consonant, as shown in (62c) above.

One quirk of Zulu segmental phonology interferes with the laryngeal harmony, namely the restriction that the aspirated velar /k^h/ is restricted to root-initial position (Khumalo 1987). Elsewhere, laryngeally unspecified /k/ occurs. Based on searches of the computerized version of Pelling (1971) in the CBOLD database, Hyman (1999) confirms that the same restriction holds in the closely related (and mutually intelligible) language

Ndebele, which displays the exact same laryngeal harmony requirement as Zulu.⁷⁰ The interplay between the ban against non-initial /k^h/ and the laryngeal harmony is quite complex. This is illustrated by the Ndebele forms in (63), taken from the dictionary of Pelling (1971) as adapted and computerized as part of the CBOLD database. In those morphemes where a non-C₁ velar would be expected to be aspirated /k^h/ because of laryngeal harmony, plain /k/ appears instead, creating a harmony violation (63a). Interestingly, /k^h/ is able to occur in this position if the stop with which it is harmonizing is *also* a velar (63b).

(63) Special status of non-initial velars in Ndebele laryngeal harmony

a. Harmony violated: No /k^h/ in non-C₁ position

- p^hek-a ‘cook, brew’
- p^hik-a ‘argue, deny’
- t^huk-a ‘abuse, curse’
- t^hikaz-a ‘be disturbed’

b. Harmony reappears if C₁, C₂ are homorganic (overrides ban against non-C₁ /k^h/)

- k^hok^h-a ‘pull, draw out’
- k^huk^h-ul-a ‘sweep away’

From the empirical perspective, the interaction between the constraint against non-root-initial /k^h/ and the two versions of laryngeal harmony (general and place-dependent) seems quite robust. In his search of consonant-initial verb stems in Ndebele, Hyman (1999) finds only 9 examples of C₂ /k^h. All but one of these forms have root-initial /k^h/ (i.e. all are

⁷⁰ Strictly speaking, the restriction on /k^h/ in Ndebele needs to refer not to absolute root-initial position, but instead to being the *first consonant* in the root. Thus /k^h/ freely occurs in VC roots like /ak^h-a/ ‘build’, /ok^h-a/ ‘roast’, etc.

/k^hVk^h.../).⁷¹ The forms in (63a) and (63b) can be accounted for if it is assumed that Ndebele is governed by two versions of laryngeal harmony that stand in a subset relation: a) a general constraint against the cooccurrence of laryngeally distinct stops; and b) a constraint against the cooccurrence of laryngeally distinct *homorganic* stops, i.e. those that already agree in place of articulation. (Note that the latter has clear parallels in many of the languages discussed elsewhere in this section.) If these are formalized as ranked constraints, the disharmonic forms in (63a) can be accounted for by assuming that the markedness constraint against (non-initial) [k^h] outranks the general version of laryngeal harmony. Thus, using somewhat informal labels: *[k^h] >> LARHARM. The forms in (63b), on the other hand, are derived correctly if the markedness constraint is in turn outranked by the more specific, place-dependent version of laryngeal harmony: LARHARM_[orPLACE] >> *[k^h] >> LARHARM. This type of interaction, as well as other similarity effects, are discussed more extensively in chapters 4 thru 6.

Voiced /g/ in Ndebele patterns in ways very similar to /k^h/ with respect to the harmony patterns in (63) above. Where laryngeal harmony would lead us to expect /d...g/ and /b...g/, we instead find (disharmonic) /d...k/ and /b...k/, with laryngeally unspecified /k/ instead of the expected /g/—just as in (63a), where /k/ appears instead of expected /k^h/. Examples are /-dak-w-a/ ‘be drunk’ and /-dik-is-a/ ‘palpitate (heart), twitch’. When the root-initial stop is also a velar, /g/ reappears under harmony, just as /k^h/ does in (63b); hence we find examples like /-gug-a/ ‘wear out’. Interestingly, however, a crucial difference between /g/ and /k^h/ in this context is that the former is *not* generally ruled out in non-initial position (cf. /-fug-a/ ‘push a cart’, /-lag-is-a/ ‘send cattle to grazing place’, /-hug-a/ ‘allure,

⁷¹ The sole exception is /-zok^hel-a/ ‘provoke’, which Hyman speculates may have reflexive structure (i.e. /-zi-ok^hel-a). Note also that postnasal deaspiration renders laryngeal harmony opaque in nouns like /in-kok^helo/ ‘wages, pay’ (from the verb /-k^hok^hel-a/ ‘to pay wages’. Finally, some nouns that appear to have /k^h/ in non-first position in the root in fact have double prefixation, e.g., /ubu-luk^huni/ ‘stiffness, hardness’ is really /ubu-lu-k^huni/ with /k^h/ = C₁. These factors account for all apparent exceptions to the generalization that /k^h/ in non-first position in the root is always due to harmony with a preceding /k^h/.

entice', etc.). There does not appear to be any phonotactic constraint against /g/ in root-internal position, and therefore it is not immediately apparent what the motivation might be for disharmony in forms like /-dik-is-a/ (instead of harmonic */dig-is-a/). It seems inevitable to appeal directly to some *dissimilatory* restriction—perhaps motivated by surface analogy with the pattern displayed by /k^h/ vs. /k/? The proper interpretation of this highly interesting case will have to await further research.

Returning to the issue of segmental transparency vs. opacity in laryngeal consonant harmony, the interesting question is how the non-harmonizing /k/'s in (63a) behave. They are obviously failing to undergo (or trigger) laryngeal harmony, and can thus be viewed as 'neutral' segments. However, they are not 'neutral' in quite the same sense as are, e.g., intervening vowels and sonorants, or intervening non-coronals in a coronal harmony system, for that matter. Rather, the /k/'s in (63a) are similar to neutral vowels in vowel harmony systems, in that they indisputably belong to the class of 'P-bearing units' or 'potential targets' of the harmony in question. In vowel harmony systems, neutral vowels may either be transparent, allowing a harmony span to hold across (or 'through') them, or they may be opaque, blocking the further propagation of the harmony in question—and potentially initiating a new harmony span of their own. It is therefore reasonable to ask whether the 'neutral' C₂ /k/ in Ndebele or Zulu is transparent or opaque. A tentative answer is provided by evidence from loanword adaptation, as in the Zulu words in (64), which are borrowed from English (Khumalo 1987). As the forms in (64a) show (repeated from 62c above), the rendering of English word-final /t/ in Zulu is governed by laryngeal harmony with any preceding stop. Zulu renderings of English source words where a medial velar intervenes between a word-final /t/ and an initial stop, such as the ones in (64b), clearly show that the disharmonic /k/ is *transparent*, not opaque.

(64) Transparency of medial /k/ in Zulu loans from English (Khumalo 1987)

- | | | | |
|----|---|--------------------------------------|---|
| a. | í-k ^h ô ^{t^h} o | ‘court’ | (T ^h ...T ^h) |
| | úm-bídi | ‘conductor’ (< English <i>beat</i>) | (D...D) |
| b. | i:-p ^h áket ^h e | ‘packet’ | (T ^h ...k...T ^h) |
| | i:-bakêde | ‘bucket’ | (D...k...D) |

The fact that the rendering of English word-final /t/ obeys laryngeal harmony with the root-initial stop even in (64b) indicates that the C₁-C₃ harmony interaction holds across the C₂ velar /k/.

To summarize the facts presented in this section, laryngeal consonant harmony is reasonably well attested in the world’s languages. However, its effects rarely extend across morpheme boundaries, and therefore this type of consonant harmony manifests itself almost exclusively in the form of static root-level cooccurrence restrictions. Also, laryngeal harmony is remarkably often dependent (or ‘parasitic’) on identity in place of articulation and/or other laryngeal features than the one defining the harmony (e.g., identity in voicing). The combined effect is more often than not the *total* identity of the harmonizing consonants. As for which phonological oppositions can be targeted by laryngeal consonant harmony, it appears that virtually every conceivable type is attested. Harmony along the voiced vs. voiceless dimension is attested in Yabem, Kera, Ngizim, Ndebele and Zulu, and parasitic on [+constricted glottis] in Hausa. Harmony with respect to the (voiceless) aspirated vs. unaspirated distinction is found in Ndebele and Zulu, and parasitic on [αPlace] in Aymara (all dialects) and Gojri. Harmony in terms of [±constricted glottis] on stops that agree in voicing—i.e. plain voiced stops vs. implosives and/or plain voiceless stops vs. ejectives—is found in Kalabari Ijo, and parasitic on [αPlace] in Hausa, Tzutujil, Modern Yucatec, Aymara (all dialects), and possibly also Old Georgian. Finally, the cooccurrence of [+spread glottis] and [+constricted glottis] stops—i.e. aspirates and ejectives—is ruled out by laryngeal

harmony in ‘Peruvian’ Aymara, and parasitic on [αPlace] in ‘Bolivian’ Aymara and possibly in Old Georgian.

2.4.8. Major place consonant harmony — an unattested harmony type?

Previous works dealing with consonant harmony phenomena have usually made the observation that one important feature type is conspicuously absent from the list of phonological properties that may be subject to long-distance assimilation between consonants: major place of articulation, e.g., [dorsal], [labial], etc. (see, e.g., Shaw 1991; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997; Walker to appear). True, autosegmental spreading of the [coronal] node is proposed for Sanskrit /n/-retroflexion by Schein & Steriade (1986) and for Tahltan coronal harmony by Shaw (1991). However, these cases are rendered suspect by the fact that in both, the trigger and target segments are already coronals, such that the end result is assimilation in terms of any and all features subordinate to the [coronal] node ([±anterior, ±distributed, ±strident]), rather than assimilation in *coronality* as such. In fact, alternative solutions involving spreading of sub-coronal features (or rather articulatory gestures) have been proposed for the Sanskrit and Tahltan cases by Gafos (1996[1999]; cf. also Ní Chiosáin & Padgett 1997). It thus remains an as yet undisputed claim that consonants never assimilate in major place of articulation across vowels, yielding, e.g., /dVg/ → /gVg/ or /bVn/ → /bVm/.

The apparent lack of major place harmony—i.e. long-distance assimilation—is all the more striking in light of two additional observations. Firstly, long-distance major place *dissimilation* is quite well attested cross-linguistically. The most famous example by far is the dissimilatory constraints holding over Semitic roots, e.g., in Classical Arabic (see, e.g., Greenberg 1950; McCarthy 1986, 1988, 1994; Yip 1989; Pierrehumbert 1993; Frisch et al. 1997; Frisch 2000; Frisch & Zawaydeh 2001). Other examples of morpheme-internal dissimilatory restrictions on place include Javanese (Uhlenbeck 1949, 1950; Mester

1986[1988]; Yip 1989) and Russian (Padgett 1995a). Long-distance major place dissimilation may also result in affix alternations, e.g., in Akkadian (Von Soden 1969; McCarthy 1981; Yip 1988) and Imdlawn Tashlhiyt Berber (Elmedlaoui 1995); in both cases a prefix /m(a)-/ dissimilates to /n(a)-/ before roots containing a labial consonant. Of course, the existence of long-distance place dissimilation but lack of place harmony only constitutes a paradox under the *a priori* assumption that harmony and dissimilation are closely related phenomena and should therefore exhibit a similar typological profile. The significance of the observed mismatch between the cross-linguistic typologies of consonant harmony and long-distance consonant dissimilation thus depends on what connection, if any, is posited between the two phenomena.

The second and perhaps more puzzling fact is that the apparent absence of major place harmony only holds with respect to *adult* language, not child language. In the phonological acquisition process, long-distance assimilation between consonants is a very frequent and well attested phenomenon (see, e.g., Lewis 1936; Smith 1973; Vihman 1978; Berg 1992; Bernhardt & Stemberger 1998; Berg & Schade 2000). In some cases, the assimilations involved closely match consonant harmony types that exist in adult language, e.g., sibilant harmony ([s] vs. [ʃ]), nasal consonant harmony ([l] vs. [n], [b] vs. [m], etc.) or stricture harmony ([s] vs. [t]). The one glaring exception is major place harmony, which—although apparently unattested in adult language—is by far the most common type of consonant harmony in child language. Again, the importance of the mismatch depends on whether one assumes that consonant harmony in child and adult language are related (or ‘homologous’) phenomena.

The claim that major place harmony does not exist in adult language has been repeated so often in the theoretical phonological literature as to almost constitute a truism. However, a close examination of the full range of cross-linguistically attested assimilatory cooccurrence restrictions reveals that this claim is in fact not categorically true—at least not

without some further qualifications. Numerous cases exist where a language requires cooccurring segments of a particular type (e.g., two ejectives, two aspirates, two nasals, etc.) to be totally identical in all respects. In most cases, this simply translates into a requirement that the two segments agree in place of articulation—after all, two non-identical ejective stops are by definition identical in all respects *except* place (the same is true of heterorganic pairs of aspirated stops, nasals, and so on).⁷² One conceivable formulation of these types of cooccurrence restrictions is that they constitute ‘parasitic’ place harmony, i.e. harmony that is dependent on identity in certain other features, such as [+constricted glottis], [+nasal], etc. As such, this phenomenon would then be no more remarkable than other types of parasitic consonant harmony, such as voicing harmony in Ngbaka (dependent on Place) or Ngizim (dependent on [\pm constr. glottis]), stricture harmony in Yabem (dependent on Place), and so on.⁷³

Most potential examples of such parasitic place harmony involve segments that agree in some marked *laryngeal* feature. In fact, many of the languages reported on and analyzed by MacEachern (1997[1999])—and mentioned in section 2.4.8 above—have root-level restrictions that can be characterized in this way. In Gojri, for example, two (voiceless) aspirated plosives must be identical. The same restriction holds in ‘Peruvian’ dialects of Aymara, where two ejective plosives are also required to be identical. The same ban against non-identical ejectives holds in ‘Bolivian’ dialects of Aymara (which lack the restriction on aspirates), as well as in Tzutujil (cf. Dayley 1985) and numerous other Mayan languages,

⁷² This requires a definition of ‘homorganic’ and ‘place of articulation’ that is somewhat stricter than is customary. For example, in a language which contrasts, say, alveolar and retroflex stops, /t^h/ and /t^h/ are non-identical without being ‘homorganic’ in the conventional sense—in that both are coronals.

⁷³ Of course, the cases mentioned here do not result in alternations. Thus there is no overt evidence for an input with two heterorganic consonants surfacing with one ‘actively’ assimilating to the other in place of articulation. However, this is true of *all* kinds of static root-level cooccurrence restrictions, and does not constitute a valid argument against treating this particular class of them as involving consonant harmony. Nevertheless, it would be interesting to know if any of these cases can be corroborated by *diachronic* evidence (such that long-distance place assimilation did take place through sound change), although this seems rather unlikely.

such as Tzotzil (Weathers 1947), Chontal (Keller 1959) and Yucatec—both the classical (Lombardi 1990) and modern language (Straight 1976). Finally, Hausa requires two glottalic consonants to be identical; since the language has both ejectives and implosives, this entails that the two glottalic consonants agree in both place and voicing (i.e. homorganic ejectives vs. implosives cannot cooccur, and neither can heterorganic ejectives or heterorganic implosives).

Apparent examples of place harmony parasitic on identity in *non-laryngeal* features are rarer and somewhat more suspicious. In Ganda roots—and possibly this was true already in Proto-Bantu—two nasals are required to be identical, i.e. homorganic (Katamba & Hyman 1991); thus /-mVm-/ , /-nVn-/ are permissible roots, but not /-mVn-/ , /-nVm-/. The palatal nasal /ɲ/ appears to be exempt, in that it may cooccur with both /m/ and /n/.⁷⁴ A similar restriction holds in Pohnpeian, where alveolar (or dental) /n/ vs. velar /ŋ/ constitute one of the segment pairs that ‘are almost never found within the same morpheme’ (Rehg 1981:46). As in Ganda, the cooccurrence restriction does not hold over all places of articulation: labial /m/ and /mʷ/ may freely cooccur with both alveolar and velar nasals in Pohnpeian (cf. /nim/ ‘drink’, /mʷɛŋɛ/ ‘eat’, /mɔŋɛ-/ ‘head’).

As noted above, all of the potential cases of consonant place harmony are such that the interacting consonants are required to agree in *all* features, i.e. they must be totally identical segments. How significant is this? Does it justify a separate category of ‘total’ consonant harmony? If so, how should the phenomenon be analyzed? Cases such as the Mayan one, where ejectives may cooccur only when identical, were discussed in earlier works on autosegmental phonology (see, e.g., McCarthy 1989; Yip 1989). This type of interaction was handled by the same mechanism as other long-distance consonantal agreement effects (such as coronal harmony), i.e. in terms of spreading/sharing of feature-

⁷⁴ Even this is a slight oversimplification of Katamba & Hyman’s (1991) findings: /n/ and /ɲ/ only cooccur in the order /nVɲ/, whereas *ɲVn/ roots are unattested. Order plays no role in the cooccurrence of /m/ and /ɲ/: both /mVɲ/ and /ɲVm/ roots exist.

geometric nodes. In the case of ‘total harmony’, the node in question is the Root node, which, in the Mayan case, may then be shared by C_1 and C_2 in a C_1VC_2 root. Needless to say, autosegmental root-node spreading across a vowel requires V/C planar segregation, if association lines are not to be crossed. In fact, cases such as the Mayan one were adduced as evidence that V/C planar segregation was *not* dependent on Cs and Vs belonging to separate morphemes in the language in question (McCarthy 1989).

Other examples that would superficially fit the description of ‘total harmony’ between root consonants include Javanese and Semitic. In the Semitic case, so-called ‘geminate’ or biliteral roots (where $C_2 = C_3$, as in Arabic /samam/ ‘poison (v)’) defy the otherwise general OCP restriction that root consonants may not agree in place of articulation (see, e.g., Greenberg 1950; McCarthy 1981, 1986). In Javanese roots, where similar OCP-Place restrictions hold, total identity is allowed between C_1 and C_2 (e.g., /babot/ ‘carpet’; cf. Uhlenbeck 1949, 1950; Mester 1986[1988]; Yip 1989). In the tradition of autosegmental phonology, both cases were analyzed as involving root-node sharing/spreading across an intervening vowel (made possible by assuming V/C planar segregation). In recent work, Gafos (1996[1999], 1998) has argued quite persuasively for the elimination of long-distance consonantal spreading (‘LDC-spreading’)—and, by implication, feature-geometric V/C planar segregation as well—from phonological theory. Gafos instead reduces the consonant-identity effects found in Semitic ‘geminate’ roots to *correspondence*, more specifically base-reduplicant correspondence (see 4.1.3 below). This is rendered possible by assuming that the interdigitated vocalic morphemes in Semitic are in fact reduplicative affixes—thus triggering the presence of a base-reduplicant correspondence relation—whereas the presence of a stem-final C is enforced by independent phonotactic constraints. In a stem such as /s₁am₂am₃/ ‘poison’, /m₃/ is thus *not* part of the root (and thus does not violate the OCP-Place constraint on roots), but belongs to a reduplicative affix. Finally, the fact that the reduplicant is a *suffix*—i.e. right-

aligned—accounts for the fact that stems with $C_1 = C_2$ do not occur (**/sasam/*, etc.), since these would inevitably violate OCP-Place.

Gafos (1998) does not extend this analysis to the similar facts obtaining in Javanese. Here the edge effects are opposite ($C_1 = C_2$ is allowed in CVCVC roots, but not $C_2 = C_3$), and it does seem likely that this is somehow connected to the fact that *prefixing* reduplication is also rampant in the language.⁷⁵ But as for the total-identity effects on ejectives in Mayan languages—or the other putative place harmony cases mentioned above—an analysis in terms of *reduplicative* correspondence is hardly appropriate. Unlike the Semitic case, there is no superimposed non-root morpheme involved which could be analyzed as being reduplicative and thus creating a base-reduplicant correspondence relation. Furthermore, the typical state of affairs in these languages is that total identity is only required if the cooccurring consonants agree in some specific (marked) property. For example, in Bolivian Aymara, cooccurring [+constricted glottis] plosives (i.e. ejectives) must be totally identical, whereas the same is not required of pairs of [+spread glottis] plosives, or of [-constr.gl., -spr.gl.] ones.

It should be noted that for Gafos (1996, 1998), the ulterior motive for eliminating LDC-spreading is a more general one: the general idea that all spreading is strictly local, in the sense that intervening segments are never ‘skipped’ (see, e.g., Padgett 1995b, Ní Chiosáin & Padgett 1997; Walker 1998[2000], Walker & Pullum 1999). Since Gafos (1996[1999], 1998) does assume that spreading is in fact involved in consonant harmony (which he claims to be limited to coronal-specific tongue tip/blade gestures, cross-linguistically), it is all the more important to ‘explain away’ alleged cases of LDC-spreading such as the Semitic one. The approach to consonant harmony that is defended here, on the

⁷⁵ If an analysis in the spirit of Gafos (1998) turns out to be feasible for Javanese roots as well, then this invites the possibility of treating liquid harmony in the closely related language Sundanese (cf. 2.4.5 above) as a matter of correspondence between the root-initial consonant and a reduplicative infix. An analysis along these lines is proposed by Suzuki (1999); see sections 4.1.3 and 4.3.3 for discussion.

other hand, puts matters into a somewhat different perspective. Rather than analyze coronal harmony as strictly-local spreading of articulatory gestures that have no audible effect on intervening segments—and ignore other types of long-distance consonantal assimilations (as Gafos largely does)—the present work argues, instead, that consonant harmony is *never* due to spreading. Thus the view of strict locality in feature/gesture spreading is upheld. Furthermore, the analysis of consonant harmony phenomena presented in chapters 4 and 5 (cf. also Walker 2000ab, to appear) does appeal to the notion of a correspondence relation—just as Gafos (1996, 1998) does in his account of LDC-spreading—but one which is not a matter of *reduplicative* identity.

Although the analysis of total-identity effects in Gafos (1996, 1998) may well be the appropriate one for cases like Arabic, Hebrew, and possibly even Javanese, it is much less suitable for the other potential cases of place harmony (or ‘total harmony’), as mentioned earlier. The move to analyze all consonant harmony effects as being due to segment-to-segment correspondence provides an alternative way of dealing with these cases *without* resorting to non-local spreading or gapped phonological representations in general. In fact, MacEachern’s (1997[1999]) analysis of cooccurrence restrictions involving total identity (e.g., in Tzutujil, where ejectives must be identical) is very much in the same spirit. As discussed in 4.1.2 below, MacEachern proposes a constraint BEIDENTICAL which, in effect, enforces complete identity between the relevant segments.⁷⁶ Through rather ingenious use of the powerful tool of constraint conjunction/disjunction involving OCP constraints and *IDENTITY (the converse of BEIDENTICAL), MacEachern is able to make BEIDENTICAL completely irrelevant *except* when the two segments agree in the property on which the ‘total harmony’ is parasitic, such as [+constr. glottis]. Although a constraint like BEIDENTICAL is too narrowly defined to be applicable to most cases of consonant harmony (i.e. those that

⁷⁶ Interestingly, MacEachern (1999:93) also suggests that this constraint may lie behind ‘segment harmony processes in child speech’, a phenomenon which is here argued to be directly related to adult-language consonant harmony.

simply require agreement in some feature [F] rather than complete identity), something akin to it may well turn out to be the appropriate tool for analyzing ‘total harmony’ effects.

The question thus remains whether the root cooccurrence restrictions in Mayan languages, Hausa, Aymara, Gojri, Ganda, etc. should be regarded as actual examples of consonant *place* harmony, or whether ‘total harmony’ (agreement in all features/gestures) is a more appropriate interpretation. Although it is true that all of the potential cases involve total identity, the same is true of many individual cases within other subtypes of consonant harmony, such as stricture harmony in Yabem, liquid harmony in Bukusu and Pare, etc. In fact, almost all attested cases of laryngeal consonant harmony (especially those involving [spread glottis] or [constr. glottis]) have the effect of enforcing total identity. However, the existence of laryngeal consonant harmony systems that do not (e.g., Kalabari Ijo) shows that the total-identity effect is entirely secondary—a by-product of the fact that laryngeal harmony is in most cases parasitic on place of articulation.⁷⁷

These observations shed a somewhat different light on the dilemma. Different types of consonant harmony appear to differ in how dependent they are on the segments agreeing in certain other features—or, more broadly speaking, on the relative similarity of the segments. Coronal harmony appears to be not only the most commonly occurring type, but also the least restrictive in this sense. Laryngeal harmony is less common, less likely to hold beyond the confines of the root, and also more dependent on the ‘trigger’ and ‘target’ agreeing in place, manner, etc. Stricture harmony appears to be more restrictive yet, but its sheer rarity makes it hard to conclude much about it. Finally, place harmony—if it exists—is so restrictive that it can *only* hold between segments that are already identical in all other

⁷⁷ All of the cases of laryngeal harmony that MacEachern (1997[1999]) deals with involve total identity (in addition, of course, to various *dissimilatory* effects that are irrelevant in this context). In other words, in all of them is the harmony parasitic on identity in place of articulation (as well as voicing, where applicable). In fact, this is the only reason she is able to analyze laryngeal harmony by using BEIDENTICAL in the first place. MacEachern is apparently unaware of the existence of cases such as Kalabari Ijo, where agreement in the laryngeal feature in question is enforced without necessarily entailing complete segmental identity.

respects (and typically ‘marked’ in some sense), and only within roots. From this perspective, the contrast between child and adult language is not one of presence vs. absence of place harmony, but in its relatively unconstrained vs. highly restrictive character. Whereas place harmony can be non-parasitic in child phonology (e.g., /næp/ → [mæp]), it can only manifest itself in adult language when parasitic on manner, voicing, and often features like [constr. glottis] or [spread glottis].

2.5. Summary

This chapter has presented an overview of the kinds of consonant harmony effects that are attested in the world’s languages, based on the most comprehensive survey to date of such phenomena. Using the working definition of consonant harmony introduced in section 1.1 above, it was found that a surprisingly wide range of phonetic/phonological parameters can be involved in consonant harmony interactions. By far the most common type of consonant harmony involves distinctions between coronal sibilants (fricatives and/or affricates), such as apical/laminal, dental/alveolar/retroflex/‘palato-alveolar’, or some combination of these. Coronal harmony may also involve plosives (stops and nasals), and there are even cases where [+anterior] stops and [-anterior] affricates interact.

Other types of consonant harmony include dorsal harmony (relating velar vs. uvular obstruents), secondary-articulation harmony (where consonants agree in velarization, pharyngealization, perhaps even palatalization), liquid harmony (relating laterals vs. rhotics, or glides vs. liquids), nasal consonant harmony, laryngeal harmony, and even stricture harmony (relating stops vs. fricatives, fricatives vs. affricates, etc.). Each of these types was discussed in detail and illustrated with examples from one or more attested cases.

Although it is clear that consonant harmony *can* be based on a wide range of phonological parameters, not all the types are equally well attested. For example, stricture harmony is exceedingly rare, as is secondary-articulation harmony, and liquid harmony is

also surprisingly uncommon (considering how frequently liquids are involved in *dissimilation*). Nasal consonant harmony is found in a sizable number of languages, but most of these are closely related members of the Bantu family; presumably the harmony is largely ‘cognate’ across that group. Laryngeal harmony is quite common root-internally, but very rarely reaches beyond the root to give rise to alternations; where it does, the parameter involved tends to be voicing. By contrast, coronal harmony (and in particular sibilant harmony) frequently drives alternations, but is also often observed as a mere cooccurrence restriction on roots.

The variety of attested consonant harmony types raises the question whether there are any properties that *never* give rise to harmony of this kind. Major place of articulation is the most obvious candidate (though see 2.4.8 for discussion). Rose & Walker (2001) suggest that the major classificatory features [sonorant] and [continuant] do not enter into assimilatory agreement patterns. The survey in this chapter shows that this is clearly not true in the case of [continuant], since stricture harmony does exist (see 2.4.6), although it is very rare. It is also unclear how to interpret in featural terms those harmonies that involve a glide /j/ alternating with a liquid (Basaa, Pare) or even an obstruent (Pare). The latter comes close to being a candidate for [sonorant] harmony. A general problem may be that consonants rarely differ *only* in [\pm son], without also differing in one or more of [\pm cont], [\pm nas], [\pm lat] and so on.

It remains an issue for further research why certain features are more commonly found to participate in consonant harmony than others, why some tend to participate only in morpheme-internal harmony, and why properties like major place of articulation seem never to participate in consonant harmony. In this respect it will no doubt be fruitful to examine the diachronic origins of the synchronic harmony patterns in question, especially for the relatively rarer types. For example, the typologically unique sibilant pharyngealization harmony of Tsilhqot’in (2.4.3) is a reflex of what was no doubt once a normal coronal

harmony system involving a dental vs. alveolar contrast, where that contrast has now come to involve pharyngealization (Hansson 2000). Some cases may well originate in local coarticulatory/perceptual effects across a single vowel, which have then been phonologized as a non-local agreement relation between consonants. This is almost certainly the case with many plosive retroflexion harmonies (2.4.1.2), and quite possibly also dorsal consonant harmony (2.4.2); Dolbey & Hansson (1999) argue for a similar origin of nasal consonant harmony in Bantu. Finally, there are some cases which seem likely to have arisen through analogical reanalysis of identity patterns which are due to other morpho-phonological effects. The curious glide/obstruent alternations of Pare may well be connected to ‘cyclic mutation’ effects (see 2.4.6), and the lateral/glide alternations of Basaa (2.4.5) may have a similar analogical origin. At this point, however, these hypotheses are little more than speculation, but it seems likely that a diachronic perspective can shed light on the asymmetries between different types of consonant harmony with respect to their relative frequency of occurrence.

Although the attested kinds of consonant harmony systems are quite varied in terms of the features involved, and may constitute a heterogeneous set with regard to their diachronic origins, the consonant harmony systems that have been surveyed here comprise a remarkably uniform set. The following chapter will focus on some overarching generalizations that can be stated over attested consonant harmony systems, some of which set consonant harmony apart from what is otherwise common in vowel and vowel-consonant harmony systems. What emerges is a remarkably consistent synchronic-typological profile, which in turn provides the basis for the generalized Optimality-Theoretic analysis of consonant harmony developed in chapters 4 and 5.

CHAPTER 3
TYPOLOGICAL ASYMMETRIES:
CONSONANT HARMONY VS. OTHER HARMONIES

The survey in the preceding chapter focussed on the phonological/phonetic parameters that form the basis of consonant harmony phenomena in the world's languages, and classified attested cases in terms of the property involved in the assimilatory interaction. The resulting picture is that of a diverse and seemingly somewhat heterogeneous set. What this chapter aims to show is that, in spite of the fact that their featural basis is diverse, consonant harmony systems have a strikingly uniform typological profile in a number of respects. In the following sections, I examine certain aspects of the consonant harmony systems in the database and extract generalizations that can be compared with what is known to be attested in other types of harmony systems, i.e. vowel harmony and vowel-consonant harmony.

Three main topics are investigated, the first of which is directionality effects. As I will show, anticipatory (right-to-left) assimilation is the norm for consonant harmony processes, and can be regarded as a default. Although progressive (left-to-right) harmony is also attested, this can always be attributed to other independently motivated factors, such as the influence of morphological constituent structure. The second topic under consideration is segmental opacity, or blocking effects, which are extremely common in both vowel harmony and vowel-consonant harmony systems. I will demonstrate that such opacity effects are completely unattested in the typology of consonant harmony systems; instead, intervening segments are consistently 'transparent' in the sense that they are ignored by the harmony and have no effect whatsoever on its properties. The third and final topic is interaction with prosodic structure. Other kinds of harmony systems are very frequently sensitive to prosody (e.g., stress, foot structure, etc.). However, consonant harmony systems never interact with prosodic structure in any way; for example, they are never affected by

stress, syllable weight or segmental length, and are never limited to prosodically-defined domains such as the foot.

The consistent typological profile that emerges from this investigation forms an important justification for the phonological analysis, proposed in chapters 4 and 5, of consonant harmony as a (potentially) distinct phenomenon from other types of harmony. This is particularly true of the generalizations regarding directionality effects and opacity effects (or lack thereof), which fall out directly from the analysis developed in this work. The absence of prosody-sensitivity is also significant, and may perhaps shed light on the diachronic sources of consonant harmony vs. other types of harmony phenomena.

The structure of the chapter is as follows. Directionality effects are examined in section 3.1. Against the background of directionality patterns in other kinds of harmony systems (3.1.1), directionality in consonant harmony systems is examined both across morpheme boundaries (3.1.2) and within morphemes (3.1.3). Section 3.2 then turns to the issue of segmental opacity vs. transparency. Various kinds of opacity effects attested in other harmony types are briefly discussed (3.2.1). It is pointed out that in consonant harmony systems blocking effects are entirely unattested, with intervening segments being consistently transparent (3.2.2). A famous case which at first appears to be a counterexample to this claim, Sanskrit *n*-retroflexion, is also discussed in detail (3.2.3). Finally, section 3.3 addresses the question of how prosodic structure does or does not interact with harmony. A detailed overview is given of different types of prosody-sensitivity that are attested in vowel and vowel-consonant harmony systems (3.3.1). No such effects of prosody are attested in the typology of consonant harmony. Section 3.3.2 addresses the only potential counterexample to this claim, Yabem voicing harmony, and dismisses it as irrelevant in this context.

3.1. Directionality, dominance and stem control

The first aspect of consonant harmony systems that will be examined here is that of *directionality* effects. Harmony may in principle be enforced equally well in the form of perseveratory or progressive (left-to-right) assimilation as anticipatory or regressive (right-to-left) assimilation. The choice between the two might conceivably depend on a variety of factors, or it might need to be stipulated on a system-by-system basis. Although directionality issues have been discussed in the literature on other harmony systems, such as vowel harmony, nasal harmony, etc., previous studies of consonant harmony as a general phenomenon have not addressed this topic specifically.

In the following sections, the types of directionality patterns attested in other types of harmony systems are discussed very briefly (section 3.1.1). Sections 3.1.2 and 3.1.3 deal with directionality patterns in consonant harmony systems, the former in heteromorphemic contexts and the latter in morpheme-internal contexts. The striking generalization that emerges from the database surveyed here and in chapter 2 is that right-to-left is the default directionality for consonant harmony processes. Although left-to-right harmony is found as well, this can always be attributed to other factors, such that the directionality need not be stipulated in any way. The same kind of ‘reductionist’ explanation in terms of other independent factors cannot be applied to most instances of right-to-left harmony—these seem to be genuinely directional, with the directionality being an integral and inherent property in harmony itself. In subsequent chapters, this discovery is incorporated into the synchronic phonological analysis of consonant harmony (chapters 4 and 5), and parallels in the domain of speech planning and slips of the tongue are demonstrated (chapter 6).

3.1.1. Directionality patterns in other harmony systems

In a recent study of the typology of vowel harmony and its analysis, Baković (2000) puts forward the strong empirical claim that vowel harmony systems can only exhibit two

possible directionality patterns: *stem control* and *dominance*. In a stem-controlled harmony system, affixes yield to (i.e. harmonize with) the base or stem to which they attach. An alternative label for this type is *cyclic* harmony (which does not necessarily imply a serial derivation, cf. Orgun 1996). Harmony is enforced at successively larger domains—[root], [root+sfx1], [root+sfx1+sfx2], etc. The end result is a pattern of ‘inside-out’ directionality; in suffixation contexts, harmony will propagate from left to right, whereas in prefixation context it will go from right to left. In other words, a harmony system under *stem control* does not exhibit any independently stipulated directionality. Instead, directionality falls out from morphological constituent structure. In the analysis developed by Baković (2000) this is implemented by ranking Faithfulness to the base of affixation higher than general Faithfulness (which thus holds for the affixal material).

The second directionality pattern, that of dominance, involves one of the feature values being dominant (‘active’) and the other recessive (‘passive’). For example, [+ATR] vowels may be dominant and [-ATR] vowels recessive. Recessive vowels always yield to dominant vowels, regardless of their linear order or morphological affiliation. Thus, in a full-blown dominant system, where [+F] is dominant, both [+F]...[-F] and [-F]...[+F] will harmonize to [+F]...[+F], irrespective of which feature specification belongs to the root and which to the affix. Thus a dominant-recessive harmony system also does not exhibit any fixed and stipulated directionality. Instead, the directionality of assimilation is dependent on which feature value is the dominant one. On this particular point, Baković (2000) makes the further claim that it is always the less marked feature value which acts as dominant (‘Assimilation to the Unmarked’).

The main properties of these two attested types of vowel harmony systems are summarized in (1).

(1) Directionality patterns in vowel harmony systems (following Baković 2000)

a. *Stem control*

Affix vowels harmonize with stem vowels, regardless of the feature value involved, yielding ‘inside-out’ harmony.

Result:

Left-to-right harmony in [[stem]+suffix] contexts

Right-to-left harmony in [prefix+[stem]] contexts

b. *Dominance*

One feature value is ‘dominant’, the other ‘recessive’. Recessive vowels harmonize with dominant vowels, regardless of order or morphological constituency.

Result (if [+F] is dominant):

Left-to-right harmony in +F...-F contexts

Right-to-left harmony in -F...+F contexts

A corollary of the exhaustive dichotomy proposed by Baković is the complete absence of vowel harmony systems with any kind of fixed (i.e. stipulated) directionality. Apparent cases of uniform directionality are explained as instances of stem control. Whether this strong claim about directionality in vowel harmony systems is borne out by the facts has yet to be seen, and this issue will not be addressed here. The important thing to note in the present context is that vowel harmony may apply in a left-to-right and/or right-to-left fashion, depending on various factors. If anything, progressive vowel harmony appears to be more common cross-linguistically than regressive vowel harmony, but this may well be due to the fact that suffixation is far more common than prefixation.

In the domain of vowel-consonant harmony, i.e. such phenomena as nasal harmony or pharyngealization (a.k.a. emphasis) harmony, both left-to-right and right-to-left directionality are attested. In a large number of such cases, it does not appear that the

observed directionality can be explained away in terms of stem control (and certainly not dominance). The typical state of affairs in such systems is that the property in question (e.g., [+nasal] or [+RTR]) spreads leftwards and/or rightwards until it either reaches the edge of the relevant domain or encounters an opaque segment which blocks the further propagation of harmony in that direction.

For example, left-to-right nasal harmony is found in a large number of Austronesian languages. The harmony triggers are usually full nasals like /m/, /n/, etc., but individual languages differ in which types of intervening consonants are opaque to harmony. The examples in (2) are from the Johore dialect of Malay (Onn 1980; cited via Walker 1998[2000]). In Johore Malay, nasalization affects vowels, glides and glottals (which are here transcribed as phonetically nasalized, following Walker 1998[2000]), but liquids and obstruents block the spreading of the [+nasal] feature. The span of nasalization is indicated with underlining, and triggering nasals are in boldface.

(2) Left-to-right nasal harmony in Johore Malay (data cited from Walker 1998[2000])

<u>mā̃jā̃ŋ</u>	‘stalk (palm)’
<u>mā̃ʔā̃p</u>	‘pardon’
<u>mā̃kan</u>	‘to eat’
pəŋ <u>ā̃wā̃san</u>	‘supervision’
pəŋ <u>ā̃hā̃n</u>	‘central focus’

In Malay, harmony thus propagates leftwards from any nasal plosive, regardless of where the nasal is located in the word. The reverse directionality is found in a number of West African languages, such as those of the Kwa group. Examples from the Kolokuma dialect of Ijo (Williamson 1965, 1987; cited via Walker 1998[2000]) are shown in (3). In this language, harmony is triggered either by a nasal plosive (as in Malay above) or by a nasal-

ized vowel. Nasalization spreads leftward to vowels, glides and liquids, but is blocked by obstruents. With respect to nasal harmony, [n] acts as the nasalized counterpart of [l].

(3) Right-to-left nasal harmony in Kolokuma Ijo (data cited from Walker 1998[2000])

<u>w</u> āĩ	‘prepare sugarcane’
ǰāĩ	‘shake’
sōĩ	‘five’
tōĩ	‘light (a lamp)’
sānlo	‘gills’
ũmba	‘breath’

Walker (1998[2000]) contains a wealth of examples of nasal harmony, with references to descriptive sources. In some of these nasalization spreads in a left-to-right fashion, as in Malay, whereas in others the directionality is right-to-left, as in Ijo. There are also cases where nasalization spreads in both directions from the relevant segment types (e.g., Seneca, Urdu, Cayuvava). In light of the generalizations that will be made about directionality in consonant harmony systems in the following sections, it is interesting to note that, in the database which Walker (1998[2000]) reports on, *left-to-right* spreading appears to be considerably more common than right-to-left spreading.

Pharyngealization or ‘emphasis’ harmony also typically involves directional spreading. It is frequently bidirectional, but often leftward and rightward spreading differ somewhat in their extent and susceptibility to blocking effects. Only a few examples will be mentioned here, all of them from Middle Eastern languages discussed by Hoberman (1989).¹ In Palestinian Arabic (see also Shahin 1997), emphasis spreads both leftwards and

¹ Pharyngealization/uvularization spreading of a similar kind also exists in Interior Salish languages (see, e.g., Bessell 1992, 1997, 1998; Shahin 1997). The individual languages differ in the directionality of spreading, some showing regressive harmony, some progressive harmony, and some both. For example, the

rightwards from an underlyingly pharyngealized consonant; in each direction, spreading is blocked by /i, j, ʃ/. In Cairene Arabic, on the other hand, rightward spreading is more limited than leftward spreading. The latter is unbounded, affecting any and all preceding segments up until the beginning of the word. Rightward spreading, by contrast, is triggered only by a *closed* emphatic syllable, and only targets a following *low-vowel* syllable. Thus, for example, /Saahib-ak/ ‘your (m.) friend’ → [SAH.BAK], but /Saahib-ik/ ‘your (f.) friend’ → [SAH.bik], where capitalization indicates emphasis (following Hoberman 1989:83). In yet another case discussed by Hoberman (1989), the modern Aramaic dialect of the Jews of Iranian Azerbaijan, emphasis harmony appears to be exclusively left-to-right. In this harmony system, words may be either fully emphatic, fully non-emphatic, or mixed. In the mixed case, a word must consist of one or more non-emphatic syllables, followed by one or more emphatic syllables. In other words, the sequence [-RTR][+RTR] is allowed, whereas *[+RTR][-RTR] is not. This is consistent with an interpretation that [+RTR] spreading is left-to-right and unbounded; any *[+RTR][-RTR] sequence would thus harmonize to [+RTR][+RTR].

This concludes the brief overview of the kinds of directionality patterns that are attested in other types of harmony systems. The concepts of stem control and dominance were introduced, which will be of importance in the subsequent sections. It was shown that whereas the existence of truly directional vowel harmony systems is somewhat controversial, vowel-consonant harmony frequently displays fixed directionality. This may take the form of either leftward or rightward spreading, or sometimes a combination of both, though the two directionalities may differ slightly in their application.

easternmost languages have a ‘faucal harmony’ which is an unbounded harmony with strictly right-to-left directionality (see Bessell 1998).

3.1.2. Stem-control vs. absolute directionality in consonant harmony

Turning now to directionality effects in consonant harmony systems, the first thing to note is that truly dominant-recessive systems do not appear to exist. A system of this type would involve a particular feature value [α F] triggering harmony both leftwards and rightwards, regardless of what kind of morpheme is ‘sponsoring’ the [α F] specification (a root or an affix). Morphemes specified with the recessive value [- α F] would always yield to the dominant [α F] morphemes. This does not appear to be attested in consonant harmony, at least not as it applies in heteromorphemic contexts (see 3.1.3 for some dominance-like patterns in morpheme-internal consonant harmony). However, the absence of truly dominant-recessive consonant harmony systems is less striking once we consider the fact that even among vowel harmony systems, dominance is rare. In fact, dominant-recessive systems appear to be attested only for tongue-root vowel harmony.

The other major type that Baković (2000) recognizes for vowel harmony systems, stem control, is robustly attested in consonant harmony as well. For example, in suffixation contexts harmony frequently results in a suffix consonant assimilating to a consonant in the preceding stem. The latter may either be in the root itself or in an ‘inner’ suffix. The application of harmony is thus ‘inside-out’. A case in point is the sibilant harmony found in numerous Omotic languages, such as Koyra (Hayward 1982). Some representative forms are shown in (4), repeated from 2.4.1.1 above. Note that here and in subsequent examples, the root/stem is indicated in boldface.

- (4) Stem-controlled sibilant harmony in Koyra (data from Hayward 1982)
- | | | | |
|------------------|---|----------------|---------------------------------|
| /ʃaj-(u)s-/ | → | [ʃaj-ʃ-] | ‘cause to urinate’ |
| /go:tʃ-(u)s-/ | → | [go:tʃ-uʃ-] | ‘cause to pull’ |
| /ʔordʒ-(u)ʃ-/ | → | [ʔordʒ-uʃ-] | ‘make big, increase (tr.)’ |
| /ʔordʒ-os:o/ | → | [ʔordʒ-oʃ:o] | ‘he/they got big’ |
| /dʒaʃ-(u)s-es:e/ | → | [dʒaʃ-uʃ-eʃ:e] | ‘let him/them frighten (s.o.)!’ |

In the first three examples, the /s/ of the causative suffix /-(u)s/ assimilates in [±anterior] to a sibilant in the immediately preceding verb root. The same is true of the geminate /s:/ of the 3SgMasc perfective ending /-os:o/ in the fourth example. Finally, the last example shows that this ‘inside-out’ harmony is recursive: The causative suffix /-(u)s/ harmonizes with the preceding stem (= root) /dʒaʃ-/ , giving rise to /dʒaʃ-uʃ-/; this in turn triggers harmony in the 3SgMasc jussive ending /-es:e/, yielding [dʒaʃ-uʃ-eʃ:e] as the resulting surface form.²

Stem control is also attested in prefixation contexts, where prefixes harmonize with the following stem (which, again, may itself be morphologically complex). This is the case in the sibilant harmony and dorsal consonant harmony found in Totonacan languages, such as Misantla Totonac (MacKay 1999) or Tlachichilco Tepehua (Watters 1988). This is illustrated in (5) with examples of dorsal consonant harmony from the latter; the data is repeated from section 2.4.2 above. In Misantla Totonac, harmony applies only to derivational prefixes, not inflectional ones. (This is true of both dorsal and sibilant harmony, according to MacKay 1999.) Note that suffixation is involved as well; it is unclear to me whether suffixes ever contain the kinds of consonants which would be potential targets for the harmony (/k/ or /k’/).

² Recall from 2.4.1.1 that sibilant harmony in Koyra (unlike that of some related languages) is strictly transvocalic, and thus does not apply when the trigger and target are separated by an intervening syllable. This entails that the /s:/ of /-es:e/ is harmonizing with the [ʃ] of the preceding causative suffix, *not* directly with the [ʃ] (or [dʒ]) of the root /dʒaʃ-/.

(5) Stem-controlled dorsal consonant harmony in Misantla Totonac (MacKay 1999)

a. Harmony in derivational prefixes:

- /min-kə:k-**paqəʔ**/ → mɪN-qá:q-paχéʔ ‘your shoulder’
/ut maka-**ʃqat**/ → ʔút maqá-ʃqét ‘s/he scratches X (with hand)’
/maka-**tuqwan**-la(ʔ)/ → maqa-ʔɔqwa-ʔ ‘s/he tired X’

b. No harmony in inflectional prefixes:

- /kin-**squ**-jan-ni-la(ʔ)/ → kí-sqə-jú-ni-ʔ ‘s/he smokes X for me’
/ik-lak-**tsəqə**/ → ʔík-láq-tsəqə ‘I chew X’

In (5a) the root induces harmony on a derivational (body-part or valence-changing) prefix. The forms in (5b) illustrate the fact that inflectional prefixes such as 1Obj /kin-/ or 1Subj /ik-/ are outside the scope of harmony. In the last example, we see harmony affecting the derivational prefix /lak-/ but not the inflectional prefix /ik-/.

The clearest cases of stem control are those where harmony affects prefixes and suffixes alike, resulting in bidirectional harmony ‘outwards’ from the root. An example of this is obstruent voicing harmony in the Chadic language Kera, which was discussed in 2.4.7 above. Some representative examples are repeated in (6).

(6) Stem-controlled voicing harmony in Kera (data from Ebert 1979)

- a. /k-**dàarə**/ → gə-dàarə ‘friend’
/k-**dàjgá**-w/ → gə-dàjgá-w ‘jug (plur.)’
b. /**dzàr**-ká/ → dzàr-gá ‘colorful (fem.)’
c. /k-**dzàr**-káŋ/ → gə-dzàr-gáŋ ‘colorful (coll.)’
/k-**dzír**-kí/ → gi-dzír-gí ‘colorful (masc.)’

In (6a), voicing harmony affects the nominal prefix /k-/ , whereas in (6b) it reaches the feminine suffix /-ká/. Finally, examples such as the ones in (6c) clearly indicate the bidirectionality of this stem-controlled harmony, in that both the /k-/ prefix and suffixes like /-káŋ/ (collective) and /-kí/ (masculine) are simultaneously affected.

It appears that *all* apparent cases of left-to-right (i.e. progressive) consonant harmony can in fact be reduced to stem control.³ The table in (7) lists all languages with left-to-right harmony (in heteromorphemic contexts) in the database surveyed in this study. For convenience they are grouped according to the property involved, following the categorization used in chapter 2 above.

(7) Consonant harmony systems with left-to-right directionality

Coronal (sibilant) harmony

Aari (Omotic), Koyra (Omotic), Gimira (Omotic), Zayse (Omotic), Rumsen (Costanoan), Izere (Bantu), ?Wanka Quechua (Quechuan)

Coronal (nonsibilant) harmony

Mayak (Nilotic), ?Päri (Nilotic)

Liquid harmony

Bukusu (Bantu), Sundanese (Austronesian), Basaa (Bantu), Pare (Bantu), ?Mwiini (Bantu)

Nasal consonant harmony

Bemba (Bantu), Lamba (Bantu), Luba (Bantu), Ndonga (Bantu), Tonga (Bantu), Herero (Bantu), Ila (Bantu), Kwanyama (Bantu), Suku (Bantu), Kongo (Bantu), Yaka (Bantu), KiMbundu (Bantu), Teke (language cluster; Bantu), Tiene (Bantu)

Laryngeal harmony

Kera (Chadic)

³ At least, this is the case for consonant harmony applying in *heteromorphemic* contexts. For directionality effects morpheme-internally, see the following section.

Stricture harmony

?Pare (Bantu)

Some of the languages in (7) involve *infixes* rather than suffixes, where harmony applies left-to-right from the preceding part of the stem to the infix. This is the case in Izere sibilant harmony and Sundanese liquid harmony (see 4.3.3 below for detailed discussion of the latter). A third system involving infixation is Tiene nasal consonant harmony, which actually combines infixation with suffixation (the choice between the two is driven by templatic considerations, cf. 2.4.4 above). In suffixation contexts, harmony in Tiene applies from root to suffix, just as in the other cases listed in (7) above; cf. [sɔn-ɔ] ‘write’ but [sɔn-ɔŋ-ɔ] ‘be written’ (with stative suffix /-(V)k/ → [(ɔ)ŋ]). In infixation contexts, on the other hand, the *denasalizing* version of the harmony applies left-to-right *from infix to stem*; cf. [tóm-a] ‘send’ but [tó=se=b-ɛ] ‘cause to send’ (with causative infix /-s(V)-/, triggering /m/ → [b] in the root /tóm-/). This cannot be attributed to stem-control, since the directionality is from affix to stem.⁴ However, Tiene is the only exception I have been able to find to the generalization that, in heteromorphemic contexts, left-to-right consonant harmony can *always* be attributed to stem control.⁵

Anticipatory consonant harmony, where the assimilation applies in a right-to-left fashion, cannot be reduced to stem control effects in the same way. True, there are individual cases which display right-to-left directionality and for which stem control is a plausible analysis. The sibilant and dorsal consonant harmonies of the Totonacan languages

⁴ When applicative /-l-/ is infixed, it undergoes harmony triggered by a root-final nasal; the directionality in that particular situation is simultaneously right-to-left and stem-to-affix and as such poses no problems. See section 4.3.3 below for further discussion of the Tiene case and its implications.

⁵ Another possible counterexample is sibilant harmony in Terafene Flemish (Willem de Reuse, pers. comm.), which applies from left to right in compounds like /kəlɪʃə/ ‘liquorice’ + /zɑp/ ‘juice’ to yield [kəlɪʃə-zɑp] ‘liquorice juice’, as well as morpheme-internally ([zəʔzɛp] ‘Josep’, etc.). The data currently available to me on this particular case are too limited to allow anything conclusive to be said about it. However, it is also conceivable that we are here dealing with a ‘dominant-recessive’ system of sorts, since it appears that the trigger is always a [-anterior] sibilant and the target a [+anterior] one. This is completely in line with the ‘Palatal Bias’ effects discussed in detail in chapter 6.

mentioned above are a case in point, and Kera voicing harmony even more conclusively so. The consonant harmony systems (typically involving sibilants) of a great number of Athapaskan languages might also fall in this category, although this is less clear (see below).

But there is a considerable number of consonant harmony cases that exhibit right-to-left directionality which goes *against* what the morphological structure dictates. In these cases, suffixes induce harmony in a preceding stem—whether the target consonant be in the root itself, or in some ‘inner’ suffix that is part of the base to which the triggering suffix attaches. Perhaps the most striking system of this type is the sibilant harmony found in numerous Chumashan languages, including Ineseño, Barbareño and Ventureño, which were mentioned in section 2.4.1.1 above. Some relevant examples from Ineseño are repeated in (8); again, root morphemes are indicated in boldface.⁶ The examples in (8a) show prefixes assimilating to the following root (causative /su-/, 3Subj /s-/). In (8b), we see that a prefix also assimilates to a suffix (past /-waf/), across the intervening root. Finally, forms such as the ones in (8c) clearly show the absolute directionality; suffixes like 3Obj /-us/ and past /-waf/ trigger harmony on any and all preceding morphemes, be they other suffixes, stem morphemes, or prefixes.

(8) Absolute right-to-left directionality in Ineseño sibilant harmony (Applegate 1972):

- | | | | | |
|----|---|---|---------------------------------|--------------------------------|
| a. | /k-su- fojin / | → | k-ʃu-fojin | ‘I darken it’ |
| | /s- api-tʃ^ho -it/ | → | ʃ-api-tʃ ^h ol-it | ‘I have a stroke of good luck’ |
| b. | /ha-s- xintila -waf/ | → | ha-ʃ-xintila-waf | ‘his former Indian name’ |
| c. | /s- api-tʃ^ho -us/ | → | s-api-ts ^h ol-us | ‘he has a stroke of good luck’ |
| | /s- api-tʃ^ho -us-waf/ | → | ʃ-api-tʃ ^h ol-uf-waf | ‘he had a stroke of good luck’ |
| | /s-iʃ- tʃi -jep-us/ | → | s-is-tisi-jep-us | ‘they (2) show him’ |

⁶ Some of the examples have a compound stem, consisting of /api/ ‘quick’ + /tʃ^ho/ ‘good’.

It is interesting to contrast Ineseño sibilant harmony and Kera voicing harmony, cf. (6) above. In both cases prefixes, roots and suffixes are all within the scope of harmony, but whereas Kera has ‘inside-out’ harmony (from root to prefixes/suffixes), Ineseño shows a fixed right-to-left directionality which is blind to morphological structure.

Another clear example of absolute right-to-left directionality is the sibilant harmony found in some Lacustrine Bantu languages, such as Rundi and Rwanda. This is illustrated in (9) for Rwanda.

(9) Absolute right-to-left sibilant harmony in Rwanda (data from Kimenyi 1979):

- a. /ba-ra-**sa:z**-je/ → ba-ra-ʃa:ʒ-e ‘they are old’
 /a-**sa**s-je/ → a-ʃaʃ-e ‘he just made the bed’
 /a-**soko**z-je/ → a-ʃokoʒ-e ‘he just combed’
- b. /ku-**sa**s-i:ʃ-a/ → gu-ʃaʃ-i:ʃ-a ‘to cause to make the bed’
 /ku-**sa:z**-i:ʃ-a/ → gu-ʃa:ʒ-i:ʃ-a ‘to cause to get old’
 /ku-**uz**uz-i:ʃ-a/ → k-u:ʒuʒ-i:ʃ-a ‘to cause to fill’

The examples in (9a) show that harmony operates from right to left *within* the root, when a root-final /s, z/ becomes [ʃ, ʒ] by fusion with a following glide /j/ (in this case belonging to the perfective suffix /-je/). Forms like the ones in (9b) show that suffixes such as causative /-i:ʃ/ also trigger harmony in the preceding root, just as in the Ineseño case discussed above.

Related languages occasionally differ in terms of the directionality of harmony, with one language exhibiting stem control and another absolute right-to-left directionality. For example, nasal consonant harmony in Bantu languages is stem-controlled in the vast majority of cases. A suffix /l/ (or /d/) will harmonize with a nasal in the preceding root, or a preceding (and thus ‘inner’) suffix. However, there is at least one language where the effect goes in the exact opposite direction: Pangwa (Stirnemann 1983). In this language, the nasal

of the reciprocal suffix /-an/ triggers harmony in a preceding stem-final velar /x/; thus, e.g., /pulix-an-/ → [puliŋ-an-] ‘listen to each other’ (cf. /pulix-/ ‘listen to’).

Aside from clear-cut examples like Ineseño and Rwanda, there is a large number of indeterminate cases that may well involve absolute right-to-left directionality. These are cases where the observed directionality is always right-to-left, but where harmony can only be seen in prefixation contexts, such that they *could* be attributed to stem control. The consonant harmonies of some Totonacan languages discussed above are an example of this, where stem control is a plausible explanation. Other ambiguous cases include Berber (coronal harmony, voicing harmony), Kera (coronal harmony), Tzeltal (coronal harmony), Tzotzil (coronal harmony) and Yabem (stricture harmony).

The most important group of languages that displays right-to-left directionality in prefixing contexts is Athapaskan, where consonant harmony of various kinds involving coronals is found (including sibilant *pharyngealization* harmony in Chilcotin, cf. section 2.4.3 above). Most, if not all, of the Athapaskan consonant harmony systems are cognate with each other diachronically, although as a set they do show a significant range of variation in terms of their synchronic properties.

With very few exceptions (and most of them irrelevant for the harmony in question), Athapaskan morphology is exclusively prefixing. This is most striking in the case of verbs, which have a highly elaborate structure where the ‘stem’ (≈ root) may be preceded by a long string of prefixes—inflectional, derivational, and lexical—in an order which frequently goes against the usual ‘derivation-inside-inflection’ pattern. (See Rice 2000 for a radically different view of Athapaskan affix ordering, as well as for references to other works on this topic.)

With respect to directionality, the pan-Athapaskan pattern is quite uniform. With hardly any exceptions, harmony applies in a right-to-left fashion, with roots triggering harmony in prefixes, and prefixes in turn triggering harmony in earlier prefixes. Because of

the prefixing character of the morphology, it is not straightforward to determine if this right-to-left directionality is *absolute* (as in Ineseño or Rwanda), or whether it simply falls out from stem control. Enclitics are never affected, but this may well be an effect of a morphological restriction, rather than being evidence for absolute right-to-left directionality; significantly, enclitics also do not *trigger* harmony (cf. Sapir & Hoijer 1967:16). There are independent reasons to believe that Athapaskan consonant harmony is limited to a particular morphological domain, in that prefixes in the so-called ‘disjunct’ (i.e. outer) domain are typically not affected, whereas prefixes in the ‘conjunct’ (inner) domain are.

Consonant harmony of the Athapaskan type is illustrated in (10), using Sarcee as an example (Cook 1979, 1984). In this language, a [-anterior] sibilant (/ʃ/, /ʒ/, /tʃ/, /tʃʰ/ or /dʒ/) triggers harmony in a preceding [+anterior] sibilant (/s/, /z/, /ts/, /tsʰ/ or /dz/).⁷ In the first three examples in (10), the harmony trigger is a consonant within the verb stem. In the last example, the triggering [ʃ] is the result of fusion of the valence prefix /s-/ with the root-initial glide /j/.

(10) Sibilant harmony in Sarcee (data from Cook 1979, 1984)

/si- tʃ iz-aʔ/	→	[ʃi-tʃidz-àʔ]	‘my duck’
/si- tʃ ogo/	→	[ʃi-tʃógò]	‘my flank’
/na-s- y atʃ/	→	[nā-ʃ-yátʃ]	‘I killed them again’
/sa-tsʰi-gu-si-ni-s- j áj/	→	[ʃá-tʃʰi-gù-ʃi-ʃáj]	‘you forgot me’

The first two examples in (10) are possessed forms of nouns, where the 1SgPoss prefix /si-/ undergoes harmony to [ʃi-] under the influence of a /tʃ/ in the following noun stem. In the third example, the 1SgSubj marker /s-/ harmonizes with the following verb stem in the same way. In the fourth example, the incorporated postpositional phrase /sá-/ , the deictic

⁷ Certain tokens of the palatal glide /j/ also trigger this harmony; see Cook (1978, 1979) for discussion.

subject marker /ts'i-/ and the perfective marker /si-/ all undergo harmony. In all cases in (10), the right-to-left directionality could either be taken at face value (i.e. as absolute) or attributed to stem control.

The same directionality pattern obtains in the other Athapaskan languages in the database surveyed here, such as Chiricahua Apache, Beaver, Kiowa-Apache, Slave, Tahltan, Tanana and Tsilhqot'in (Chilcotin). In the best-studied case of consonant harmony in Athapaskan, that of Navajo sibilant harmony, there are certain wrinkles in the general pattern that may shed light on the nature of the directionality in Athapaskan consonant harmony in general.

In most cases, the directionality of Navajo sibilant harmony follows the same basic pattern as the Sarcee case in (10) above. Stem sibilants trigger harmony in prefix sibilants, and prefix sibilants in turn trigger harmony on earlier prefix sibilants. The examples in (11) illustrate this simple pattern; as before, the 'stem' (\approx root) is indicated in boldface.

(11) Right-to-left sibilant harmony in Navajo (data cited from McDonough 1991)

- | | | | | |
|----|------------------------|---|-------------|-----------------------------------|
| a. | /dʒ-i-z- dá / | → | [dzizdá] | 'he sat down' |
| | /dz-iʃ- ha:l / | → | [dʒiʃha:l] | 'I tumble into the water' (impf.) |
| b. | /si- dʒé:ʔ / | → | [ʃidʒé:ʔ] | 'they (s.s.o.) lie' ⁸ |
| | /dz-iʃ- ts'in / | → | [dzists'in] | 'I hit him below [the belt]' |

In the forms in (11a), a later prefix (perfective /i)z-/, 1SgSubj /i)ʃ-/) triggers harmony in an earlier prefix ('4th person' /dʒ-/, adverbial /dz-/'away from'). In (11b), the triggering sibilant is in the root, affecting any and all preceding prefix sibilants.

However, as has been noted by several works on the morphology and phonology of Navajo (e.g., Kari 1976; Young & Morgan 1992; McDonough 1991), there are cases where

⁸ In the gloss of this example, 's.s.o.' stands for 'slender stiff object(s)'.

harmony applies *from left to right* within the prefix string. The first of these involves the conjugation (or ‘mode’) marker /s(i)-/ and its interaction with an immediately following subject marker. The /s(i)-/ prefix defines paradigms which typically are perfective (the ‘s-perfective’ in Athapaskanist terminology), but it also occurs in imperfective paradigms based on certain verb stems. Synchronically speaking, the conjugation marker may in fact no longer be a separate morpheme in its own right. For example, the analysis of Navajo verb morphology developed by McDonough (1990, 1991) treats the combination of conjugation/mode prefix with a following (1st or 2nd person) subject marker as an indivisible unit, the Inflectional Stem. Although this analysis may well be appropriate synchronically, it is nevertheless the case that *diachronically* the ‘Inflectional Stem’ consists of two separate morphemes. The facts which will be presented should be understood in this light.

The combinations of the /s(i)-/ prefix with subject prefixes in perfective paradigms in Navajo are shown in (12), based on the presentation in Faltz (1998). Note that the parenthetic morpheme boundary indicates the separation between conjugation marker and subject prefix (if any); as explained above, this boundary is probably a *historical* fact rather than a synchronic reality. In any case, the precise location of the boundary should be taken with a grain of salt (and is not important in this context).

(12) Navajo: Subject prefix paradigm for ‘s-perfectives’ (Faltz 1998:74)⁹

	<i>Sing.</i>	<i>Plur.</i>
<i>1st</i>	s(-)is-	s(-)i:d-
<i>2nd</i>	sí(-)ní-	s-o:h
<i>3rd</i>	s-(Ø-)	s-(Ø-)

⁹ To be accurate, the prefix shapes in (12) are those which are used specifically with verb stems that carry a /d-/ or /l-/ ‘classifier’ (i.e. valence) prefix. The paradigm used for verb stems with no classifier, or a /t-/ classifier, differs slightly from the one in (12), but this is irrelevant in the present context.

What is notable about the prefix paradigm in (12) is the 1Sg prefix combination. In other contexts, the 1SgSubj marker contains /ʃ/ (as does the 1Sg possessive prefix on nouns). It thus appears that in the combination of the conjugation marker /s(i)-/ with the 1SgSubj prefix /(i)ʃ-/, the resulting string /s-iʃ-/ undergoes *left-to-right* harmony to [sis-] rather than the expected right-to-left harmony (*[iʃ-]).

Interestingly, this reversed directionality is found only in the cases where the /s(i)-/ prefix defines a *perfective* paradigm. In *imperfective* paradigms that make use of this prefix (these are relatively few in number), harmony applies in the expected way. This is shown in (13), again based on the exposition in Faltz (1998).

(13) Navajo: Subject prefix paradigm for ‘s-imperfectives’ (Faltz 1998:383)

	<i>Sing.</i>	<i>Plur.</i>
<i>1st</i>	ʃ(-)iʃ-	s(-)i:d-
<i>2nd</i>	s(-)i-	s(-)oh-
<i>3rd</i>	s-(Ø-)	s-(Ø-)

Note that in the paradigm in (13), it is the 1SgSubj prefix /(i)ʃ-/ which triggers harmony on the preceding conjugation marker /s(i)-/, unlike what happens in the perfective paradigm in (12) above. The directionality of the assimilation in (13) is thus consistent with the general right-to-left directionality of Navajo sibilant harmony.

Note that McDonough (1990, 1991) analyzes the prefix combinations in (12)-(13) as indivisible wholes, i.e. as alternate realizations of an inflectional stem rather than combinations of a conjugation/mode prefix with a subject prefix. The inflectional stem is treated as a single morph without internal structure, and this entails that the sibilant harmony seen in the 1SgSubj slot in each of the two paradigms is equivalent to *morpheme-internal* consonant harmony. On this account, the difference between the two 1SgSubj morphs /sis/

(perfective) and /ʃiʃ/ (imperfective) is essentially random, equivalent to the difference between two verb roots differing only in /s/ vs. /ʃ/. The diachronic fact that the distinct phonological shape of the two is due to different directionality of sibilant harmony is lost in this synchronic analysis.

The same is not true of the other prefix that triggers left-to-right harmony in Navajo. Incidentally, this prefix also has the shape /s(i)-/, and is used in verbs of killing (with a singular object). This prefix, referred to as the ‘s-destruct’ by McDonough (1991), occurs in roughly the same linear position in the prefix string as the conjugation marker /s(i)-/ discussed earlier.¹⁰ Just like the latter, the ‘s-destruct’ prefix is typically followed directly by the subject prefixes. When it is followed by the 1SgSubj prefix /(i)ʃ-/, as in the examples in (14), this /s(i)-/ prefix can be seen to trigger progressive harmony.

(14) Navajo: Left-to-right sibilant harmony with ‘s-destruct’ prefix (McDonough 1991)

/s-iʃ-ł-jé/	→	sixé	‘I’m killing it (impf.)’
/s-iʃ-dlí/	→	sisdlí	‘I froze to death (perf.)’

In both the s-perfective and the s-destruct cases, the /ʃ/ of the 1SgSubj prefix harmonizes with a preceding prefix. In the McDonough’s (1991) analysis, the s-destruct prefix *is* a separate morpheme, unlike the s-perfective. Her proposal is to mark this particular morpheme diacritically as ‘reversing the direction of the spread’ (of [\pm anterior] values).

Before dealing with the implications of the Navajo facts for the typology of directionality effects in consonant harmony systems, it is worth pointing out one more detail. Harmony from the verb root *overrides* the left-to-right harmony effects found in the s-perfective and s-destruct paradigms. This is illustrated by the s-perfective form in (15).

¹⁰ Young & Morgan (1992) interpret this /si-/ prefix as being in ‘position VI’, along with various adverbial prefixes, rather than ‘position VII’ which hosts the conjugation/mode prefixes. However, it is unclear to me whether this is based on any evidence other than the semantics and morphological function of the two.

For the sake of illustration, the underlying representation given in (15) presupposes that the conjugation marker /s(i)-/ and 1SgSubj /(i)ʃ-/ are in fact separate prefixes.

(15) Navajo: Harmony with root overrides left-to-right effects (McDonough 1991)

/s-iʃ-l-ʒe:ʔ/ → ʃiʃʒe:ʔ (no gloss)

The fact is thus that Navajo displays left-to-right harmony (albeit to a very limited degree) from what appears to be an ‘outer’ prefix to an ‘inner’ prefix. This seems to contradict the generalization stated earlier in this section, that left-to-right directionality in consonant harmony systems can always be reduced to an effect of stem control.

However, things are not as simple as they seem at first glance. Note that in both the s-perfective and s-destruct cases, the triggering prefix is an aspectual or adverbial one. As such, this prefix defines an entire inflectional (sub)paradigm, with individual slots in that paradigm characterized by particular person/number specifications for the subject (and sometimes the object as well). The targeted prefix, on the other hand, is a subject agreement marker, i.e. the kind of prefix that defines a single *slot* in such a paradigm (or, rather, in a series of parallel paradigms: perfective, imperfective, etc.). In most languages, affixes of the former type tend to occur *inside* of affixes of the latter type; in this respect, Athapaskan languages are somewhat unique.

What is more, the morphology of Athapaskan shows various dependency effects that may be relevant in this context. For example, the choice of perfective paradigm (s-perfective being one of the options) is to a great extent *lexically* determined, i.e. based on the particular lexical entry involved. Furthermore, the realization of the subject agreement prefixes can depend on the particular *paradigm* involved. For example, 1SgSubj is generally marked with /(i)ʃ-/ , but for verbs of a particular type the s-perfective paradigm (and certain other paradigms as well) uses the alternative allomorph /é-/ , yielding /s-é-/

rather than the /s-ij-/ (\rightarrow [sis-]) shown in (12) above. In other words, allomorph selection for subject prefixes is sometimes dependent on conjugation markers. By contrast, subject prefixes never condition allomorph selection in conjugation markers.

For reasons such as these, it is not altogether clear that the subject prefixes should be considered to be ‘inside’ the conjugation markers (and aspectual prefixes like the *s-*destruct), in spite of what the linear order appears to tell us. It seems reasonable to interpret the directionality from conjugation marker to subject agreement marker as being ‘inside-out’—from the point of view of stem control—in the sense that more lexicalized affixes are ‘closer’ to the root (morphosemantically) than purely inflectional ones. Interestingly, the radical reanalysis of Athapaskan verb morphology developed by Rice (2000) takes the entire (conjunct) prefix domain to be a *left-branching* structure, i.e. [[[x]y]z]...], where earlier prefixes are thus ‘inside’ later ones. If this analysis is correct—even if only with respect to conjugation/mode markers vs. subject agreement markers—then the left-to-right directionality observed in (12) and (14) is due to stem control. On this interpretation, the Navajo case is not a counterexample to the generalization that left-to-right directionality is always attributable to stem control. This furthermore entails that the prevailing right-to-left harmony observed elsewhere in Navajo—as well as in other Athapaskan languages, such as the Sarcee case in (10) above—is a matter not of stem control (as the prefixation morphology may lead us to believe), but of *absolute* right-to-left directionality. In this respect, consonant harmony in Athapaskan languages is more like that of Ineseño in (8) or Rwanda in (9) above.

To sum up, consonant harmony in heteromorphemic contexts seems to display only two fundamental directionality patterns. One is stem control, whereby affixes harmonize with the base to which they attach. This can give rise either to right-to-left harmony (in prefixation contexts) or to left-to right harmony (in suffixation contexts), or a combination of both (i.e. ‘bidirectional’ harmony) in those cases where prefixes and suffixes are both

within the domain in which harmony holds. The other type is fixed directionality, which is insensitive to morphological structure. In this case, harmony applies in a right-to-left fashion, i.e. as *anticipatory* assimilation. There are no cases of fixed directionality involving progressive (left-to-right) assimilation. Put somewhat differently, a suffix may affect the stem it attaches to, or it may be affected by that stem; a prefix, on the other hand, may be affected by the stem it attaches to, but it may *not* affect that stem. In other words, progressive harmony never goes against what the morphological structure dictates, but anticipatory harmony frequently does.

In this sense, right-to-left appears to be the default directionality for consonant harmony processes. It is the directionality that holds when other things are equal. By contrast, left-to-right directionality may occur, but only as a result of other things *not* being equal, i.e. when harmony is governed by morphological constituent structure. The following section shows that morpheme-internally, where such constituent structure is absent, the default nature of right-to-left harmony can also be observed.

3.1.3. Directionality effects and morpheme-internal consonant harmony

In a large number of languages in the database surveyed in chapter 2, consonant harmony is solely manifested as a morpheme-internal cooccurrence restriction. In most such cases, the harmony pattern is a static one, and little can be inferred about any kind of directionality effects. However, even in such systems it is occasionally possible to see harmony ‘in action’, as it were. One source of evidence is comparative-historical, where the earlier disharmonic stage is documented or can be reconstructed based on comparison with closely related dialects or languages. Furthermore, morpheme-internal consonant harmony is frequently fed by independent phonologically or morphologically induced alternations. Incidentally, this is not confined to systems where harmony is limited to the root. In the

Rwanda examples in (9a), for example, the fusion of root-final /s, z/ with suffixal /j/, yielding [ʃ, ʒ], triggers harmony in an earlier root sibilant.

If right-to-left is the default directionality of consonant harmony, as argued in the preceding section, then we would expect morpheme-internal contexts (where the confounding factor of stem control is inapplicable) to display *exclusively* right-to-left harmony. As I will attempt to show in this section, this prediction is indeed borne out (with certain qualifications).

A case where the directionality is mostly evident from comparative data is sibilant harmony in the Mayan language Ixil (Ayres 1991). Here harmony is only found in the Nebaj dialect, and cognate disharmonic forms in the neighboring Chajul dialect attest to the fact that Nebaj harmony obeys right-to-left directionality, as in (16a). Furthermore, even within Nebaj, harmony is to some extent optional. As a result, harmonic and disharmonic versions of the same forms can be compared, as in (16b); these too attest to the right-to-left directionality of Nebaj Ixil sibilant harmony.¹¹

(16) Right-to-left sibilant harmony in Ixil (data from Ayres 1991)

a. Dialect differences (Nebaj vs. Chajul dialects):

<i>Nebaj</i>	<i>Chajul</i>	
tʃitʃam	tʃitʃam	‘coach, car’
tʃʷatʃ	tʃʷatʃ	‘bed’

¹¹ Note that the last example in (16b) is in fact morphologically complex; this is the only such form cited by Ayres (1991), who does not mention whether Nebaj Ixil harmony applies regularly across morpheme boundaries. Since it is unclear to me whether the relational morpheme /-ʃeʔ/ should be analyzed as a stem or as a suffix (or clitic), I hesitate to categorize this case as an example of either stem control or fixed right-to-left directionality.

b. Doublet forms in Nebaj dialect:

tʃ'isis ~ ts'isis	'cypress'
tʃ'eveʃ ~ tʃ'eveʃ	'annona, custard apple'
si:n-ʃeʔ ~ ʃi:n-ʃeʔ	'with me'

Another case which also clearly shows right-to-left directionality is obstruent voicing harmony in the Chadic language Ngizim (Schuh 1978, 1997), discussed in detail in 2.4.7 above (cf. also the analysis developed in section 4.2.3). A few representative examples are given in (17). In Ngizim directionality is evident from comparison with cognates in related languages, as in (17a), from which it is evident that [+voi] obstruents triggered anticipatory harmony. But the directionality also leaves its mark in the form of an asymmetry in the synchronic pattern. Since there was no assimilation in [-voi], only [+voi], the end result is that while *[-voi]...[+voi] sequences are ruled out, [+voi]...[-voi] sequences are unaffected by harmony and are quite frequent.

(17) Right-to-left voicing harmony in Ngizim (data from Schuh 1997)

a. Harmonic roots (T...T, D...D):

kùtór	'tail'	
tàsáú	'find'	
gâazá	'chicken'	(< *k...z, cf. Hausa /kàazáa/)
dóbâ	'woven tray'	(< *t...b, cf. Hausa /tàafii/ 'palm')
zèdù	'six'	(< *s...d, cf. Hausa /ʃídà/)

b. Disharmonic roots (D...T allowed, but not *T...D):

bàkú	‘roast’
gùmtǎí	‘chin’
dùkǎí	‘heavy’ (Schuh 1978: 251)
zùktú	‘pierce’ (Schuh 1978:273)

Perhaps the most interesting evidence for the fundamental nature of right-to-left directionality comes from systems which exhibit stem-controlled *progressive* directionality in heteromorphemic contexts, but *anticipatory* harmony within morphemes. The only clear-cut case of this type appears to be the sibilant harmony found in Omotic languages, cf. the Koyra examples in (4) above. In these languages, where root-internal sibilant harmony must be reconstructed already in Proto-Omotic (Hayward 1988), the only evidence available for the directionality of morpheme-internal harmony comes from loanword adaptation. In Zayse, borrowings from Amharic typically replace /t'/ with Zayse /ts'/; where this would be disharmonic with a following sibilant, the affricate harmonizes (Hayward 1988). Thus Amharic /t'ädʒ:/ ‘mead’ becomes not */ts'ädʒ:e/ but /tʃ'ädʒ:e/ in Zayse, and Amharic /t'iloʃ/ ‘brideprice’ is likewise adapted not as */ts'ilo:ʃa/ but as /tʃ'ilo:ʃa/.

Just as Zayse sibilant harmony is fed by disharmonic borrowings into the language, independent sound changes may feed consonant harmony. An example is sibilant harmony in Wanka Quechua (Cerrón-Palomino 1977). This harmony is a static cooccurrence restriction on morphemes, and as such its inherent directionality cannot be determined directly. In the Huaicha dialect, however, the interaction of two independent sound changes would be expected to yield disharmonic morpheme-internal sequences. These are on the one hand */tʃ/ > /tʃs/ (except before /i/), and on the other hand */ʎ/ > /tʃ/ (except word-initially). When a root contained an original sequence */tʃ...ʎ/, these regular sound changes should have yielded disharmonic /tʃs...tʃ/. Instead, this disharmony has been ‘repaired’ by applying

right-to-left harmony, as illustrated in (18). (Note that I have assumed, for expository purposes, that the historical development passed through a disharmonic stage; this is by no means necessary.)

(18) Right-to-left sibilant harmony in Wanka Quechua (Cerrón-Palomino 1977)

<i>Reconstructed</i>		<i>Disharmonic</i>		<i>Actual</i>	
*/tʃukʌ/	>	*/tʃuktʃa/	>	/tʃuktʃa/	‘hut’
*/tʃuʔʌ/	>	*/tʃuʔtʃu/	>	/tʃuʔtʃu/	‘corn’
*/tʃuʌ-/	>	*/tʃutʃu-/	>	/tʃutʃu-/	‘to melt’
*/tʃukʌʃ/	>	*/tʃuktʃuʃ/	>	/tʃuktʃuʃ/	‘cricket’

Alternatively, the process that feeds harmony may be a morphologically driven alternation of some kind. This is the case in most of the Western Nilotic languages which have coronal harmony involving dental vs. alveolar stops (and sometimes nasals as well); this phenomenon was discussed in section 2.4.1.2 above. In these languages, morphological alternations in the root-final consonant may lead to a potentially disharmonic form. For example, root-final /l/ changes to alveolar /t/ or /nd/ in certain forms; in roots of the shape /d̥...l-/ or /t̥...l-/, this would be expected to yield disharmonic [d̥...nd-], etc., other things being equal.

Different languages resolve this in different ways. Shilluk (Gilley 1992) appears to go for right-to-left harmony, as in the cases discussed above. Thus the root /t̥al/ ‘cook (s.t.)’ is realized in the antipassive form as /t̥at/, in the instrumental form as /t̥ā:d-ā/. In both cases the derived alveolar triggers harmony in the preceding root-initial /t̥/. The closely related Pāri (Andersen 1988), on the other hand, applies *left-to-right* harmony in such contexts, as witnessed by pairs such as /t̥iɔl/ ‘snake’ vs. /t̥iɔnd-à/ ‘my snake’. In this case

it is the root-initial dental /t̥/ that triggers harmony in the derived alveolar /nd/, rather than the other way around.

A plausible explanation for the left-to-right directionality in Pāri has to do with the historical origin of the root-final consonant alternations. It seems clear, for example, that the alveolar /t/ in the antipassive was originally a suffix (Hall & Hall 1996), and the same was likely true of the /nd/, etc., which supplant a root-final /l/ or /n/ (or sometimes appear out of nowhere) in certain morphological categories. If this is true, then the directionality observed in Pāri may be a remnant of *stem control*, whereby these erstwhile suffixes assimilated to the preceding root. Note that stem control is attested for coronal harmony in the related language Mayak (Andersen 1999), where suffixes like singulative /-i̥t̥/ harmonize (optionally) with an alveolar stop in the preceding root, e.g., /d̥r̥:n-ε̥t̥/ → [d̥r̥:n-ε̥t̥] ‘bird’. Because of this tentative possibility, Pāri was listed as a questionable case in the table in (7) above, where systems with left-to-right harmony in heteromorphemic contexts were listed.

Another possible explanation has to do with the underlying vs. derived distinction. In the Pāri case, it is the realization of a *derived* segment which is determined by harmony. If stem control is a matter of differential faithfulness (to the stem of affixation vs. in general), as will be assumed in the analysis developed in chapters 4 and 5, then this too may be a case of faithfulness effects. If in Pāri faithfulness to underlying dental vs. alveolar specifications has priority over the realization of the root-final /t/ or /nd/ alternants as alveolar, then the progressive application will fall out naturally from that fact. In this way, the progressive directionality of Pāri may be an ‘accidental by-product’ of other factors, rather than being inherent in the harmony itself.

A somewhat similar case, where the same logic could be applied, is dorsal consonant harmony in Tlachichilco Tepehua (Watters 1988). As discussed in 2.4.2 above, this phenomenon interacts with an independent process of coda dorsalization. To summarize, alveolar or labial stops and nasals are not allowed in coda position; when an underlying

labial or alveolar gets parsed into coda position, it becomes velar (e.g., /ʃap-ʔa/ ‘X pants (impf.)’ → [ʃa.p’a], but /ʃap-ʔi/ ‘X panted (perf.)’ → [ʃawk.ʔi]). In roots with the shape /q...t/ or /q...p/, coda dorsalization would result in a uvular-velar combination, which is prohibited by dorsal consonant harmony. Where this occurs, harmony ‘repairs’ the sequence by making the derived velar into a uvular; the apparent directionality is therefore left-to-right. An example is /q’ut-ʔa/ ‘X drinks it (impf.)’ → [ʔo.t’a], but /q’ut-ʔi/ ‘X drank it (perf.)’ → [ʔoq.ʔi], rather than the otherwise expected *[ʔok.ʔi].¹² In this case, just as in the Pări case, the left-to-right effect may result from faithfulness to an *underlying* uvular taking priority over faithfulness to a *derived* velar.

Yet another alternative interpretation has to do with the fact that in both the Pări and the Tepehua cases, it is specifically a root-initial consonant which is triggering (left-to-right) harmony. Several works have assumed that the root-initial position is somehow privileged (see, e.g., Beckman 1998 for one implementation of such a view). This may well be the explanation for the left-to-right directionality in these particular cases. The root-initial consonant is immune to harmony, and therefore the only way to enforce harmony is to have the *non*-initial consonant(s) yield to the root-initial one. For example, this appears to be what happens in loanword adaptation in Zulu, where the realization of English word-final /t/ varies according to laryngeal harmony with an initial stop (Khumalo 1987; see 2.4.7 above). Thus, for example, *court* is borrowed as í-k^hô^to and *packet* as i:p^háket^he, whereas *beat* is borrowed as úm-bídi ‘conductor’ and *bucket* as i:-bakêde. In the former cases, English /t/ = Zulu /t^h/ because of harmony with the root-initial /p^h, k^h/; in the latter, English /t/ = Zulu /d/ due to harmony with root-initial /b/.

A case which does appear to be genuinely problematic is Bantu nasal consonant harmony (cf. section 2.4.4). In heteromorphemic contexts, the general left-to-right direc-

¹² Note that ejective /q’/ is realized phonetically as [ʔ]. Nonetheless it has the same lowering effect on neighboring vowels, and the same harmony effect on nearby /k, k’/, as non-ejective /q/ does (as can be seen from the example just cited). This is not directly relevant here; see section 2.4.2 and Watters (1988) for discussion of this issue.

tionality of this phenomenon can easily be attributed to stem control. Morpheme-internally, however, left-to-right directionality still holds. One way of accounting for nearly all of the problematic examples is to assume that the root-initial consonant is immune, combined with the additional assumption that the nasal consonant harmony is fundamentally ‘dominant-recessive’ morpheme-internally (in heteromorphemic contexts stem control would eliminate any possible traces of dominance effect). In other words, the assumption is that /...n...d.../ and /...d...n.../ sequences *both* harmonize to /...n...n.../; the all-important exception is when C₁ is root-initial and thus immune to harmony. This would explain why sequences like #mVd- become #mVn-, whereas sequences like #b...n- remain unaffected. The implications of an analysis along these lines is discussed in greater detail in section 4.3.3 below.

The suggestion that morpheme-internal Bantu nasal consonant harmony is fundamentally dominant-recessive (with [+nas] the dominant value) is not as ad hoc as it may seem. For example, as noted in 2.4.4 above, the Proto-Bantu root *bon- ‘see’ is realized as /mon-/, with what appears to be *right-to-left* harmony, in an area virtually coextensive with the area where left-to-right nasal consonant harmony is found. Another similar example from Yaka (Larry M. Hyman, pers. comm.) is the reciprocal formed from the root /lu-/ ‘fight (s.o.)’. With the reciprocal suffix /-an-/, we should expect /lu-an-a/ → [lwa:na], but instead we find [nwa:na] ‘fight each other’. It would be well worth searching for other sporadic examples of this kind.

Secondly, there are other cases that appear to involve directionality of the dominant-recessive type. For example, in Moroccan Colloquial Arabic sibilant harmony, comparison with Classical Arabic reveals that harmony is typically in favor of the [-anterior] sibilant, regardless of linear order (Heath 1987). This is shown in (19); in the forms in (19a),

harmony is anticipatory, whereas in (19b) it is progressive (MCA = Moroccan Colloquial Arabic; CA = Classical Arabic).¹³

(19) ‘Dominant-recessive’ sibilant harmony in Moroccan Arabic? (Heath 1987)

	<i>CA</i>	<i>MCA</i>	
a.	/za:dʒ-/	/ʒaʒ/	‘glass’
	/zulajdʒ-/	/ʒlliʒ/	‘tiles’
	/sardʒ-/	/ʃrʒ/	‘saddle’
b.	/ʃams-/	/ʃəmʃ/	‘sun’

Not all dialects in this area appear to have sibilant harmony with this dominant-recessive character, but instead with absolute right-to-left directionality. Heath (1987:216, n.5) notes that whereas Classical Arabic /dʒ/ generally undergoes deaffrication in the sequence /dʒ...z/ in Moroccan Arabic (yielding /d...z/ or /g...z/), the same is not true in most Algerian and Tunisian dialects. Here classical /dʒ/ instead becomes /ʒ/ even in this context, resulting in disharmonic /ʒ...z/ sequences, e.g., in /ʒǎz:ar^s/ ‘butcher’. In a number of Tunisian dialects, such disharmonic sequences are repaired by right-to-left harmony, yielding /zǎz:ar^s/ instead, and also /zuz/ ‘go past’ instead of the otherwise expected /ʒuz/ (from CA /-dʒuz:z/). Note that in this case, the ‘spreading’ feature value is [+ant], the one which behaves as recessive in (19).

Another case of morpheme-internal harmony with certain dominant-recessive characteristics is sibilant harmony in Basque (Hualde 1991; Trask 1997). This case was described in section 2.4.1.1 above, where relevant details were discussed. This particular sibilant harmony system involves a pure apical vs. laminal alveolar contrast. Morpheme-internally, laminals and apicals are simply not allowed to cooccur, and there is no direct

¹³ Note that the dominant vs. recessive asymmetry observed here is completely in line with the Palatal Bias effects which are discussed in chapter 6.

evidence for any inherent directionality in the harmony requirement. However, directionality effects can be observed when loanwords are adapted, and also when compounds are reanalyzed as single morphemes and thus subjected to sibilant harmony. In such cases, harmony appears to be consistently in favor of the apical—which could thus be construed as the ‘dominant’ value of the apical/laminal parameter. To take loanword adaptation as an example (Michelena 1985), Spanish *francés* ‘French’ is borrowed as /fran(t)se̞/ > /fran(t)̞se̞/, with right-to-left harmony, whereas Spanish *sazón* is found dialectally in Basque as */̞saso(i)n/ > /̞saso(i)n/, with left-to-right harmony. However, some dialects appear to have absolute right-to-left directionality even in [apical]...[laminal] sequences, giving rise to /saso(i)/ for the last example.¹⁴

To sum up, the default nature of right-to-left directionality in consonant harmony manifests itself even in morpheme-internal contexts. Here anticipatory assimilation is the norm. Progressive assimilation is found in a small number of cases, but virtually all of these can be accounted for by appealing to other independent factors (analogous to stem control in the heteromorphemic cases). For example, an underlying specification in one consonant may take priority over a derived specification in another, resulting in reversed (left-to-right) directionality. Alternatively, specifications of root-initial consonants may take priority, again resulting in directionality reversal. Finally, there are some cases where harmony seems to have a dominant-recessive character, where left-to-right directionality is to be expected precisely in those contexts where a dominant consonant is followed by a recessive one. All attested cases of left-to-right directionality can be accounted for in one (or more) of these ways; the only directionality that ever requires stipulation as an absolute is right-to-left harmony. Moreover, even in cases where left-to-right harmony occurs—whatever the likely

¹⁴ It should be pointed out that the tentative generalizations made here for Basque are based on a very small list of forms mentioned in various sources, and may therefore turn out to be false when more data is taken into account.

reason for this—related dialects or languages frequently display the exact same harmony but with the default right-to-left directionality.

In the generalized analysis of consonant harmony developed in chapter 4 and 5, an attempt is made to encode the default status of anticipatory harmony into the architecture of the analysis itself. As discussed in detail in sections 4.2.1.2 and 6.1 below, consonant harmony phenomena are much like phonological speech errors with respect to the predominance of anticipatory effects. The implications of this and other such parallels is discussed in more detail in the remaining chapters (see esp. chapter 6).

3.2. Locality, transparency and blocking

In this section, we will discuss another respect in which the cross-linguistic typology of consonant harmony systems seems remarkably uniform. This is the area of locality-related effects, more specifically those involving segmental *opacity* vs. *transparency*. In any harmony system, potential target segments can be classified as ‘undergoers’ (those that do assimilate) vs. ‘non-undergoers’ (those that fail to assimilate). The latter are often also referred to as *neutral* segments, although different works vary in their use of that term. Non-undergoers may be *transparent*, allowing the harmonic property to propagate across them while themselves remaining unaffected by the harmony. Alternatively, they may be *opaque*, blocking the further propagation of harmony. In such cases, the opaque segment itself often (though by no means always) initiates a new harmonic span of its own.

Locality-related effects such as blocking vs. transparency are very important in the context of consonant harmony phenomena and their analysis, if only for the reason that the trigger and target are frequently spaced far apart, separated by a long stretch of segments that *appear* to be non-undergoers in the sense given above. The strict-locality approach to consonant harmony, outlined in section 1.2.3 above, assumes that all segments are potential targets, and that when harmony appears to apply in a long-distance fashion, intervening

segments are in fact undergoers, just as they are in such processes as nasal harmony. Since opacity effects are quite commonplace in such systems—where particular segment types function as blockers (opaque non-undergoers)—one might expect to find at least some instances of such effects in the typology of consonant harmony as well. However, as this section aims to show, segmental opacity effects are completely unattested in consonant harmony systems. The vowels and consonants that intervene between the interacting consonants—whether they are in fact undergoers or (transparent) non-undergoers—are consistently and uniformly irrelevant to the harmony. As such they never block its application by interrupting the propagation of the harmonizing feature.¹⁵

Section 3.2.1 gives a brief overview of the extent to which segmental opacity is found in vowel harmony and vowel-consonant harmony systems, as well as the kinds of opacity effects that such systems may display. In section 3.2.2 the (non-)existence of opacity effects in the typology of consonant harmony systems is discussed. Finally, section 3.2.3 deals in detail with an apparent counterexample, the well-known case of (Vedic) Sanskrit *n*-retroflexion. It is argued that this phenomenon should in fact not be classified as consonant harmony at all, as it exhibits a wide range of properties that are otherwise unattested in consonant harmony systems in the world’s languages.

3.2.1. Opacity effects in other harmony systems

Overall, segmental opacity is extremely common in the general typology of harmony phenomena. In general, it might even be said that for segments that are not ‘undergoers’—in the sense that they are (demonstrably) not permeated by the spreading property—opacity is the rule and transparency the exception. In vowel harmony systems, for example, neutral vowels

¹⁵ Recall that the definition of consonant harmony used in this work (see 1.1) includes only those assimilations where intervening segments—and vowels in particular—are not noticeably affected (or have not been recorded as affected) by the assimilating property. This does not make the argument circular. In any harmony system, a non-undergoer—i.e. a segment which is not (noticeably) affected—will either be opaque or transparent. In vowel harmony and vowel-consonant harmony systems, each is quite common; in consonant harmony systems, on the other hand, opaque behavior is not found.

are frequently opaque; in addition to being themselves unaffected by the harmony, they typically initiate a new harmonic span. In tongue-root vowel harmony, either high vowels (Yoruba) or low vowels (Tangale) are often opaque. The same is true of rounding harmony systems, where opaque behavior is attested for high vowels (Oroch) as well as low vowels (Turkish); occasionally it is high *rounded* vowels specifically that are opaque, whereas high unrounded vowels are transparent (Buriat). In height harmony systems where high and mid vowels interact, low vowels are frequently opaque (Shona).

Likewise, particular types of consonants can be opaque to vowel harmony, blocking its propagation from one syllable to the next. Typically these are consonants which are already specified for the spreading property, or which contain a specification which is somehow incompatible with it (although this does not always seem to be the case). For example, palatalized/palatal consonants (liquids and dorsals) are opaque to backness harmony in Turkish (see, e.g., Clements & Sezer 1982); these segments block the rightward spread of [+back] and themselves initiate a new [-back] domain. (Interestingly, the palatal glide /j/ does not block backness harmony in this way; cf. Levi 2001.) In some rounding harmony systems, such as in Bashkir, the glide /w/ is opaque, blocking the propagation of rounding (as do high vowels; cf. van der Hulst & van de Weijer 1995:529). Similarly, plain labial consonants like /f/, /b/, /m/, etc. (but not /w/!) are opaque to rounding harmony in Nawuri (Casali 1995).

In the context of the present study, a closer analogue to consonant harmony are those phenomena which have here been referred to as vowel-consonant harmony. These involve properties such as nasality or pharyngealization. Frequently they are *triggered* by consonants of a particular type, just as consonant harmony is, but in this case the harmonic property clearly and audibly spreads through all segments in its path, vowels as well as consonants.¹⁶ Segmental transparency effects are occasionally encountered, whereby segments

¹⁶ In the faucal harmony found in some Interior Salish languages, Bessell (1998) shows that the harmony (which is triggered by pharyngeals and uvulars) affects only *vowels* in its path, whereas the non-faucal

of a particular type are ‘skipped’, but such cases are the exception rather than the rule. More importantly, these involve an *individual* segment being skipped, while the harmonic property spreads up to it and commences again on the other side. In nasal harmony systems, we might thus find, e.g., /naka/ → [nãwãkã], where the intervening [k] is obviously not nasalized (see Walker 1998[2000] for detailed discussion of such cases). What we typically do not find is stretches of several segments, all transparent and unaffected by the spreading property.

Most vowel-consonant harmony systems display segmental opacity effects to some degree. For example, pharyngealization or ‘emphasis’ harmony is frequently blocked by the high front vowel /i/ or the corresponding palatal glide /j/, and occasionally even by such ‘palatal’ obstruents as /ʃ/; this is the case in Palestinian Arabic (Hoberman 1989).¹⁷ In Tsilhqot’in (Chilcotin) pharyngealization harmony, also known as ‘vowel flattening’, front velars and contrastively non-pharyngealized sibilants block rightward and leftward spreading of [RTR] from a uvular, and rightward (but not leftward) spreading from a pharyngealized sibilant (Krauss 1975; Cook 1983, 1987, 1993).

As for nasal harmony, Walker (1998[2000]) surveys a wealth of such systems and arranges them into a typological hierarchy with regard to opacity effects. Going from most to least restrictive, the classes Walker distinguishes are the following. In some languages, all non-glottal consonants, including glides, are opaque and block the propagation of nasalization (Sundanese, Mixtec). In the next set of languages, glides are targeted as well, but all non-glottal consonants are blockers (Acehnese, Capanahua). The next possibility is for liquids to be added to the list of undergoers, whereas all obstruents are opaque (Kayan, Kolokuma Ijo). In yet another set of languages, only obstruent *stops* are opaque, whereas

consonants that fall within the harmony span appear to be relatively unaffected phonetically. Such cases provide an interesting near-parallel to consonant harmony, but nevertheless the two are quite distinct phenomena. Consonant harmony is assimilatory interaction *between consonants*, whereas phenomena such as faucal harmony involve assimilatory effects *from consonants to vowels*.

¹⁷ More accurately, only long /i:/ is opaque, whereas short /i/ generally does undergo harmony. However, according to Shahin (1997), all long vowels are in fact opaque in Palestinian Arabic, not just /i:/.

fricatives undergo nasalization along with sonorants (Applecross Gaelic). Finally, stops may be targeted as well (Cayuvava, Gokana). In the last set of languages, *voiceless* obstruents are sometimes opaque, blocking the propagation of nasality (Bribri, Cabécar).

Aside from this implicational hierarchy regarding the class of opaque consonants in nasal harmony systems, certain types of *vowels* occasionally also act as blockers. For example, in the Mòbà dialect of Yoruba, mid vowels are never nasalized, and block the leftward propagation of nasalization (Ajíbóyè 2001). A similar effect is found in the Applecross dialect of Scottish Gaelic, where upper-mid vowels always remain oral and block nasal spreading (Ternes 1973). It should also be noted that, as pointed out by Walker (1998[2000]), some languages appear to categorize the glottal consonants /ʔ, h/ with *obstruents*, and these can therefore occasionally be opaque to nasal harmony in the same way as obstruents typically are (e.g., in Rejang, Kaiwá, Terena).

To conclude, then, we see that segmental opacity effects are very common cross-linguistically in both vowel harmony and vowel-consonant harmony systems. Under the interpretation that harmony is due to spreading, such effects are to be expected. A given segment may be ill-compatible with the spreading property. This may either be because it contains some conflicting property (as in the case of /i, j/ in pharyngealization harmony) or because the segment that would result is excluded from the surface inventory of the language in question (as in the case of mid vowels in nasal harmony). Such factors may determine whether or not a particular segment will undergo harmony. If it does not, *blocking* appears to be the most common result (rather than transparency). In other words, opacity effects are to be expected wherever there is any chance of ‘incompatibility’ of certain segment types with the harmonizing property.

3.2.2. Opacity vs. transparency in consonant harmony

Turning now to consonant harmony systems, a clear generalization emerges from the cross-linguistic survey carried out as part of the present study. Consonant harmony processes consistently ignore the segmental material intervening between trigger and target. Segmental opacity effects are completely unattested: The propagation of the harmony property is never blocked by a particular class of consonants and/or vowels, the way it frequently is in other types of harmony systems. In this sense, intervening segments always behave as if they were entirely *transparent* to the harmony.

It is important to note that the construal of consonant harmony as strictly-local spreading, where all intervening segments are actually targets (Flemming 1995b; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997), does not entail that every individual consonant harmony system should display some kind of opacity effects. For example, there are numerous vowel harmony systems that do not. What is surprising is rather that opacity effects are completely and consistently absent in *all* attested consonant harmony systems. Recall that it has not yet been demonstrated for any actual consonant harmony system that intervening vowels and consonants are targeted by the spreading property, as proponents of the strict locality hypothesis suggest. In light of this, the typological consistency that consonant harmony systems show with respect to opacity vs. (apparent) transparency is highly conspicuous.

There are numerous cases of consonant harmony processes where it would be perfectly possible for a given subclass of segments to act as opaque, blocking the propagation of harmony. For example, in the dorsal consonant harmony found in some Totonacan languages (Totonac, Tepehua), discontinuous velar...uvular sequences undergo assimilation to uvular...uvular: /k...q/ → /q...q/. This phenomenon was described and illustrated in 2.4.2 above. The tongue retraction inherent in the articulation of a uvular [q] is ill-compatible articulatorily with the tongue posture required for high vowels, especially a

high front vowel like [i]. Indeed, these very same languages show a local effect whereby the high vowels /i, u/ are lowered when adjacent to a uvular. Thus in Misantla Totonac (MacKay 1999), we find /i/ → [ɛ] and /u(:)/ → [ɔ(:)] in contexts like /Vq/ and /qV/. Long /i:/ frequently becomes a diphthong, lowering only that portion which is next to the uvular, thus /i:/ → [iə] ~ [ɛ:] in pre-uvular and [ɛi] ~ [ɛ:] in post-uvular environments. In short, high vowels, and especially [i], have properties that conflict with the gestures involved in the articulation of [q] (as distinct from [k], which has no effect on neighboring vowels). We might therefore expect that an /i/ or /u/ which finds itself within a dorsal harmony span would either *block* the harmony or show signs of being affected by the spreading articulatory property. In other words, a sequence like /k...i...q/ would be expected either to remain unharmonized (as [k...i...q]) or else to surface as [q...ɛ...q].

However, neither is the case; instead, harmony appears to apply across the vowel without having any phonological or phonetic effect on its realization. This can be illustrated by the forms in (20) from Tlachichilco Tepehua (Watters 1988), repeated from section 2.4.2. In this language, /i, u/ lower to [e, o] next to a uvular. (Note that an underlying uvular ejective /qʔ/, unlike its non-ejective counterpart, surfaces debuccalized as [ʔ]; this has no bearing on the workings of dorsal harmony in this language.)

(20) Tlachichilco Tepehua: No lowering within dorsal harmony span (Watters 1988)

- a. /lak-pu:tiqʔi-ni-j/ → [laq-pu:teʔe-ni-j] ‘X recounted it to them’
- b. /ʔak-pitiqʔi-j/ → [ʔaq-piteʔe-j] ‘X folds it over’

Ignoring the orthogonal debuccalization effect, we see in (20a) that the underlying sequence /k...u...qʔ/ → [q...u...qʔ], with /u/ behaving as transparent, rather than *[q...o...q] (/u/ being a target) or *[k...u...qʔ] (/u/ being opaque). Similarly, the (20b) sequence /k...i...qʔ/ becomes [q...i...qʔ] rather than harmonizing to *[q...e...qʔ] or remaining as *[k...i...qʔ].

A similar example can be cited from the Northern Athapaskan language Tsilhqot'in (Chilcotin), discussed previously by Krauss (1975), Cook (1983, 1987, 1993) and Gafos (1996[1999]). In this language, alveolar sibilants contrast in pharyngealization, i.e. the feature [\pm RTR], between 'sharp' /s, z, ts, ts', dz/ vs. 'flat' /s^ʰ, z^ʰ, ts^ʰ, ts'^ʰ, dz^ʰ/. Tsilhqot'in consonant harmony involves precisely this distinction, and can thus be classified as 'sibilant pharyngealization harmony' (cf. 2.4.3 above). All alveolar sibilants in a word agree in [\pm RTR], with the rightmost one determining the [RTR] value of the entire sequence.¹⁸ The third sibilant series, postalveolar /ʃ, ʒ, tʃ, tʃ', dʒ/, do not contrast for pharyngealization, and do not participate in the harmony in any way. Tsilhqot'in also has a velar vs. uvular contrast, /k/ vs. /q/, etc., which Cook (1993) also analyzes as involving [\pm RTR]. The reason is that uvulars and 'flat' sibilants have the exact same lowering and/or backing effect on neighboring vowels, resulting in /æ/ → [ɑ], /u/ → [o] and so forth.

Tsilhqot'in sibilant pharyngealization harmony interacts in a complex way with a synchronically independent process of pharyngealization harmony ([RTR] spreading; see Cook 1993 for details); the latter is somewhat analogous to the emphasis harmony found in many Middle Eastern languages (cf. Hoberman 1989).¹⁹ Because of the complexities of this interaction, the independent effect of the sibilant harmony is seen most clearly in situations where it results in *depharyngealization*, converting a [+RTR]...[-RTR] sibilant sequence into [-RTR]...[-RTR]. Thus, for example, a verb stem containing non-

¹⁸ Gafos (1996[1999]) interprets this sibilant distinction as a dental vs. alveolar one, and thus treats the harmony as coronal harmony of the same type as that found in many related languages, such as Tahltan or Navajo. However, although Tsilhqot'in consonant harmony is most certainly cognate with these phenomena, the phonological distinction over which the Tsilhqot'in harmony operates is clearly one of pharyngealization. My own preliminary fieldwork on this language suggests that some of the sibilants freely vary between alveolar and dental articulation, *regardless* of their [RTR] specification, especially the voiced fricatives /z, z^ʰ/ (cf. also Krauss 1975). Furthermore, Gafos (1996[1999]) is forced to assume that the /ʃ/-series sibilants must be true dorso-palatals (in order to explain the fact that they are transparent to harmony). But this too is inconsistent with the phonetic facts; these consonants are clearly coronals, virtually identical to English /ʃ/, /dʒ/, etc. The only exception is that /ʃ/ is realized as palatal [ç] in absolute word-final position, but this is irrelevant to the workings of consonant harmony.

¹⁹ Although the two pharyngealization harmonies are synchronically separate, it is likely that they are diachronically related, with [RTR] spreading having arisen through the analogical reanalysis of sibilant harmony effects (Hansson 2000).

pharyngealized /s/, /z/, /ts/, etc. will cause a preceding perfective or negative prefix /s^ʕ(ε)-/ to surface as [s(ε)-] with non-pharyngealized [s]. What is most important in this context, however, is that this assimilation in [-RTR] between the two sibilants can take place *across* a sequence containing [+RTR] consonants and vowels. This was already noted in section 2.4.3; the relevant examples are repeated in (21), cited from my own field notes. The intervening [+RTR] span is indicated by square brackets.

(21) Tsilhqot'in: Transparency of intervening [+RTR] segments

- a. ʔæ jɛt^hɛz[ʌʔɑ]dʒɛz /jɛ-tɛ-s^ʕɛ-ʔæ-id-jɛz/ 'we're not g. to get the hiccups'
 b. ʔæ næ^hɛz[ʌʔɑ]lk'ɛs /næ-tɛ-s^ʕɛ-ʔæ-id-l-k'ɛs/ 'we're not g. to be stiff' (spkr A)
 ʔæ næ^hɛz[ɑ]lk'ɛs /næ-tɛ-s^ʕɛ-ʔæ-id-l-k'ɛs/ 'we're not g. to be stiff' (spkr B)

In both the (21a) and (21b) cases, sibilant harmony involving [-RTR] applies across a series of intervening segments which includes within it a [+RTR] span. This span consists of the uvular fricative [ʔ] of the progressive prefix /ʔɛ-/, as well as the vowels immediately adjacent to it, which are retracted by a local process of [RTR] spreading. (In the pronunciation of speaker B, the entire VʔV sequence is contracted to [ɑ].) What is important to note is that the intervening [+RTR] segments in no way interfere with the consonant harmony which holds across them. Things could very well have been different—it would have been perfectly conceivable for the sibilant harmony to be *blocked* in the cases in (21). However, this is not the case in this or any other attested consonant harmony system.

In harmony systems that display opacity effects, intervening segments that act as blockers do not necessarily have specifications that *conflict* with the spreading property. For example, there are numerous languages where a rounded vowel like /u/ is opaque to rounding harmony. Similarly, retroflex stops like /d/ are opaque to retroflexion spreading in Sanskrit (see 3.2.3 below). Although it is not always clear how such cases of opacity are

best analyzed, the generalization still holds true when it comes to consonant harmony systems: non-participating segments never block the propagation of harmony.

For example, intervening sonorants—which are phonetically voiced—are never opaque to obstruent voicing harmony.²⁰ Note also that laryngeal harmony is frequently parasitic on identity in place and/or manner. No cases are attested where segments with a different place/manner of articulation block this kind of laryngeal agreement. In unbounded nasal consonant harmony systems (e.g., in Yaka or Kongo), prenasalized stops—whether they are to be construed as contour segments or as NC clusters—do not undergo harmony, and also do not block it (cf. section 2.4.4 for examples).

An especially illustrative example of the consistent failure of intervening segments to act as blockers in consonant harmony is the coronal harmony found in many Western Nilotic languages, in particular that of the Northern Burun language Mayak (Andersen 1999; cf. 2.4.1.2 above). In this language, as in many closely related ones, dental /t̪, d̪/ and alveolar /t, d/ are not allowed to cooccur within morphemes. In Mayak, there is no dental-alveolar contrast in nasals (nor in the liquids). Thus /n/ is consistently alveolar, even when it cooccurs with dental /t̪, d̪/ in a morpheme. (Dental [n̪] does occur as an allophone of /n/, but only in the clusters [n̪d̪], [n̪t̪].)

More importantly, Mayak coronal harmony extends to suffixes like singulative /-ɛt̪/, /-ʌt̪/ or /-it̪/. When these are affixed to roots containing alveolar /t/ or /d/, they harmonize (optionally), surfacing with alveolar [t] instead of dental [t̪], as shown in (22a). The alveolar nasal /n/, unlike its oral stop counterparts, does not trigger harmony (22b). However, an

²⁰ If the forms cited by Kenstowicz (1994:547) are any indication, then sibilant voicing harmony in Imdlawn Berber *may* be a case of consonant harmony which displays opacity effects. Superficially, it appears as if assimilations of the type /s...z/ → [z...z] apply across sonorants and voiced obstruents, but not across voiceless obstruents (which thus seem to be opaque). The phenomenon is described in Elmedlaoui (1992), but as this source has not been available to me, the interpretation of the data in light of the generalizations made here must await further investigation. If the voicing of intervening stops is indeed relevant, it is conceivable that the rather unique phonotactics and syllable structure of Berber is somehow involved. (For example, if sibilant fricatives can be syllabified as nuclei, then the phenomenon might perhaps more akin to vowel harmony?)

alveolar stop will trigger harmony *across* /n/, as shown in (22c). (In all examples cited here, the optional nature of the harmony is ignored for clarity.)

(22) Mayak: Inertness of /n/ to coronal harmony (data from Andersen 1999)

- | | | | | |
|----|------------|---|----------------------|----------------|
| a. | /tid-ɲt/ | → | tid ^h -ɲt | ‘doctor’ |
| | /tuy-it/ | → | tuy-it | ‘back of head’ |
| b. | /ʔin-ɲt/ | → | ʔin-ɲt | ‘intestine’ |
| | /kan-it/ | → | kan-it | ‘torch’ |
| c. | /di:n-ɛt/ | → | di:n-ɛt | ‘bird’ |
| | /ket-m-ɛt/ | → | ket-m-ɛt | ‘star’ |

In a harmony system of this type, it would be perfectly conceivable for /n/ to be opaque, and thus block the propagation of coronal harmony in the (22c) cases. This would be entirely analogous to phenomena such as Sanskrit *n*-retroflexion, where those retroflex consonants that are not triggers block the spreading of the relevant feature/gesture (cf. 3.2.3 below). Likewise, in rounding harmony systems where the high vowel /u/ is not a trigger, it often blocks the propagation of the [round] feature from preceding vowels that are triggers. But this is not what we find in Mayak, nor in any other consonant harmony system.

In short, segmental opacity effects are entirely unattested in the cross-linguistic typology of consonant harmony systems. If it were true that intervening vowels and consonants are targeted by the assimilating feature/gesture, and thus ‘permeated’ by it, we would expect to see at least *some* cases where considerations of markedness and/or articulatory incompatibility lead to the blocking of harmony. This is, after all, an extremely common phenomenon in vowel harmony and vowel-consonant harmony systems. The complete absence of such effects lends support to the notion that consonant harmony is a matter not of spreading but *agreement*, as in the analysis developed in chapters 4 and 5.

Effects that superficially look like instances of segmental opacity do occur, however, when harmony is overridden by phonotactic constraints. Recall from 2.4.1.1 that in Ineseño Chumash (and certain other Chumashan languages as well), right-to-left sibilant harmony interacts with an independent ‘pre-coronal effect’, whereby the sibilant /s/ is realized as [ʃ] before the plain coronals /t, l, n/. (The change only takes place across a morpheme boundary, i.e. in derived environments, but this aspect of it will be ignored here.) When sibilant harmony would be expected to give rise to [ʃ] immediately preceding /t/, /l/ or /n/, it is blocked by the pre-coronal effect (see Poser 1982 for discussion of this interaction). This is illustrated by the examples in (23), repeated from section 2.4.1.1.

- (23) Ineseño: Sibilant harmony overridden by pre-coronal s → ʃ
- | | | |
|------------|-----------------|--------------------------|
| ʃtɨjɛpus | /s-tɨ-jɛp-us/ | ‘he tells him’ |
| ʃiʃlusisin | /s-iʃ-lu-sisin/ | ‘they (2) are gone awry’ |
| ʃiʃtiʔi | /s-is-tiʔi/ | ‘he finds it’ |

In some sense, then, a [ʃ] which is immediately followed by [t], [n] or [l] is ‘opaque’ to sibilant harmony. It does not undergo it, and itself initiates a new harmonic span, as in the second and third examples in (23). However, this is simply a by-product of the fact that a particular contextual neutralization effect (the pre-coronal merger of /s/ and /ʃ/) *overrides* harmony, preventing it from applying to certain sibilants. As such it has no bearing on the general issue whether intervening consonants are genuinely transparent or whether they are targets (and thus ‘permeated’ by the harmonizing property). The data in (23) do not tell us anything about whether intervening *non*-sibilants are targets or not. All the ‘opacity’ of the precoronal [ʃ] tells us is that *it* is a (potential) target—but we already know this; in a sibilant harmony system, all sibilants are by definition targets. The fact that precoronal [ʃ] blocks harmony rather than being transparent to it (yielding *[siʃlusisin] in the second example) is

significant in itself, though hardly surprising.²¹ But as such it has no bearing on the generalization that segments intervening between the trigger and target consonants are never opaque in consonant harmony system.

Finally, there are a number of consonant harmony systems that may at first appear to show opacity effects—with all non-participating consonants acting as blockers—but where this is due to the *distance* separating the trigger and target, not the nature of the segments that intervene. Consonant harmony systems are quite frequently sensitive to distance. For example, related languages displaying similar (and cognate) harmony effects often differ in the maximum distance allowed to separate the target consonant and the harmony trigger. Several such cases were discussed in chapter 2. For example, the sibilant harmony found in many Omotic languages (cf. 2.4.1.1) may be unbounded (Aari, Benchnon Gimira) or it may apply only transvocally (Koyra, Zayse). An analogous dichotomy is found in Bantu nasal consonant harmony (cf. 2.4.4), between unbounded harmony (Yaka, Kongo) and transvocalic harmony (Bemba, Lamba, Luba, etc.). In some cases, harmony is obligatory at shorter distances but optional when the target is further removed from the trigger. Among the aforementioned Bantu languages, Suku appears to be an example of this (Piper 1977), with nasal consonant harmony applying obligatorily in transvocalic contexts and optionally in (some) long-distance contexts. Similarly, liquid harmony in Bukusu (cf. 2.4.5) seems to be obligatory in transvocalic environments like /CVr-Vl-/ but optional at greater distances (/rVC-Vl-/, CVrVC-Vl-/). In Nkore-Kiga sibilant harmony, disharmonic /ʃV(n)s/ sequences are prohibited but /ʃVCV(n)s/ ones are allowed—whereas /s...ʃ/ sequences are prohibited regardless of distance. (The details of the Nkore-Kiga case, and its implications for the phonological analysis of consonant harmony, is discussed in sections 5.1.2 and 5.3 below).

²¹ It would be perfectly conceivable for [ʃ] to have been transparent in this case. A somewhat analogous case is Rundi (Bantu), where the underlying /ʃ/ of the causative suffix /-iʃ-/ never triggers right-to-left sibilant harmony (nor undergoes it), and is also transparent to harmony emanating from a later suffix (Ntahirageza 1993).

In general, descriptions of sibilant harmony systems in a wide variety of languages frequently mention the potential effect of relative distance, without illustrating this in detail. For example, in his description of Ineseño sibilant harmony, Applegate (1972:199) remarks that occasional exceptions to harmony occur, ‘particularly across longer words’. Cook (1979:27), describing sibilant harmony in Sarcee, notes that it ‘becomes gradually weaker as it gets farther from the palatal sibilant which originally triggers the process’. Sapir & Hoijer (1967:14-15) make a similar comment about Navajo sibilant harmony, clearly stating that it is ‘conditioned by the distance between the prefix consonant and that to which it is assimilated’. They note that assimilation ‘nearly always occurs when the two consonants are close together’, but that it ‘occurs less often when the two consonants are at a greater distance’. It is interesting to note that the examples they cite to illustrate the former situation involve transvocalic assimilation (/SV.SV/ and /SVS.CV/ contexts), whereas in the latter case, where harmony is rarer, the context is /SV(C).CVS/.²²

There are thus numerous examples of consonant harmony being sensitive to the distance separating trigger and target. Frequently harmony will apply across a vowel, but not across longer stretches of vowels and consonants. In most cases it is possible to define the ‘transvocalic’ context in terms of syllable adjacency, owing to the general CV syllable structure of the languages in question. In other words, harmony will apply between C₁ and C₂ in the context C₁V.C₂V but not in C₁V.CV.C₂V—in the latter case not because of the intervening consonant, but because C₁ and C₂ are not in adjacent syllables (see, e.g., Odden 1994 for suggestions along these lines). It is difficult to ascertain whether syllable adjacency is indeed the relevant notion, or rather some other metric of relative distance. The crucial evidence would have to come from languages with more complex syllable structure. The syllable-adjacency interpretation seems to make the prediction that in some languages,

²² Sapir & Hoijer also note (p. 16) that there are *morphological* limitations on sibilant harmony in Navajo, which are independent of this distance effect. Thus prefixes in the so-called disjunct domain do not undergo harmony, even when followed closely by a sibilant. Likewise, enclitics do not trigger harmony in the immediately preceding stem, and harmony occurs only rarely between the two members of a compound.

harmony might apply between C_1 and C_2 in sequences like $C_1V.CVC_2.CV$ while failing to apply in $C_1V.CV.C_2V$ sequences. Note that the segmental material intervening between C_1 and C_2 would be absolutely identical in the two cases. However, the consonants are in adjacent syllables in the former string but not in the latter one. This seems a rather unlikely state of affairs, although it cannot be ruled out in principle. The exact way distance-related restrictions are best captured will be left as a question for future research (but see section 4.2.1.1 for a possible implementation). In any case, such restrictions are distinct from opacity effects.²³

3.2.3. An apparent counterexample: Sanskrit *n*-retroflexion

Those familiar with the phonological literature on locality and long-distance interactions—and on coronal harmony in particular—are likely to raise their eyebrows at the claim that consonant harmony systems never display segmental opacity effects. The reason is that of all the phenomena traditionally discussed under the heading ‘coronal harmony’, one of the best-known and most celebrated cases does in fact show opacity effects. This is the process in (Vedic) Sanskrit known as *ṇati* or, as it will be referred to here, *n*-retroflexion. The phenomenon is generally discussed in detail in descriptive grammars (e.g., Whitney 1889)—indeed, the traditional term *ṇati* (lit. ‘curving, curvature’) goes back to the ancient Sanskrit grammarians. More importantly, Sanskrit *n*-retroflexion has received considerable attention in the phonological literature over the past half-century or so (see, e.g., Allen 1951; Johnson 1972; Sagey 1986[1990]; Schein & Steriade 1986; Humbert 1995; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997).

²³ Alternatively, it would be possible to interpret restrictions to ‘transvocalic’ contexts quite literally. In other words, it is conceivable that the reason harmony does not reach targets at greater distances is that intervening consonants *are* in fact opaque. At this point it is unclear to me if all reported distance restrictions on consonant harmony processes can be reduced to a general opacity effect in this way. Whether this alternative interpretation is feasible or not will have to remain an open question. But even if so, the generalization about opacity effects remains (though in a slightly altered form): In consonant harmony systems, non-participating consonants are either *all* transparent or *all* opaque.

It is an undeniable fact that Sanskrit *n*-retroflexion exhibits segmental opacity effects. If we follow the tradition established in the theoretical-phonological literature and classify this phenomenon as ‘consonant harmony’ in exactly the same sense as, say, Chumash sibilant harmony, then the claim made above is false. We would have to concede that although opacity effects are otherwise unheard of in consonant harmony systems, there is *one* case where they are found: Sanskrit *n*-retroflexion. On this view, the lack of opacity effects would thus be reduced to a *trend*. We would then be hard pressed to explain why opacity effects are so exceedingly rare in consonant harmony systems, given that they are quite commonplace in vowel harmony and vowel-consonant harmony systems.

However, it will instead be argued here that the Sanskrit process is in fact *not* a case of consonant harmony—in the sense that it is a fundamentally different kind of phenomenon, displaying a whole series of properties that are otherwise unattested in the typology of consonant harmony systems. The conclusion is that Sanskrit *n*-retroflexion is akin to vowel-consonant harmony phenomena, such as nasal harmony or emphasis harmony. As such, it *does* appear to involve spreading, just as assumed by previous analyses. Given this interpretation, the otherwise anomalous characteristics of the process—and the opacity effects in particular—turn out to be far less surprising.

3.2.3.1. Basic description

The (Vedic) Sanskrit consonant inventory is as presented in (24). The consonants are rendered here in the traditional way (e.g., using <c, j, ś> for the ‘palatal’ obstruents), with a few exceptions: the ‘voiced aspirates’ (breathy voiced stops) are transcribed as [b^h], [d^h], etc., the retroflex series as [ɭ, ɭ^h, ɖ, ɖ^h, ʂ, ɻ], and the palatal nasal as [ɲ]. Note that the [t, t^h, d, d^h, s, n, l] series is traditionally referred to as ‘dental’ and this practice will be followed here. (See Allen 1953 for details on the phonetics of Sanskrit as described by the ancient grammarians of India.)

(24) Sanskrit consonant inventory:

p	t	ʈ	c	k	
p ^h	t ^h	ʈ ^h	c ^h	k ^h	
b	d	ɖ	j	g	
b ^h	d ^h	ɖ ^h	j ^h	g ^h	
	s	ʃ	ś		h
m	n	ɳ	ɲ	ŋ	
v	l	r	y		

Furthermore, length will be indicated by [ː] and syllabicity by [̣], instead of the traditional diacritic macron and subscript dot, respectively. Where applicable, infixes are set off by ‘=’ in the forms cited below.

The process of *n*-retroflexion involves progressive assimilation. A continuant retroflex consonant, i.e. /ʃ/ or /r/, will cause a following dental nasal /n/ to become retroflex [ɳ]. This is illustrated in (25). The assimilation may take place under direct adjacency, when the /ʃ/ or /r/ trigger immediately precedes the target /n/, as in (25a). The assimilation also applies across a (non-coronal) consonant, as in (25b), and across a vowel, as in (25c). Finally, forms such as the ones in (25d) clearly show that the trigger and target may be separated by a considerable stretch of intervening segmental material.

(25) Examples of Vedic Sanskrit *n*-retroflexion (data from Schein & Steriade 1986)

a.	/iʃ-naː/	→	iʃ-ɳa-	‘seek (pres. stem)’
	/puːr-na-/	→	puːr-ɳa-	‘filled (pass. part.)’
	/tr=na=t-ti/	→	tɻ=ɳa=t-ti	‘splits (3Sg active)’

b.	/vrk-na-/	→	vṛk-ṇa-	‘cut up (pass. part.)’
	/grb ^h -na:-ti/	→	grb ^h -ṇa:-ti	‘seizes (3Sg active)’
c.	/cakṣ-a:na-/	→	cakṣ-a:ṇa-	‘see (middle part.)’
	/pur-a:na-/	→	pur-a:ṇa-	‘fill (middle part.)’
d.	/kṣub ^h -a:na-/	→	kṣub ^h -a:ṇa-	‘quake (middle part.)’
	/kṛp-a-ma:na-/	→	kṛp-a-ma:ṇa-	‘lament (middle part.)’
	/brahman-i/	→	brahmaṇ-i	‘brahman (LocSg)’

What makes Vedic Sanskrit *n*-retroflexion relevant in the present context is the fact that it is blocked when a coronal consonant of any kind intervenes between the triggering /ṣ, r/ and the target /n/. This includes all dental, palatal, and even retroflex consonants—obstruents as well as sonorants.²⁴ Intervening coronals are thus *opaque* to this progressive retroflexion assimilation. Examples illustrating the blocking behavior of coronals are given in (26).

(26) Intervening coronals are opaque (data from Schein & Steriade 1986)

mṛd-na:-	(*mṛd-ṇa:-)	‘be gracious (pres. stem)’
marj-a:na-	(*marj-a:ṇa-)	‘wipe (middle part.)’
kṛt-a-ma:na-	(*kṛt-a-ma:ṇa-)	‘cut (middle part.)’
kṣved-a:na-	(*kṣved-a:ṇa-)	‘hum (middle part.)’

An additional striking property of *n*-retroflexion is that it appears to be *non-iterative*, applying only to the first of a sequence of potential target nasals, rather than to all of them.

²⁴ The palatal glide /y/ does not appear to be opaque; in this respect, it behaves like a vowel rather than as a consonant.

(27) Retroflexion only targets first of a sequence of nasals:

pra-ṇina:ya (*pra-ṇi-ṇa:ya) ‘lead forth’ (/ni:-/ ‘lead’)

kṛṇ-va:na (*kṛṇ-va:ṇa) ‘make (middle part.)’

varṇ-ana:nam (*varṇ-aṇa:ṇam) *no gloss* (Ní Chiosáin & Padgett 1997)

Given certain assumptions, it seems feasible to connect the non-iterative character of *n*-retroflexion to its other properties, such as how the class of triggers and the class of opaque segments are defined. For example, Gafos (1996[1999]) argues that when sequences like /ṣ...n...n/ surface as [ṣ...ṇ...n], the second nasal does not undergo retroflexion simply because the preceding [ṇ] is not a trigger (only [ṣ, r] are). In other words, the middle [ṇ] behaves in exactly the same way as do other non-continuant retroflexes, such as [d] or [t]. As a result, we get [ṣ...ṇ...n] just as we get [ṣ...ḍ...n], [r...ṭ...n], etc., with no retroflexion of the nasal. Retroflexion does not spread from the retroflex stop/nasal in the middle, since only retroflex *continuants* are triggers; furthermore, retroflexion also does not spread *through* the middle stop/nasal. This general idea, that it is possible to reduce the non-iterative character of the process and the opacity of retroflex non-continuants to one and the same explanation—namely, that stops and nasals are non-triggers—hinges on certain fundamental assumptions which may not be entirely valid. We will return to this issue below.

In addition to intervening coronals being opaque, it appears that even non-coronal consonants can occasionally block *n*-retroflexion in Sanskrit. When the target /n/ is immediately preceded by a non-coronal (i.e. labial or velar) plosive or nasal, *n*-retroflexion applies variably, as noted already by Whitney: ‘The immediate combination of *n* with a preceding guttural or labial seems in some cases to hinder the conversion to ṇ: thus *vrtrag^hna:* etc., *kṣub^hna:ti*, *trpnoti* (but in Veda *trpṇú*), *kṣepnú*, *suṣumná*’ (Whitney 1889, §129; transcriptions adapted). In other words, an intervening labial or velar sometimes acts as

opaque to the propagation of retroflexion, the way an intervening coronal always does, though only when immediately adjacent to the target nasal. However, Steriade (1995b) dismisses this observed variation as being due to inaccurate *transcription*, arising from the fact that the retroflexion of [ŋ] in clusters like [gŋ] or [mŋ] has much weaker auditory consequences, and is thus less clearly perceived, than in vowel-nasal sequences like [aŋ]. Steriade thus argues that in examples such as the ones cited by Whitney, the nasal is in fact retroflex [ŋ], but is not being consistently recorded as such in the attested texts.²⁵

Aside from the segmental opacity facts discussed so far, *n*-retroflexion is frequently described as being sensitive to the right-hand context as well—i.e. to what, if anything, follows the potential target /n/. The descriptive generalization appears to be that in order to undergo retroflexion, the /n/ must be followed by a nonliquid sonorant (i.e. a vowel or glide, essentially). However, this appears to be not so much a restriction on *n*-retroflexion as such as a matter of the interaction of this process with other aspects of Sanskrit phonology, as shown convincingly by Schein & Steriade (1986).

As Schein & Steriade (1986) point out, the ‘failure’ of *n*-retroflexion to apply before continuants and liquids is only apparent. In the position before a (nonsyllabic) continuant, i.e. any of /s, ʃ, ç, h, r/, the nasal /n/ is realized as a nasalized vowel (the so-called *anusvāra*), and this debuccalization thus bleeds *n*-retroflexion. As for the position before /l/, no relevant word-internal /nl/ sequences appear to occur, making it impossible to determine if retroflexion would apply in that context or not. When this sequence occurs straddling a word boundary (/n#l/), the /nl/ cluster is realized as a nasal lateral—again, a process which thus bleeds *n*-retroflexion. This leaves only word-final position and nasal+stop clusters as

²⁵ There is another possibility which is at least conceivable (if not as convincing), namely that for precisely the auditory-perceptual reasons Steriade (1995b) cites, the nasal in clusters like /gn/ or /mn/ is not consistently ‘targeted’ by *n*-retroflexion. In other words, that /n/ in this position did not (always) undergo the diachronic sound change which presumably underlies the systematic alternation patterns observed. This would entail viewing that diachronic process as a perceptually motivated (and thus listener-based) sound change in the sense of Ohala (1993 et passim); see below for further suggestions along these lines.

environments where *n*-retroflexion is not found. In these environments, retroflexion can genuinely be said to fail, yielding [n] instead of retroflex [ɲ], as shown in (28).

(28) Retroflexion only if /n/ is followed by a sonorant

a. No retroflexion in word-final position:

brahman (*brahman) ‘brahman (VocSg)’ (cf. LocSg brahmaṇ-i)

b. No retroflexion before a stop:

tr=n=t-te (*tr=ɲ=t-te) ‘split (3Pl middle)’ (cf. 3Sg active tr=ṇa=t-ti)

However, Schein & Steriade (1986) show that the restrictions in (28) can also be derived from independent generalizations about Sanskrit phonotactics. In the word-final case in (28a), retroflexion is overridden by the complete neutralization of nasals to [n] in this position, cf. /a-gam/ → [agan] ‘go (2Sg aorist)’.²⁶ Even if the word-final nasal were within the domain of retroflexion, its effect would be ‘undone’ (i.e. overridden) by neutralization. Similarly, the failure of retroflexion to apply in (28b) can be attributed to an independent requirement of place assimilation in nasal-stop clusters. In such clusters, if the stop is labial, palatal or dorsal, the /n/ is forced to assimilate to it, becoming [m], [ɲ] or [ŋ], respectively, and thus immune to retroflexion. When the stop is dental, as in the example in (28b), it is reasonable to assume that the same assimilatory constraint is here responsible for the fact that /n/ does not become retroflex [ɲ]. Nasal-stop assimilation thus overrides *n*-retroflexion and prevents it from applying.²⁷

The restriction that the target nasal must be followed by a (nonliquid) sonorant can thus be argued to follow from the interaction of *n*-retroflexion with independently motivated aspects of Sanskrit phonology. For that reason, it should not be viewed as a limitation on

²⁶ In inflectional suffixes, word-final [m] does occur, as in 1Sg /-m/, 3Du /-ta:m/, GenPl /-(n)a:m/, etc.

²⁷ In nasals that are *underlyingly* retroflex, the requirement to maintain an underlying retroflex specification is sufficiently strong to force the following stop to yield instead. As a result, clusters such as /ɲ/+/t/ are realized as [ɲt], rather than as [nt] (e.g., /p^haṇ-ta/ → [p^haṇ-ta]).

n-retroflexion as such. However, there is one such right-hand contextual restriction, which rears its head in those cases when *n*-retroflexion applies between members of a compound word. Recall that *n*-retroflexion is always triggered by a retroflex continuant, i.e. /ʃ/ or /r/, occurring earlier in the word. When there is also an /ʃ/ or /r/ later in the word, retroflexion mysteriously fails to apply to the /n/ in the middle of the sequence /r...n...r/, /r...n...ʃ/, etc. Examples of this curious effect are shown in (29). In morphemes such as the ones listed in (29b), which frequently occur as the second member of compounds, the initial /n/ never undergoes retroflexion, even when preceded by an /r/ or /ʃ/.

(29) Retroflexion fails if ‘trigger’ also occurs to the right (data from Macdonell 1910)

- | | | | | | |
|----|------------------------|---------------------------------|---------------|---------|----------------------------|
| a. | pra:-nṛtyat | (*pra:-nṛtyat) | from -nṛt- | ‘dance’ | (cf. pra:-ṇīti ‘breathes’) |
| | pari-nakṣati | (*pari-ṇakṣati) | ‘encompasses’ | | (cf. pari-hṇuta: ‘denied’) |
| b. | -niṣṭ ^h a:- | (never *-ṇiṣṭ ^h a:-) | ‘eminent’ | | |
| | -niṣṣid ^h - | (never *-ṇiṣṣid ^h -) | ‘gift’ | | |
| | -nirṇij- | (never *-ṇirṇij-) | ‘adornment’ | | |
| | -nrmṇa- | (never *-ṇrmṇa-) | ‘manhood’ | | |

This rather striking property of *n*-retroflexion can be made sense of if it is interpreted from the perspective of listener-based sound change (cf. Ohala 1993 et passim). More specifically, it is plausible to assume that *n*-retroflexion is due to a *hypo-corrective* sound change, in the sense of Ohala (1993). The listener perceives the /n/ as retroflex but fails to correctly attribute this percept to contextual influence from a preceding /r/ or /ʃ/, parsing retroflexion instead as an (intentional) property of the nasal itself. If this view of the diachronic origin of *n*-retroflexion is correct, then the failure of retroflexion to apply in the contexts in (29) can be explained in the following way. When the /n/ is both preceded *and followed* by a retroflex continuant, the listener has even more reason to attribute his/her perception of the nasal

as retroflex to contextual influence from one (or both) of the surrounding retroflex segments. As a result, s/he is more likely to ‘factor out’ the retroflexion, and interpret the speaker (correctly) as having intended to produce a *non*-retroflex [n].²⁸

This concludes the presentation of the relevant details of Sanskrit *n*-retroflexion. Before addressing the important issue of how these facts relate to the general issue of segmental transparency vs. opacity in consonant harmony systems, the following section discusses how the opacity effect has been captured in phonological analyses of this phenomenon. The focus will be on analyses couched in Optimality Theory, the alignment-based treatments developed by Gafos (1999[1996]) and Ní Chiosáin & Padgett (1997).

3.2.3.2. Earlier analyses of the opacity effect

Having noted the various details and vagaries of Sanskrit *n*-retroflexion, it is now time to return to the opacity facts. Recall that all coronal consonants are opaque—dentals, retroflexes and palatals alike (except for the glide /y/)—in that they block the assimilation from applying *across* themselves.²⁹ For the sake of the argument, it is useful to break this into two separate issues: a) the opacity of dentals and palatals; and b) the opacity of retroflexes. In the former case, the opacity is clearly due to the inherent incompatibility of dental/palatal articulation (or feature specification) with the assimilating retroflexion property. For example, Gafos (1996[1999]) interprets [retroflex] as a setting of the gestural parameter Tongue-Tip Constriction Orientation (TTCO). Dentals are also specified for

²⁸ Of course, it is conceivable to ‘explain away’ this phenomenon as being due to inaccurate transcription, in the same way that Steriade (1995b) accounts for the apparent variability of *n*-retroflexion after non-coronal stops (see above). The idea would then be that the /n/ is targeted in the contexts in (29), and that it *was* in fact pronounced as retroflex [ɳ], but that *scribes* tended to render it in writing as unassimilated /n/—thus attributing the retroflexion to the following /r/ or /ʃ/, instead of parsing it (correctly) as an inherent property of the nasal. Although possible in principle, this type of explanation is hardly plausible (and unnecessarily convoluted) in this particular case.

²⁹ Of course, the retroflex continuants /ʃ, r/ are irrelevant here, since they are themselves retroflexion triggers. In the configuration ʃ/r...ʃ/r...n the middle consonant triggers retroflexion of the final /n/, and it is thus meaningless to ask whether it simultaneously ‘blocks’ a preceding /ʃ, r/ from (also) inducing retroflexion of that /n/.

TTCO, as having a ‘flat’ tongue-tip orientation; palatals, Gafos argues, require raising the tongue dorsum towards the palate. Each is articulatorily incompatible with a TTCO:[retroflex] setting. In the case of dentals this is because of their contradictory TTCO specification, but in palatals the conflict is with the specification of another gestural parameter (formalized by Gafos 1999:224 as the undominated constraint *[Tip-Blade: TTCO={retroflex}, Dorsum: CD={closed, critical}]).³⁰

As long as intervening dentals and palatals maintain their inherent specifications, their articulatory incompatibility with retroflexion accounts for why they do not themselves undergo retroflexion. Furthermore, this explains why dentals and palatals do not allow retroflexion to spread *through* them, since their articulation would necessarily interrupt the TTCO gesture which is being ‘stretched out’. A crucial notion here is contrast maintenance, and both Gafos (1996[1999]) and Ní Chiosáin & Padgett (1997) account for the opacity of intervening dentals in precisely these terms, the latter appealing to an Input-Output faithfulness constraint FAITH(TTCO), the former invoking a constraint CONTRAST(RETR) requiring the presence of a surface retroflexion contrast. In both cases, the susceptibility of dental *nasals* to retroflexion is achieved by differentiating between low-ranked FAITH(TTCO, Nasal) and higher-ranked FAITH(TTCO, Obstruent)—and similarly for the CONTRAST(RETR) constraints of Ní Chiosáin & Padgett (1997).

In this way, the opacity of palatals and dentals (other than /n/) is straightforwardly accounted for in a spreading-based analysis where strict (articulatory) locality is maintained. However, the opacity of *retroflex* consonants—and the non-iterativity of the retroflexion process, cf. (27)—does not in the same way fall out automatically. Let us first revisit the fact that only the first of a sequence of nasals undergoes retroflexion, e.g., in /pra-ninya:ya/ → [pra-ŋina:ya]. The standard explanation in earlier generative analyses of this phenomenon was that the apparent non-iterativity results from [ŋ] not being a retroflexion *trigger*. The

³⁰ Here ‘CD’ stands for Constriction Degree (of the Tongue Dorsum articulator against the palate).

preceding /r/ triggers retroflexion of the first /n/, which thus becomes [ŋ], but this nasal does not *in turn* pass the retroflexion feature on to the next /n/, because only continuants spread retroflexion. In derivational frameworks, this was easily accounted for in terms of an autosegmental spreading rule, which applies only when its structural description is met (potentially reapplying until this ceases to be true), such as that formulated by Schein & Steriade (1986). The same explanation is provided by Gafos (1996[1999]), whose Optimality Theory analysis is cast in terms of ALIGNMENT, retroflexion being driven by a constraint ALIGN-R(TTCO={retroflex}, trigger=[+cont]), which requires that the retroflexion gesture of a /ʃ/ or /r/ be spread (i.e. extended temporally) towards the right edge of the word.³¹

However, as Ní Chiosáin & Padgett (1997) point out, this traditional argument—that the first nasal blocks spreading because [ŋ] is not itself a trigger—crucially relies on *serial* rule application. As such it cannot be appealed to in an output-oriented framework such as OT; the alignment-based analysis sketched by Gafos (1996[1999]) in fact wrongly predicts that a sequence /ʃ...n...n.../ will turn out as [ʃ...ŋ...ŋ...]. The ALIGN constraint simply requires that the TTCO={retroflex} gesture be spread as far to the right as possible, and since any /n/ is in principle an undergoer (given that FAITH(TTCO, Nasal) is low-ranked), the gesture will spread up to (and potentially beyond) the second /n/. Note that there is only one trigger in this case: the /ʃ/ at the beginning of the sequence. The spreading property is not being ‘handed down’ stepwise from left to right, i.e. from /ʃ/ to the first /n/, and from the first /n/ to the second /n/, the way earlier derivational analyses assumed. The retroflexion gesture is spreading rightwards from the trigger /ʃ/ to *both* nasals—and, one might add, to all intervening vowels and non-coronal consonants as well. For better or worse, the fact that /ŋ/, like other non-continuant retroflexes, does not itself constitute a retroflexion trigger is entirely beside the point.

³¹ Although Gafos does not fully spell out the definition of the Sanskrit HARMONY(TTCO) constraint in terms of ALIGN, it is clear from the context that this is what he has in mind (see esp. Gafos 1999:218).

Although Ní Chiosáin & Padgett (1997) do not mention this, the same problem applies to the opaque behavior of intervening retroflex stops, /t, t^h, d, d^h/. Given an alignment analysis, there is no reason why the TTCO={retroflex} gesture should not spread *through* such a stop, yielding /s...d...n.../ → [s...d...ŋ...]. After all, the intervening stop is not incompatible with the spreading gesture in the way dentals or palatals are; indeed it is articulated with the very same TTCO gesture. If we indicate the temporal span of the retroflexion gesture with []_R, following Ní Chiosáin & Padgett (1997), there is no immediately apparent reason why the ALIGN(TTCO) constraint shouldn't force an underlying /CV_sV_dV_nV/ sequence to surface as *CV[_sV_dV_nV]_R rather than CV[_sV_d]_RV_nV. Again, the fact that /d/ is otherwise not a trigger is entirely irrelevant given an output-oriented, non-derivational analysis.

Ní Chiosáin & Padgett (1997) attempt to capture the non-iterativity facts by revising the alignment-based analysis by Gafos (1999[1996]). They propose that instead of aligning to the right word-edge, the [retroflex] feature is instead simply required to align with a (following) *consonant*, defining the relevant constraint as in (30):

(30) ALIGN-R([RETROFLEX], C)

Align any [retroflex] feature contained in a [+continuant] segment S_m to a consonant S_n, where n > m.

Given an input configuration like /s...n...n.../ the constraint in (30) is fully satisfied by the candidate [s...ŋ...n...], and therefore nothing prevents this from being selected as the optimal output. As regards the opacity of intervening /t/ or /d/, Ní Chiosáin & Padgett (1997) appear to attribute this to contrast maintenance—i.e. in the same way as they account for the opacity of intervening dentals—although they do not state this explicitly. This can be illustrated with one of their tableaux, shown in (31). Note that the analysis is cast in terms of

Dispersion Theory (Flemming 1995a); the candidates evaluated are thus really *inventories* of (potentially) contrasting output elements, rather than particular Input-Output mappings. The ‘•’ symbol denotes contrast.

(31) Sanskrit: Opacity of dental/retroflex stops (Ní Chiosáin & Padgett 1997)

		CONTRAST _{Cons} (RET)	ALIGN-R(retro)	CONTRAST _{Nas} (RET)
☞	a. k[ɕ] _R veda:na • k[ɕ] _R veḍa:na		*	
	b. k[ɕved] _R a:na	*!		
	c. k[ɕveḍa:ŋ] _{RA}	*!		*

Ní Chiosáin & Padgett argue that aligning the [retroflex] feature with the following stop, as in (31b), or with the subsequent nasal, as in (31c), will result in the obliteration of a /d/:/d/ contrast. This violates the undominated constraint CONTRAST_{Cons}(RET), and the alignment constraint responsible for [retroflex] spreading is prevented from having any effect. That spreading *does* occur through non-coronals like /b^h/ is attributed to the fact that the perceptual distance between non-retroflex b^h and retroflex [b^h]_R is too small to maintain a contrast—and thus to satisfy CONTRAST_{Cons}(RET) in (31). Since it is unavoidable to violate that top-ranked constraint, the lower-ranked ALIGN is able to exert its influence, forcing [retroflex] to spread across the labial stop.³²

³² Although Ní Chiosáin & Padgett do not mention this, it seems that further assumptions need to be made to explain why [retroflex] spreads all the way *through* a non-coronal like /b^h/ to reach a following /n/. All that ALIGN requires is for the feature to align to *some* following consonant, so why does spreading not stop at the labial, yielding *k[ɕ^h]_{RA}:na instead of k[ɕ^ha:ŋ]_{RA}? The former would be analogous to (31b), the latter to (31c); just as in the tableau in (31), the latter ought to lose out on CONTRAST_{Nas}(RET). It thus seems necessary to build some further stipulation about the target ‘S_n’ into the definition of the ALIGN constraint in (30), e.g., that it must be capable of *perceptually* manifesting a [retroflex] articulation, or something along those lines.

However, it need not be true that spreading necessarily entails the obliteration of a dental:retroflex contrast. Consider the following potential candidate ‘inventory’, which is not included in Ní Chiosáin & Padgett’s tableau in (31): {k[ɕ]_Rveda:na • k[ɕved̪a:ŋ]_{RA}}. In the form k[ɕ]_Rveda:na, spreading is blocked by a dental stop, whereas in k[ɕved̪a:ŋ]_{RA} it proceeds through a retroflex stop. (In terms of lexical representations, the former might correspond to hypothetical /kɕved-a:na/, the latter to /kɕved̪-a:na/.) A dental vs. retroflex stop contrast *is* maintained in the output, and hence top-ranked CONTRAST_{Cons}(RET) is satisfied. As for ALIGN-R(etro), it is only violated by one of the two members of this ‘micro-inventory’, namely by k[ɕ]_Rveda:na but not its counterpart k[ɕved̪a:ŋ]_{RA}. In the winning candidate (31a), by contrast, alignment is violated by *both* members of the output pair. It seems reasonable to assume that the alternative {k[ɕ]_Rveda:na • k[ɕved̪a:ŋ]_{RA}} should fare better. In other words, the spreading-based analysis does *not* appear to correctly predict the opacity of retroflex stops, unlike that of dentals and palatals, without some further additions.

Recall the Mayak coronal harmony case, described in 3.2.2 above, where the alveolar nasal /n/ does not trigger assimilation of a suffix dental /t̪/ (/CVn-Vt̪/ surfaces intact), but where an alveolar stop /d/ does trigger assimilation *across* the very same alveolar nasal (/dVn-Vt̪/ → [dVn-Vt̪]). This is entirely analogous to what should in principle be possible in Sanskrit: retroflex stops and nasals, although not in themselves harmony triggers, ought to be capable of letting harmony propagate through them. The fact that this does not happen in Sanskrit needs to be explicitly accounted for. Earlier derivational analyses, making use of feature geometry and autosegmental spreading rules, were able to do this in a straightforward manner, but the same result has yet to be replicated in output-oriented analyses within Optimality Theory.

3.2.3.3. Retroflexion spreading vs. consonant harmony

As noted in the previous section, the opacity effects observed in Vedic Sanskrit *n*-retroflexion are not difficult to account for in principle (although it is as yet unclear how this is best done in OT terms). As such they are quite analogous to what is found in a wide variety of harmony systems, cf. the cases mentioned in 3.2.1 above. Even the phenomenon whereby segments which themselves contain the spreading property are opaque (i.e. stops like /t/ or /d/ in the Sanskrit case) is not unheard of in the general typology of harmony effects. For example, high rounded vowels block rounding harmony in a number of Mongolian and Tungusic languages. For example, this is true of the Eastern Mongolian languages Khalkha, Buriat, and Inner Mongolian (Shuluun Höh dialect), and of the Tungusic languages Oroch, Ulcha and Even (Oxots dialect); all are described in considerable detail by Kaun (1995).³³ Regardless of how opacity effects of this particular kind are to be accounted for in a phonological analysis—cf. the problems discussed in the previous section—it can thus be said that this aspect of the Sanskrit facts is not particularly remarkable, as far as harmony effect go.

However, the fact remains that among *consonant* harmony systems, segmental opacity effects are completely unheard of, aside from this one case. This stands in sharp contrast to the typology of vowel harmony and vowel-consonant harmony systems, where opacity effects are quite commonplace. One of the central claims made in the present study is that consonant harmony is a phenomenon distinct from these other types of harmony phenomena, and should be analyzed in terms not of spreading but (long-distance) agreement. On this view, which forms the basis of the Optimality Theory analysis developed in chapters 4 and 5, the absence of opacity effects falls out as an automatic consequence. Intervening segments do not themselves enter into the agreement relation holding between

³³ In the Tungusic languages mentioned here, all high vowels are opaque, unrounded as well as rounded ones. In the Eastern Mongolian languages, by contrast, high unrounded vowels are *transparent*, whereas high rounded vowels are opaque.

the trigger-target pair, and therefore they must be irrelevant to that relation: they *cannot* be opaque. The segments separating trigger and target are thus ‘transparent’—but only in the sense that they are by definition irrelevant, not because they are exempted by way of some special device.

In order for this claim to be upheld, it must then be assumed that Sanskrit *n*-retroflexion is in fact *not* a case of consonant harmony in this sense. What I suggest here is that this phenomenon is instead a case of ‘vowel-consonant harmony’, i.e. akin to nasal harmony, pharyngealization harmony and the like. As such, the Sanskrit case presumably *does* involve spreading; on that assumption the fact that it displays segmental opacity effects is entirely to be expected. It should be noted that this is not a novel claim at all. In fact, this is exactly what earlier works assuming strict (articulatory) locality in spreading have claimed (Gafos 1996[1999]; Ní Chiosáin & Padgett 1997). The crucial difference is that these works have made the assumption that *other* coronal harmony phenomena—e.g., in Chumash or Tahltan—also involve spreading in the very same way. The claim made here is instead that these are fundamentally different and are not cases of spreading at all.

This is more than a mere ad hoc stipulation intended to save an otherwise exceptionless generalization (i.e. that consonant harmony systems do not show opacity effects). Seen against the background of the database of consonant harmony processes surveyed in this work, Sanskrit *n*-retroflexion turns out to stick out like a sore thumb in more respects than one. If we are to include it in the ranks of phenomena labelled ‘consonant harmony’, then we will be forced to admit that it is exceptional in several different ways. The most striking of these is the fact that the classes of triggers and targets are distinct ($/\text{ṣ}, r/$ vs. $/n/$). This is entirely unheard of elsewhere in the cross-linguistic typology of consonant harmony systems, where the generalization seems to be that the more similar two consonants are, the more likely they will be to agree in the harmony feature $[\pm F]$. Indeed, this similarity effect is directly built into the phonological analysis developed elsewhere in this work, cf. section

4.2.1.1 (see also 6.1 for discussion). The implication is that if a sibilant like /ʃ/ triggers ‘harmony’ in a nasal like /n/, this should entail that it will also trigger harmony in another sibilant, such as /s/. The one case that violates this generalization is Sanskrit *n*-retroflexion.³⁴

Another peculiar property of the Sanskrit phenomenon is its left-to-right directionality. As discussed in 3.1 above, the basic directionality of consonant harmony processes is anticipatory, or right-to-left. Although progressive harmony is found, this always goes hand in hand with morphological constituent structure; the directionality in such cases is not so much left-to-right as it is *inside-out*. In fact, the analysis introduced in chapter 4 builds the anticipatory directionality directly into the constraints which give rise to harmony. Progressive harmony emerges through constraint interaction, based on the relative ranking of the harmony constraint and faithfulness constraints of various types. Sanskrit *n*-retroflexion does not fit this generalization: its directionality is consistently left-to-right, regardless of the morphological makeup of the form in question, and regardless of where exactly the triggering /ʃ, r/ or the target /n/ are located in the word. As such, it cannot be accounted for within the analysis of consonant harmony developed in chapters 4 and 5. However, the consistent left-to-right directionality exhibited by the Sanskrit process is not so striking when we compare it against vowel-consonant harmony systems. For example, there are numerous cases of nasal harmony (many of them covered by the survey in Walker 1998[2000]) where nasalization spreads consistently rightward, without this necessarily being dictated by morphological constituent structure.

A third notable property of Sanskrit *n*-retroflexion is that it may occasionally cross word boundaries, thus applying in ‘external sandhi’. Although this is not a very common

³⁴ Others have made convincing arguments for why it should be precisely the continuants /ʃ, r/ that trigger retroflexion spreading, and why /n/ should be a more susceptible target than other dentals (Steriade 1995b; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997). I should emphasize that I do not disagree with these in any way. The relevant point here is simply that in *other* cases of long-distance consonant assimilation—which I argue are not cases of spreading at all—disjoint trigger vs. target classes do not occur.

phenomenon, it does occur in some vowel harmony systems. For example, vowel harmony may apply between a clitic and its host (e.g., in the famous Pasiego Spanish case, see e.g. McCarthy 1984; Vago 1988; Hualde 1989). In consonant harmony, on the other hand, this is completely unattested. If anything, consonant harmony tends to hold within relatively restrictive morphological domains; it never reaches beyond the confines of the word. Again, the Sanskrit phenomenon would be the sole exception.

Other properties could be mentioned here, but these may ultimately be related to the opacity effect and/or the disjoint sets of triggers and targets. For example, consonant harmony always applies to any and all potential targets within a domain (which is typically morphologically defined); it never ‘hits’ the nearest target, leaving the others untouched, the way Sanskrit *n*-retroflexion does. As such, the Sanskrit phenomenon is reminiscent of umlaut phenomena, whereby vowel-to-vowel assimilation applies in a non-iterative fashion (unlike vowel harmony proper, where the spreading property can reach several vowels).

To sum up, segmental opacity effects are merely one of a whole series of properties of Sanskrit *n*-retroflexion which are otherwise entirely unattested in the typology of consonant harmony phenomena. The most important ones are summarized in (32).

(32) Sanskrit *n*-retroflexion as consonant harmony—typological anomalies:

a. Segmental opacity:

In no other consonant harmony system does a particular class of segments block the propagation of harmony.

b. Harmony triggers vs. targets:

In no other consonant harmony system is the set of triggers disjoint with that of targets; consonant harmony always reflects relative similarity.

c. Directionality:

Left-to-right directionality which does not emerge from constituent structure (or other Faithfulness effects) is otherwise unattested in consonant harmony systems.

d. Harmony domain:

In no other consonant harmony system does the assimilation apply at a phrasal level, reaching across word boundaries.

There is thus ample reason to be skeptical of the status of Sanskrit *n*-retroflexion as a bona fide case of consonant harmony. This particular phenomenon does indeed appear to be an example of spreading, in the same way as vowel harmony and vowel-consonant harmony phenomena are.

Interestingly, it is not even self-evident that this phenomenon fits the working definition of consonant harmony which was introduced in section 1.1 above. This definition is repeated in (33).

(33) Consonant harmony (definition):

Any assimilatory effect of one consonant on another consonant, or assimilatory co-occurrence restriction holding between two consonants, where:

- a. the two consonants are separated by a string of segmental material consisting of at the very least a vowel; and
- b. intervening segments, in particular vowels, are *not audibly affected* by the assimilating property.

As discussed in 1.1 above, the limitation clause in (33b) is essential, in order to separate the phenomena under scrutiny in this study from vowel-consonant harmony phenomena such as nasal harmony or emphasis harmony. Thus, for example, a hypothetical process like

/makad/ → [makan] (nasal consonant harmony) fits the definition in (33), whereas a process like /maʔad/ → [mãʔãn] (nasal harmony) does not.

Note also that coronal harmony phenomena, such as sibilant harmony, do fit the definition in (33) to the extent that it is true that intervening vowels and consonants are not *audibly* affected as well. Although the analysis of such phenomena in terms of strictly-local gesture spreading by Gafos (1996[1999]) is based on the idea that these intervening segments are articulatorily affected, this is assumed to have minimal acoustic-auditory consequences. In any case, no descriptive (or other) sources on languages with coronal harmony systems explicitly describe intervening segments as being affected. The phrasing in (33b) was explicitly tailored so as to include these, simply for the reason that these segments *might* well be genuinely transparent.

But the Sanskrit case is in fact somewhat unique in this respect, in that it is a long-extinct language, such that our knowledge of its phonology derives from written texts—rather than from descriptions (or transcriptions) carried out by modern linguists.³⁵ Given these circumstances, one must bear in mind that the transcriptions to a great extent reflect what distinctions were made in the Sanskrit *orthography*. For example, retroflexion is a property which tends to have a considerable acoustic-auditory effect on vowel quality. Indeed, numerous languages have vowels that are inherently retroflex, just as vowels may be inherently nasalized; there are even attested cases of retroflex *vowel* harmony (e.g., Yurok). In light of this fact, it is quite likely that the intervening vowels in a retroflexion span were affected by the spreading feature/gesture in a clearly audible way. If so, then Sanskrit *n*-retroflexion would in fact not satisfy the definition in (33) at all—no more than a nasal harmony process where intervening vowels are audibly nasalized. As noted by Gafos (1996[1999]), the Sanskrit process was interpreted along these lines already by Whitney

³⁵ It is true that the Sanskrit linguistic tradition is impressive, especially as regards phonetics/phonology. But alas, the ancient Sanskrit grammarians did not describe in detail the phonetic quality of vowels intervening between a retroflexion-triggering [ʂ] or [ɽ] and an assimilated target [ɳ].

(1889), who clearly assumes that retroflexion involves maintaining the retroflex posture of the tongue throughout the span from trigger to target. Gafos also notes that Allen (1951) suggested that the apparent long-distance character of the retroflexion process should be treated with caution, as this interpretation is based on the Sanskrit writing system, which is bound to be phonetically imprecise. Allen interprets retroflexion as a prosody (in the Firthian sense of the London School), which is roughly analogous to a gestural span in Gafos' (1999) spreading-based analysis.

To sum up, then, there is reason to believe that Sanskrit *n*-retroflexion does involve spreading, and that it is thus distinct from all the other cases that are here categorized as consonant harmony. This accounts for the fact that this particular phenomenon displays a series of properties that are otherwise unattested in the typology of consonant harmony systems. Sanskrit *n*-retroflexion is thus *not* to be equated with other cases of coronal harmony, such as sibilant harmony systems.³⁶ The two are distinct types of phenomena, in just the same way as nasal harmony (e.g., in Sundanese) and nasal consonant harmony (e.g., in Yaka) are distinct. It is therefore an unfortunate accident of history that the Sanskrit phenomenon has come to be one of the best-known (alleged) cases of 'coronal harmony' in the literature on phonological theory.

3.3. Interaction with prosodic structure

A further asymmetry between consonant harmony and other types of harmony systems pertains to the role prosodic structure can play in determining certain aspects of the harmony. Prosodic structure here refers to such notions as quantity (phonological length and/or syllable weight), stress (or lack thereof), and the affiliation of segments to syllables,

³⁶ It is possible that certain other coronal harmony phenomena involving retroflexion are cases of spreading, like Sanskrit *n*-retroflexion, rather than agreement as in consonant harmony 'proper'. For example, some of the coronal stop harmonies (primarily in Australian and Dravidian languages) which are discussed by Steriade (1995b) and Gafos (1996[1999]) may well be of this type. In the absence of any evidence one way or the other—whether it be direct or circumstantial—this will have to remain an open question.

feet and other higher-level prosodic categories. In principle, prosody may exert its influence in a number of ways. Harmony may be bounded by a prosodic domain (e.g., the foot), or prosodic properties may determine the class of harmony triggers and/or targets.

Sensitivity to various aspects of prosodic structure is generally quite common in vowel harmony, as well as in vowel-consonant harmony processes such as nasal harmony or pharyngealization harmony. In light of this fact, it is somewhat surprising that the following clear generalization emerges from the cross-linguistic study of consonant harmony on which this study is based: Prosody-sensitivity is entirely *unattested* in the typology of consonant harmony systems. In other words, consonant harmony is never bounded by prosodic domains such as the syllable or the foot, and it is never sensitive to stress or quantity in any way.

Section 3.3.1 discusses the different ways in which harmony processes may be sensitive to aspects of prosodic structure. Since none of these are attested in consonant harmony, this overview serves the purpose of illustrating how common prosody-sensitivity in harmony systems is in general. This makes its absence in the typology of consonant harmony systems all the more conspicuous. Finally, section 3.3.2 presents an apparent counterexample to the claim that consonant harmony is never sensitive to prosodic structure: Yabem voicing harmony. It is argued that this phenomenon is in fact not a case of prosody-sensitive *consonant* harmony, neither synchronically nor diachronically, and therefore does not invalidate the generalization.

3.3.1. Types of prosody-sensitivity in harmony systems

The different ways in which harmony systems may display sensitivity to prosodic factors are here grouped into three major categories: sensitivity to length, syllable weight, and stress (as well as metrical structure in general). These are discussed in that order in the following sections. It should be kept in mind that this tripartite categorization is by no means hard and

fast. The reason is that segmental length (3.3.1.1) is intimately connected to syllable weight (3.3.1.2), and the latter is in turn frequently involved in determining stress and foot structure (3.3.1.3). Because of the interdependence of these, it is often very hard to tease them apart and determine which is the factor that is truly responsible for the observed effect. It may very well be that in all of the cases mentioned here *stress* (or foot structure in general) is ultimately to blame. The following overview takes a relatively agnostic perspective on this issue, categorizing individual cases in terms of the directly observed parameter, based on the descriptive sources consulted.

3.3.1.1. Phonological length

The first factor under consideration is segmental length, i.e. the distinction between long and short vowels—and, similarly, between geminate and singleton consonants. At issue here is whether harmony can be in any way dependent on the length (or shortness) of either the target or trigger segments. Such effects will be discussed in turn and each illustrated with attested examples. Sensitivity to length is not attested in consonant harmony, though it is frequently found in other types of harmony systems.³⁷

An important caveat should be added. Differences in vowel length often go hand in hand with a difference in vowel quality, such as height or centralization (vs. peripherality). It may well be the case that, in some apparent cases of long/short asymmetries in potential target vowels, it is the *quality* that is the crucial factor, not length. The asymmetry between long and short /e/ in Hungarian mentioned below (transparent vs. front-harmonic) is a case in point. In some of the reported cases it is rather obvious that vowel quality rather than quantity is to be blamed for the observed long/short asymmetry. However, the descriptive

³⁷ As was discussed in section 3.2.2 above, the ‘length’ of the string of segments intervening between trigger and target may be relevant. This is true of both vowel and consonant harmony. However, this is clearly a different issue than *segmental* length, i.e. the long/short or geminate/singleton distinction. Such oppositions directly involve prosodic (moraic) structure, whereas this is not obviously true in the same sense of the ‘distance metric’ that determines the maximum separation of trigger and target. (See Frisch et al. 1997 for an interesting implementation of distance effects in dissimilatory cooccurrence restrictions.)

sources do not always give very detailed information about such relatively fine-grained quality differences.

It is quite common in vowel harmony systems for the length of the *target* vowel to play a role in determining whether (or how) that vowel is affected. Examples of this interplay between length and susceptibility to harmony fall into two categories. Firstly, a long vowel may *fail* to undergo harmony whereas its short counterpart does. Secondly, long vowels may be *targeted* by harmony to the exclusion of their short counterparts. This correlation between length and susceptibility to harmony may either hold across the board, i.e. for all (relevant) long-short vowel pairs, or it may be limited to a particular pair of vowels.

There are numerous cases of the first type, where a long vowel is opaque (i.e. a non-undergoer) while its short counterpart undergoes harmony. For example, according to Shahin (1997), pharyngealization harmony in Palestinian Arabic affects only short vowels, not long ones. Likewise, in Telugu rounding harmony (Marantz 1980 apud Poser 1982; Kiparsky 1988; cf. also Venkateswara Sastry 1994), only short /i, u/ are undergoers, whereas all long vowels appear to be opaque. Other systems where the target vowel is required to be short include rounding harmony in various dialects of Maltese (Puech 1978; McCarthy 1979[1985]), suffix raising harmony in Lhasa Tibetan (Chang & Shefts 1964; Miller 1966), the lowering and front/back harmonies of Tigre (Palmer 1956, 1962; McCarthy 1979[1985]), and /a/-raising in Woleaian (Sohn 1971, 1975).

This type of sensitivity to target vowel length is illustrated for Palestinian Arabic in (34). Pharyngealization or postvelar articulation is marked with [◌̤] on consonants.

(34) Pharyngealization harmony in Palestinian Arabic (data from Shahin 1997)³⁸

- | | | | |
|----|--------------|-------------------|------------------------------|
| a. | /ʕUlÆ/ | [ʕʊ.lə] | ‘Hiba’ (fem. name) |
| | /bInIm-Æ/ | [ˈbɪ.nɪ.m-ə] | ‘goat’ |
| b. | /ʃE:f-E:n/ | [ʃɛ.ˈf-e:n] | ‘summers (Du)’ |
| c. | /t-ʃI:b-I-ʃ/ | [tʃɪ.-ʃɪ.ˈb-i:-ʃ] | ‘don’t touch (it)! (2SgFem)’ |
| | /n-ʃI:b/ | [n.-ʃɪ:b] | ‘should we touch (it)?’ |

The short vowels in (34a) are pharyngealized, i.e. retracted and lowered, due to the word-initial consonant (the status of word-final schwa is complicated, but can be ignored for the present purposes). In (34b), retraction (triggered by pharyngealized /ʃ/) only affects the short vowel of the first syllable, not the long vowel of the following syllable; note that both are long in the lexical representation. The examples in (34c) show even more clearly that it is surface rather than underlying vowel length that counts. In the first form the root vowel surfaces as short, and thus undergoes pharyngealization harmony, whereas the suffix vowel fails to undergo harmony because it is long on the surface. In the second form, the length of the root vowel is preserved on the surface; as a result, it fails to harmonize.

In Palestinian Arabic pharyngealization harmony, sensitivity to vowel length is across-the-board: all long vowels fail to harmonize. The more idiosyncratic type of length-sensitivity is exemplified by languages like Wolof (Ka 1988). In Wolof tongue-root vowel harmony, it is only with respect to the low vowel /a/ that length plays a role. Whereas short /a/ undergoes [ATR] harmony regularly, long /a:/ is opaque, being consistently [-ATR].

The systems discussed so far involve long vowels failing to undergo harmony. It appears to be much rarer for harmony to preferentially target long vowels, failing instead to apply to their short counterparts. One reported case of this type is Menomini (Bloomfield 1962, 1975; Cole 1987[1991]; Cole & Trigo 1988). In Menomini, raising of mid vowels to

³⁸ I depart from Shahin’s (1997) decision to represent *surface phonological* representations with ‘{}’, as distinct from *phonetic* forms in ‘[]’, although I agree that the two are in principle separate notions.

high under the influence of a subsequent high vowel appears to target long /e:, o:/ exclusively, whereas short /e, o/ are unaffected. Another case where the target is required to be a long vowel is Buriat rounding harmony (Kaun 1995; based on Poppe 1965). Short /u/ triggers rounding harmony on the vowel of the following syllable, but only when the latter is long, as in the first example in (35a):

(35) Rounding harmony in Buriat (data from Kaun 1995)

- a. xul-do: ‘foot (refl.dat.)’
 xul-de ‘foot (dat.)’
- b. xuzu:n-de: ‘neck (refl.dat.)’
 xuzu:n-de ‘neck (dat.)’

As the forms in (35b) indicate, there is a further restriction on Buriat rounding harmony: /u/ only triggers harmony when it is short. This is an example of the second main type of length-dependence in harmony systems: length of the harmony *trigger* as a factor. This phenomenon appears to be somewhat less common. Again, the restriction can go both ways: in some systems the trigger is required to be long, whereas in others it is required to be short. An example of the latter type is rounding harmony in Maltese (Standard and Mellieħa dialects; Puech 1978), where a suffix /e/ rounds (and backs) to [o] due to harmony from a rounded vowel in the preceding syllable. This harmony is only triggered by *short* rounded vowels, as shown in (36) for Standard Maltese.³⁹ The relevant (potential) trigger vowel is underlined; stress is marked by ‘ˈ’ where relevant.

³⁹ In the Mellieħa dialect, the target vowel is likewise required to be short.

(36) Rounding harmony in Standard Maltese (data from Puech 1978)

- | | | |
|----|----------------------------|----------------------------|
| a. | kitib-l-ek | ‘he wrote to you’ |
| | kitib- <u>om</u> -l-ok | ‘he wrote them to you’ |
| b. | kitib- <u>u</u> -l-ek | ‘he wrote yo you’ |
| | n- <u>bu</u> :s-ek | ‘I kiss you’ |
| c. | ma kitib- <u>u</u> -l-ék-ʃ | ‘I do not write it to you’ |
| | ma n- <u>bu</u> s-ék-ʃ | ‘I do not kiss you’ |

Short /u, o/ trigger harmony (/ -ek/ → [-ok]), as in (36a), but long /u:/ does not (36b). As can be seen from the examples in (36c), it is underlying rather than surface length which matters in this particular case. When an underlyingly long vowel surfaces as short (due to stress shift), it still fails to trigger rounding harmony on a following vowel.

As we saw in (35) above, another case of rounding harmony where the trigger is required to be a short vowel is Buriat. According to Poppe (1960), /u/ only triggers rounding harmony on a following vowel when it is itself short. Long /u:/ (as well as the corresponding [-ATR] vowel /u, u:/, long or short), does not trigger harmony under any circumstances. Another apparent example of a similar pattern, that of short /e/ vs. long /e:/ in Hungarian backness harmony, is better understood in terms of vowel quality rather than quantity. In Hungarian, long /e:/ is transparent (as are /i, i:/), i.e. it allows harmony from a preceding back vowel to propagate across it. Short /e/, by contrast, behaves for the most part as a harmonic vowel, i.e. a legitimate trigger of front harmony, and is generally *not* transparent. However, the two are quite distinct phonetically, short [ɛ] vs. long [e:], and this is probably the reason for their different behavior with respect to harmony. As argued by Ringen & Kontra (1989), there appears to be a gradient of ‘harmonicity’ vs. neutrality/transparency increasing along the scale [i:]-[i]-[e:]-[ɛ], with long /e:/ showing a

slight tendency towards behaving as a front harmonic vowel, but in a much more limited way than short /e/ does.

In the Maltese and Buriat cases (as well as the Hungarian one), harmony favors short vowels as triggers. The reverse pattern also appears to be attested, though not as solidly so. For example, in Tigre front/back harmony, short vowels ([ə, ɐ]) always agree in backness with a following long vowel (Palmer 1962; McCarthy 1979[1985]). The triggering long vowel imposes its [±back] value on any and all preceding short vowels. However, since the only vowels that are specified for [±back] in the first place are long vowels, it is not in fact necessary to interpret harmony as being sensitive to length at all. A similar re-statement also works for Tigre lowering harmony as well (Palmer 1956), by which short [ɐ] becomes fully low before the long low vowel [a:]. Since there is no independently existing short [a], the length condition on the trigger appears to be superfluous.

A second possible case of harmony where the trigger is required to be long is Old Norwegian (Hagland 1978; Majors 1998). Aside from the fact that Old Norwegian vowel harmony is also sensitive to *stress*, there seems to be a restriction such that a long (and stressed) /a:/ requires the vowel of a following (unstressed) syllable to be mid rather than high. The examples in (37) are given in pseudo-orthographic representation:

(37) Height harmony in Old Norwegian (data from Hagland 1978)

- a. 'va:r-er 'our (NPIMasc)
'læ:r-d-er 'learned (NPIMasc)
'mæ:l-t-o 'said (3PI)
- b. 'adr-um 'other (DSgMasc)
'æll-u 'all (DSgNeut)
'æll-er 'all (NPIMasc)

As evidenced by the forms in (37b), the short low vowels /a, æ/ fail to trigger harmony, and can thus be followed by either high or mid vowels. However, it is possible to analyze this as a consequence of vowel *reduction* rather than length-sensitive vowel harmony. Hagland (1978) and Majors (1998) thus interpret the restriction observed in (37a) as being due to the neutralization of high and mid vowels in those final syllables that are not parsed into the same (bimoraic) foot as the preceding stressed vowel.

To sum up, various harmony systems are sensitive to the length of either the trigger or the target. Harmony may be triggered by short vowels but not long ones, or by long vowels but not short ones (though the latter is not as firmly attested). Likewise, harmony may affect long-vowel targets but not short ones, or short-vowel targets but not long ones. In such cases, the non-undergoers (whether short or long) are neutral, and are either opaque—blocking the propagation of harmony—or, occasionally, transparent. Note that although length-sensitivity is attested for both vowel harmony and vowel-consonant harmony (cf. the case of pharyngealization in Palestinian Arabic), it is always *vowel* length that is involved, not the geminate/singleton distinction among consonants. It is thus perhaps not surprising that consonant harmony systems are never sensitive to whether the trigger or target consonant is short (singleton) or long (geminate). Nevertheless, it should be emphasized that the strictly-local-spreading approach to consonant harmony (cf. sections 1.2.3 and 4.1.1) treats intervening vowels as targets (i.e. undergoers) no less than the consonants. It should thus be possible *in principle* for consonant harmony to be blocked by long vowels—perhaps a particular long vowel—while spreading through any and all short vowels (or, conversely, to be blocked by short vowels but not long ones).

3.3.1.2. Syllable weight

In the cases mentioned in the previous section, harmony systems of various types are sensitive to vowel length. Since vowel length is directly correlated with syllable weight—in

that a vowel length renders a syllable heavy—it is conceivable that weight is actually the crucial factor in some of these systems. The question is then whether syllable weight as such can be demonstrated to interact with harmony phenomena. If this were so, one would expect there to exist vowel harmony systems where a short vowel is specifically required to be in a closed syllable (or, conversely, required *not* to be in a closed syllable) in order to function as a trigger (or, alternatively, as a target) of harmony.

There appear to be extremely few examples of vowel harmony being sensitive to syllable weight in this obvious fashion. The best candidate I have come across is a sound change in the history of Sinhalese (Geiger 1938; Bright 1966), whereby the back vowels /u, o, a/ have been fronted to [i, e, æ] under the influence of a front vowel in the following syllable. This only took place if the target vowel was in a heavy syllable, i.e. when /u, o, a/ were either long or in a closed syllable. However, as in the case of length-sensitive harmony, it is always possible that the crucial factor is *stress* and foot structure—which in turn is sensitive to syllable weight.

Pharyngealization harmony in Cairene Arabic (cf. Hoberman 1989 and references therein) may also be a case of syllable weight influencing harmony. In this language, [RTR] is a property of entire syllables, rather than individual segments. Rightward spreading of [RTR] to subsequent syllables is only triggered by a closed syllable (and the *target* syllable is furthermore required to contain a low vowel). The fact that the relevant notion appears to be ‘closed’ rather than ‘heavy’ syllable raises some suspicion. This entails that the conditioning environment could, in effect, be restated as ...C.CV..., where C₁ belongs to an [RTR] syllable and C₂ does not. It might thus be possible to derive rightward harmony by the interaction of various constraints, one of which requires adjacent consonants to agree in [RTR], another that there be [RTR] agreement throughout the syllable, etc. It is not even clear that notions like ‘closed syllable’ or ‘coda’ would have to come into play—and much less syllable weight as such.

Yet another potential case, again involving reference to *closed* syllables, is suffix rounding harmony in Maltese (Puech 1978). In Standard Maltese, rounding harmony exclusively targets vowels in word-final closed syllables. The same restriction appears to hold for the ‘unrounding’ version of rounding harmony in the Qormi and Siggiewi dialects: An unrounded vowel triggers unrounding of an (underlyingly rounded) suffix vowel in the following syllable, but only if the latter is in a word-final closed syllable. This is evident from the fact that Puech (1978) states the right-hand environment for the relevant harmony rules as $_C_1\#$. For the Standard Maltese case, Puech (1978) explicitly states that it is only ‘a final I in a closed syllable’ which undergoes rounding harmony to [o] (‘I’ = short [i]/[e]) when preceded by [o]. However, it is unclear whether final vowels in open syllables (i.e. in absolute final position) fail to undergo harmony for the reason that they are in an open syllable, or for other reasons. Recall from above that Standard Maltese rounding harmony applies only to underlyingly *short* vowels. As Puech (1978) notes, all vowels that are found in absolute final position happen to be underlyingly *long* (although they surface as short). This alone would make these vowels exempt from harmony, and it is therefore unclear that the closed vs. open syllable distinction is relevant at all.⁴⁰

The general conclusion is that there is little conclusive evidence that harmony systems can make direct reference to, or be directly dependent on, the distinction between light and heavy syllables. This implies that mora count is only directly relevant to harmony processes as a property of individual *segments* rather than syllables. In addition, it can be indirectly relevant, in that harmony may be sensitive to foot structure, which in turn is frequently weight-sensitive.

⁴⁰ Alternatively, the restriction may be ‘string-based’, rather than sensitive to syllable weight or syllable structure, in the sense that the target vowel is required to be flanked by consonants. Evidence for ‘inter-consonantal’ position as a well-defined category comes from cases like Nawuri (Casali 1995), where underlyingly short front vowels become centralized inter-consonantly, i.e. everywhere but in absolute initial or final position.

3.3.1.3. Stress and metrical structure

We now turn to the issue of how stress and related metrical notions (e.g., foot structure), can exert an influence on harmony systems. This appears to be considerably more common than direct sensitivity to segmental length or syllable weight. For a recent investigation into stress-dependent harmony systems, see Majors (1998), where several of the cases mentioned here are discussed in greater detail. It should be kept in mind that stress-sensitivity is relatively common, and the coverage of representative cases below is bound to be very limited and sketchy.

The ways in which stress can factor into the workings of individual harmony systems fall into three broad classes, each of which will be considered separately in the following discussion. Firstly, stress may come into play as a *trigger* condition, such that a triggering vowel is either required to be stressed or unstressed. Secondly, there may be instead be a requirement that a *target* vowel be stressed or unstressed. Thirdly, stress may have a purely delimiting or bounding function, such that harmony does not spread past a stressed vowel, or that harmony holds only within the foot but not between adjacent feet.

A very common way in which vowel harmony systems may be sensitive to stress is for the trigger to be required to be a stressed vowel. This vowel then spreads the harmonic feature onto an unstressed vowel (or an entire span of unstressed vowels) in nearby syllables. Examples of this include height harmony in the Pasiego and Tudanca dialects of Spanish (Penny 1969ab, 1978; McCarthy 1984; Vago 1988; Hualde 1989; Flemming 1994), suffix-induced height harmony in Lhasa Tibetan (Sprigg 1961; Chang & Shefts 1964; Miller 1966), height harmony in Old Norwegian (Flom 1934; Hagland 1978), backness and rounding harmony in Eastern Mari (a.k.a. Cheremis; Hayes 1985; Flemming 1994), and height harmony among mid vowels in Breton (Falc'hun 1951; Anderson 1974).

The requirement that the harmony trigger be a stressed vowel is also attested in certain types of vowel-consonant harmony systems, such as nasal harmony. For example, in

the Applecross dialect of Scottish Gaelic, nasalization spreads rightward from a stressed nasalized vowel through all subsequent unstressed syllables in the word, unless blocked by a stop or one of the mid vowels /e, o, ə/ (Ternes 1973; van der Hulst & Smith 1982a).⁴¹ This is illustrated in (38). Note that stress is typically root-initial in this language. In (38b), nasal harmony is blocked by a stop, in (38c) by a mid vowel.

(38) Nasal harmony in Applecross Gaelic (data from van der Hulst & Smith 1982a)

a.	/ʃɛ̃nɛ:var/	ʃɛ̃nɛ:̃vār	‘grandmother’
	/k ^h ɔ̃vía:t/	k ^h ɔ̃vía:t	‘how much’
b.	/sNán ^d an/	šNán ^d an	‘thread’
	/k ^h ɔ̃ispaxk/	k ^h ɔ̃ispaxk	‘wasp’
c.	/má:riçən/	má:riçən	‘mothers’
	/sáũLəxkən ^j /	šáũLəxkən ^j	‘to compare’

Another well-known case of stress-sensitive nasal harmony is Guaraní (Gregores & Suárez 1967; Rivas 1975; van der Hulst & Smith 1982a; Piggott 1992; Flemming 1994; Majors 1998; Walker 1998[2000]; Beckman 1998). In Guaraní, nasalization spreads from a stressed nasalized vowel to unstressed syllables in both directions (with certain restrictions that are irrelevant here).

Harmony may also be sensitive to whether or not a potential *target* vowel is stressed or unstressed. This is frequently the case in those systems that are typically labelled ‘umlaut’ or ‘metaphony’, where a stressed vowel assimilates to a vowel in an adjacent unstressed syllable (usually the immediately following one). To the extent that harmony and umlaut are related phenomena, these are relevant in the present context.

⁴¹ Nasalization also spreads leftward to the onset consonant of the stressed syllable (i.e. it spreads throughout the stressed syllable), but that need not concern us here.

One case where harmony exclusively targets the stressed vowel of the word is the so-called ‘metaphony’ found in various Asturian dialects of Spanish (Hualde 1998). In most cases, a word-final unstressed high vowel (typically /u/) triggers raising of a stressed non-high vowel, without any observable (or as yet documented) effect on intervening vowels. In the Lena dialect, this raising takes the form of a vowel shift, merging /e, o/ with /i, u/, and /a/ with (unraised) /e/. In the Alto Aller dialect, by contrast, no merger occurs, with /e, o, a/ raising to the intermediate allophonic values [ɛ, ɔ, ɛ]. Finally, in the Nalón valley dialect, raised /e, o/ merge with /i, u/, whereas the raising of /a/ is allophonic, yielding [ɔ]. The examples in (39) are from the Lena dialect; the forms in (39b) illustrate the transparency of an intervening unstressed vowel.

(39) ‘Metaphony’ in Lena (Asturian) dialect of Spanish (data from Hualde 1998)

- | | | | |
|----|----------------|--------------|---|
| a. | <i>nínu</i> | ‘boy’ | cf. <i>nénos</i> ‘boys’, <i>néna</i> ‘girl’ |
| | <i>tsúbu</i> | ‘wolf’ | cf. <i>tsóbos</i> ‘wolves’, <i>tsóba</i> ‘she-wolf’ |
| | <i>pélu</i> | ‘stick’ | cf. <i>pálos</i> ‘sticks’ |
| b. | <i>kéndanu</i> | ‘dry branch’ | cf. <i>kándanos</i> ‘dry branches’ |
| | <i>péfaru</i> | ‘bird’ | cf. <i>páfara</i> ‘female bird’ |

There are also a great number of harmony systems which require the target vowel to be *unstressed* rather than stressed. However, it appears that such cases are more appropriately classified either as being bounded by stress (i.e. operating within the domain of the foot) or as being sensitive to the stressed vs. unstressed nature of the *trigger* vowel. When harmony spreads from a stressed vowel to vowels in adjacent syllables, it virtually always happens to be the case that the latter are unstressed. Similarly, harmony which exclusively targets unstressed vowels will be blocked by a stressed syllable. But it is more appropriate to think of such a situation as a case of higher-level prosodic categories imposing a boundary on the

spreading of the harmonic property. In fact, Flemming (1994) argues, in effect, that all cases of stress-sensitivity can and should be reinterpreted as involving foot-bounding (or dependency on higher-order metrical structure in some other way). Flemming makes the strong claim that relative stress—in the sense of prominence relations (e.g., between the trigger and target vowels)—plays no role whatsoever in any assimilation processes, including harmony. Metrical structure, however, can condition assimilation by providing a bounding domain of feature association. This controversial issue is beyond the scope of the present study (see Beckman 1998 for an alternative view of some of the relevant cases).

As an example of potentially foot-bounded harmony, some Spanish dialects display a centralization or [ATR] harmony which emanates from a word-final vowel and spreads leftward up to and including the stressed vowel. This is the case in the Tudanca dialect (Hualde 1989; Flemming 1994), and also in the probably unrelated [ATR] harmony of (Eastern) Andalusian dialects, at least according to Zubizarreta (1979).⁴²

Vowel-consonant harmony systems are also frequently bounded by stress. For example, Schourup (1972, 1973, citing David Stampe, pers.comm.) describes an unidentified Midwestern dialect of English as having a nasal harmony which spreads leftward from a coda nasal up to and including the stressed syllable. In a word like *rewiring*, only the pretonic syllable *re-* remains oral: [ri.¹wāĩ.rĩŋ]. Another example of nasal harmony with similar characteristics is that of Guaraní, which was briefly mentioned above. Here nasalization spreads from a stressed vowel to unstressed vowels in both directions, but is blocked by a stressed syllable, as illustrated in (40). Note that under rightward spread (40b), nasalization is blocked by the the stressed syllable as a whole (rather than the stressed vowel as such), and does not affect the onset consonant of that syllable. Interestingly, a

⁴² In the latter case, there is some controversy as to whether or not pretonic vowels are affected as well (cf. Hualde & Sanders 1995). Zubizarreta (1979) claims that stressed high vowels act as transparent and allow the centralization feature to propagate further to the left. In Pasiego, a dialect closely related to the Tudanca one, ATR harmony is not bounded by the foot; instead, it propagates to the very beginning of the phonological word (including proclitics and prepositions). See McCarthy (1984) and Hualde (1989) for discussion and analyses of the Pasiego pattern and, in the latter case, the differences between this and the Tudanca one.

prenasalized stop blocks rightward nasalization only if there is a stressed vowel somewhere further to the right, as the pair in (40c) shows.

(40) Nasal harmony in Guaraní (data from Walker 1998[2000])

- | | | | |
|----|--|--|----------------------|
| a. | /ro- ^m bo-por ^á / | [r ^õ m ^õ p ^õ r ^á] | ‘I embellished you’ |
| | / ⁿ do-roi- ⁿ dup ^á -i/ | [n ^õ r ^õ i ⁿ ũp ^á i] | ‘I don’t beat you’ |
| b. | /ir ^ù -ré/ | [i ^r ũ-ré] | ‘ex-friend’ |
| | /ak ^à r ^{ay} ^{wé} / | [ãk ^à r ^ã y ^{wé}] | ‘hair (of the head)’ |
| c. | / ^m b ^é ⁿ da/ | [m ^é nã] | ‘husband’ |
| | / ^m b ^è ⁿ da-ré/ | [m ^è ⁿ da-ré] | ‘widow(er)’ |

There are other cases of vowel-consonant harmony that show a similar kind of bounding effect. For example, progressive [RTR] harmony in Thompson (Salish; Thompson & Thompson 1992) is triggered by a root consonant or vowel specified as [+RTR], and this pharyngealization affects any subsequent ‘retractable’ segments, up to and including a stressed (suffix) vowel. This is illustrated in (41), where the extent of the [+RTR] span is indicated with brackets; the root is marked with ‘√’ in the underlying representation. Forms such as the one in (41b) suggest that the consonant immediately following the stressed vowel also falls within the harmony domain, even though it is strictly speaking not part of the stressed syllable.

(41) Progressive RTR harmony in Thompson:

- | | | | |
|----|----------------------------------|--------------------------------|---------------------------------|
| a. | /ʔes-√ç ^ɸ m-eleʔ=xən/ | ʔes-[ç ^ɸ m-á]leʔ-xn | ‘he has feet smeared with dirt’ |
| b. | /nə-√k’əʔ=us-n-t-es/ | n-k’[ʔ-óʃ]-es | ‘he smears the window’ |

To sum up, sensitivity to higher-level prosodic structure, such as stress and foot boundaries, is relatively common in vowel harmony and vowel-consonant harmony systems. In consonant harmony systems, on the other hand, such effects are entirely unattested. The next section examines one apparent exception to this generalization, voicing harmony in Yabem, and explains why this does in fact not constitute an example of foot-bounded consonant harmony.

3.3.2. Yabem: An apparent case of foot-bounded consonant harmony

There exists one relatively well-documented case which may appear to be a counterexample to the generalization stated earlier, i.e. that consonant harmony is never sensitive to prosodic structure in any way. This is the obstruent voicing harmony found in Yabem, an Austro-nesian language of Papua New Guinea (Dempwolff 1939; Bradshaw 1979; Ross 1993, 1995). In this and other related languages of the Huon Gulf chain, a phonological tone opposition (high vs. low) has developed, correlated historically with the voicing vs. voicelessness of neighboring consonants. Even synchronically in Yabem, voicing and tone are intimately connected. It is precisely this interdependence, as we shall see below, that makes Yabem harmony a rather special case. As it turns out, Yabem is *not* a counterexample to the generalization about prosody-sensitive harmony systems.

As can be seen from examples such as the ones in (42), Yabem has a two-way tone contrast, with every syllable carrying either high tone or low tone. However, absolute minimal pairs are only possible when there are no obstruents present (other than /s/; see below), as in (42a). This is because in obstruents, tone is directly correlated with voicing: In high-toned syllables, stops are voiceless, whereas in low-toned syllables, they are voiced (42b). Note that the transcription has been modified from the data sources, e.g., by using /j/ rather than ‘y’ for the palatal glide, and marking tone consistently on all syllables.

(42) Tone and obstruent voicing within Yabem morphemes (Ross 1993, 1995)

a. Minimal pairs without obstruents (other than /s/):

áwé	‘outside’	àwè	‘woman’
ólí	‘body’	òlì	‘wages’
jáó	‘prohibition’	jàò	‘enmity’
-sáʔ	‘to hammer’	-sàʔ	‘put on top of’

b. Minimal pairs containing obstruents:

píŋ	‘shell’	bìŋ	‘speech’
típ	‘all at once’	dìb	‘thud’
páliŋ	‘careless’	bàliŋ	‘far away’
sákíŋ	‘service’	sàgìŋ	‘house partition’

The sole fricative in the Yabem inventory, /s/, is phonetically voiceless but cooccurs with both high and low tone. This is the result of a relatively recent merger of voiced */z/ (in low-toned syllables) with voiceless /s/, which originally occurred only in high-toned syllables. Interestingly, Dempwolff (1939:7) explicitly states that /s/ becomes somewhat voiced (‘etwas stimmhaft’) when the following vowel is low-toned, although this does not seem to be true anymore, judging by the description by Ross (1995).

Note that in the examples in (42) above were uniformly high- or low-toned, even when disyllabic. The reason is that in Yabem words, the final two syllables form an iambic foot, and both syllables of this foot must agree in tone (and thereby also in obstruent voicing). When inflectional prefixes attach to monosyllabic roots, this results in harmony alternation, whereby the prefix has high tone (and voiceless stops) before a high-toned root, as in (43a), but low tone (and a voiced stop) before a low-toned root, as in (43b).

(43) Harmony alternations in verb prefixes: 1Sg /ka-/, 1PlIncl /ta-/ (Ross 1995)

a. Before monosyllabic high-toned roots:

ká-táŋ ‘I weep’ (realis)

ká-téŋ ‘I ask’ (realis)

tá-táŋ ‘we weep’ (realis/irrealis)

tá-téŋ ‘we ask’ (realis/irrealis)

b. Before monosyllabic low-toned roots:

gà-dèŋ ‘I move towards’ (realis)

gà-dèŋ ‘I put (on a shelf)’ (realis)

dà-dèŋ ‘we move towards’ (realis/irrealis)

dà-dèŋ ‘we put (on a shelf)’ (realis/irrealis)

Beyond the confines of the word-final iambic foot, syllables are consistently high-toned. Consequently, the same prefixes as above surface with high tone and a voiceless stop when they attach to a disyllabic root, regardless of whether that root is high- or low-toned. This is illustrated in (44).

(44) No harmony alternations outside the foot (Ross 1993, 1995)

a. Before disyllabic high-toned roots:

ká-léí ‘I run’ (realis)

ká-kátóŋ ‘I make a heap’ (realis)

b. Before disyllabic low-toned roots:

ká-dàbìŋ ‘I approach’ (realis)

ká-gàb^wà? ‘I untie’ (realis)

ká-dàm^wè ‘I lick’ (realis)

ká-màdòm ‘I break in two’ (realis)

If we leave tone aside and consider only obstruent voicing, the descriptive generalization is that voicing harmony is enforced within the foot, but its effects do not reach across a foot boundary. Cooccurring stops are required to agree in voicing, with affix stops assimilating to root stops (just as in the case of Kera; cf. 3.1.2 above)—but only if the stops belong to the same *prosodic* domain, namely the foot. It thus appears that Yabem is a counterexample to the claim made earlier, that consonant harmony systems are never sensitive to prosodic factors such as stress or foot structure, and can only be bounded by morphological domains, never prosodic ones.

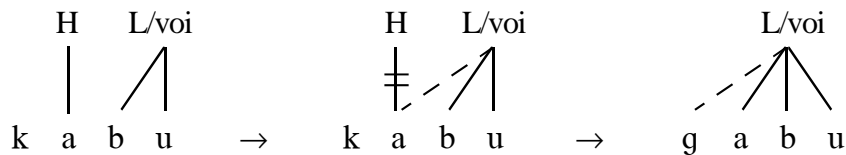
Although this characterization of Yabem does observational justice to the facts, it should be emphasized that there is in fact no need to assume that Yabem has voicing harmony at all. As noted above, voicing vs. voicelessness of obstruents and low vs. high tone are interdependent. More accurately, *tone* is the property which is distinctive (i.e. unpredictable) in Yabem—as evidenced by minimal pairs such as the ones in (42a) above, which do not contain any stops. Wherever stops do occur, their voicing vs. voicelessness is always predictable from the tone of the syllable in question. It is therefore perfectly reasonable to interpret Yabem as having foot-bounded *tone* harmony rather than foot-bounded obstruent voicing harmony. For example, the closely related language Bukawa also has foot-bounded tone harmony of exactly the same type as in Yabem, but without voicing being dependent on tone (Ross 1993).⁴³ On this interpretation, harmony as such is only determining the *tone* of the prefix syllable in the alternations observed in (43) above. The concomitant voicing alternations, by contrast, are not due directly to harmony, but rather fall out from the restriction that stops are realized as voiced in low-toned syllables but as voiceless in high-toned syllables (cf. Poser 1981). On this interpretation of the synchronic

⁴³ It appears that the dependence of voicing on tone has been *lost* in Bukawa. In the final syllable (the head of the iambic foot), onset stops are voiceless, but in the penultimate syllable (the non-head portion of the foot), onset stops are voiced. See Ross (1993) for further discussion.

phonology of Yabem tone and voicing, this language is not a case of foot-bounded consonant harmony after all.

An interesting alternative is proposed by Bradshaw (1998), who argues for a multi-planar (feature-geometric) treatment of tone/voicing interactions. Bradshaw suggests that the traditional feature [voice] and low tone (L) should be replaced by a single privative feature, [L/voice]. She argues that this feature can be associated either subsegmentally (to the Laryngeal node) or prosodically (to the mora). In the former case, the phonetic realization of the feature is voicing, whereas in the latter case it is low tone. This treatment allows for the possibility of capturing the Yabem facts in terms of the (foot-bounded) spreading of the single feature [L/voice]. For example, Bradshaw spells out the derivation of /ká-bù/ → [gàbù] ‘I insult (realis)’ as follows:

(45) Tone/voice harmony in Yabem (Bradshaw 1998)



In the first step of the derivation in (45), [L/voice] spreads to the mora of the prefix syllable. In the second step, it spreads to (the Laryngeal node of) the initial /k/. The same spreading process is thereby responsible for both tone and voicing within the foot.

When reinterpreted in the manner Bradshaw suggests—and this is independent of the particular feature-geometric analysis she proposes—the Yabem harmony is more akin to vowel-consonant harmony phenomena, such as the spreading of nasalization, pharyngealization, or retroflexion (as in Sanskrit, cf. 3.2.3 above). Here, as in those cases, a single property is spreading throughout a particular domain, affecting all segments within its purview, vowels as well as consonants. In this context, the foot-bounded character of Yabem

tone/voicing harmony is not surprising at all. As we saw in the previous section, harmony phenomena of this kind are frequently sensitive to metrical structure, stress and so forth.

Having dismissed Yabem as a case of foot-bounded consonant harmony synchronically, we must still consider the possibility that the *diachronic* change underlying the synchronic facts was a process of this type. Although it is possible to treat tone as distinctive and voicing predictable *synchronically*, it is nevertheless the case that historically, what gave rise to the tone contrast in the first place was, in fact, the voicing vs. voicelessness of neighboring consonants (cf. Bradshaw 1979; Ross 1993, 1995). In the diachronic scenario reconstructed by Ross (1993), syllables containing a voiced obstruent acquired low tone, whereas all others acquired high tone. The latter thus includes syllables containing a voiceless obstruent, but also syllables without any obstruent. In an earlier work, Ross had suggested that the diachronic process of tonogenesis was preceded by obstruent voicing harmony; this would have been a separate sound change, entirely independent from any considerations of tone (Ross 1988). If this reconstructed scenario were correct, then it would be the case that Yabem had undergone foot-bounded consonant harmony as a diachronic sound change. Yabem would thus count as a refutation of the claim made here, that consonant harmony is never sensitive to prosodic structure.

However, Ross (1993) shows that his earlier reconstruction was problematic in several respects. Instead, he suggests that tonogenesis took place first (as outlined above). This was then followed by a general harmony process, defined as in (46). Recall that the foot is iambic and word-final; hence the ‘strong’ syllable is final and the ‘weak’ one penultimate.

- (46) Tone and voicing harmony in Pre-Proto North Huon Gulf (Ross 1993)
- Where the weak and strong syllables of a foot differ in tone and voicing,
- (a) if the onset of the *strong* syllable is a Post-Proto Huon Gulf obstruent, the weak syllable acquires the tone and voicing of the strong;
 - (b) otherwise, if the onset of the *weak* syllable is a Post-Proto Huon Gulf (voiced) obstruent, the strong syllable acquires the tone and voicing of the weak.

Note that this process is quite analogous to the kind of synchronic analysis Bradshaw (1998) suggested, in that tone and voicing assimilate as one and the same property. Indeed, Ross himself describes the change in (46) in exactly this way: ‘spreading of voicing and tone occurs together’ (1993:145). The voicing specification of obstruents is significant, in that they seem to be acting as *triggers*.⁴⁴ However, the crucial point is that what they trigger is the combined spreading of tone and voicing, not voicing agreement at-a-distance in the sense of consonant harmony. As it turns out, then, Yabem is not an example of prosody-sensitive consonant harmony, neither synchronically nor diachronically.

⁴⁴ Note that it is only obstruent *onsets* that trigger harmony. A (word-final) coda obstruent will not have this effect, and may in fact have its voicing determined by the harmony process in (46). Thus, the root ‘fly’ (Proto Huon Gulf **lovok*) developed into /-lóp/ by a series of segmental changes combined with tonogenesis. After a high-toned prefix such as 1Sg Irrealis /á-/ , it has retained this shape: /á-lóp/. By contrast, the 1Sg Realis prefix is low-toned, /gà-/ , and the combination /gà-/ + /-lóp/ developed into /gà-lòb/ by (46b). In other words, harmony determined not only the *tone* of the root syllable, but also the voicing of the final stop; as a result, the root ‘fly’ alternates synchronically between /-lóp/ and /-lòb/.

CHAPTER 4
AN OPTIMALITY-THEORETIC ANALYSIS
OF CONSONANT HARMONY

This chapter develops a generalized phonological analysis of consonant harmony, based on the empirical generalizations that emerged from the typological survey presented in the preceding chapters. The analysis is couched in the constraint-based framework of Optimality Theory (Prince & Smolensky 1993). In part, it makes extensive (though somewhat novel) use of the notion of *correspondence*, as embodied in most current work within the theory (see McCarthy & Prince 1995). The analytical framework developed in this chapter borrows heavily from Walker (2000ab, to appear), who analyzes some of the phenomena which are treated as consonant harmony in the present study. In addition, crucial use is made of the notion of targeted constraints, as developed by Wilson (2000, in progress; see also Baković & Wilson 2000).

The chapter is structured as follows. Section 4.1 discusses earlier analyses of consonant harmony (and assimilatory cooccurrence restrictions in general) within Optimality Theory. Section 4.2 sketches the central components of the proposed model, the types of constraints involved and the fundamental constraint rankings required to give rise to harmony. Directionality effects are discussed in section 4.3, and it is shown how these arise from interaction with faithfulness constraints.

4.1. Earlier proposals within Optimality Theory

This section examines a few analyses of consonant harmony and related phenomena that have been proposed within the context of Optimality Theory. Section 4.1.1 briefly discusses spreading-based analyses and the main objections which have been raised elsewhere in this work against the validity of this approach to consonant harmony phenomena.

Section 4.1.2 outlines the way MacEachern (1997[1999]) handles assimilatory effects in her analysis of laryngeal cooccurrence restrictions and discusses the problems inherent in extending this approach to consonant harmony in general. Finally, section 4.1.3 introduces correspondence as a viable alternative for analyzing consonant harmony. This section focuses heavily on the framework developed by Walker (2000ab, to appear), since Walker's proposals form the basis of the generalized analysis of consonant harmony which is then developed in the remainder of this chapter.

4.1.1. Analyses based on spreading and strict locality

In the tradition of autosegmental phonology and feature geometry, it has generally been taken for granted that all assimilation involves *spreading* of features or feature classes. Since harmony is by definition a matter of assimilation, it has been regarded as a prime example of autosegmental spreading. The fact that harmony systems give the appearance of involving assimilation at-a-distance, skipping intervening segments, raises the important issue of *locality*: it is an empirical fact that phonological segments do not interact with each other at arbitrary distances. Non-linear frameworks, such as the metrical or autosegmental ones, solve this problem by appealing to the notion of 'legitimate target'. Locality is obeyed as long as no legitimate target ('feature-bearing unit', 'anchor', etc.) is being skipped; see, e.g., Poser (1982); Shaw (1991).

Feature geometry, where different features and feature classes are represented along different tiers, allows apparent long-distance assimilations to be interpreted as feature spreading, without resulting in association-line crossing (see Odden 1994 for extensive discussion of locality in feature geometry). In some cases, this necessitates appealing to *underspecification*, especially in the case of consonant harmony processes. For example, Shaw (1991) assumes (following Steriade 1987) that any segment that is transparent to harmony in feature [F] is unspecified for [F] at the point when the harmony rule applies. As

a consequence, transparent /t/, /n/, etc. in sibilant harmony systems must be taken to be unspecified for [\pm anterior]—and possibly even the place feature [coronal] as well—and receive their default [+ant] specification *after* harmony has applied.

The use of underspecification in this manner is inherently problematic in non-derivational, surface-oriented frameworks such as Optimality Theory.¹ More recently, numerous works have adopted an alternative and much more stringent view of locality in spreading, whereby all spreading is seen to obey *strict segmental locality* (e.g., Flemming 1995b; Padgett 1995b; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997; Walker 1998). According to this view, all feature spreading occurs between root-adjacent segments. Any and all segments that fall within a harmony domain are necessarily participants in that harmony; intervening segments are thus not transparent but *permeated* by the feature in question. A particularly strong version of this view equates phonological features with articulatory gestures (cf. Browman & Goldstein 1986, 1989, 1992 et passim). Spreading is then a matter of the real-time extension of one continuous articulatory gesture, and skipping is by definition impossible (see Gafos 1996[1999] in particular).

As was discussed in section 1.2.3 above, the typology of consonant harmony systems has figured quite prominently in the justification of the strict locality approach. Consonant harmony constitutes a much more blatant *prima facie* counterexample to this view than vowel harmony. This is because in consonant harmony systems, the interacting segments are often spaced quite far apart, separated by a long stretch of (seemingly) transparent vowels and consonants. However, as noted by Flemming (1995b), Gafos (1996[1999]) and Ní Chiosáin & Padgett (1997), the features involved in coronal harmony are typically correlated with gestures carried out by the tongue tip/blade, and as such they

¹ Underspecification in lexical (= Input) representations is by no means contrary to the tenets of Optimality Theory (see Inkelas 1995). However, harmony results from constraints evaluating *surface* representations, which presumably are fully specified, lest there be a third level (a ‘phonetic’ representation of some sort). What is problematic for OT is the reliance on *intermediate* representations with underspecification—which is precisely what a traditional autosegmental spreading rule was able to produce as its output.

could easily permeate vowels and non-coronal consonants without interfering with their articulation or acoustic realization in any significant way. Combined with the oft-noted predominance of coronal harmony within the typology of consonant harmony systems, this observation leads these researchers conclude that the strict locality approach is vindicated.

Optimality-Theoretic analyses of consonant harmony in terms of strict locality make use of the same analytical devices as are applied in spreading-based analyses of vowel harmony, nasal harmony, and so forth. For example, both Gafos (1996[1999]) and Ní Chiosáin & Padgett (1997) assume that consonant harmony is driven by alignment constraints (ALIGN-L, ALIGN-R), which require the feature in question (or the corresponding articulatory gesture) to be extended as far as possible toward a particular edge of some morphological or phonological domain. Gafos (1999:218) defines the constraint responsible for right-to-left coronal harmony in Tahltan as ALIGN(TTCA, Word, L). This constraint requires that a specification in terms of the gestural parameter TTCA (Tongue-Tip Constriction Area) must spread leftwards in order to align with the left edge of the word.

Any segment that is incompatible with the spreading feature [\pm F]—e.g., because faithfulness to underlying [\pm F] specifications in that segment type is high-ranked—will block the propagation of harmony. This is how both Gafos (1996[1999]) and Ní Chiosáin & Padgett (1997) capture the fact that Sanskrit n-retroflexion is blocked by any coronal obstruent (see 3.2.3 for the relevant facts). Gafos takes retroflexion to involve assimilation in the parameter TTCO = Tongue-Tip Constriction Orientation, more specifically the value [retroflex] of that parameter. He differentiates nasals from obstruents in terms of their susceptibility to retroflexion by assuming the following ranking: FAITH(TTCO, Obstruent) >> FAITH(TTCO, Nasal).² The ALIGN(TTCO=[retroflex]) constraint responsible for retro-

² Instead of IO faithfulness, Ní Chiosáin & Padgett (1997) appeal to constraints enforcing *contrast* in the feature in question, i.e. [retroflex]. The relevant constraints are CONTRAST_{NAS}(RET), which demands that a [retroflex] contrast be maintained on nasals, and CONTRAST_{CONS}(RET), which demands the same for other

flexion spreading outranks only FAITH(TTCO, Nasal) but not FAITH(TTCO, Obstruent). As a result, coronal obstruents block the rightward propagation of the [retroflex] property.

As argued elsewhere in this work, there are several flaws with the strict locality approach to consonant harmony. Only a few will be mentioned here. First of all, note that it is based on the *assumption* that consonant harmony involves feature/gesture spreading. It is perfectly possible to retain the fundamental tenet of the strict locality approach—that spreading always targets root-adjacent segments, with no skipping allowed—while interpreting consonant harmony as involving something *other* than spreading. Secondly, the strict locality approach to consonant harmony wrongly assumes that coronal harmony is the *only* attested type of consonant harmony; the truth is that coronal harmony is simply the most common type. Other types are robustly attested as well, some of which cannot by definition involve local spreading of articulatory gestures (e.g. nasal consonant harmony, obstruent voicing harmony, etc.). In fact, the true empirical generalization is that *sibilant* harmony in particular (rather than coronal harmony in general) is vastly more common than any other type of consonant harmony. Interestingly, contrasting sibilants strikingly often interalso act in speech errors, where gesture spreading is demonstrably not involved (see section 6.1 below for discussion). Appealing to speech planning (phonological encoding) rather than gestural timing as the source domain for consonant harmony phenomena has the added advantage that it can help account for empirical generalizations such as the ‘palatal bias’ effects discussed in chapter 6 and the predominance of right-to-left directionality.

Another important objection is that the strict locality approach wrongly predicts that segmental opacity is as much to be expected in consonant harmony systems as it is in vowel harmony or nasal harmony systems, since these are assumed to be equivalent phenomena, all involving the temporal extension of articulatory gestures. For example, in Yoruba [ATR] harmony, high vowels are required to be [+ATR] and block the left-to-right propagation of

consonant types. The ranking $\text{CONTRAST}_{\text{CONS}}(\text{RET}) \gg \text{ALIGN-R}(\text{RET}) \gg \text{CONTRAST}_{\text{NAS}}(\text{RET})$ gives rise to the Sanskrit pattern.

[-ATR] harmony (see, e.g., Archangeli & Pulleyblank 1989). There is no a priori reason why a language with apical/laminal sibilant harmony couldn't in the same way require its stops /t, d/ to be laminal, and thus block the propagation of sibilant harmony. As we saw in section 3.2, however, opacity of this kind is *never* observed in consonant harmony.³ Segments are either 'legitimate targets', and as such are affected by harmony, or they are completely inert and freely allow the harmony feature to propagate through/across themselves. This typological fact is highly surprising under the strict locality approach.

The strict locality approach assumes that intervening segments that appear to be transparent are in actual fact permeated by the spreading feature/gesture. True transparency, if it exists at all, must be explained away as a special phenomenon requiring special devices (see Ní Chiosáin & Padgett 1997; Walker 1998 for some suggestions). However, it should be kept in mind that the evidence that intervening segments in coronal harmony systems are permeated rather than genuinely transparent is merely *conjectural*—consisting of the argument that the spreading feature/gesture *could* potentially be maintained through these segments. This conjecture has not been confirmed with instrumental phonetic studies on any existing coronal harmony system. In fact, what concrete evidence does exist points towards genuine transparency rather than permeation (see 3.2.2 above for discussion of some relevant cases).

Moreover, the need to assume permeation rather than transparency ultimately forces defenders of the strict locality approach to call into question the accuracy of a great number of descriptive studies of languages with consonant harmony systems. In his discussion of Chumash sibilant harmony, where the non-sibilants /t, n, l/ appear to be transparent, Gafos (1996[1999]) clearly states that the phonetic realization of a non-sibilant like /n/ will vary depending on which harmonic domain it happens to be in. Gafos takes the relevant

³ See section 3.2.3 for arguments that the best-known apparent counterexample, Sanskrit n-retroflexion, is in fact not a case of consonant harmony at all (and that, as such, this phenomenon *does* involve local spreading).

parameter to be apical vs. laminal, and gives the following schematic example (the phonetic representation of apicals vs. laminals is modified to conform to current IPA standards):

(1) Non-sibilants as participants in Chumash coronal harmony (Gafos 1999:183)

Apical domain: /...N...S/ → [... η ...S]

Laminal domain: /...N...Š/ → [... η ...Š]

In other words, the theory of strict articulatory locality forces us to assume that /n/ must have apical vs. laminal *allophones*, [η] vs. [η], whose distribution is governed by coronal harmony. Gafos proposes ‘that the reason why the nasal N and the other coronal stops are transparent is that the two stop articulations [...] are not contrastive in Chumash and are thus not perceived as distinct’ (1999:182). We have no detailed phonetic data from any of the (now extinct) Chumashan languages, but Gafos adds that neither Beeler (1970) nor Harrington (1974) report any apical-laminal contrasts for the non-sibilant coronals. This is certainly true, but these studies also do not report any *allophonic* apical-laminal distinctions for these segments, which the strict locality analysis assumes to be present in Chumash.⁴

There are several cases where we do have detailed descriptive sources on languages with coronal harmony that do go into a considerable amount of allophonic detail. In spite of the fact that sub-phonemic variants *are* described in these sources, the allophonic distinctions postulated by the strict locality approach are conspicuously absent from the descriptions. A case in point is the coronal harmony found in numerous Western Nilotic languages (see 2.3 and 2.4.1.2 above for data and references), where contrastively dental vs. alveolar consonants harmonize with each other. In some languages both stops and nasals maintain the dental/alveolar contrast, and harmonize with each other (e.g., Pāri, Anywa, Shilluk).⁵

⁴ It could be added that J. P. Harrington was often quite meticulous in recording phonetic detail in his transcriptions of elicited data.

⁵ As noted in 2.4.1.2 above, the distribution of dental [η] in Anywa is in fact mostly predictable (Reh 1996), although it is not allophonic in the strictest sense of that term. Depending on how the terms

Sequences like [d...n] or [d̥...n̥] are thus allowed, whereas *[d̥...n] is not. However, in some of these languages, the dental/alveolar contrast is absent in nasals (e.g., Dholuo, Mayak). In these languages, /n/ is described as consistently alveolar—and is neutral to coronal harmony, cooccurring with dental and alveolar stops alike (the same is also true of /l, r/ in all the languages). The strict locality approach must assume that in such cases, the nasal /n/ is in fact realized as alveolar [n] or dental [n̥] depending on the harmonic domain it occurs in. Thus, we are forced to believe that even in languages with the single nasal /n/, the harmony facts are exactly the same at the *phonetic* level: [d...n] and [d̥...n̥] occur but not *[d̥...n]. If this had indeed been the case, there is little doubt that this would have been noted in at least some of the relevant descriptive literature. In his description of Mayak, one of the languages with a single /n/ instead of a /n/:/n̥/ contrast, Andersen (1999) notes that /n/ is realized as dental [n̥] when immediately followed by a dental stop; thus we find dental [n̥] in the clusters /nd̥/, /nt̥/, but otherwise alveolar [n]. Had it been the case that dental [n̥] was *also* found as a result of coronal harmony, this would no doubt have been duly noted in Andersen's description.

Interestingly, Ní Chiosáin & Padgett (1997) invite the possibility that intervening segments in consonant harmony systems are genuinely transparent—i.e. not permeated by the propagating feature. They concede that true transparency certainly does exist in some cases of vowel harmony, and consider the possibility that the same might apply in some consonant harmony cases as well. The hypothetical example they mention is a coronal harmony system ‘in which a learner fails to maintain the tongue tip/blade gesture throughout a domain of spreading, because its effect isn't audible in non-sibilant segments’—in other words, where *apparent* transparency (actual permeation) has been reanalyzed as *genuine* transparency. This is certainly an interesting idea, especially from the point of view of the

‘contrastive’ vs. ‘redundant’ are defined, Anywa may thus be a rare example of consonant harmony not obeying Structure Preservation. (Another somewhat similar case is Nkore-Kiga sibilant harmony, which is discussed in detail in section 5.1.2 below.)

diachronic development of individual consonant harmony systems, although it creates a loophole which renders the strict locality approach to consonant harmony empirically unfalsifiable. But the fact remains that the strict locality approach treats genuine transparency as an aberration rather than the norm, and expects opacity where none is to be found.

As mentioned above, analyses of consonant harmony that assume strict locality have generally used ALIGN constraints to drive the spreading of the harmony feature or gesture. For example, Gafos (1996[1999]) formalizes the constraint responsible for Tahltan coronal harmony as ALIGN(TTCA, Word, L); this constraint is intended to spread an underlying TTCA specification leftwards, towards the beginning of the word. This is intended to capture the fact that it is the rightmost coronal that determines the TTCA value for all preceding segments. However, it is interesting to note that neither Gafos (1996[1999]) nor Ní Chiosáin & Padgett (1997) notice the inability of ALIGN by itself to give rise to this effect. Take the hypothetical inputs /sVfV/ and /fVsV/, which should yield the outputs [fVfV] and [sVsV], respectively, given the right-to-left directionality of Tahltan coronal harmony. In order for anything to happen, ALIGN must of course outrank faithfulness to underlying TTCA specifications: ALIGN-L(TTCA) >> FAITH(TTCA). As the tableaux in (2) show, this is not sufficient to derive the right result. The brackets in the output representations indicate the extent of the spreading TTCA gesture.

(2) Inadequacy of ALIGN for capturing uniform directionality:

	/sV]V/	ALIGN-L(TTCA)	FAITH(TTCA)
a.	[s][V]V	*!	
b. ☞]V]V		*
c. ! ☞	[sVs]V		*

	/]VsV/	ALIGN-L(TTCA)	FAITH(TTCA)
d.]][Vs]V	*!	
e. ☞	[sVs]V		*
f. ! ☞]V]V		*

The desired winners are (2b) and (2e), respectively. However, candidates (2c) and (2f) do just as well, even though the harmonic domain contains the ‘wrong’ TTCA value in these latter two candidates. The reason is that the ALIGN constraint does not (and cannot) specify *whose* TTCA value is to be aligned with the left edge of the word. As long as any and all output TTCA specifications are aligned properly, the constraint is satisfied. It is for this reason that ALIGN-based analyses of vowel harmony systems end up invoking other constraints (such as positional faithfulness to root vowels) in order to ‘anchor’ the harmonic domain correctly (see, e.g., Ringen & Vago 1998; Ringen & Heinämäki 1999).

As discussed in section 3.1, consonant harmony systems frequently exhibit right-to-left directionality that is blind to the morphological affiliation of the interacting segments. In other words, the rightmost consonant is always the trigger, regardless of whether it is located in the root or in an affix (and also regardless of whether the *target* is in the root or an affix). In such cases, it is impossible to appeal to faithfulness in order to determine which consonant will determine the feature value of the harmonic span.⁶ This difficulty in


⁶ One could certainly imagine faithfulness being ‘stronger’ in later segments than in earlier segments in the output string. But how is such a notion to be captured formally, where ‘stronger’ must translate into ‘higher-ranked’? We would need something along the lines of FAITH[F]_m >> FAITH[F]_n (m > n). But these are abstract constraints, neither of which can be interpreted without reference to the other (how do we know whether a given segment should be evaluated by FAITH[F]_m or FAITH[F]_n?) and they cannot possibly be

deriving fixed directionality is a general problem, arising from the output-oriented nature of Optimality Theory, and one aspect of it will rear its head again in section 4.2.3 below. For our present purposes, suffice it to point out that the ALIGN-based analyses advocated by Gafos (1996[1999]) and Ní Chiosáin & Padgett (1997) are fundamentally inadequate in ways which have not been addressed by these authors.

4.1.2. The complete-identity effect and BEIDENTICAL

In her study of laryngeal cooccurrence restrictions, MacEachern (1997[1999]) formulates constraint-based analyses of such restrictions in a wide range of languages. For the most part, the restrictions are dissimilatory in nature. For example, Cuzco Quechua does not permit two ejectives to cooccur within morphemes. MacEachern accounts for such patterns by adopting the generalized Obligatory Contour Principle schema argued for by Suzuki (1998).⁷ In Suzuki's formulation, the OCP is insensitive to factors such as adjacency, distance, etc. For Cuzco Quechua, the relevant OCP constraint is *[constricted glottis]...[constricted glottis], here abbreviated *2CG for simplicity. The example in (3) illustrates how the dissimilatory effect arises from the ranking *2[F] >> MAX[F].

(3) Laryngeal dissimilatory effect in Cuzco Quechua (MacEachern 1997[1999])

	/t'ak'a/	*2CG	MAX[c.g.]
a.	t'ak'a	*!	
b.	 t'aka		*

integrated into the overall constraint ranking in any meaningful way. For example, imagine that a markedness constraint against [+F] in a particular context intervenes between FAITH[F]_m and FAITH[F]_n. Will a given [+F] segment change to [-F] (because *[+F] >> FAITH[F]_n) or remain as [+F] (because FAITH[F]_m >> *[+F])? Unless *m* and *n* are given absolute values, it is impossible to tell. If they do represent absolute numbers (say, if *m* = 3 and *n* = 4), then this will entail that a segment will remain [+F] if it is among the first three segments in the string, but not if it occurs later in the word. In sum, this kind of solution is either impossible to implement or it is far too powerful. There must be other alternatives to capturing fixed directionality of assimilation.

⁷ Other proposals for formalizing OCP effects include self-conjunction (or disjunction) of constraints, cf. Itô & Mester (1996); Alderete (1997).

The example in (3) involves heterorganic ejectives, but the dissimilatory restriction in Cuzco Quechua does not distinguish between heterorganic and homorganic sequences; thus, /t'at'a/ becomes dissimilated to [t'ata] just as /t'ak'a/ → [t'aka].


However, several of the languages examined by MacEachern (1997[1999]) display what she refers to as the *complete identity effect*. In such languages, violation of the relevant OCP constraint is allowed just in case the two segments in question are identical. In other words, [t'at'a] is allowed even though [t'ak'a] is not. One such language is Peruvian Aymara. In order to account for this identity effect, MacEachern proposes a new constraint, BEIDENTICAL defined as follows:

(4) BEIDENTICAL (MacEachern 1997[1999])

Segments should be identical. One violation is assessed for every pair of non-identical segments.

Given an input /t'at'a/, BEIDENTICAL then prefers the (faithful) candidate [t'at'a] over the dissimilated [t'ata]. However, this is not enough, since a third candidate, [tata], fares even better, by satisfying both BEIDENTICAL and *2CG:⁸

(5) Complete identity effect in Peruvian Aymara (wrong result!)

/t'at'a/	BEIDENTICAL	*2CG	MAX[c.g.]
a. t'at'a		*!	
b. t'ata	*!		*
c. !  tata			**

⁸ Here and elsewhere, only consonant violations of BEIDENTICAL are counted. Given the definition in (4), violations should also be counted for consonant-vowel and vowel-vowel pairs, although these are omitted here for the sake of simplicity. For example, a hypothetical string such as [kunap] should receive 10 violations (4+3+2+1) of BEIDENTICAL, strictly speaking.

In order to get around this problem, MacEachern invokes yet another constraint which has the exact opposite effect of BEIDENTICAL, namely to *prohibit* the cooccurrence of identical segments. This constraint, here referred to as *IDENTITY, is in fact nothing more than an OCP constraint on (identical) root nodes. The distribution of *IDENTITY violations in the tableau is exactly complementary to that of BEIDENTICAL violations (the former penalizes precisely those candidates that the latter doesn't penalize). The mere addition of *IDENTITY to the tableau—regardless of its ranking—will therefore not help promote candidate (5a) over (5c), since both violate this constraint equally. Instead, MacEachern combines the two OCP constraints, *IDENTITY and *2CG, into one large conjunctive constraint (in the sense of Hewitt & Crowhurst 1996), as shown in (6).⁹

(6) *IDENTITY & *2CG

This constraint is violated by the cooccurrence of one or more of the following: two identical segments *or* two segments characterized by [constricted glottis].¹⁰


Replacing *2CG with the conjunctive constraint *IDENTITY & *2CG gives the right result, allowing a double-ejective candidate like [t'at'a] to emerge as the optimal one, as shown in (7). This is because the conjunction has the effect of collapsing violations of *2CG and

⁹ The actual conjunctive constraint that MacEachern proposes is even more complex, in that it involves a third conjunct, the OCP constraint *2(LAR ∨ [-son]). This constraint serves the purpose of prohibiting the cooccurrence of ejectives and aspirates (i.e. obstruents with a Laryngeal node). For the purposes of exposition, this aspect of the Peruvian Aymara cooccurrence restrictions is ignored—and MacEachern's analysis simplified accordingly.

¹⁰ Note that constraint conjunction as defined by Hewitt & Crowhurst (1996) treats constraints in a Boolean fashion, such that the conjunctive constraint *IDENTITY & *2CG requires segments to be non-identical *and* to disagree with respect to [constr. glottis]. This constraint is thus only 'true' (i.e. obeyed) when both *IDENTITY and *2CG are 'true'. This in turn entails that the conjunctive constraint is 'false' (i.e. violated) when *either* *IDENTITY *or* *2CG is 'false' (or both). Notice that the concept of constraint conjunction as used in many other works in Optimality Theory (going back to Smolensky 1995) is really a matter of *disjunction* in the definition of Hewitt & Crowhurst (1996), since such a constraint is obeyed when either one of the components is obeyed (or both are)—and hence violated only when neither component is obeyed.

*IDENTITY into one single violation. Even though [tʼatʼa] violates both *2CG and *IDENTITY, whereas [tata] violates only the latter, the two candidates fare equally badly on the large conjunctive constraint. What the constraint in (6) requires is that candidates satisfy *both* *IDENTITY and *2CG simultaneously; neither [tʼatʼa] nor [tata] does this, and thus each receives a violation mark. The choice between [tʼatʼa] and [tata] is thereby passed on to the lower-ranked constraint MAX[c.g.], which prefers the faithful (7a) over the maximally unfaithful (7c).

(7) Complete identity effect in Peruvian Aymara (revised)

/tʼatʼa/	BEIDENTICAL	*ID & *2CG	MAX[c.g.]
a.  tʼatʼa		*	
b. tʼata	*!		*
c. tata		*	*!*

Although MacEachern’s (1999) analysis manages to capture the relevant patterns of cooccurrence restrictions, there is reason to be somewhat skeptical of its general validity. Firstly, the analysis makes crucial use of of constraint conjunction and disjunction. These are extremely powerful formal tools, and the potential consequences of their usage on the overall generative capacity of OT grammars have by no means been investigated thoroughly enough. Secondly, the interdependence of BEIDENTICAL and *IDENTITY—two constraints that are in fact polar opposites of each other—seems somewhat suspect. Wherever BEIDENTICAL plays any role in deriving cooccurrence effects in the languages MacEachern analyzes, it does so by immediately outranking a large conjunctive constraint of the type *IDENTITY & *2[F] (where [F] is some feature targeted by the OCP in the language in question). It is this interplay, rather than BEIDENTICAL as such, which derives the complete identity effect. Nowhere do we see the constraint BEIDENTICAL ‘acting alone’, as it were.

Finally, there are problems with the constraint BEIDENTICAL itself, its definition and effects. For example, it is not entirely clear which segment pairs are supposed to fall within its scope. If the constraint evaluates any and all pairs of segments in the string, then one might expect total-assimilation effects between consonants and vowels, given the right constraint ranking—a highly counterintuitive result. A more serious drawback is the fact that BEIDENTICAL refers only to total identity, rather than identity in a particular feature or feature class, or some measure of overall similarity. From the point of view of this constraint, segment pairs differing only in one or two features, such as [kʰ]/[k] or [s]/[ʃ], are equivalent to much less similar pairs like [kʰ]/[ð] or [m]/[ʃ]. This does not cause problems in the particular cases that MacEachern (1997[1999]) analyzes, but it greatly reduces the applicability of the constraint to a wider range of phenomena. Interestingly, MacEachern (1997[1999]) justifies introducing BEIDENTICAL by motivating it in the domain of articulatory planning, and suggests that it may have other linguistic effects as well:

The preference for identical segments is likely to have an articulatory basis: programming two identical segments is probably easier than programming two different segments. Linguistic phenomena such as morphological reduplication, segment harmony processes in child speech, and reduplication processes among speakers with language deficits may offer other illustrations of this constraint in action. (MacEachern 1999:93)

Although consonant harmony in adult language is not among the phenomena MacEachern lists, the mention of harmony in child language is suggestive. If BEIDENTICAL is what is responsible for consonant harmony processes in child speech, then it may well be applicable to adult consonant harmony as well. However, the rigidity of BEIDENTICAL causes a problem here. Even in child language, consonant harmony frequently results in

partial rather than total identity, enforcing assimilation in a particular property (e.g., place or nasality) while leaving other properties unaffected, yielding forms like [gɪŋk] ‘drink’, [dʊt] ‘boot’, [minz] ‘beans’, etc. The same is of course true of consonant harmony in adult language, which usually involves agreement in a particular feature, rather than identity in all features.

Admittedly, MacEachern’s OT analysis is limited to cooccurrence restrictions on laryngeal features, and certainly does not purport to provide a formal account of consonant harmony in general.¹¹ It turns out, however, that even within the class of laryngeal cooccurrence phenomena there are systems that involve agreement in particular features without necessarily resulting in total identity. Although the set of languages examined by MacEachern (1997[1999]) does not include any such cases, several are reported in section 2.4.7 above. For example, the obstruent voicing harmony attested in Kera (Chadic), Yabem (Oceanic) and Ngizim (Chadic) holds between heterorganic and homorganic obstruents alike, and in Ngizim, even between stops and fricatives (homorganic and heterorganic). Likewise, the laryngeal harmony found in some southern Bantu languages (e.g., Zulu and Ndebele) holds regardless of differences in place of articulation between the stops in question. The same is also true of the root-internal implosion harmony observed in the Ijoid languages (e.g., Kalabari Ijo, Bumo Izon), which allow sequences like /b...d/ but not disharmonic */b...d/ or */b...d/.

¹¹ From MacEachern’s introductory discussion of the general phenomenon of ‘cooccurrence restrictions’ (1999:3-4), it seems clear that she considers consonant harmony to be homologous to the (mostly dissimilatory) phenomena to which her study is devoted. For example, her description of the essence of Chumash sibilant harmony is that ‘[w]ords do not contain sibilants that differ in place of articulation’. Perhaps not incidentally, the examples chosen as illustrations involve otherwise-identical sibilants (/osos/ ‘heel’, /pʃoʃ/ ‘garter snake’, but */osoʃ/). Furthermore, in the subsequent discussion MacEachern paraphrases the Chumash cooccurrence restriction as restricting ‘non-identical sibilants’ from cooccurring. This is a gross oversimplification, since non-identical sibilants are perfectly free to cooccur in Chumash words, provided that they agree in the particular feature [\pm anterior] (e.g., /s...ts/, /tʃ...ʃ/, etc.). If Chumash sibilant harmony were as simple as MacEachern appears to imply, then it would indeed be possible to capture it with a constraint along the lines of BEIDENTICAL. Unfortunately, the facts of Chumash sibilant harmony and most other consonant harmony systems go far beyond this simple scenario.

In short, there is reason to believe that the ‘complete identity effect’ observed by MacEachern is merely a specific instantiation of a more general phenomenon. In a sense, the total identity pattern constitutes the limiting case, where the two interacting segments *already* agree in all other properties. The survey reported on in chapter 2 includes numerous instances of consonant harmony systems—involving a wide range of phonological features—where the harmony is parasitic on identity in other features.

Although the analysis proposed by MacEachern (1997[1999]) is too constrained to account for the full range of attested laryngeal cooccurrence restrictions, let alone consonant harmony in general, it nevertheless has certain attractive aspects. For example, the analysis treats intervening segmental material as entirely irrelevant, something which is indeed characteristic of consonant harmony (cf. section 3.2 above for detailed discussion). Furthermore, MacEachern’s idea that the ‘identity effect’ (and BEIDENTICAL as such) has its roots in the domain of articulatory planning is very much in line with the account of consonant harmony phenomena presented in this thesis. The same appeal to speech planning is made by the correspondence-based analysis proposed by Walker (2000ab, to appear), which is outlined in the following section. This analysis also has the advantage of relativizing the identity-enforcing constraint to specific features, unlike MacEachern’s monolithic BEIDENTICAL.

4.1.3. Correspondence-based analyses

The constraint that MacEachern (1997[1999]) proposes, BEIDENTICAL, has the effect of requiring two segments in the same output string to be identical. As argued above, it is necessary to relativize this requirement, such that the constraints in question require that the two segments be identical with respect to particular features (or perhaps feature classes). In terms of their content, such constraints would be suspiciously similar to a family of constraints that already exist in Optimality Theory: *correspondence constraints*, in

particular IDENT[F] constraints. The similarity is quite striking: segments that stand in a correspondence relation to each other—e.g., in the input vs. output representations, or in a reduplicant affix vs. the base of reduplication—are required to be identical. This pressure towards identity is exerted by individual IDENT[F] constraints, each of which penalizes *non-agreement* with respect to a given feature [F].

Is it perhaps possible to reduce some or all instances of consonant harmony—long-distance assimilatory interactions between consonants—to cases of identity (total or partial) under correspondence? In order to answer this question, we must first consider in what sense C_1 and C_2 in a sequence $/...C_1...C_2.../$ can be said to stand in a correspondence relation to one another. First of all, the correspondent Cs are part of the same output string. Input-Output correspondence is thus ruled out as a possibility, as is ‘Output-Output correspondence’ in the sense of a mapping between related members of a paradigm (Benua 1997; cf. also Kenstowicz 1996, 1997; Steriade 2000). Within standard OT, the only type of correspondence that potentially holds between different portions of *the same output string* is Base-Reduplicant (BR) correspondence (see, e.g., McCarthy & Prince 1993, 1994, 1995).

Indeed, there have been proposals appealing to BR correspondence to account for certain effects involving long-distance agreement or identity between consonants. For example, Gafos (1998) proposes that phenomena previously analyzed as ‘long-distance consonantal spreading’ (LDC-spreading) actually involve identity under BR correspondence. The best-known examples involve nonconcatenative (root-and-pattern) morphology, such as that found in many Semitic languages. In Modern Hebrew denominal verb formation, a biconsonantal noun like /kod/ ‘code’ is mapped onto a CVCVC template, along with the vocalic melody /ie/, to yield /kided/ ‘to code’.¹² In earlier approaches, the realization of both C_2 and C_3 as /d/ was explained in terms of spreading of the entire root node of /d/ to

¹² Strictly speaking, the template is simply $[\sigma \sigma]$, with the undominated constraint FINAL-C ensuring that the stem ends in a consonant (thus CVCVC rather than CVCV).

both C positions. This was possible under the assumption that in nonconcatenative languages, consonantal and vocalic melodies reside on different planes (McCarthy 1979[1985], 1981), such that the intervening vowel would not block the spreading. In his reinterpretation of such phenomena, Gafos (1998) rejects LDC-spreading altogether, as well as V/C planar segregation. Instead, he assumes that the vocalic melody /ie/ is actually a *reduplicative* morpheme (/ie^{RED}/). It is only when the consonantal material of the input is less than what is required by the CVCVC template that the reduplicative affix is realizable as such. Thus the reduplication is visible in the verb /kided/ from /kod/ (where C₃ ‘copies’ C₂), but not in /jiven/ ‘to hellenize’ from /javan/ ‘Greece’. The constraints ALIGN^{AFF}-R and ANCHOR-R together ensure that the reduplicant is spelled out on C₃ (rather than on C₁ or C₂) and that the reduplicant C₃ corresponds to C₂ /d/ rather than to C₁ /k/.

In most cases of long-distance consonant assimilations it is not feasible to appeal to BR correspondence as an explanation. Nevertheless, there are certain individual cases where it may be relevant. One potential example is the /-ar-/ infix in Sundanese, cited in 2.4.5 above as a possible case of liquid harmony, in that the infixal /r/ assimilates to a base-initial /l/ (cf. /k=ar=usut/ from /kuset/ ‘messy’, but /l=al=itik/ from /litik/ ‘small’). In his analysis of the assimilatory and dissimilatory behavior of the Sundanese /-ar-/ infix, Suzuki (1999) suggests that the assimilation just noted is due to the infix in fact being a reduplicative morpheme, /-aL^{RED}-/ (where ‘L’ is an underspecified liquid). Other things being equal, the /L/ of the infix surfaces as [r], due to the markedness constraint *l. When the base-initial consonant is itself a liquid, then the realization of /L/ will be determined by undominated IDENT(LIQ)-BR, which requires corresponding segments to agree with respect to the feature [LIQUID].¹³ (See also the discussion of Sundanese liquid assimilation and dissimilation in 4.3.3 below.)

¹³ It should be noted that in addition to BR correspondence, Suzuki (1999) also invokes a special kind of string-internal correspondence (between adjacent-syllable onsets), not unlike Walker’s proposal which will be discussed below. He suggests that a special constraint IDENT $\sigma_1\sigma_2$ (rhotic)_{ONS} be responsible for the failure of /r...r/ → /l...r/ dissimilation in forms like /c=ar=uriga/ ‘suspicious (pl.)’ (not dissimilated to

Note that the effect is agreement in [LIQUID] (or [\pm lateral], alternatively) between two liquids cooccurring in the same string. The infix consonant never assimilates, completely or in part, to a *non*-liquid in base-initial position. Nevertheless, it is possible to account for the liquid agreement as a matter of identity under BR correspondence, for two reasons. The first is the fact that the assimilation is a property of one particular morpheme (/ar-), and that this morpheme is an affix—this makes it possible to stipulate that this particular affix is reduplicative. Secondly, the assimilation trigger is always in the same position; moreover, this position happens to be at the (left) *edge* of the base to which /ar- is being affixed. Under most analyses of reduplication in Optimality Theory, constraints such as ANCHOR-L would ensure that it is the base-initial consonant, rather than a base-medial or base-final consonant, to which the infixal liquid corresponds.

Although Base-Reduplicant correspondence is quite possibly involved in cases such as Sundanese liquid harmony, the same is not true in the vast majority of consonant harmony systems surveyed here. For example, in many cases, root consonants harmonize with affix consonants. Furthermore, BR correspondence is of course inapplicable in cases of morpheme-*internal* consonant harmony, i.e. static (assimilatory) cooccurrence restrictions. If correspondence is to provide the basis for a generalized analysis of consonant harmony phenomena, we must look elsewhere. Crucially, the type of correspondence relation involved cannot be assumed to be Base-Reduplicant or Input-Output, or even Output-Output correspondence, but must instead belong to a separate domain—one involving some kind of *string-internal* correspondence. The question is then whether segments can be assumed to stand in a correspondence relation to one another merely by virtue of cooccurring in the same (output) string? Interestingly, several recent works argue this to be the case for *adjacent* segments. The clearest, most elaborate example is Krämer (to appear), who proposes a separate family of SYNTAGMATIC IDENTITY (S-IDENT[F]) constraints,

*/c=al=uriga/). The OCP constraint against /r...r/ sequences is overridden by this constraint, which requires adjacent syllables to have identical onset rhotics.

paralleling the IDENT[F] constraints involved in other correspondence mappings (IO, BR, etc.). Krämer's definition of S-IDENT[F] constraints is as shown in (8). Note that this definition allows for agreement in [F] to hold between higher prosodic units (syllables, feet, etc.), and it also allows the agreement to be bounded by prosodic domains (the syllable, the foot, the prosodic word, etc.).

(8) S-IDENT[F] (Krämer to appear)

Let x be an entity of type T in domain D , and y be any adjacent entity of type T in domain D , if x is $[\alpha F]$ then y is $[\alpha F]$.

$T \in \{\text{segment, mora, syllable, foot}\}$

$D \in \{\text{PPh, PWd, foot, syllable}\}$

(Within the domain of a Prosodic Phrase, Prosodic Word, foot or syllable, a segment, mora, syllable or foot has to have the same value for a feature [F] as the adjacent segment, mora, syllable or foot in the string.)

Krämer (to appear) appeals to this kind of correspondence-by-adjacency in order to analyze vowel harmony and dissimilation, among other syntagmatic effects. In his analysis of vowel harmony, Baković (2000) advocates an essentially equivalent proposal, invoking constraints of the type AGREE[F], as defined in (9):¹⁴

(9) AGREE[F] (Baković 2000)

Adjacent segments must have the same value of the feature [F].

The notion of assimilation as agreement under adjacency can be paraphrased as follows. Adjacent segments—and possibly higher-level entities as well—automatically stand in a

¹⁴ The AGREE family of constraint is argued for by Lombardi (1999). Related proposals include ASSIM in Gnanadesikan (1997) and Pulleyblank's (1997) IDENTICAL CLUSTER CONSTRAINT family.

correspondence relation to one another. This correspondence relation is evaluated (as to its ‘faithfulness’) by a set of special S-IDENT[F] constraints, just as IDENT[F]-IO compares input-output correspondent pairs, IDENT[F]-BR base-reduplicant correspondent pairs, and so forth. Note that other types of correspondence constraints are inapplicable in the case of syntagmatic correspondence, since the correspondence mapping relates individual *segments* rather than whole *strings* of segments. CONTIGUITY and LINEARITY, which enforce the preservation of precedence relations within corresponding strings, are thus meaningless in this case. MAX and DEP are likewise vacuous. The correspondents involved are by definition pairs of individual segments. An output segment *A* can only correspond to an adjacent (output) segment *B*, and thus both *A* and *B* are by necessity present in the string. It is therefore impossible to conceive of a situation which could be construed as violating the hypothetical ‘S-MAX’ or ‘S-DEP’. In short, the only constraints applicable to syntagmatic correspondence are those of the IDENT[F] family.

Correspondence under adjacency is clearly not adequate for dealing with consonant harmony, since the trigger and target segments are usually at a great distance from one another, and any intervening segmental material is consistently irrelevant, as discussed in 3.2 above. We would therefore need to appeal to a *non-local* version of syntagmatic correspondence, a relation holding between segments that are not necessarily string-adjacent. How would such a correspondence relation be construed? Going back to MacEachern’s (1999) analysis with BEIDENTICAL, we can say that it reflects the simple idea that any and all segments in the string ‘correspond’ to each other (in the sense that there is a pressure towards them being identical). However, the fact that consonant harmony tends to involve segment pairs that are (already) similar along several parameters suggests that a more subtle interaction may be involved. Is it perhaps possible that similarity per se is the crucial factor in establishing a correspondence relation between consonants?

In a series of papers, Walker (2000ab, to appear) develops a detailed correspondence-based analysis of certain types of long-distance assimilatory interactions between consonants. Walker's model is based on the fundamental notion that correspondence can indeed be driven by similarity. The more similar two Cs in the same output string are, the more likely it is that they will be correspondents of one another, and thus potentially required to agree in one or more features (by constraints of the IDENT[F] family). The particular phenomena that Walker analyzes in this manner are Ngbaka morpheme-internal voicing and nasality agreement between homorganic consonants (Thomas 1963; Mester 1986[1988]), Kera obstruent voicing agreement (Ebert 1979; Odden 1994), and the nasal consonant harmony found in various Bantu languages, such as Yaka and Lamba (see, e.g., Odden 1994; Hyman 1995; Piggott 1996).¹⁵ The generalized analysis of consonant harmony that will be presented in this chapter borrows quite heavily from Walker's analysis of these phenomena, and the latter will therefore be described in some detail. It should be emphasized, however, that Walker does not suggest that her analysis be extended to *all* phenomena conventionally labelled 'consonant harmony'. Indeed, from the discussion in Walker (to appear) it is perfectly clear that in the case of coronal harmony, she supports the strictly-local spreading analysis (Flemming 1995b; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997; see 1.2.3 and 4.1.1 for discussion).¹⁶

The idea that correspondence is triggered by similarity is based on the assumption that the long-distance interactions in question are motivated in the domain of phonological encoding in speech production. Psycholinguistic studies of speech errors have found that consonants are more likely to interact in slips of the tongue if they share a large number of

¹⁵ All of these are described in sections 2.4.4 and 2.4.7 above. Walker (2000a) also appeals to the same analysis to account for obstruent voicing dissimilation in Gothic (Thurneysen's Law), but this will be ignored here.

¹⁶ In a recent manuscript which further develops Walker's proposals, Rose & Walker (2001) suggest that the correspondence-based agreement analysis should in fact be extended to cover (at least some) coronal harmony systems as well—which is exactly what I argue in this study. As mentioned earlier (chapter 1, fn. 13), Rose & Walker's manuscript did not become available to me until the final stages of the present work; otherwise the exposition in this and following sections would no doubt have been quite different.

phonological properties (see, e.g., Nooteboom 1969; MacKay 1970; Fromkin 1971; Shattuck-Hufnagel & Klatt 1979; Frisch 1996). In neural network models of speech production (see, e.g., Dell 1984, 1986; Stemberger 1985), this effect falls out from spreading activation. In the case of two consonants which share a large number of features, there is a great deal of overlap in the neurons activated for C_1 and C_2 , and thus a greater likelihood that the activation associated with one of the two will interfere with the execution of the other. The greater the overlap, the greater the potential for interference effects such as slips of the tongue.

From the point of view of the phonological grammar, Walker (2000ab, to appear) interprets these psycholinguistic findings as support for the notion that speakers construct a relation between similar segments in the phonological output representation. This relation is assumed to be one of correspondence, henceforth referred to as *CC correspondence* (as distinct from IO correspondence, etc.). Rather than assume that correspondence between similar Cs is automatic—as it is in the case of IO or BR correspondence—Walker proposes that the very presence of a correspondence relation between consonants is a matter of ranked and violable constraints. For this purpose, she proposes a new family of correspondence-establishing constraints, $\text{CORR-}C_1 \leftrightarrow C_2$, defined by the schema given in (10):

(10) $\text{CORR-}C_1 \leftrightarrow C_2$ (Walker to appear)

Given an output string of segments S , and consonants $C_1 \in S$ and $C_2 \in S$, where C_2 follows C_1 in the sequence of segments in S , then C_1 is in a relation with C_2 , that is, C_1 and C_2 are correspondents of one another.

Walker notes that relative similarity plays a role not only in speech errors, but also in the phonological agreement phenomena she sets out to analyze. In Kera, for example, voicing

agreement only holds between stops (neither fricatives nor sonorants participate), and in Ngbaka, voicing agreement as well as nasal agreement is restricted to obstruents that agree in place of articulation. She interprets this as suggesting that the demand for a correspondence relation is stronger the more similar C_1 and C_2 are. Walker's suggestion for encoding this in formal terms is to array $\text{CORR-}C_1 \leftrightarrow C_2$ constraints in a hierarchy. The fixed rankings in (11) show a portion of this hierarchy, relevant for the voicing agreement observed in Ngbaka:

- (11) Similarity-based hierarchy of $\text{CORR-}C_1 \leftrightarrow C_2$ constraints (Walker to appear)
- $\text{CORR-}T_1 \leftrightarrow T_2 \gg \text{CORR-}T_1 \leftrightarrow D_2 \gg \text{CORR-}K_1 \leftrightarrow D_2 \gg \dots$

The topmost constraint, $\text{CORR-}T_1 \leftrightarrow T_2$, enforces a correspondence relation between pairs of identical oral stops, e.g., $[p_i \dots p_i]$, $[d_j \dots d_j]$, $[g_k \dots g_k]$ (CC correspondence is indicated by subscript indices). Identical segments by definition share *all* features—in this case some relevant ones are $[\pm\text{voiced}]$, $[\alpha\text{Place}]$, $[-\text{continuant}]$, $[-\text{nasal}]$ —and such pairs thus constitute the extreme of similarity. The second constraint, $\text{CORR-}T_1 \leftrightarrow D_2$, establishes correspondence between pairs of oral stops that differ at most in $[\pm\text{voi}]$, but agree in all other features (including $[\alpha\text{Place}]$). These include $[p_i \dots b_i]$, $[g_j \dots k_j]$, $[d_k \dots t_k]$ etc., as well as identical-stop pairs such as $[p_i \dots p_i]$, etc.¹⁷ Finally, the third constraint shown in (11), $\text{CORR-}K_1 \leftrightarrow D_2$, requires correspondence between stops that differ at most in $[\pm\text{voi}]$ *and* $[\text{Place}]$, thus $[k_i \dots d_i]$, $[g_j \dots p_j]$, $[b_k \dots t_k]$, etc., in addition to the segment pairs affected by the two higher-ranked constraints. Put somewhat differently, $\text{CORR-}T_1 \leftrightarrow T_2$ singles out pairs of identical stops, $\text{CORR-}T_1 \leftrightarrow D_2$ in turn picks out pairs of homorganic stops (regardless of voicing) and $\text{CORR-}K_1 \leftrightarrow D_2$ picks out any pairs of stops (regardless of place or voicing). The ranking in (11) thus reflects an inclusion relationship between the natural classes to which

¹⁷ Note that the order of the segments is irrelevant here; $\text{CORR-}T_1 \leftrightarrow D_2$ establishes correspondence in $[g_j \dots k_j]$ no less than in $[k_j \dots g_j]$. For more complicated cases where directionality is involved, see below.

the individual constraints refer. The class of identical oral stops ($[\alpha\text{voi}, \beta\text{Place}, -\text{cont}, -\text{nas}]$) is a subset of the class of homorganic oral stops ($[\beta\text{Place}, -\text{cont}, -\text{nas}]$), which in turn is a subset of the class of all oral stops ($[-\text{cont}, -\text{nas}]$).

The $\text{CORR-}C_1 \leftrightarrow C_2$ constraints do nothing more than *establish* a CC correspondence relation; they do not in and of themselves enforce identity, or agreement in some feature [F], between C_1 and C_2 . That is the responsibility of $\text{IDENT}[F]\text{-CC}$ constraints. In the case of voicing agreement, as in Ngbaka or Kera, the relevant constraint is $\text{IDENT}[\text{voice}]\text{-CC}$. The definition in (12) is slightly altered from Walker (to appear); the consonants are referred to as ‘ C_x ’ and ‘ C_y ’ rather than ‘ C_1 ’ and ‘ C_2 ’, in order to emphasize the fact that the correspondence relation is symmetric (C_1 is as much a correspondent of C_2 as C_2 is of C_1).

(12) $\text{IDENT}[\text{voice}]\text{-CC}$ (Walker to appear)

Let C_x be a consonant in the output and C_y be any correspondent of C_x in the output. If C_x is $[\alpha\text{voi}]$, then C_y is $[\alpha\text{voi}]$.

Voicing harmony—voicing agreement under CC correspondence—is forced when both the relevant $\text{CORR-}C_1 \leftrightarrow C_2$ constraint(s) and $\text{IDENT}[\text{voice}]\text{-CC}$ outrank faithfulness to input $[\text{voice}]$ specifications ($\text{IDENT}[\text{voice}]\text{-IO}$). The ranking responsible for voicing harmony in Ngbaka is illustrated by the example in (13). A hypothetical *disharmonic* input /tida/ surfaces as harmonized [tita] (or, alternatively, [dida]).¹⁸

¹⁸ The candidate $[d_{1,i}ida]$ is omitted from the tableau in (13) for the sake of simplicity. It would fare exactly the same as the winner (13c) on the constraints considered here. Since we are dealing with a static cooccurrence restriction on morphemes in the Ngbaka case, it is immaterial whether the hypothetical input /tida/ gets harmonized to [tita] or to [dida]—both are perfectly acceptable output strings in Ngbaka. The decision might fall to positional IO faithfulness (giving priority to preserving the $[-\text{voi}]$ specification on the word-initial /t/), or to differentially-ranked $\text{IDENT}[\text{+voi}]\text{-IO}$ vs. $\text{IDENT}[\text{-voi}]\text{-IO}$.

(13) Ngbaka: Voicing harmony between homorganic stops (Walker to appear)

$/t_1id_2a/$	ID[voi]-CC	CORR- $T_1 \leftrightarrow T_2$	CORR- $T_1 \leftrightarrow D_2$	ID[voi]-IO	CORR- $K_1 \leftrightarrow D_2$
a. $t_{1,i}id_{2,j}a$			*!		*
b. $t_{1,i}id_{2,i}a$	*!				
c. $t_{1,i}it_{2,j}a$		*!	*	*	*
d. $t_{1,i}it_{2,i}a$				*	


In the above tableau, IO correspondence is indicated with subscript ‘1, 2’ and CC correspondence with subscript ‘i, j’. Of the candidates listed in the tableau, (13a) and (13b) are faithful to all input [voi] specifications, whereas in (13c) and (13d), the input voiced /d/ surfaces as output /t/. The difference between (13a) and (13b) lies in the CC correspondence relations; the output /t/ and /d/ correspond to each other in (13b) but not in (13a). The non-faithful candidates (13c-d) differ from each other in the very same way. Finally, note the implicational relationship between the hierarchically-ranked CORR- $C_1 \leftrightarrow C_2$ constraints. Violating CORR- $T_1 \leftrightarrow T_2$ implies violating both CORR- $T_1 \leftrightarrow D_2$ (13c), and violating CORR- $T_1 \leftrightarrow D_2$ in turn implies violating CORR- $K_1 \leftrightarrow D_2$ (13a and 13c). The reason is that a segment pair that fits the ‘structural description’ of CORR- $T_1 \leftrightarrow T_2$ (e.g. /d...d/, /t...t/) will also fit the description of CORR- $T_1 \leftrightarrow D_2$ (regardless of the fact that the latter *also* encompasses pairs like /d...t/, /t...d/), and so forth.

The ranking CORR- $T_1 \leftrightarrow D_2 \gg$ ID[voi]-IO means that homorganic stops will correspond to each other, even at the expense of changing input [voi] specifications. This means that (13b) and (13d) are both better than the candidates which lack CC correspondence, (13a) and (13c). But note that if this were all, the winner would be (13b), since it obeys *both* CORR- $T_1 \leftrightarrow D_2$ and ID[voi]-IO. The choice between (13b) and (13d) is decided by the ranking IDENT[voi]-CC \gg IDENT[voi]-IO. When a given output segment (in

this case C_2) has both a CC-correspondent and an IO-correspondent, agreement in [voi] with the former is more important than with the latter. Thus C_2 will be realized as [t], agreeing with its CC-correspondent C_1 ([t]) but disagreeing with its IO-correspondent /d/. The end result is that homorganic input stops are forced to agree in voicing in the output.

On the other hand, as shown in the tableau in (14), agreement is not forced in the case of *non*-homorganic stops. The hypothetical input /duka/ thus surfaces faithfully, despite being ‘disharmonic’ in terms of voicing agreement.

(14) Ngbaka: No voicing harmony between heterorganic stops (Walker to appear)

/d ₁ uk ₂ a/	ID[voi]-CC	CORR- T ₁ ↔T ₂	CORR- T ₁ ↔D ₂	ID[voi]-IO	CORR- K ₁ ↔D ₂
a.  d _{1,i} uk _{2,j} a					*
b. d _{1,i} uk _{2,i} a	*!				
c. d _{1,i} ug _{2,j} a				*!	*
d. d _{1,i} ug _{2,i} a				*!	

In this case, the relevant CORR- $C_1 \leftrightarrow C_2$ is CORR- $K_1 \leftrightarrow D_2$, since the two stops disagree in place of articulation. As in the previous case, candidates (14b) and (14d) have a CC correspondence relation between C_1 and C_2 . As before, the ranking IDENT[voi]-CC >> IDENT[voi]-IO means that, if the choice were to lie between (14b) and (14d), the latter would win, since ‘unfaithful’ CC correspondence is more costly than unfaithful IO correspondence. But here there is an even less costly alternative—to sacrifice the CC correspondence relation itself! In the case of heterorganic stops, IO faithfulness outranks the demand for CC correspondence (IDENT[voi]-CC >> CORR- $K_1 \leftrightarrow D_2$), and therefore (14a) does better than ‘harmonic’ (14d). In spite of the fact that IDENT[voi]-CC is top-

ranked, it is rendered vacuous in (14a), since there is no CC correspondence relation for it to evaluate.

In sum, the sensitivity to relative similarity is captured in Walker's model by expanding the $\text{CORR-C}_1 \leftrightarrow \text{C}_2$ constraints into a hierarchy. The interpolation of IO faithfulness constraints with this hierarchy establishes where a given language sets the similarity threshold, above which agreement is required to hold. For example, Kera voicing harmony holds between heterorganic plosives as well as homorganic ones, cf. /dʒàr-ká/ 'colorful (fem.)' → /dʒàrgá/. This difference between Ngbaka and Kera would simply be captured by assuming that in the latter, IO faithfulness to [voi] ($\text{IDENT}[\text{voi}]\text{-IO}$) is ranked *below* $\text{CORR-K}_1 \leftrightarrow \text{D}_2$, rather than sandwiched between $\text{CORR-T}_1 \leftrightarrow \text{D}_2$ and $\text{CORR-K}_1 \leftrightarrow \text{D}_2$ as it is in Ngbaka.

This concludes our somewhat sketchy description of the correspondence-based model developed by Walker (2000ab, to appear). The analysis has several more intricate details which have largely been glossed over here, for reasons of economy. The generalized OT analysis of consonant harmony which is described in the remainder of this chapter is in many respects an extension of Walker's model, and it will be more useful to discuss such details as they come up in the context of the generalized model. Where ideas and/or formal devices are borrowed wholesale from Walker, this is noted accordingly.

4.2. The basic architecture: String-internal correspondence and agreement

This section outlines the fundamental ingredients of the generalized OT analysis of consonant harmony proposed in this work. The analysis borrows heavily from the correspondence-based model proposed by Walker (2000ab, to appear) and outlined in the previous section. Nevertheless, the generalized model differs from Walker's in certain important ways, e.g., with respect to the 'directionality' of the correspondence relation and the nature of the agreement-enforcing constraints. It should be noted, however, that the analysis

sketched in this section represents a slightly simplified first attempt. In the following chapter, we will encounter evidence suggesting that the overall structure of the analysis may need to be modified, especially as regards how the role of relative similarity is encoded (see section 5.3). As a result, the affinity with Walker's model becomes significantly reduced.

4.2.1. The CORR-CC constraint family

For the purposes of this preliminary outline of the model, I will assume (following Walker 2000ab, to appear) that long-distance consonant assimilation results from the combined efforts of two different types of constraints. Under this view—which we will have reason to revise later in the chapter—the ‘task’ of enforcing long-distance agreement is divided into two components. Firstly, a correspondence relation is established between two segments in the output string if they are sufficiently similar to one another. This is the responsibility of the CORR-CC constraints. Secondly, the segments that come to stand in such a correspondence relation are evaluated as to whether they agree in some feature [F]—the harmonizing property. This is the job of correspondence constraints of the type IDENT[F]-CC, which are confined to string-internal correspondents (just as IDENT[F]-IO evaluates only input-output correspondent pairs, IDENT[F]-BR only base-reduplicant correspondent pairs, etc.).

This section explains in greater detail the nature of the CORR-CC constraints and of the correspondence relation they establish. We first discuss the dependence of correspondence on relative similarity and the distance separating the trigger-target pair (4.2.1.1). With respect to these issues the analysis presented here draws heavily on Walker's proposals. We then take up the issue of symmetric vs. asymmetric correspondence relations, and how this distinction is relevant for the understanding of directionality effects in consonant harmony systems (4.2.1.2). Based on the findings reported in section 3.1 above, a more restrictive view of string-internal correspondence is taken than that advocated by Walker.

4.2.1.1. Scaling of CORR-CC constraints by similarity and distance

As in Walker's model, I assume that the CORR-CC constraints are relativized with respect not only to the similarity of the interacting consonants but also to the distance separating them. Looking first at relative similarity, CORR-CC constraints arrange themselves in a (partially) fixed ranking, essentially forming an implicational hierarchy. Correspondence between segments that differ in features [F, G, H] implies correspondence between those that differ only in [F, G] (or for that matter in [F, H] or in [G, H]), and correspondence between segments differing in [F, G] in turn implies correspondence between those differing only in [F] (or only in [G]). An illustrative example is shown in (15), borrowed from Walker (2000b) with minor changes. In order to avoid accidental reference to the order of the interacting consonants, I use labels like CORR-[nas] and CORR-[nas, Place] rather than Walker's $\text{CORR-N}_1 \leftrightarrow \text{D}_2$, $\text{CORR-N}_1 \leftrightarrow \text{B}_2$, etc.

(15) Similarity-scaling in terms of fixed CORR-CC constraint hierarchies

a. $\text{CORR-[nas]} \gg \text{CORR-[nas,Place]}, \text{CORR-[nas,voi]} \gg \text{CORR-[nas,Place,voi]}, \dots$

b. Definition of CORR-[F₁, ..., F_n] (first pass):

Given an output string S, and consonants C₁ ∈ S and C₂ ∈ S, where C₁ < C₂ (C₁ precedes C₂) and C₁ and C₂ differ at most in the features [F₁, ..., F_n], then a correspondence relation must be present between C₁ and C₂.

To paraphrase the hierarchy in (15), the presence of a correspondence relation between two consonants differing only in nasality (e.g., /m/ ↔ /b/) is enforced more strictly than in the case of consonants differing in nasality and place of articulation (/m/ ↔ /d/) or nasality and voicing (/m/ ↔ /p/), and so on. (Recall that we are here dealing merely with enforcing the *presence* of a correspondence relation between the two consonants; how perfect or

imperfect that correspondence is with respect to some particular feature is an entirely different matter.)

Note that, as stated in (15), there is no fixed ranking between CORR-[nas, Place] and CORR-[nas, voi], since there is no intrinsic implicational relationship between the two. This does of course not entail that their relative ranking is indeterminate or irrelevant in any given language. For example, Walker's (2000b) analysis of Bantu nasal consonant harmony crucially relies on the ranking CORR-[nas, Place] >> CORR-[nas, voi] (heterorganic nasals and voiced stops harmonize, but homorganic nasals and voiceless stops do not). Since the hierarchy of CORR-CC constraints encodes relative similarity, it might be said that in the phonology of these languages, a pair like [m]/[d] is judged to be more similar than a pair like [m]/[p]. For the time being, I will leave it as an open question whether this is a matter of *extrinsic* (and thus language-specific) constraint ranking, or whether the ranking is *intrinsic*, a consequence of some universal and deterministic similarity metric.¹⁹ The issue of relative similarity and its precise definition will be revisited in section 5.3.

In addition to similarity, many consonant harmony systems display some degree of sensitivity to the distance between the trigger and target segments, as was discussed earlier (cf. section 3.2.2). For example, many Bantu languages restrict nasal consonant harmony to segments separated by at most a single vowel (short or long)—a pattern referred to as 'transvocalic' harmony in 2.4.4 above. Given the syllable structure that the languages in question happen to follow, the restriction can be restated as limiting harmony to segments that are onsets of adjacent syllables. Thus, in languages such as Lamba, nasal consonant harmony applies in contexts like /...NV.DV.../, but not in /...NV.CV.DV.../. Similar proximity effects can be observed in various other types of consonant harmony, including many sibilant harmony systems. Drawing on proposals by Suzuki (1998), Walker (2000b)

¹⁹ Note that even if universal and deterministic, such a similarity metric may still be sensitive to language-specific properties such as the structure of the segment inventory, redundancy relations between feature specifications, etc. An excellent example is the natural classes model of similarity (Frisch 1996; Frisch, Broe & Pierrehumbert 1997), which will be briefly discussed in section 5.3 below.

suggests that proximity effects be captured by relativizing the CORR-CC constraints with respect to the distance separating C_1 and C_2 .²⁰ For each CORR-CC constraint, this proximity scaling yields a fixed hierarchy, as illustrated in (16):

(16) Proximity scaling in terms of fixed CORR-CC hierarchies

$$\text{CORR-[F]}_{\text{CC}} \gg \text{CORR-[F]}_{\text{C-}\mu\text{-C}} \gg \text{CORR-[F]}_{\text{C-}\sigma\text{-C}} \gg \dots \gg \text{CORR-[F]}_{\text{C-}\infty\text{-C}}$$

The ranking in (16) shows the proximity scaling of one particular constraint, CORR-[F], a constraint requiring a correspondence relation between consonants differing at most in the feature [F]. The top-ranked version of this constraint, CORR-[F]_{CC}, requires correspondence between such a consonant pair under adjacency—the greatest conceivable degree of proximity. The lower-ranked version CORR-[F]_{C-μ-C} requires correspondence between such pairs that are separated by no more than a mora (e.g., onset and coda of the same syllable, or onsets of adjacent syllables), and so on. The lowest-ranked version of the constraint, CORR-[F]_{C-∞-C}, represents the opposite extreme, requiring correspondence between the relevant consonant pair at *any* distance.

The analysis of consonant harmony presented in this chapter will adopt Walker’s proposal to encode proximity effects in terms of fixed constraint hierarchies. Note that the similarity hierarchy in (15) and the proximity hierarchy in (16) are completely orthogonal to one another. For each level of similarity, the relevant CORR-CC constraint ‘expands’ into a hierarchy of proximity-scaled versions of the same constraint. In other words, just as CORR-[F] yields the entire hierarchy in (16) above, so does the lower-ranked CORR-[F,G] spawn its own hierarchy: CORR-[F, G]_{CC} >> CORR-[F,G]_{C-μ-C} >> CORR-[F,G]_{C-σ-C} >> ... >> CORR-[F,G]_{C-∞-C}. This perspective takes a particular similarity threshold as the ‘point of reference’, as it were, but one may just as well look at the interaction of the two

²⁰ This aspect of Walker’s analysis has been omitted in the published version of the paper (Walker 2000b), but was included in the original conference presentation; it is also hinted at in Walker (2000a, to appear).

hierarchies from the point of view of particular proximity levels. Thus, at any given proximity threshold, such as $C-\mu-C$ (C_1 and C_2 separated by at most a mora), a full similarity hierarchy holds true. In other words: $\text{CORR-[F]}_{C-\mu-C} \gg \text{CORR-[F,G]}_{C-\mu-C} \gg \text{CORR-[F,G,H]}_{C-\mu-C}$, and so forth.

It should also be pointed out that since the similarity and proximity hierarchies are essentially orthogonal, the way in which they are conflated into a single constraint ranking can vary from language to language. As an example, take four CORR-CC constraints, each of them specified as holding above a certain similarity threshold and a certain proximity threshold: $\text{CORR-[F]}_{C-\mu-C}$, $\text{CORR-[F]}_{C-\infty-C}$, $\text{CORR-[F,G]}_{C-\mu-C}$ and $\text{CORR-[F,G]}_{C-\infty-C}$. The possible ranking relationships between these four are shown in (17). The proximity hierarchy dictates that a fixed ranking hold between the first two, and also between the second two (17a). The similarity hierarchy in turn demands a fixed ranking between the first and third constraints, as well as between the second and fourth (17b). But note that the relative ranking between $\text{CORR-[F]}_{C-\infty-C}$ and $\text{CORR-[F,G]}_{C-\mu-C}$ is *not* fixed. In terms of similarity alone, the former would have priority, since it applies to a narrower set of consonants (those differing at most in [F], as opposed to those potentially differing in both [F] and [G]). In terms of proximity alone, on the other hand, the latter has priority, since it applies to consonant pairs that are closer to one another. There is thus room for two different rankings, depending on which metric is given higher priority—similarity or distance (17c).

(17) Interplay of similarity-scaling and proximity-scaling (schematic illustration)

a. Fixed rankings due to proximity hierarchy:

$$\text{CORR-[F]}_{C-\mu-C} \gg \text{CORR-[F]}_{C-\infty-C}$$

$$\text{CORR-[F, G]}_{C-\mu-C} \gg \text{CORR-[F, G]}_{C-\infty-C}$$

b. Fixed rankings due to similarity hierarchy:

$\text{CORR-[F]}_{\text{C-}\mu\text{-C}} \gg \text{CORR-[F, G]}_{\text{C-}\mu\text{-C}}$

$\text{CORR-[F]}_{\text{C-}\infty\text{-C}} \gg \text{CORR-[F, G]}_{\text{C-}\infty\text{-C}}$

c. Alternative possibilities for *complete* ranking of the constraints:

$\text{CORR-[F]}_{\text{C-}\mu\text{-C}} \gg \text{CORR-[F]}_{\text{C-}\infty\text{-C}} \gg \text{CORR-[F,G]}_{\text{C-}\mu\text{-C}} \gg \text{CORR-[F,G]}_{\text{C-}\infty\text{-C}}$

$\text{CORR-[F]}_{\text{C-}\mu\text{-C}} \gg \text{CORR-[F,G]}_{\text{C-}\mu\text{-C}} \gg \text{CORR-[F]}_{\text{C-}\infty\text{-C}} \gg \text{CORR-[F,G]}_{\text{C-}\infty\text{-C}}$

There is no *a priori* reason to assume that only one of the rankings in (17c) is possible. For example, consonant harmony in language A might obey a very strict similarity threshold without showing any clear distance-related effects (i.e. being unbounded). In language B, by contrast the same kind of harmony might obey a very strict proximity threshold (e.g., never skipping a syllable) but be *less* stringent on the similarity requirements on the trigger/target consonant pairs than A is. In terms of the alternatives in (17c), language A would have a ranking resembling the first one, with language B resembling the second one.

4.2.1.2. Asymmetric CC correspondence and directionality effects

Thus far our definition of CORR-CC constraints and their scaling based on relative similarity and relative distance has been essentially identical to that assumed by Walker (2000ab, to appear). But there is one extremely important aspect of these constraints that has yet to be addressed, namely the precise *nature* of the correspondence relation imposed by CORR-CC constraints. It is with respect to this issue that the analysis presented here will depart significantly from Walker's. The question revolves around the notion of symmetric vs. asymmetric correspondence relations. As was noted in 3.1 above, numerous consonant harmony systems obey a strict directionality, usually right-to-left, which cannot be reduced to other factors such as cyclicity (inside-out effects) or the dominant status of a particular feature value. If consonant harmony is indeed a matter of agreement under correspondence,

it seems inevitable to conclude that directional consonant harmony indicates ‘directional’—i.e. *asymmetric*—correspondence.

This is precisely the conclusion drawn by Walker (2000b) in her analysis of Yaka nasal consonant harmony, which appears to obey strict left-to-right directionality (e.g., /n...d/ → /n...n/, but not /d...n/ → /n...n/). Walker captures the unidirectionality of this process by stipulating that the CC correspondence relation be asymmetric in Yaka, i.e. ‘from C_1 to C_2 ’ or $C_1 \rightarrow C_2$. This means that properties of C_1 can influence C_2 , but there is no direct requirement for C_1 to ‘take after’ its correspondent C_2 . In particular, the constraint ultimately responsible for enforcing the agreement, IDENT[+nas]-CC, is violated only by the sequence / $n_i \dots d_i$ / but not by its mirror image / $d_j \dots n_j$ /. Under the assumption that C_2 corresponds to C_1 ($C_1 \rightarrow C_2$), but not vice versa, the IDENT constraint simply requires that if C_1 is [+nasal], then C_2 (its correspondent) must also be [+nasal]. It has nothing to say about cases where C_1 is [-nasal], regardless of whether C_2 is [+nasal] or [-nasal]. Since C_1 is *not* a correspondent of C_2 , a [+nasal] specification on the latter cannot influence the former.

In her analysis of Kera obstruent voicing harmony, on the other hand, where [+voiced] ‘spreads’ bidirectionally from the root to both prefixes and suffixes, Walker (2000a, to appear) concludes that the CC correspondence in this case is a symmetric relation, $C_1 \leftrightarrow C_2$. Indeed, this is how CC correspondence was defined in the discussion of Walker’s model in 4.1.3 above. But is it then necessary to assume that string-internal correspondence is somehow ‘parametrized’ on a language-particular basis? Do some languages have symmetric (non-directional) CC correspondence and others asymmetric (directional) CC correspondence? In the latter case, do languages have a further choice between left-to-right correspondence, $C_1 \rightarrow C_2$, and right-to-left correspondence, $C_1 \leftarrow C_2$? More importantly, how does this issue relate to the empirical generalizations about directionality effects in consonant harmony systems that were reported in section 3.1?

Before answering these questions, it is useful to shed some further light on the somewhat confusing issue of symmetric vs. asymmetric correspondence relations and the implications of this dichotomy. Let us therefore step back and briefly reconsider the most basic (and least contentious) type of correspondence relation—the one linking Input and Output representations.

In the most intuitive sense, Input-Output (IO) correspondence is a *symmetric* relation relating input and output representations. Individual correspondence constraints (MAX, DEP, IDENT[F], LINEARITY, CONTIGUITY, etc.) have the role of ensuring that the two representations be as similar to *each other* as possible (cf. McCarthy & Prince 1995). In practice, of course, evaluating an input-output pair is really a matter of evaluating the output representation relative to the input representation, rather than vice versa. The input thus provides a fixed point of comparison, against which the output representation is judged in terms of its ‘faithfulness’ to it.²¹ In this sense, there is a certain asymmetry built into the evaluation of IO correspondence, although this asymmetry could be argued to be purely epiphenomenal. But there are other reasons why IO correspondence cannot be considered entirely symmetric. In order to see why this is so, first consider constraints of the IDENT[F] family. Under one popular point of view (indeed, the one originally intended for these constraints, cf. McCarthy & Prince 1995), the constraint IDENT[F] penalizes any kind of I/O mismatch with respect to feature [F], both the one depicted in (18a) and the one in (18b). From the point of view of IDENT[F], the IO correspondence relation is thus entirely symmetric. It penalizes any I↔O mapping where an [αF] segment in one representation has a [-αF] correspondent in the other representation.

²¹ An exception to this is the alternative mode of phonological computation referred to as Lexicon Optimization, where the learner establishes an input (lexical representation) based on an actual output representation (Prince & Smolensky 1993; cf. also Inkelas 1995). However, this is irrelevant for the purposes of the present discussion. Another possible exception is allomorph selection, where the selection of the optimal output candidate involves the parallel selection of one of two (or more) alternative input representations (see, e.g., Mester 1994; Kager 1996; Dolbey 1996).

(18) IO mappings violating IDENT[F] (symmetric correspondence):

- | | |
|-----------------------|-----------------------|
| a. <i>Input:</i> [+F] | b. <i>Input:</i> [-F] |
| | |
| <i>Output:</i> [-F] | <i>Output:</i> [+F] |
| (i.e. [+F] → [-F]) | (i.e. [-F] → [+F]) |

But now consider the constraints MAX and DEP, which mitigate against deletion and epenthesis, respectively. Each of these penalizes a state of affairs whereby a segment in one representation is absent from the other representation.²² This is represented schematically in (19), with the segment lacking a correspondent indicated as ‘S’.

(19) IO mappings violating MAX or DEP (“symmetric” correspondence?!)

- | | |
|-------------------------|---------------------------|
| a. MAX violation: | b. DEP violation: |
| <i>Input:</i> S | <i>Input:</i> Ø |
| | |
| <i>Output:</i> Ø | <i>Output:</i> S |
| (i.e. S → Ø = deletion) | (i.e. Ø → S = epenthesis) |

If IO correspondence were truly symmetrical, the configurations in (19a) and (19b) ought to be penalized by a *single* constraint (which we might call “HAVECORRESPONDENT”), just as it is the job of the single constraint IDENT[F] to penalize both (19a) and (19b). The same, of course, would apply in the domain of Base-Reduplicant (BR) correspondence, and in all other domains involving correspondence mappings. For example, analogous to (symmetric) IDENT[F]-BR, we would expect a unitary and symmetric “HAVECORRESPONDENT-

²² Strictly speaking, what MAX and DEP are penalizing is the absence of a *correspondent* in the other representation, not ‘deletion’ or ‘epenthesis’ as such. Thus, a hypothetical input-output pair like /p_ia_jn_kd_la_m/ ↔ [p_ia_jd_{k,l}a_m] would not in fact count as violating MAX (even though /n/ is in some sense being ‘deleted’). A hypothetical pair like /p_ia_jn_kd_la_m/ ↔ [p_ia_jn_qd_la_m], on the other hand, would be penalized by MAX (even though no ‘deletion’ is happening). Note that the second example—however bizarre it may seem—violates both MAX and DEP at once, since input /n_k/ lacks an output correspondent and output [n_q] lacks an input correspondent.

BR”, rather than splitting it into two independent constraints, MAX-BR and DEP-BR, as is customary.

Most practitioners of Optimality Theory would no doubt agree that conflating MAX and DEP into one constraint is not feasible on practical grounds—after all, differential ranking of MAX and DEP is precisely what defines whether a given language prefers deletion over epenthesis (or vice versa) as a strategy for obeying well-formedness constraints. But it cannot be emphasized enough that the very notion of MAX and DEP as two separate and independent constraints implies a certain asymmetry in the correspondence mapping. The only cogent way to define these two constraints in a general, domain-independent way is to designate one of the two corresponding domains as somehow ‘primary’ (Input, Base of Reduplication, Base of Derivation, etc.) and the other as ‘secondary’ (Output, Reduplicant, Truncatum, etc.). MAX is then violated when a segment in a primary domain lacks a counterpart in the corresponding secondary domain, whereas DEP is violated when a segment in the secondary domain lacks a counterpart in the primary domain.

A simpler way—but completely equivalent—of capturing this is to assume that the correspondence relation *itself* is asymmetric. From this perspective, the correspondence holding between a ‘primary’ domain A (e.g., the Input) and a ‘secondary’ domain B (e.g., the Output) can be represented as $A \rightarrow B$. Furthermore, the meaning and use of the terms ‘correspondent of’ and ‘correspond to’ has to be made very precise. Under the view of asymmetric correspondence adopted here ($A \rightarrow B$), *B corresponds to A* but not vice versa; likewise, *B is a correspondent of A* but not vice versa. In other words, output segments correspond to input segments, reduplicant segments to base segments, and so forth. However, it is then incorrect to say that an input segment (A) ‘corresponds to’ or ‘is a correspondent of’ an output segment (B). The directionality of the arrow in the mapping $A \rightarrow B$ signifies the directionality of the implicational relationship holding between A and B:

individual faithfulness constraints require that B ‘take after’ A with respect to certain properties, rather than vice versa (e.g., ‘if A is $[\alpha F]$, then B is $[\alpha F]$ ’ or ‘ $A[\alpha F] \supset B[\alpha F]$ ’).

Let us now revisit the definition of IDENT constraints, since these are obviously the ones involved in enforcing harmony (i.e. agreement under CC correspondence). In (18) it was assumed that IDENT constraints are symmetric, penalizing any kind of [F]-value mismatch between the two corresponding domains. Thus both (18a) and (18b) count as violations of the single constraint IDENT[F]. However, a growing body of evidence has been accumulating that the symmetric IDENT[F] model is inadequate. On the one hand, certain languages seem to tolerate a $[\alpha F] \rightarrow [-\alpha F]$ (input-to-output) mapping better than the reverse $[-\alpha F] \rightarrow [\alpha F]$. One proposal for capturing such effects has been to make IDENT constraints refer to particular feature *values*, such that IDENT[+F] and IDENT[-F] are independent constraints (see McCarthy & Prince 1995, 1999; Pater 1999, among others). On the other hand, there are phenomena which appear to involve individual (privative) features acting as free autosegments. This has been interpreted as evidence that features themselves stand in a correspondence relation across domains, evaluated by MAX[F] and DEP[F] constraints (see, e.g., Lombardi 1995, 1998; Pulleyblank 1996; Causley 1997; Myers 1997). As enriched versions of the original ‘symmetric-IDENT’ model, both alternatives suggest an asymmetric correspondence relation. For the purposes of the analysis of consonant harmony, the value-specific IDENT[αF] approach and the MAX[F]/DEP[F] approach are more or less equivalent in terms of their implications. However, the latter requires that a series of additional issues be addressed (binarity vs. privativity of features; ‘deletion’ vs. ‘epenthesis’ of association lines; the possibility of floating features; etc.). For this reason, I will adopt the IDENT[αF] approach here.

Note that splitting IDENT[F] into the independent constraints IDENT[+F] and IDENT[-F] presupposes an *asymmetric* correspondence relation. The [F]-value mentioned in the constraint label refers to a specification in what was called the ‘primary’ domain

above (Input, Base, etc.) and the constraint requires that this feature specification be preserved in the ‘secondary’ domain (Output, Reduplicant, etc.). This is illustrated in (20).

(20) IDENT[α F] under asymmetric IO correspondence (Input \rightarrow Output):

- a. IDENT[+F] violation: b. IDENT[-F] violation:

Input: [+F]
 ↓
Output: [-F]

Input: [-F]
 ↓
Output: [+F]

If the IO correspondence relation were perfectly symmetric (I \leftrightarrow O rather than I \rightarrow O), IDENT[+F] would be violated by *both* (20a) and (20b). This is because both cases involve a [+F] segment whose correspondent is not [+F]. Likewise, IDENT[-F] would be violated by both, since in both cases there is a [-F] segment whose correspondent is not [-F]. In short, the distinction between IDENT[+F] and IDENT[-F] is meaningless unless asymmetric correspondence is assumed.

Finally, it should be emphasized that although value-specific IDENT[+F]/IDENT[-F] presupposes an asymmetric correspondence relation, it is *not* the case that value-neutral IDENT[F] presupposes symmetric correspondence. Even though the correspondence mapping in (20) is asymmetric, I \rightarrow O, both (20a) and (20b) violate IDENT[F], since this constraint merely requires that if a segment is [α F], then its correspondent must also be [α F]. In (20a), [α F] is ‘spelled out’ as [+F]; in (20b), [α F] is [-F]. The end result is thus exactly the same as in (20) above, where a symmetric correspondence relation was assumed (I \leftrightarrow O). Asymmetric correspondence is thus equally compatible with value-neutral IDENT[F] constraints and value-specific IDENT[+F] vs. IDENT[-F].

The purpose of this somewhat lengthy excursus has simply been to show that interpreting the CC correspondence relation (as established by CORR-CC constraints) as being *asymmetric* is neither an ad hoc move nor a radical departure from current practice.

However, this does not answer the questions raised earlier: Is it the case that CC correspondence is symmetric ($C_1 \leftrightarrow C_2$) in some languages but asymmetric ($C_1 \rightarrow C_2$ or $C_1 \leftarrow C_2$) in others? In the latter case, is the asymmetric correspondence sometimes left-to-right ($C_1 \rightarrow C_2$) and sometimes right-to-left ($C_1 \leftarrow C_2$)? Since the manifestation of asymmetric correspondence is *directionality* of assimilation, this brings us back to the issue of which directionality patterns are attested in consonant harmony systems.

As was discussed in the preceding chapter (section 3.1), the typological survey of consonant harmony systems revealed very clear empirical generalizations regarding directionality effects. It was found that consonant harmony always obeys one of two directionality patterns: it is either *cyclic* or *anticipatory* (regressive). In other words, consonant harmony can be sensitive to morphological structure, applying in an ‘inside-out’ fashion (stem-to-affix), or it can be insensitive to morphology, in which case it is always strictly regressive (right-to-left). There is thus a clear cross-linguistic preference for anticipatory harmony, other things being equal (the ‘other things’ in this case being morphological constituency). Attested counterexamples—systems that clearly exhibit *progressive* harmony regardless of morphology—are at best extremely few. It would thus seem desirable to build the bias towards anticipatory assimilation directly into our generalized analysis of consonant harmony.

If we assume, with Walker (2000b), that the proper way to capture directionality effects is to assume an asymmetric correspondence relation, then strict right-to-left directionality translates into strict right-to-left correspondence. In a string $/\dots C_1 \dots C_2 \dots /$ (where the pair C_1/C_2 meets the relevant similarity and proximity criteria), the correspondence relation is thus $C_1 \leftarrow C_2$: C_1 corresponds to C_2 , but not vice versa. In other words, C_1 is a correspondent of C_2 , but C_2 is *not* a correspondent of C_1 . This becomes relevant when we consider the IDENT-CC constraints that evaluate the $C_1 \leftarrow C_2$ correspondence, as will be discussed in greater detail in the following section. A constraint

IDENT[+F]-CC, when applied to such an asymmetric $C_1 \leftarrow C_2$ correspondence relation, will be violated by the sequence $C_1[-F] \dots C_2[+F]$ (if a given C is [+F], then its correspondent C must also be [+F]), but it will have nothing to say about the pair $C_1[+F] \dots C_2[-F]$. The end result is that [+F] ‘spreads’ from C_2 to C_1 in the first case (right-to-left harmony), but [+F] does *not* spread from C_1 to C_2 in the second case (i.e. no left-to-right harmony).

In order to capture the cross-linguistic preference of anticipatory harmony, I will assume that the right-to-left directionality is built into the definition of the correspondence relation established by the CORR-CC constraints, and thus part of the definition of these constraints themselves. Revising the definition in (15b) above—and ignoring specifications as to the maximum distance between C_1 and C_2 —we thus arrive at the following:

(21) CORR-[F_1, \dots, F_n] (revised definition):

Given an output string S and consonants $C_1 \in S$ and $C_2 \in S$, where $C_1 \prec C_2$ (C_1 precedes C_2) and C_1 and C_2 differ at most in the set of features [F_1, \dots, F_n], then a correspondence mapping is present *from* C_2 to C_1 ($C_1 \leftarrow C_2$) such that C_1 is a correspondent of C_2 .

Defining CC correspondence as a strictly right-to-left relation may seem to be entirely ad hoc stipulation. However, there are two good reasons for adopting this view. One is the simple empirical observation that right-to-left is very clearly the default directionality for consonant harmony effects, barring any interference from morphology. The definition of consonant harmony as resulting from a right-to-left correspondence mapping is not so much stipulated as *inferred* from this observation. But the other, more persuasive argument for the definition in (21) is that the right-to-left bias is in fact grounded outside of the domain of formal phonological theory. The fundamental thesis of this study can be said to be the claim that consonant harmony phenomena are grounded in (or ‘are motivated by’, or

‘arise from’) the domain of speech planning, and share many distinguishing properties with phonological speech errors. Several typological properties of consonant harmony systems fall out from this view—sensitivity to the relative similarity of the trigger/target pair, the inertness of intervening segmental material, and the existence of a ‘Palatal Bias’ effect in coronal harmony systems (see chapter 6). As it turns out, the bias towards *anticipatory* interactions is yet another trait which consonant harmony has in common with speech errors.

Schwartz et al. (1994) and Dell et al. (1997) have found that, under normal circumstances, anticipatory errors (e.g., *cuff of coffee*) are more frequent than perseveratory ones (e.g., *beef needle soup*), the former often outweighing the latter by a ratio of 2:1 or 3:1. Dell et al. (1997) refer to this as the *general anticipatory effect*. Furthermore, it appears that under conditions when error rates are elevated, the proportion of perseveratory errors increases. It is a well-known fact that error rate is higher in less familiar, more difficult phrases. Schwartz et al. (1994) found a clear *anticipatory practice effect* in such cases, whereby practice not only reduced the overall error rate but also had a large effect on the anticipatory:perseveratory ratio. For the first practice block of difficult phrases such as *chef’s sooty shoe soles*, anticipatory errors were outweighed by perseveratory ones (constituting only 38% of the relevant errors), but by the eighth block, anticipations dominated (at 70%). This anticipatory practice effect was robustly replicated by Dell et al. (1997). Another related factor is speech rate. Dell (1990) found that the proportion of perseveratory errors increased as the available time for speaking decreased (i.e. with increasing speech rate); a similar speech-rate effect was found by Dell et al. (1997). Another finding reported by Schwartz et al. (1994) is that many aphasics’ speech is characterized by a much higher proportion of perseveratory errors than nonaphasic speech. Finally, age appears to be a factor as well. Stemberger (1989) found that while adults’ slips

of the tongue were predominantly anticipatory, children tended to perseverate more, especially younger children (for age 2, the anticipatory:perseveratory ratio was appr. 2:3).

In sum, the generalization appears to be that *other things being equal*, speech errors are much more likely to involve anticipation (right-to-left interference) than perseveratory (left-to-right interference). Dell et al. (1997) derive this from the general properties of their theory of serial order in speech production, as implemented in a particular formal model:

[A] theory of serial order in speech must satisfy a set of functional requirements: The system must activate the present, deactivate the past, and prepare to activate the future. [...T]he general anticipatory effect follows from these functions, given certain assumptions. In short, we claim that when the language-production system is working well, *it looks to the future and does not dwell on the past*.

(Dell et al. 1997:123, emphasis added)

The definition of the CC correspondence relation as an asymmetric, anticipatory one ($C_1 \leftarrow C_2$) is a direct reflection of the very properties of serial encoding in speech production that Dell et al. describe. In the production domain, C_2 is already being activated at the point when C_1 is being executed. In the phonological domain, C_1 is a correspondent of C_2 ; this means that the realization of C_1 can be influenced by C_2 . Given the assumption that consonant harmony represents the phonologized counterpart of on-line production errors, the correlation is not surprising. It should be emphasized, however, that consonant harmony effects are not the *same* as speech errors. The former are phonologized, systematic sound patterns, thoroughly entrenched in the grammatical system of the language in question, and have all the hallmarks of truly *phonological* phenomena. For example, the recursive character of sibilant harmony in Chumash (e.g., /s-ij-tij-jep-us/ 'they (2) show him' → sistisijepus) is a property which is atypical of speech errors. Furthermore, the intricate

interaction of many consonant harmony systems with morphological structure attests to the grammatical nature of the phenomenon.

Recall that in those consonant harmony systems where morphological constituency defines directionality, perseveratory harmony (left-to-right, stem-to-suffix) is frequently found. At first glance, this appears to be incompatible with the definition in (21) of CC correspondence being a strictly anticipatory relation. However, as we shall see in subsequent sections, strict right-to-left correspondence can actually give rise to actual left-to-right directionality effects, as a result of constraint interaction and factorial typology.

To conclude, CORR-CC constraints establish an anticipatory correspondence mapping from C_2 to C_1 , when the C_1/C_2 pair is above a certain threshold of relative similarity and distance. The asymmetry of the correspondence relation accounts for the cross-linguistic generalization that, other things being equal, consonant harmony obeys right-to-left directionality. This asymmetry is a direct reflection of how sequentially ordered segments interact in the speech production. However, when other things are *not* equal—e.g. when morphological constituency mitigates against this default directionality—constraint interaction can give rise to left-to-right harmony.

4.2.2. IDENT[F]-CC constraints

As explained above, CORR-CC constraints merely establish a correspondence relation from C_2 to C_1 —provided that the C_1/C_2 pair fulfills certain criteria of relative similarity and distance. This correspondence relation is a purely abstract relation; it does not in and of itself involve any specific demands for identity between C_1 and C_2 . As such, CC correspondence merely establishes a kind of ‘coindexing’ of C_1 and C_2 . For the purpose of a particular CORR-CC constraint, the two representations $/k_i ik^h_i a/$ and $/k^h_i ik^h_i a/$ are equally good; in both cases, the C_1 corresponds to C_2 . The fact that the correspondence is an *imperfect* one in the first case ($k \leftarrow k^h$ rather than $k^h \leftarrow k^h$) is an entirely separate issue,

with which CORR-CC constraints are not concerned. A third possibility, $/k^h_i i k^h_j a/$, is in fact worse according to CORR-CC, in spite of the fact that C_1 and C_2 are identical (k^h). The reason is that in $/k^h_i i k^h_j a/$, C_1 is not a correspondent of C_2 , as indicated by the subscript indices.

Favoring perfect correspondence over imperfect correspondence is the responsibility of the *faithfulness* constraints that operate on the CC correspondence mapping. These constraints belong to the IDENT[F]-CC family. Each IDENT[F]-CC constraint requires that if a given consonant in the output string is $[\alpha F]$, then its CC correspondent must also be $[\alpha F]$. The definition in (22) is more or less identical to that in Walker (2000ab, to appear); we shall have reason to alter this definition later on.

(22) IDENT[F]-CC (to be revised!)

If an output consonant C_x is $[\alpha F]$, and C_y is any correspondent of C_x in the output, then C_y is also $[\alpha F]$.

It is important to note that, since CC correspondence is strictly right-to-left (as explained in the previous section), this in effect means that if C_2 is $[\alpha F]$, then C_1 must also be $[\alpha F]$. The effect of IDENT[F]-CC is shown schematically in (23), where the presence of a CC correspondence relation between the two consonants is stipulated, for reasons of simplicity. Note that we are dealing here with sequences of consonants, potentially separated by long stretches of intervening segmental material. Thus, for example, $/C_1 \dots C_2/$ might stand for the $/s \dots \int/$ sequence in an output string like $/ʔəs;ɪmɪ'leʃ;əɪn/$. That particular sequence would violate IDENT[ant]-CC, as in the second example in (23b), since $/\int/$ is [-ant] whereas its correspondent $/s/$ is [+ant].

(23) The effect of IDENT[F]-CC under asymmetric CC correspondence ($C_1 \leftarrow C_2$)

a. Output sequences which satisfy IDENT[F]-CC

C_1	(←)	C_2	C_1	(←)	C_2
[+F]		[+F]	[-F]		[-F]

b. Output sequences which violate IDENT[F]-CC

C_1	(←)	C_2	C_1	(←)	C_2
[-F]		[+F]	[+F]		[-F]

In (22) IDENT[F]-CC was stated as a value-neutral constraint, requiring that C_1 assume the same value for [F] as C_2 , regardless of whether that value is [+F] or [-F]. Under these conditions, the asymmetric (right-to-left) nature of the correspondence relation is not immediately apparent. Both of the disharmonic sequences in (23b) violate IDENT[F]-CC in the same manner, and both of the harmonic sequences in (23a) satisfy the constraint. The fact that it is C_1 which is required to agree with C_2 , rather than the other way around, is not directly visible. This changes if IDENT constraints are broken down into their value-specific components, as has been argued for by, e.g., McCarthy & Prince (1995, 1999) and Pater (1999). Instead of a single IDENT[F]-CC, we then have the two separate constraints IDENT[+F]-CC and IDENT[-F]-CC, as defined in (24).

(24) Value-specific IDENT[F]-CC (to be revised!)

a. IDENT[+F]-CC

If an output consonant C_x is [+F], and C_y is any correspondent of C_x in the output, then C_y is also [+F].

b. IDENT[-F]-CC

If an output consonant C_x is [-F], and C_y is any correspondent of C_x in the output, then C_y is also [-F].

Under value-specific IDENT, the right-to-left asymmetry inherent in the $C_1 \leftarrow C_2$ correspondence relation becomes evident. The schematic examples in (25) show the effect of the [+F] version of the constraint. The same applies, *mutatis mutandis*, to the [-F] version of the same constraint.

(25) The effect of value-specific IDENT[+F]-CC under $C_1 \leftarrow C_2$ correspondence

a. Output sequences which satisfy IDENT[+F]-CC:

C_1	(\leftarrow)	C_2		C_1	(\leftarrow)	C_2		C_1	(\leftarrow)	C_2
[+F]		[+F]		[-F]		[-F]		[+F]		[-F]
				<i>(vacuous)</i>				<i>(vacuous)</i>		

b. Output sequence which violates IDENT[+F]-CC:

C_1	(\leftarrow)	C_2
[-F]		[+F]

Note that unlike its value-neutral counterpart, IDENT[+F]-CC only penalizes one type of ‘disharmony’: the situation where a [+F] specification on C_2 is not matched by [+F] in C_1 . In those cases where C_2 is *not* [+F], the constraint is vacuously satisfied, since there is no [+F] specification to ‘carry over’ onto C_1 . The constraint is defined as an implication, *if P then Q* ($P \supset Q$). When C_2 is not [+F], the antecedent P does not hold, and Q is therefore not required to hold either.

There is reason to believe that we do need value-specific IDENT constraints in order to account for the full range of attested consonant harmony phenomena. In some cases, the harmony involves ‘spreading’ of only one feature value, not both. Nasal consonant harmony in Bantu languages is one example of single-value consonant harmony: voiced oral consonants become [+nasal] when preceded by a [+nasal] consonant in the stem, but nasals do not get ‘oralized’ when preceded by a [-nasal] consonant. Thus /m...d/ \rightarrow

/m...n/, but not /b...n/ → /b...d/.²³ Not surprisingly, Walker (2000b) uses value-specific IDENT[+nas]-CC in her correspondence-based analysis of Yaka nasal consonant harmony. Other examples involve obstruent voicing harmony, where the ‘spreading’ feature is [+voiced] (to the exclusion of [-voiced]), or sibilant harmony systems where alveolars ([+ant]) assimilate to postalveolars ([-ant]) but not vice versa. (See chapter 6 for discussion of such ‘palatal bias’ effects and their source.)

In the literature on harmony systems in general, single-value *vowel* harmony systems are traditionally called *dominant-recessive*. In such systems, vowels carrying the active [F]-value (usually [+ATR]) are called ‘dominant’, since they determine the [F]-value for the entire harmony domain. Vowels with the inactive value, by contrast, are called ‘recessive’. Single-value consonant harmony systems could be called ‘dominant-recessive’ as well, but there are reasons to avoid this terminology here. First of all, drawing seemingly-intuitive parallels between vowel harmony and consonant harmony may do more harm than good. As has been argued throughout this thesis, the a priori assumption that consonant harmony is homologous with vowel harmony (e.g., that both must involve feature/gesture spreading) has impeded our understanding of the true nature of consonant harmony as a phenomenon in its own right.

Secondly, dominant-recessive vowel harmony systems usually involve *bidirectional* assimilation. In a language where [+ATR] vowels are dominant, both [+ATR]...[-ATR] and [-ATR]...[+ATR] thus harmonize to [+ATR]...[+ATR]. In fact, Baković (2000) has made the strong claim that *unidirectional* dominant-recessive harmony is entirely unattested. However, this generalization does clearly not carry over to single-value

²³ An interesting exception is Tiene, where nasals *do* ‘oralize’ in order to harmonize with (non-nasalizable) /s/, as discussed in section 2.4.4 (Hyman & Inkelas 1997; see also discussion in 4.3.3 below). Note that the issue of single-value vs. double-value harmony is orthogonal to that of directionality. Thus, the fact that /b...n/ does not surface as /m...n/—spreading [+nasal] as in the attested cases—follows from the generalization that the harmony obeys *inside-out* directionality, with suffixes harmonizing to the preceding stem. Cases do exist where the harmony instead obeys *right-to-left* directionality, however, regardless of morphology. In Pangwa, reciprocal /-an-/ triggers nasalization on a preceding (stem-final) velar: /pulix-/ ‘listen to’, but /puliŋ-an-/ ‘listen to each other’ (Stirnemann 1983). See section 4.3.3 for further discussion.

consonant harmony systems. For example, there are single-value sibilant harmony systems (where the active value is [-ant]) which clearly obey strict right-to-left directionality, without any regard to morphological structure. In Nkore-Kiga sibilant harmony, for example, the agreement between sibilants separated by more than one syllable is ‘dominant-recessive’ in this way: /s/ assimilates to /ʃ/, rather than /ʃ/ to /s/. At the same time, the harmony is strictly right-to-left (potentially from suffix to stem), such that /sVVCVʃ/ → /ʃVVCVʃ/, but /ʃVVCVs/ does not harmonize to /ʃVVCVʃ/.²⁴ In short, single-value consonant harmony *can* indeed be unidirectional. In fact, truly bidirectional single-value systems—ones that would be direct analogues to the typical dominant-recessive vowel harmony system—appear to be entirely unattested.²⁵ However, this is perhaps not too surprising, given the fact that even dominant-recessive vowel harmony systems are quite rare, and appear to be confined to [±ATR] harmony.

Finally, Baković (2000) claims that in dominant-recessive vowel harmony systems, the dominant vowels are always less marked than their recessive counterpart (a general pattern referred to as ‘assimilation to the unmarked’). This is most certainly untrue of single-value consonant harmony systems as a class. As will be discussed in greater detail in chapter 6, single-value sibilant harmony always involves the postalveolar (‘palatal’) series as the active one, such that /ts/, /s/, /z/, etc. assimilate to /tʃ/, /ʃ/, /ʒ/, etc. rather than vice versa. Likewise, in obstruent voicing harmony the active value is generally [+voiced], even though [-voiced] ought to be the unmarked option for obstruent consonants. If anything, the typology of consonant harmony points toward assimilation to the *marked* being the prevalent pattern in single-value systems. Incidentally, similar asymmetries have been observed in speech error studies. For example, Stemberger (1991) finds that in contextual

²⁴ At shorter distances, the sibilant harmony is double-value rather than single-value, ‘spreading’ [-ant] and [+ant] alike. The right-to-left directionality still holds in these cases: /sVʃ/ → /ʃVʃ/, /ʃVs/ → /sVs/.

²⁵ In such a system, the active value [αF] would ‘spread’ from *any* morpheme (prefix, stem or affix) to [-αF] consonants in preceding and following morphemes. Kera voicing harmony does not qualify, even though it ‘spreads’ [+voi] bidirectionally, because the directionality is strictly *inside-out* (or ‘cyclic’), with affixes assimilating to the stem to which they attach (cf. section 3.2 above).

speech errors (anticipations or perseverations), postalveolar sibilants tend to replace alveolar sibilants (see chapter 6), voiced obstruents tend to replace voiceless ones, nasals and fricatives tend to replace stops, labials tend to replace alveolars, and so forth.²⁶ Such parallels between speech errors and consonant harmony processes are only to be expected if the latter are rooted in the domain of speech planning, as argued here.

To conclude, there are cases where the analysis of consonant harmony seems to require value-specific IDENT constraints, notably what I have chosen to call single-value harmony systems. These are analogous to dominant-recessive vowel harmony systems, in that only one [F]-value is ‘active’ (triggering assimilation), but there is reason to be wary of making too much of this analogy. Baković (2000) explicitly rejects the use of value-specific IDENT-IO constraints to account for dominant-recessive vowel harmony, on the grounds that it fails to capture his generalization about ‘assimilation to the unmarked’. However, as explained above, consonant harmony does *not* obey this generalization, and it is therefore irrelevant as an argument against using value-specific IDENT in this case. In the following section, the basic machinery of the correspondence-based analysis of consonant harmony is illustrated with a simple example of a single-value system. The analysis utilizes both value-specific IDENT constraints and the right-to-left asymmetry built into the CC correspondence relation. It also introduces the idea that the harmony-enforcing constraints (IDENT-CC) are in fact to be understood as *targeted* constraints (in the sense of Wilson 2000, in progress; Baković & Wilson 2000), a notion which becomes crucial later on in this chapter.

4.2.3. Fundamental ranking requirements

In this section, we will see how the constraints introduced in 4.2.1 and 4.2.2 interact to give rise to consonant harmony effects. We shall illustrate this with a relatively simple case; sub-

²⁶ Stemberger (1991) explicitly argues that his findings reflect radical underspecification of segments, not markedness differences as such. In the present context, however, the distinction is irrelevant; the important point is simply that the consonant harmony phenomena are *not* consistent with ‘assimilation to the unmarked’, and neither are the speech error generalizations discussed by Stemberger.

sequent sections will introduce progressively more complex phenomena that call for more intricate constraint interactions. The particular example that will be analyzed here is the obstruent voicing harmony found in the West Chadic language Ngizim (Schuh 1978, 1997). The basic facts were described in 2.4.7 above, but are recapitulated here. Ngizim voicing harmony is a morpheme-internal cooccurrence restriction. Since it does not reach beyond the confines of the root, the harmony does not manifest itself in the form of alternations, but merely as a constraint on (non-adjacent) obstruent sequences within roots. Examples of roots containing obstruents that agree in voicing are given in (26). Note that the effect of the harmony as a diachronic process in Ngizim can clearly be seen by considering cognates in related languages, as shown in (26b).

(26) Ngizim voicing harmony (data from Schuh 1997, unless noted otherwise)

- | | | | |
|----|--------|--------------------|---------------------------------------|
| a. | kùtór | ‘tail’ | |
| | ɬəpú | ‘clap’ | (Schuh 1978:260) |
| | tàsáú | ‘find’ | |
| | sètú | ‘sharpen to point’ | (Schuh 1978:260) |
| b. | gâazá | ‘chicken’ | (< *k...z, cf. Hausa /kàazáa/) |
| | dóbâ | ‘woven tray’ | (< *t...b, cf. Hausa /tàafii/ ‘palm’) |
| | zàbìjú | ‘clear field’ | (< *s...b, cf. Hausa /sássàbée/) |
| | zèdù | ‘six’ | (< *s...d, cf. Hausa /jídà/) |

As is evident from the Hausa cognates in (26b), Ngizim voicing harmony is a matter of anticipatory assimilation, involving the feature value [+voiced]. A voiceless obstruent is harmonized to [+voi] when a [+voi] obstruent follows within the same morpheme. The asymmetry inherent in this process is also evident synchronically within the Ngizim

lexicon. Although voiceless-voiced sequences are disallowed (*T...D), voiced-voiceless ones abound, as shown in (27).

(27) Asymmetric character of Ngizim voicing harmony (D...T, but no *T...D)

bàkú	‘roast’ (Schuh 1997)
zàpènú	‘churn’ (Schuh 1978:254)
gùmtǎí	‘chin’ (Schuh 1997)
dùkǎí	‘heavy’ (Schuh 1978: 251)
zùktú	‘pierce’ (Schuh 1978:273)
mbàsú	‘sit’ (Schuh 1978:262)

Ngizim harmony is thus a strictly right-to-left effect: a *preceding* [+voi] obstruent will not induce voicing harmony (thus /bàkú/ ‘roast’ does not harmonize to *[bàgú]). Furthermore, the restriction is a matter of single-value harmony, [+voi] being the ‘active’ value. A [-voi] obstruent does not trigger right-to-left *devoicing* harmony (/bàkú/ does not harmonize to *[pàkú]). An adequate analysis of Ngizim harmony must account for these asymmetries.

As explained in 4.2.1.2 above, the correspondence relation established by CORR-CC constraints is inherently anticipatory, i.e. ‘from C₂ to C₁’ or C₁←C₂. Furthermore, CORR-CC constraints form a hierarchy, based on the relative similarity of C₁ and C₂. The greater the similarity, the stronger the demand for C₁←C₂ correspondence. To some extent, the effect of relative similarity on the ranking of CORR-CC constraints is inherently predictable. The constraint demanding correspondence between consonants differing *only* in features [F] and [G] dominates that demanding correspondence between consonants differing in [F], [G] *and* [H]. But what about consonants differing only in [F] and [G] vs. those differing only in [F] and [H]? Here the question of relative similarity is more complicated. As was argued in 4.2.1.1, there is reason to believe that different languages may impose different

similarity judgements in such cases—i.e. that they may differ in the relative ranking of the CORR-CC constraints in question.

For the purposes of Ngizim voicing harmony, the set of consonants ‘picked out’ by the CORR-CC constraints includes all obstruents (stops, fricatives, affricates), regardless of differences in place of articulation and/or stricture. Sonorants, by contrast, do not trigger voicing harmony (/kùtár/ ‘tail’ does not become *[gùdár], and /zàpènú/ ‘churn’ does not become *[zàbènú]). Two consonants differing in [\pm voiced] and [\pm sonorant] (e.g., /b/ vs. /m/) are thus treated by the phonology of Ngizim as *less* similar than ones differing in [\pm voiced], [Place] and [\pm continuant] (e.g. /b/ vs. /s/).²⁷ The similarity scale relevant for Ngizim, encoded in terms of differentially-ranked CORR-CC constraints, is shown in (28).

- (28) CORR-CC constraint hierarchy relevant for Ngizim obstruent voicing harmony
 CORR-[voi] >> CORR-[voi,Pl] >> CORR-[voi,Pl,cont] >> CORR-[voi,son], ...

As before, the bracketed features denote the properties in which the two consonants in question may differ. Thus CORR-[voi] demands correspondence between consonants differing *at most* in [\pm voiced] (/d...t/, /s...z/, /k...g/, as well as /k...k/, /z...z/, etc.). CORR-[voi, Place] demands correspondence between consonants differing at most in [\pm voiced] *and* in [Place]; this includes all pairs addressed by higher-ranked CORR-[voi], but also heterorganic pairs such as /d...p/, /k...b/, etc. The fact that CORR-[voi, Place, cont] outranks CORR-[voi, son] reflects the generalization that the demand for C₁←C₂ correspondence between two obstruents is greater than that between an obstruents and a sonorant, even when the two obstruents differ in [Place] and [\pm continuant].

²⁷ Of course, /b/ and /m/ also differ in [\pm nasal], but note that the [+nasal] specification on /m/ is redundant, in the sense that it is predictable from [+son, -cont]. Besides, the pair /b/ : /s/ could be said to differ in [\pm strident] as well, which also is a redundant feature.

The hierarchically-ranked CORR-CC constraints have the effect of establishing a correspondence relation in obstruent...obstruent sequences. Note that this alone does not induce voicing harmony, nor any other kind of influence of one obstruent on the other. The constraint responsible for enforcing voicing agreement between the two obstruents is IDENT[+voi]-CC. When a given output candidate contains a sequence of consonants /C₁...C₂/, where C₁ is a correspondent of C₂ (C₁←C₂), IDENT[+voi]-CC requires that if C₂ is [+voiced], then its correspondent C₁ must likewise be [+voiced].

In order for voicing harmony to be enforced, faithfulness to [±voiced] specifications in the input representation must be outranked by IDENT[+voi]-CC, as well as by the relevant CORR-CC constraints. The combined effect of these constraints is illustrated in (29) with the example /gâazá/ ‘chicken’ (< */k...z/, cf. Hausa /kâazáa/). The *actual* input representation of this particular word in the Ngizim lexicon would of course be /gâazá/ (by Lexicon Optimization; see Prince & Smolensky 1993). Nevertheless, the derivation in the tableau shows us how voicing harmony would apply even to a hypothetical disharmonic input /kâazá/.

As in the tableaux in section 4.1.3 above, IO correspondent pairs are indicated with subscript digits (‘1, 2’) and CC correspondent pairs with subscript letters (‘i, j’). Thus in candidate (29b) the output segment [k_{1,i}] corresponds to the input segment /k₁/ (by IO correspondence) and also to the following output segment [z_{2,i}] (by CC correspondence). Its faithfulness to /k₁/ is evaluated by IDENT-IO constraints, among them IDENT[voi]-IO. Its ‘faithfulness’ (agreement, rather) to [z_{2,i}] is assessed by IDENT-CC constraints, in particular IDENT[+voi]-CC. In candidate (29a), by contrast, the output segment [k_{1,i}] corresponds only to input /k₁/ . It does *not* correspond to the following output segment [z_{2,j}], as the subscript indices show (i≠j). In that case, IDENT[+voi]-CC is vacuously satisfied, since there is no CC correspondent pair present for it to evaluate.

(29) Ngizim obstruent voicing harmony (heterorganic stop vs. fricative):

$/k_1\hat{a}az_2\acute{a}/$	ID[+voi]- CC	CORR- [voi,Place]	CORR- [voi,Place,cont]	ID[voi]-IO	CORR- [voi,son]
a. $k_{1,i}\hat{a}az_{2,j}\acute{a}$			*!		
b. $k_{1,i}\hat{a}az_{2,i}\acute{a}$	*!				
c. $g_{1,i}\hat{a}az_{2,j}\acute{a}$			*!	*	
d. $\text{☞ } g_{1,i}\hat{a}az_{2,i}\acute{a}$				*	


With respect to the similarity hierarchy of CORR-CC constraints, the tableau lists only the relevant portion CORR-[voi, Place] >> CORR-[voi, Place, cont] >> CORR-[voi, Place]. The top-ranked CORR-[voi] is omitted in order to reduce cluttering in the tableau. In the particular example in (29), C_1 and C_2 differ in three features: $[\pm\text{voi}]$, [Place] and $[\pm\text{cont}]$; the CORR-CC constraint responsible for demanding a correspondence relation in this case is therefore CORR-[voi, Place, cont]. The tableau in (30) shows an example where the higher-ranked CORR-[voi, Place] is instead the relevant constraint. Here the consonants differ only in $[\pm\text{voi}]$ and [Place], not in $[\pm\text{cont}]$. The example derives the correct output for $/d\acute{o}b\hat{a}/$ ‘woven tray’, even in the face of a disharmonic input $/t\acute{o}b\hat{a}/$.

(30) Ngizim obstruent voicing harmony (heterorganic stops):

$/t_1\acute{o}b_2\hat{a}/$	ID[+voi]- CC	CORR- [voi,Place]	CORR- [voi,Place,cont]	ID[voi]-IO	CORR- [voi,son]
a. $t_{1,i}\acute{o}b_{2,j}\hat{a}$		*!	*		
b. $t_{1,i}\acute{o}b_{2,i}\hat{a}$	*!				
c. $d_{1,i}\acute{o}b_{2,j}\hat{a}$		*!	*	*	
d. $\text{☞ } d_{1,i}\acute{o}b_{2,i}\hat{a}$				*	

Finally, the analysis accounts for the fact that sonorants fail to trigger voicing harmony. As shown in (31), /t̀ə́r_á/ ‘moon’ surfaces intact, not harmonized to *[d̀ə́r_á]. The relevant CORR-CC constraint in this case is CORR-[voi, son]. Since this is ranked lower than IO faithfulness to [±voi] specifications, the best option is to sacrifice the CC correspondence relation between /t/ and /r/, as in (31a). With no CC-correspondent pair present, the constraint IDENT[+voi]-CC is vacuously satisfied.

(31) Ngizim obstruent voicing harmony (sonorants are not triggers):

/t̀ə́r_á/	ID[+voi]-CC	CORR-[voi,Place]	CORR-[voi,Place,cont]	ID[voi]-IO	CORR-[voi,son]
a.  t̀ _{1,i} ə́r_2,j_á					*
b. t̀ _{1,i} ə́r_2,i_á	*!				
c. d̀ _{1,i} ə́r_2,j_á				*!	*
d. d̀ _{1,i} ə́r_2,i_á				*!	

Another aspect of Ngizim voicing harmony that was mentioned in section 2.4.7 is that voiced *implosives* do not trigger it either, as is evident from the examples in (32). Even though they are unquestionably obstruents, implosives are just as inert as sonorants are.

(32) Ngizim: Voiced implosives are non-triggers (data from Schuh 1997)

p̀ə́d_á_k	‘morning’	(not *b̀ə́d_á_k)
k̀i_i_d_ú	‘eat (meat)’	(not *g̀i_i_d_ú)
f̀ə́d_ú	‘four’	(not *v̀ə́d_ú)
s̀ə́p_d_ú	‘pound (v)’	(not *z̀ə́p_d_ú or *z̀ə́b_d_ú)

Assuming that the voiced pulmonic vs. voiced implosive distinction is a matter of the feature [±constricted glottis] (henceforth [±cg]), the CORR-CC constraint covering sequences like

/t...d/, /b...p/, etc. is CORR-[voi, cg]. The inertness of implosives in Ngizim voicing harmony can thus be accounted for by assuming the ranking CORR-[voi, Place, cont] >> CORR-[voi, cg]. In other words, the phonology of Ngizim considers a segment pair like /t/ vs. /d/ to be *less* similar than one like /z/ vs. /k/ or /f/ vs. /d/. By ranking CORR-[voi, cg] lower than IO faithfulness, we get the right result, as shown in (33). The particular input-output pair in (33) is a hypothetical one, intended to illustrate the fact that voicing harmony fails even between *homorganic* stops differing in [\pm cg].

(33) Ngizim obstruent voicing harmony (implosives are not triggers):


/t ₁ ad ₂ a/	ID[+voi]-CC	CORR-[voi,Place]	CORR-[voi,Place,cont]	ID[voi]-IO	CORR-[voi,cg]
a. \rightarrow t _{1,i} ad _{2,j} a					*
b. t _{1,i} ad _{2,i} a	*!				
c. d _{1,i} ad _{2,j} a				*!	*
d. d _{1,i} ad _{2,i} a				*!	

Most likely the inertness of sonorants and implosives in Ngizim voicing harmony is due to the fact that voicing is *redundant* in these consonants. Whereas pulmonic obstruents contrast in [\pm voi] (/p/ vs. /b/, /f/ vs. /v/, /t/ vs. /d/, /s/ vs. /z/, etc.), sonorants and implosives do not, and the specification [+voi] in these segments is thus predictable from combinations of other feature specifications. I will return to the issue of contrastiveness and its relevance for consonant harmony in section 5.3 of the following chapter.

All the previous tableaux have completely ignored the issue of right-to-left directionality and the designation of [+voi] as the active feature value. In order to be complete, the analysis must account for the fact that /tá**b**â/ does not harmonize to *[tápâ] (instead of the correct [dábâ]), and that /bàkú/ does not harmonize at all, neither to *[pàkú] (by right-to-left [-voi] harmony) nor to *[bàgú] (by left-to-right [+voi] harmony). Let us

start with the second case, the fact that D...T sequences are not subject to harmony at all. This is shown in (34). To reduce cluttering, all the CORR-CC constraints have been omitted from the tableau; the candidate set has been reduced by simply taking for granted the presence of a $C_1 \leftarrow C_2$ correspondence relation between the two consonants (ensured by CORR-[voi, Place] >> IDENT[voi]-IO). Note also that the constraint IDENT[-voi]-CC has been added for completeness, although it is ranked too low to have any effect.

(34) Ngizim: No voicing harmony in [+voi]...[-voi] sequences

/b _{1,i} àk _{2,i} ú/	IDENT[+voi]-CC	IDENT[voi]-IO	IDENT[-voi]-CC
a.  b _{1,i} àk _{2,i} ú			*
b. p _{1,i} àk _{2,i} ú		*!	
c. b _{1,i} àg _{2,i} ú		*!	

It is important to note that the faithful winning candidate (34a) does *not* violate the top-ranked IDENT[+voi]-CC constraint, even though it is ‘disharmonic’ with respect to voicing. Recall that the CC correspondence relation is inherently directional, $C_1 \leftarrow C_2$. The constraint thus requires that a [+voi] specification on C_2 must be reflected in its correspondent C_1 . In (34a), C_2 is not [+voi], and IDENT[+voi]-CC is therefore vacuously satisfied. There is no incentive to apply left-to-right [-voi] harmony, as in (34c); this explains why D...T sequences are not harmonized to D...D. The fact that C_1 is [+voi] but not C_2 is completely irrelevant. Since C_2 is *not* a correspondent of C_1 , IDENT[+voi]-CC in no way requires that the [+voi] specification on C_1 be copied onto C_2 .

On the other hand, the winning candidate (34a) does violate the low-ranked constraint IDENT[-voi]-CC. This constraint would require right-to-left harmony with respect to the feature value [-voi]: if C_2 is [-voi], then its correspondent C_1 must also be [-voi]. Unlike its counterpart IDENT[+voi]-CC, this constraint is outranked by IO faithfulness and is

therefore unable to exert its influence. In general, the ranking schema IDENT[α F]-CC >> IO-Faith >> IDENT[- α F]-CC gives rise to a single-value harmony system, with [α F] being the active or ‘dominant’ value.

The example derivation in (34) showed how, in the case of an input sequence /D...T/, complete faithfulness is better than either left-to-right [+voi] harmony (D...D) or right-to-left [-voi] harmony (T...T). In the earlier examples in (29)-(30), which demonstrated voicing harmony, we saw how right-to-left [+voi] harmony can win out over faithfulness, /tóbâ/ surfacing as [dóbâ] ‘woven tray’ rather than as *[dóbâ]. But what about the other harmonic alternative, namely [tópâ]? Here we run into an unexpected problem. The CC correspondence relation was defined as strictly anticipatory, C₁←C₂, precisely in order to account for the right-to-left directionality found in numerous consonant harmony systems, Ngizim being one of them. Furthermore, IDENT[voi]-CC was split up into (high-ranked) IDENT[+voi]-CC and (low-ranked) IDENT[-voi]-CC, in order to account for the fact that only [+voiced] is active in Ngizim. Given that these measures have been taken, one should think that the analysis would at the very least correctly derive ‘spreading’ of [+voi] from C₂ to C₁, harmonizing [-voi]...[+voi] sequences to [+voi]...[+voi]. However, things are not so simple, as shown by the tableau in (35).

(35) Ngizim: Indeterminacy in deriving voicing harmony (to be revised!)

	/t ₁ ób ₂ â/	IDENT[+voi]-CC	IDENT[voi]-IO	IDENT[-voi]-CC
a.	t _{1,i} ób _{2,i} â	*!		
b.	☞ d _{1,i} ób _{2,i} â		*	
c.	!☞ t _{1,i} óp _{2,i} â		*	

As it turns out, only the disharmonic (and faithful) candidate (35a) is ruled out, but the IDENT-CC constraints are unable to choose *which* harmonic candidate is better, the one with

right-to-left [+voi] harmony (35b)—our expected winner—or the one with left-to-right [-voi] harmony (35c). The choice will therefore be left to other lower-ranked constraints that have nothing whatsoever to do with voicing harmony. For the sake of the argument, let us imagine a language pseudo-Ngizim, exactly like Ngizim but with a very low-ranked constraint mitigating against voiced stops in high-toned syllables. In the derivation in (35), this constraint might result in (35c) winning rather than (35b), since the latter contains the marked sequence [dǎ]. Such bizarre results are clearly undesirable.

What is the reason for the tie in (35)? In particular, why is IDENT[+voi]-CC unable to force the right outcome, given that it by definition requires a [+voiced] C₂ to induce [+voiced] in C₁? The key to understanding the problem is the fact that IDENT[+voi]-CC is ultimately an *output* constraint—in effect, a well-formedness constraint on output representations (even though it is formalized as a correspondence constraint). As such, the only effect this constraint can have is to penalize a particular output configuration, namely a [-voi]...[+voi] sequence of consonants under C₁←C₂ correspondence. In this way, IDENT[+voi]-CC is able to rule out the faithful candidate (35a) as ill-formed; in other words, what the constraint effectively does is merely to penalize disharmony of a certain kind. It does not specify a particular ‘repair strategy’, any more than other output constraints do. For this reason, IDENT[+voi]-CC cannot distinguish between the two ‘non-disharmonic’ candidates (35b) and (35c).

One way to force the correct outcome in this particular case is to split IO faithfulness to [voi] into value-specific constraints, IDENT[+voi]-IO and IDENT[-voi]-IO. By ranking the former above the latter, as in (36), disharmony will be ‘repaired’ by voicing an underlyingly voiceless consonant (36b), rather than devoicing an underlyingly voiceless consonant (36c).²⁸

²⁸ In fact, this is exactly how Walker (2000b) handles the fact that Yaka nasal consonant harmony involves nasalization (/m...d/ → /m...n/) but never oralization (/b...n/ → /b...d/). Undominated IDENT[+nas]-IO ensures that underlying [+nasal] consonants will never surface as [-nasal] due to harmony; in other words, the relative ranking IDENT[+nas]-IO >> IDENT[-nas]-IO is stipulated.

(36) Breaking the tie with value-specific IDENT[voi]-IO constraints:

	/t ₁ ǫb ₂ â/	ID[+voi]-CC	ID[+voi]-IO	ID[-voi]-IO	ID[-voi]-CC
a.	t _{1,i} ǫb _{2,i} â	*!			
b.	d _{1,i} ǫb _{2,i} â			*	
c.	t _{1,i} ǫp _{2,i} â		*!		

The end result in (36) is that right-to-left harmony comes to be preferred over left-to-right harmony. But this solution is unfortunate in several respects. Firstly, it is somewhat inelegant, in that value-specific IDENT is crucially involved along both IO and CC dimensions. Secondly, the preference of (36b) over (36c) is simply stipulated, by assuming that, other things being equal, Ngizim generally prefers the change [-voi] → [+voi] over the reverse change [+voi] → [-voi]. Most importantly, however, the preference of (36b) over (36c) has nothing whatsoever to do with CC correspondence, or with the IDENT-CC constraints that evaluate it. If our original intention was to derive directionality effects from a directional correspondence relation, the conclusion to draw from (36) is that we have failed. It would have been just as easy to stipulate the exact opposite ranking, namely IDENT[-voi]-IO >> IDENT[+voi]-IO, with the result that the voicing agreement would manifest itself in *left-to-right voicelessness* harmony. This in spite of the fact that CC correspondence has been explicitly defined as a *right-to-left* relation (C₁←C₂), and that the constraint responsible for harmony, IDENT[+voi]-CC, is designed so as to ‘spread’ *voicing* from C₂ to C₁, not voicelessness from C₁ to C₂!

There is a sense in which an important generalization is being missed here, one which was hinted at earlier. Recall that IDENT[+voi]-CC is defined as a conditional (if-then) proposition: ‘*if* C₁←C₂ and C₂ is [+voi], *then* C₁ is [+voi]’. As explained before, neither [dǫbâ] (36b) nor [tǫpâ] (36c) violate this constraint. But they satisfy it for very different

reasons. Candidate (36b) can be said to truly satisfy the constraint, in the sense that the antecedent ('if ...') holds true and the consequent ('then ...') also holds true. The 'reverse-harmonized' candidate (36c), by contrast, satisfies the constraint *vacuously*: the antecedent does not apply (C_2 is not [+voi]), and the consequent is thus entirely irrelevant. From this perspective, [tápâ] 'passes' on the constraint IDENT[+voi]-CC in much the same way as innumerable bizarre candidates would, such as [támâ], [ábâ], etc. In short, there is a much more direct relationship between the disharmonic candidate (36a) and the harmonic candidate (36b) than there is between (36a) and (36c). The former two, (36a) and (36b), both satisfy the description inherent in the antecedent ('if $C_1 \leftarrow C_2$ and C_2 is [+voi]'); they differ in that (36a) violates the consequent ('... then C_1 is [+voi]') but (36b) satisfies it.

We can thus say that (36b) is in some sense the 'harmonized counterpart' to (36a). The completely faithful candidate (36a) would be the favored output if it were not for high-ranked IDENT[+voi]-CC; candidate (36b), in a sense, represents a minimal adjustment from (36a) in order to obey this constraint. Can the close relationship between such candidate pairs be formalized within an OT analysis? The answer is yes. This, essentially, is the core of the theory of *targeted constraints* as proposed by Wilson (in progress, 2000; see also Baković & Wilson 2000; Baković 2000). A targeted constraint differs from ordinary output constraints in that it *targets* a specific portion of the output representation—namely some particular marked element—and forces it to move out of its marked state *while the surrounding elements remain constant*. In other words, a targeted constraint is an 'other-things-being-equal' version of the usual kind of output constraint; given two candidates which are otherwise identical, the one containing the targeted (marked) element is dispreferred.



For example, in their analysis of [ATR] vowel harmony in Wolof, Baković & Wilson (2000) propose that the constraint requiring high vowels to be consistently [+ATR] is in fact a targeted constraint, \rightarrow NO(+HI,-ATR). (The arrow ' \rightarrow ' serves as a diacritic to

identify a constraint as targeted.) This constraint targets [+high, -ATR] vowels, forcing them to change (minimally) into a less marked state. The effect of $\rightarrow\text{NO}(+\text{HI},-\text{ATR})$ can be summarized as follows: given two output candidates x and x' , candidate x' is preferred over x ($x' > x$) if and only if x' is exactly like x except that at least one [+high, -ATR] vowel has been replaced by a vowel that is not [+high, -ATR].²⁹ Given two candidates [tɛɛr-uw-ɔɔn] and [tɛɛr-uw-ɔɔn], $\rightarrow\text{NO}(+\text{HI},-\text{ATR})$ prefers the latter over the former: the marked vowel [ɔ] has been replaced with [u], but the two strings are otherwise completely identical. In other words, transparency is preferred over full harmony. A third alternative, [tɛɛr-uw-ooɔ], where the medial [u] is opaque rather than transparent, is not preferred over fully-harmonized [tɛɛr-uw-ɔɔn]. The reason is that [tɛɛr-uw-ooɔ] is *not* ‘exactly like’ [tɛɛr-uw-ɔɔn] except for the marked vowel [ɔ]. This pair does thus not fit the description of x and x' implicit in the definition of $\rightarrow\text{NO}(+\text{HI},-\text{ATR})$, and this constraint therefore has nothing to say about the relative well-formedness of this particular candidate pair.

The proposal that will be advocated in this work is that the constraints ultimately responsible for consonant harmony—the IDENT[F]-CC constraints—are in fact to be construed as *targeted* constraints. The full implications of this move will be discussed in greater detail in section 4.3.1 below. Here it will suffice to sketch how this alternative interpretation affects the indeterminacy problem we encountered in (35) above. The relevant tableau is repeated in (37). (Low-ranked IDENT[+voi]-CC is omitted, since it is irrelevant in this context.)

²⁹ This characterization omits an important aspect of the definition of the targeted constraint $\rightarrow\text{NO}(+\text{HI},-\text{ATR})$, namely that the vowel replacing the targeted [+high, -ATR] vowel has to be minimally distinct from it, according to a particular (perceptual) similarity metric. The constraint does not prefer x' over x if it replaces, say, [i] with [æ] (instead of with [ɪ]). Although grounding in terms of perceptual and articulatory considerations is an integral part of Wilson’s notion of targeted constraints, it will not be directly relevant for our present purposes (but recall that our understanding of agreement under CC correspondence *is* grounded in the domain of speech planning).

(37) Ngizim: Indeterminacy problem revisited (= 35)

	/t ₁ ó b ₂ â/	IDENT[+voi]-CC	IDENT[voi]-IO
a.	t _{1,i} ó b _{2,i} â	*!	
b. 	d _{1,i} ó b _{2,i} â		*
c. 	t _{1,i} ó p _{2,i} â		*

In order to understand how construing IDENT[+voi]-CC as a targeted constraint can resolve the dilemma in (37), we must first define the constraint as such. A tentative definition of the targeted constraint \rightarrow IDENT[+voi]-CC is given in (38):

(38) \rightarrow IDENT[+voi]-CC

Let x and x' be two output candidates, each of which contains two consonants C_x and C_y where $C_x \rightarrow C_y$ (C_y corresponds to C_x) and C_x is [+voi]. Candidate x' is preferred over x ($x' > x$) iff x' is exactly like x except that the correspondent C_y is [+voi] rather than [-voi].

Recall that CC correspondence is strictly right-to-left, and thus $C_x=C_2$ and $C_y=C_1$. It is extremely important to note that a targeted constraint compares *pairs* of candidates as to their relative well-formedness, not individual candidates. The three candidates in (37) can be paired off with each other in three ways— a vs. b , a vs. c , and b vs. c . We must then ask what, if anything, the constraint \rightarrow IDENT[+voi]-CC has to say about each of these pairwise comparisons. First of all, the constraint clearly prefers b over a (i.e. $b > a$). Each contains two corresponding output consonants $C_2 \rightarrow C_1$ where C_2 is [+voi], and b is exactly like a except that C_1 is [+voi] rather than [-voi].

But what about the other two candidate pairs? Closer inspection reveals that neither of them can qualify as x vs. x' , because candidate c simply does not fit the description stated in the premise (or ‘antecedent’) built into the constraint. Candidate c does contain two corresponding output consonants, $C_2 \rightarrow C_1$, but C_2 is *not* [+voi]. Therefore the constraint \rightarrow IDENT[+voi]-CC has nothing whatsoever to say about the relative goodness of c as compared to any other candidate, a or b . This is analogous to the Wolof situation mentioned above. From the point of view of the targeted constraint \rightarrow NO(+HI,-ATR), the opaque-[u] candidate [tɛɛr-uw-oon] is simply not comparable to either the transparent-[u] candidate [tɛɛr-uw-ɔɔn] or the full-harmony candidate [tɛɛr-ɔw-ɔɔn]. In these comparisons, other things are *not* equal—‘other things’ being everything except the crucial [ɔ]/[u] distinction. In our example in (37), \rightarrow IDENT[+voi]-CC cannot compare (37c) to either (37a) or (37b)—here the ‘other things’ that are not equal include the premise that C_2 be [+voi].

How would the tableau in (37) look if we substituted targeted \rightarrow IDENT[+voi]-CC for its non-targeted counterpart? In order to represent the interaction of a targeted constraint with other constraints, it is crucial to understand the fact that targeted constraints impose a *partial* ordering of the candidate set supplied by GEN. In Optimality Theory, each constraint can be said to impose a harmonic ordering on the representations that make up the candidate set. A constraint \mathbb{C} thus prefers candidate x' over candidate x ($x' > x$) if x violates \mathbb{C} but x' does not (or x violates \mathbb{C} more severely than x' does). With non-targeted constraints, this harmonic ordering is *complete* in the sense that it exhausts the candidate set: *every* candidate that satisfies \mathbb{C} is preferred over *every* candidate that violates \mathbb{C} once, which is in turn preferred over *every* candidate that violates \mathbb{C} twice, and so forth. This is not the case with targeted constraints, which merely pick out individual pairs of candidates and order these relative to each other.

From this perspective on the evaluation of individual constraints, the EVAL function can be characterized as singling out the optimal output candidate in the following way. The

harmonic orderings imposed by individual constraints are added up in a cumulative fashion, with higher-ranked constraints overriding lower-ranked ones in cases of conflict. Take two constraints, \mathbb{C} and \mathbb{C}' , which disagree in the ordering of candidates x and y , \mathbb{C} stating that $x > y$ and \mathbb{C}' stating that $y > x$. If their relative ranking is $\mathbb{C} \gg \mathbb{C}'$, then the ordering $x > y$ is the one that prevails and contributes to the cumulative ordering. The end result is a full cumulative harmonic ordering where one particular candidate stands out as preferred over all others in the set; this is the optimal output.

The visual representation of this interaction requires a slight revision of how OT tableaux are depicted graphically. The example in (39) illustrates one possible way of representing targeted constraints and their interaction with other constraints.

(39) Indeterminacy problem resolved with targeted constraint $\rightarrow\text{IDENT}[+\text{voi}]\text{-CC}$:

$/t_1\acute{o}b_2\hat{a}/$	$\rightarrow\text{IDENT}[+\text{voi}]\text{-CC}$	$\text{IDENT}[\text{voi}]\text{-IO}$
a. $t_{1,i}\acute{o}b_{2,i}\hat{a}$	$(b > a)$	
b. $\text{☞} d_{1,i}\acute{o}b_{2,i}\hat{a}$	$(b > a)$	*
c. $t_{1,i}\acute{o}p_{2,i}\hat{a}$	N/A	*
<i>Harmonic ordering by constraint</i>	$\underline{b} > a$	$a > \{b, c\}$ <i>i.e.</i> $a > b; \underline{a} > c$
<i>Cumulative harmonic ordering</i>	$b > a$	$\text{☞} \mathbf{b} > a > c$

The representation in (39) is a hybrid one, merging the traditional OT tableau with the kind of tableau used by Baković & Wilson (2000). As in an ordinary tableau, the candidates are shown (in the upper half), along with the information on how each candidate does on particular constraints. Note that a targeted constraint does not deal out violation marks the

way constraints usually do. Rather than leave the \rightarrow IDENT[+voi]-CC column empty in this part of the tableau, the pairwise ordering imposed by this constraint is stated after each of the relevant candidates; hence ‘ $b > a$ ’ in rows a and b .

Immediately below, the distribution of violation marks for each individual constraint is translated into harmonic ordering relations. The fact that (39b) and (39c) both violate the constraint IDENT[voi]-IO, whereas (39a) does not, translates into the ordering $a > b$ and $a > c$. However, the former of these, $a > b$, directly contradicts an ordering imposed by a higher-ranked constraint, and is therefore overridden by it. Because $b > a$ overrides $a > b$, the only thing that IDENT[voi]-IO contributes to the *cumulative* harmonic ordering is $a > c$. The contribution that each constraint makes to the cumulative ordering is indicated with underlining; an ordering that is not underlined ($a > b$) is one which is overridden by a higher-ranked constraint. Finally, the last row of the tableau shows how the cumulative harmonic ordering of candidates is built up. The first column shows the ‘cumulative’ ordering given the sole constraint \rightarrow IDENT[+voi]-CC—needless to say, this is identical to the ordering imposed by that individual constraint. The second column shows the cumulative ordering given \rightarrow IDENT[+voi]-CC \gg IDENT[voi]-IO. Combining the individual orderings $b > a$ and $a > c$ (those underlined in the row above), we get $b > a > c$. In our simplified example with only three candidates to choose from, we need look no further. Candidate (39b) has by now been singled out as preferred both over (39a) and over (39c)—in the latter case by transitivity, as it were—and this is indicated with the characteristic pointing-finger symbol.

This concludes our introduction to the basic components of the agreement-based analysis of consonant harmony proposed in this work. In the remainder of this chapter we will see how a wide range of effects observed in the cross-linguistic typology of consonant harmony systems falls out from constraint interaction given this basic framework.

4.3. Interaction with faithfulness: Deriving directionality and stem control

Section 3.1 stated the empirical generalization that all attested consonant harmony systems obey one of two directionality patterns. The difference between these two patterns is fundamentally a matter of sensitivity to morphological constituent structure—the two types can be characterized as morphology-sensitive vs. morphology-insensitive harmony. In the first case, the directionality of harmony is cyclic or ‘inside-out’, with affixes assimilating to the stem to which they attach. Following Baković (2000), this type will be referred to as *stem-controlled* harmony. When consonant harmony is not sensitive to constituent structure—and stems thus potentially assimilate to affixes—the directionality is always anticipatory, i.e. right-to-left. For simplicity, this pattern will be referred to as *directional* harmony. The generalization may be summarized as follows. In stem-suffix contexts, the suffix may assimilate to the stem (stem-controlled harmony) or the stem may instead assimilate to the suffix (directional harmony). In prefix-stem contexts, by contrast, the prefix may assimilate to the stem (stem-controlled *and/or* directional harmony), but the stem *never* assimilates to the prefix.

In the preceding sections, the default nature of right-to-left directionality in consonant harmony was associated with findings in the study of speech errors and phonological encoding, and directly encoded in terms of a strictly right-to-left correspondence relation, $C_1 \leftarrow C_2$. This section shows how, given these assumptions, the two major directionality patterns fall out from the interaction of ranked constraints. The analysis of directional (right-to-left) harmony is presented in 4.3.1, making crucial use of the notion of *targeted* constraint, as introduced at the end of the preceding section. An analysis of stem-controlled harmony is given in section 4.3.2, and it is demonstrated how constraint interaction can give rise to left-to-right directionality even in the face of right-to-left correspondence. Finally, section 4.3.3 discusses some potential problem cases, as well as outstanding issues related to the general question of directionality effects.

4.3.1. Directional harmony: IDENT[F]-CC as a targeted constraint

Our first task is to deal with those consonant harmony systems which were the motivation for postulating asymmetric $C_1 \leftarrow C_2$ correspondence in the first place—namely those which exhibit right-to-left directionality regardless of morphological constituent structure. In a sense, we already encountered one example of this type of directionality: morpheme-internal voicing harmony in Ngizim (see 2.4.7 and 4.2.3 above), where [+voi] ‘spread’ from a voiced obstruent to a *preceding* obstruent but not to a following one. Since this harmony operates within individual morphemes, its directionality cannot by definition be governed by morphological constituent structure. In the Ngizim case, we saw how the strict right-to-left directionality required that IDENT[F]-CC constraints be construed as *targeted* constraints, assessing the relative well-formedness of individual candidate pairs. This analysis will be further illustrated and elaborated in this section.

Although morpheme-internal harmony cannot by definition be morphology-sensitive (at least not in terms of directionality effects) it would be wrong-headed to describe it as morphology-*insensitive*. In Ngizim voicing harmony, it is not the case that the directionality goes *against* constituent structure—it is merely that constituent structure is irrelevant. Much clearer cases of strict right-to-left directionality involve languages where consonant harmony does reach beyond the confines of the morpheme, resulting in surface alternations. A particularly striking example is sibilant harmony in the Chumashan languages, illustrated by the examples in (40) from Ineseño (cf. also the discussion in 2.4.1.1 and 3.1.2); the stem is indicated in boldface.

(40) Right-to-left sibilant harmony in Ineseño Chumash (data from Applegate 1972)

- a. ʃapitʰolit /s-**api-tʰo**-it/ ‘I have a stroke of good luck’
- b. sapitʰolus /s-**api-tʰo**-us/ ‘he has a stroke of good luck’
- c. ʃapitʰolufwaf /s-**api-tʰo**-us-waf/ ‘he had a stroke of good luck’

In the form in (40a), the sibilant /s/ of the 3Subj prefix /s-/ assimilates to the /tʰ/ in the stem to which it attaches, /-api-tʰo-/ (= /-api-/ ‘quick’ + /-tʰo-/ ‘good’).³⁰ Since the trigger is in the stem, this example would be consistent with stem control. However, examples (40b-c) show without any doubt that the right-to-left directionality prevails *in spite of* constituent structure. The form in (40b) is identical to that in (40a), except that instead of 1Obj /-it/ we now have the 3Obj suffix /-us/. The /s/ of this suffix triggers harmony on any preceding sibilant, regardless of whether it is found in the stem (/tʰo-/) or in another affix (/s-/). Finally, (40c) clearly demonstrates the recursive nature of this ‘outside-in’ effect. When the past tense suffix /-waf/ is added to the string in (40b), the /ʃ/ of this suffix causes all preceding sibilants to ‘flip back’ to [-anterior].

The tableau in (41) shows an attempt at deriving the right-to-left directionality in Ineseño, with IDENT[ant]-CC being evaluated as an ordinary correspondence constraint. The existence of a C₁←C₂ correspondence relation, indicated by the subscript ‘i’, is due to high-ranked CORR-CC constraints. For the sake of simplicity, only the stem+suffix portion of the form /s-api-tʰo-us/ in (40b) is shown—our main interest is in deriving the suffix-to-stem directionality of sibilant harmony in examples like these. The portion of the input that belongs to the stem of affixation is enclosed in brackets, [...tʰo]. (Note that the epenthesis of [l] as a hiatus-breaker is ignored here.)

³⁰ The suffix /-it/ is the 1Obj marker; a more literal translation might perhaps be ‘a stroke of good luck befalls me’? The epenthesis of [l] in hiatus contexts is irrelevant for our present purposes.

(41) Ineseño: Directional sibilant harmony—indeterminacy problem (to be revised!)

/[...tʃ ^h o]-us/	IDENT[ant]-CC	IDENT[ant]-IO
a. ...tʃ ^h _i olus _i	*!	
b. ☞ ...ts ^h _i olus _i		*
c. ☞ ...tʃ ^h _i oluf _i		*
d. ...ts ^h _i oluf _i	*!	**

The derivation in (41) runs into the exact same indeterminacy problem that we encountered in the case of Ngizim voicing harmony in (37) above. IDENT[ant]-CC alone is unable to distinguish between right-to-left harmonized (41b) and left-to-right harmonized (41c)—since neither of them *violates* the constraint (by having a $C_1 \leftarrow C_2$ sequence where C_1 fails to agree with C_2). The choice between the two candidates will ultimately be up to lower-ranked constraints which have nothing to do with sibilant harmony per se. For example, (41c) would do better than (41b) on stem faithfulness (see 4.3.2 below), since (41c) preserves the stem-internal sibilant /tʃ^h/ intact.

Furthermore, unlike the Ngizim case, we do not even have the option of forcing the choice of (41b) over (41c) by making IO faithfulness sensitive to specific feature values and stipulating the ranking IDENT[+ant]-IO >> IDENT[-ant]-IO. To be sure, this would get us the right result in (41), since [+ant] → [-ant] (as in 41c) would then be penalized more severely than [-ant] → [+ant] (as in 41b). But as a general analysis of Ineseño sibilant harmony, this would fail, since the rightmost sibilant will *always* win out, regardless of whether it is [+ant] or [-ant]. For example, /k-sunon-ʃ/ ‘I am obedient’ is realized as [kʃunotʃ]. An analysis using IDENT[+ant]-IO >> IDENT[-ant]-IO would instead predict the output [ksunots]; when given the choice, [+ant] specifications would be preserved at the expense of [-ant] ones.

In short, when the rightmost sibilant is [+ant], the ‘spreading’ value is [+ant], as in the desired winner (41b); when the rightmost sibilant is [-ant], on the other hand, the ‘spreading’ value is [-ant] (as in /k-sunon-ʃ/ → [kʃunotʃ]). Any attempt to resolve the indeterminacy problem in (41) must do so by privileging the suffixal /s/ *not* because it is [+ant], but because it follows its ‘rival’ /tʃ^h/ rather than precedes it. Given the asymmetric correspondence relation $C_1 \leftarrow C_2$, we must somehow force C_1 (the correspondent) to yield to C_2 (the ‘source’). It is precisely this that a targeted-constraint analysis achieves. Before showing how the Ineseño facts can be captured by such an analysis, it is useful to review the details of the targeted-constraint analysis of consonant harmony.

First of all, consider the definition of a constraint like IDENT[ant]-CC. Recall once again that the CC correspondence is asymmetric, $C_1 \leftarrow C_2$; thus IDENT[ant]-CC requires C_1 to have the same value for [\pm anterior] that C_2 has, whichever value that may be. If constraints are interpreted as predicates which can carry truth values (true=satisfied, false=violated), then IDENT[ant]-CC is best understood as a *conditional* predicate. If it is true that C_1 is a correspondent of C_2 ($C_1 \leftarrow C_2$) and it is also true that C_2 is [α ant], then it must be true that C_1 is [α ant]. This is stated in a somewhat more formal fashion in (42).

(42) IDENT[ant]-CC as a conditional predicate:

$P \supset Q$ (‘if P, then Q’), where:

P: ($C_1 \leftarrow C_2$ & $C_2 = [\alpha \text{ant}]$);

Q: $C_1 = [\alpha \text{ant}]$.

If the antecedent P is true, the consequent Q must also be true in order for the constraint to be satisfied. Any candidate with P & $\neg Q$ violates IDENT[ant]-CC, whereas any candidate with P & Q satisfies it. Furthermore, the constraint is also satisfied (vacuously) if P is *false*, i.e. $\neg P$.

In light of this definition of IDENT[ant]-CC, let us revisit the tableau in (41), repeated below. The violation/satisfaction marks for IDENT[ant]-CC are accompanied by the information on whether or not P and Q hold true for that particular candidate. Note that as stated in (42) above, P contains a variable, α , ranging over $\{+, -\}$. In (43a-b), α is positive (C_2 is [+ant]); this is indicated by the superscript ‘+’ (P^+ , meaning ‘P is true with $[\alpha\text{ant}]=[\text{+ant}]$ ’). In (43c-d), on the other hand, α is negative (P^- , i.e. ‘P is true with $[\alpha\text{ant}]=[\text{-ant}]$ ’).

(43) Ineseño: Indeterminacy problem revisited

/[...t ^h o]-us/	IDENT[ant]-CC	IDENT[ant]-IO
a. ...t ^h _i olus _i	*! (P^+ & $\neg Q$)	✓
b. ☞ ...ts ^h _i olus _i	✓ (P^+ & Q)	*
c. ☞ ...t ^h _i oluf _i	✓ (P^- & Q)	*
d. ...ts ^h _i oluf _i	*! (P^- & $\neg Q$)	**

The translation of the ‘*’ and ‘✓’ marks into truth-values of P^+/P^- and Q brings out an important pattern. With respect to satisfying vs. violating IDENT[ant]-CC, candidates (43a-b) form one closely related pair, and (43c-d) form another such pair. The constraint states that given a particular state of affairs (either P^+ or P^-), Q is allowed but $\neg Q$ constitutes an ill-formed element of structure. Candidates (43a) and (43b) are exactly identical—up to and including the fact that both fit P with $[\alpha\text{ant}]$ being [+ant] (hence ‘ P^+ ’)—the sole difference being that Q holds for (43b) but not for (43a). In the same way, (43c) and (43d) are exactly identical—up to and including P^- —except for the fact that Q holds for (43c) but not for (43d).³¹

³¹ This can be brought out even more clearly by splitting IDENT[ant]-CC into IDENT[+ant]-CC and IDENT[-ant]-CC. In the former, P stands for $C_1 \leftarrow C_2$ & $C_2 = [\text{+ant}]$; in the latter, P means $C_1 \leftarrow C_2$ & $C_2 = [\text{-ant}]$. The violation record is then as shown in (i):

There is thus a sense in which only (43b) is ‘comparable’ with (43a), in that they satisfy the antecedent P in the same way (P⁺); candidate (43c) is not comparable to (43a) in the same way, since the antecedent P is satisfied in a slightly different manner (P⁻ vs. P⁺). From this perspective, it is only (43b) that is outright ‘better’ than (43a), rather than both (43b) and (43c) being ‘better’ than (43a), as the ‘✓’ vs. ‘*’ marks would otherwise suggest. If only we could capture this notion directly in the way IDENT[ant]-CC is evaluated, (43b) would become the winner. Candidate (43a) is the one which otherwise does best, and so, if (43b) *alone* were to outdo (43a) on top-ranked IDENT[ant]-CC, then (43b) would emerge as the optimal candidate, and the tie in (43) would be resolved in the correct manner.

This is precisely what we achieve by redefining IDENT[ant]-CC as a *targeted* constraint, i.e. as \rightarrow IDENT[ant]-CC (the prefixed arrow is to be read ‘targeted’). In terms of our earlier definition of the constraint as a conditional predicate, ‘if P then Q’, \rightarrow IDENT[ant]-CC can be understood as nothing more than a contextual well-formedness constraint: ‘given the context P, Q is preferred over \neg Q’. What the constraint *targets* is then the ill-formed state of affairs \neg Q *in the context P*. One possible way to formulate \rightarrow IDENT[ant]-CC is by first separating out a (contextual) markedness statement—a kind of ‘grounding condition’ (cf. Archangeli & Pulleyblank 1994)—about [ant] agreement under CC correspondence. Let us refer to this markedness statement as CC/ANT, for the sake of the argument, and spell it out as in (44):

(i) Indeterminacy problem with value-specific IDENT-CC constraints:

/[...t ^h o]-us/	IDENT[+ant]-CC	IDENT[-ant]-CC	IDENT[ant]-IO
a. ...t ^h _i olus _i	*! (P & \neg Q)	✓ (\neg P ...)	✓
b. \Rightarrow ...ts ^h _i olus _i	✓ (P & Q)	✓ (\neg P ...)	*
c. \Rightarrow ...t ^h _i oluf _i	✓ (\neg P ...)	✓ (P & Q)	*
d. ...ts ^h _i oluf _i	✓ (\neg P ...)	*! (P & \neg Q)	**

With respect to the [+ant] version of the constraint, candidates (c)-(d) satisfy it *vacuously*, since they do not fit the description inherent in the antecedent P. The same is true of (a)-(b) with respect to the [-ant] version of the constraint.

(44) CC/ANT (contextual markedness statement)

- a. Given a CC-correspondence pair of consonants, $C_1 \leftarrow C_2$, where $C_2 = [\alpha\text{ant}]$, then:
- b. $C_1 = [-\alpha\text{ant}]$ is marked.

CC/ANT consists of two components, a *context* (44a) and a markedness (or ‘ill-formedness’) statement (44b) which holds in that context. The former is equivalent to our antecedent P from before, whereas the latter represents the consequent Q (or, rather, ‘not $\neg Q$ ’). The formulation clearly brings out the notion that it is specifically an ‘unfaithful’ *correspondent* consonant (C_1) which is marked, rather than the sequence $C_1[-\alpha\text{ant}] \dots C_2[\alpha\text{ant}]$ as a whole. We can now define the targeted constraint $\rightarrow\text{IDENT}[\text{ant}]\text{-CC}$ with direct reference to the markedness statement CC/ANT.³²

(45) $\rightarrow\text{IDENT}[\text{ant}]\text{-CC}$

Candidate x' is preferred over x ($x' > x$) iff x' is exactly like x except that at least one target consonant C_i is not marked according to CC/ANT.



In order to qualify as x vs. x' , two candidates have to be exactly alike in all respects, with the sole difference being that in one, C_1 is $[\alpha\text{ant}]$ (x'), whereas in the other, C_1 is $[-\alpha\text{ant}]$. In other words, the two candidates *may differ only in the [ant] value of C_1* , if $\rightarrow\text{IDENT}[\text{ant}]\text{-CC}$ is to be applicable. Everything else must be exactly identical in the two candidates. This means that even the [ant] value of C_2 must be identical, in order for $\rightarrow\text{IDENT}[\text{ant}]\text{-CC}$ to

³² Admittedly, when formulated in this way, the IDENT[F]-CC constraints start to look less and less like true correspondence constraints, and more like markedness constraints. This is perhaps not surprising. As has already been pointed out, IDENT[F]-CC constraints are by definition *output* constraints—what they penalize are particular configurations in output representations. This is exactly what markedness constraints do. In fact, in 5.3 below we shall see that there may be reason to abandon the notion of CC correspondence altogether (and with it the division of labor between CORR-CC constraints and IDENT[F]-CC constraints). By instead building the sensitivity to similarity and proximity directly into the IDENT[F]-CC constraints, these can then be redefined as true well-formedness constraints rather than correspondence constraints. This also brings the targeted nature of these constraints more in line with the original conception of targeted constraints (Wilson 2000; in progress).

have anything to say about their relative well-formedness. Candidates with [-ant]...[+ant] and [+ant]...[-ant], respectively, are not comparable to each other, since they differ not only in the *targeted* element (C_1) but also in other respects (namely C_2). The same is true of [-ant]...[+ant] vs. [-ant]...[-ant] as well; with respect to the targeted element (C_1), the two are identical, but they differ in other respects. The only pairs that will qualify as x' vs. x in the definition in (45) are [+ant]...[+ant] vs. [-ant]...[+ant] on the one hand, and [-ant]...[-ant] vs. [+ant]...[-ant] on the other.

Given two candidates that differ only in the [ant] value of C_1 , then, the constraint \rightarrow IDENT[ant]-CC will prefer the one with a ‘faithful’ value (i.e. identical to that of C_2) over the one with an ‘unfaithful’ value. Recast in this manner, the Ineseño indeterminacy problem from (41)/(43) is resolved as shown in (46).

(46) Ineseño: Indeterminacy resolved with targeted \rightarrow IDENT[ant]-CC:

/[...tʃ ^h o]-us/	\rightarrow IDENT[ant]-CC	IDENT[ant]-IO
a. ...tʃ ^h _i olus _i	(b > a)	
b.  ...ts ^h _i olus _i	(b > a)	*
c. ...tʃ ^h _i oluf _i	(c > d)	*
d. ...ts ^h _i oluf _i	(c > d)	**
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	a > {b, c} > d <i>i.e.</i> a > b; <u>a > c</u> ; <u>a > d</u> ; <u>b > d</u> ; <u>c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	 b > a > c > d

The undominated constraint \rightarrow IDENT[ant]-CC prefers (46b) over (46a), since these are completely identical except in the targeted consonant C_1 —which is ‘faithful’ in (46b) but not in (46a). The same applies to (46c) vs. (46d). Hence the preference orderings $b > a$ and $c > d$. This already tells us that neither (46a) nor (46d) can possibly win, since each is dispreferred relative to some other candidate. But we do not yet know if it is (46b) or (46c) that will emerge as the optimal output.

What does it take for (46b) to win rather than (46c)? Recall in this connection that the optimal output is, by definition, a candidate x for which there exists no candidate y such that $y > x$ (in the *cumulative* harmonic ordering). Imagine that the second-ranked constraint were one which explicitly stated the preference $b > c$; in that case, (46b) would of course become the optimal output. But there is another possibility: it is enough that the second-ranked constraint prefer *any* candidate over (46c), i.e. $y > c$ (as long as $b > y$ also holds). In that case, (46c) cannot possibly be the optimal output, since there does exist a candidate which is preferred over it.

This is exactly what happens in the tableau in (46). No constraint explicitly prefers (46b) over (46c); rather, the ordering $b > c$ emerges from the accumulation of individual harmonic orderings, as contributed by \rightarrow IDENT[ant]-CC and IDENT[ant]-IO independently of each other. The lower-ranked constraint encodes the following orderings: $a > b$, $a > c$, $a > d$, $b > d$ and $c > d$. One of these is entirely superfluous ($c > d$), since it has already been stated by the higher-ranked constraint. More importantly, one of the harmonic orderings, $a > b$, directly contradicts an ordering imposed by the higher-ranked constraint ($b > a$). The ordering $a > b$ is therefore *overridden*—as indicated by the lack of underlining—and does not contribute to the cumulative harmonic ordering. What remains as the net contribution of IDENT[ant]-IO to the cumulative ordering is $a > c$, $a > d$ and $b > d$. When we add these to the already-established orderings $b > a$ and $c > d$, the result is $b > a > c > d$. (Note that $a > d$ and $b > d$ are true by transitivity.)

In sum, (46b) is the optimal output. This is not because (46b) outdoes (46c) on any individual constraint, but because (46b) is preferred over (46a), which in turn is preferred over (46c). True, the particular constraint which prefers (46a) over (46c) likewise prefers (46a) over (46b) *in principle*, but the latter preference is overridden by a higher-ranked constraint. The effect of the two constraints can be paraphrased as follows: ‘right-to-left harmony is better than faithful disharmony, which is in turn better than any harmony at all’. At first glance, this sounds contradictory, because it fails to capture the fact that the preference of right-to-left harmony over faithful disharmony *cancel out* one half of the general preference of faithful disharmony over any harmony at all. The end result of the constraint interaction is ‘right-to-left harmony is better than faithful disharmony, which is in turn better than left-to-right harmony’. Incidentally, this is a direct parallel to Baković & Wilson’s (2000) analysis of high-vowel transparency in Wolof [ATR] harmony. There the interaction of $\rightarrow\text{NO}(\text{HI,ATR})$ with lower-ranked $\text{AGREE}(\text{ATR})$ could be paraphrased in the following counter-intuitive way: ‘disharmony-by-transparency is better than full harmony, which in turn is better than *any* disharmony’.³³ As a result of the fact that higher-ranked constraints override lower-ranked ones in case of conflict, the actual outcome is ‘disharmony-by-transparency is better than full harmony, which is in turn better than disharmony-by-opacity’.

We have now solved the indeterminacy problem of (41)/(43), and showed how the preference of right-to-left harmony over left-to-right harmony emerges from the interaction with Input-Output faithfulness, given the interpretation of $\rightarrow\text{IDENT}[\text{F}]\text{-CC}$ as targeted constraints. The Ineseño example in (46) resulted in [+ant] ‘spreading’ from C_2 to C_1 . The tableau in (47) demonstrates that the right-to-left directionality is independent of which

³³ This is simplifying things a bit. Disharmony-by-transparency actually does *worse* on $\text{AGREE}(\text{ATR})$ than disharmony-by-opacity—since a transparent vowel disagrees with both its neighbors, whereas an opaque vowel only disagrees with the vowel on one side. In order to deal with the issues that this raises, Baković & Wilson appeal to an independent principle from the theory of targeted constraints, referred to as ‘priority of the more harmonic’. This need not concern us here.

feature values are involved: if C_2 is [-ant], then C_1 will surface as [-ant] as well. The derivation shows how /k-sunon- f / \rightarrow [k f unot f] ‘I am obedient’ (/k-/ 1Subj, /-sunon-/ ‘obey’, /- f / stative).³⁴

(47) Ineseño: Right-to-left [-ant] harmony (from suffix to stem)

/k-[sunon]- f /	\rightarrow IDENT[ant]-CC	IDENT[ant]-IO
a. ks _i unot f _i	(b > a)	
b. \rightarrow k f _i unot f _i	(b > a)	*
c. ks _i unots _i	(c > d)	*
d. k f _i unots _i	(c > d)	**
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	a > {b, c} > d i.e. a > b; <u>a > c</u> ; <u>a > d</u> ; <u>b > d</u> ; <u>c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	\rightarrow b > a > c > d

In (47), the stative suffix /- f / here triggers [-ant] agreement in the stem, just as the 1Obj suffix /-us/ triggered [+ant] harmony in (46). Ineseño sibilant harmony is thus strictly directional, with the right-to-left directionality prevailing even when it goes against constituent structure (the stem yielding to the affix rather than vice versa).

Before leaving the topic of directional harmony, it is also important to demonstrate that the analysis presented here correctly accounts for the *iterativity* of sibilant harmony in Ineseño. The rightmost sibilant consistently imposes its [\pm ant] value on any and all preceding sibilants, regardless of their number or of their underlying [\pm ant] specifications.

³⁴ The predictable realization of /n+ f / as [t f] is ignored here (cf. /k-sunon-us/ \rightarrow [ksunonus] ‘I obey him’).

The tableau in (46) above accounted for the derivation /...tʰo-us/ → [...tsʰolus], as in [sapitsʰolus] ‘he has a stroke of good luck’ in (40b). When the past marker /-waf/ is added, the /ʃ/ of this suffix becomes the harmony trigger, with the result that all preceding sibilants become [-ant] /...tʰo-us-waf/ → [...tʰoluʃwaf], as in [ʃapitʰoluʃwaf] ‘he had a stroke of good luck’ in (40c). The forms cited in (48) further illustrate the iterative nature of Ineseño sibilant harmony:

(48) Iterative sibilant harmony in Ineseño (data from Applegate 1972)

ʃitʰiwifutʃ	/s-tsʰiwis-Vtʃ/	‘he plays the rattle’
ʃluʃifiniwaf	/s-lu-sisin-waf/	‘it is all grown awry’

In the first form in (48), the /tʃ/ of the verbalizing suffix /-Vtʃ/ forces all three preceding [+ant] sibilants to surface as [-ant] by sibilant harmony. In the second form, the same is true of the /ʃ/ belonging to the past suffix /-waf/.³⁵

The derivation /s-tsʰiwis-Vtʃ/ → [ʃitʰiwifutʃ] is shown in (49) below. Since our interest is specifically in generating the correct sibilant harmony pattern, some irrelevant details are ignored ([i]-epenthesis and the realization of the /V/ as [u]). Since the input contains no less than *four* sibilants, the number of candidates we need to consider is greater than in any of the tableaux encountered so far—as a result, the tableau is somewhat cluttered. With respect to CC correspondence, the sequence of four sibilants is broken down into three pairs, each of which is potentially relevant to →IDENT[ant]-CC. Schematically: S_i...S_{i,j}...S_{j,k}...S_k, which then consists of the pairs S_i...S_i, S_j...S_j and S_k...S_k.

³⁵ To be exact, the initial [ʃ] in the second example (from 3Subj /s-/) would surface as such regardless of sibilant harmony, due to the so-called ‘precoronal effect’, whereby /s/ → [ʃ] before /t, l, n/. The interaction of this effect with sibilant harmony will be discussed in detail in section 5.1.1 below.

(49) Ineseño: Right-to-left sibilant harmony is iterative

/s-ts'iwis-Vtʃ/	→IDENT[ant]-CC	IDENT[ant]-IO
a. s _i its' _{i,j} iwi s _{j,k} utʃ _k	(b > a)	
b. s _i its' _{i,j} iwiʃ _{j,k} utʃ _k	(c > b; b > a)	*
c. s _i itʃ' _{i,j} iwiʃ _{j,k} utʃ _k	(d > c; c > b)	**
d. ↗ ʃ _i itʃ' _{i,j} iwiʃ _{j,k} utʃ _k	(d > c)	***
e. s _i its' _{i,j} iwi s _{j,k} uts _k	N/A	*
<i>Harmonic ordering by constraint</i>	<u>d > c</u> ; <u>c > b</u> ; <u>b > a</u>	a > {b, e} > c > d <i>i.e.</i> a > b; <u>a > e</u> ; a > c; a > d; b > c; b > d; e > c; e > d; c > d
<i>Cumulative harmonic ordering</i>	d > c > b > a	↗ d > c > b > a > e

Candidates (49a-d) represent a gradient scale from completely faithful to completely harmonized: [s...ts'...s...ʃ] (49a), [s...ts'...ʃ...ʃ] (49b), [s...tʃ'...ʃ...ʃ] (49c), [ʃ...tʃ'...ʃ...ʃ] (49d). Candidate (49e) represents the alternative strategy of left-to-right harmony: [s...ts'...s...s]. In that case, the first three [+ant] sibilants have 'ganged up' on the right-most [-ant] sibilant, as it were.

First of all, let us consider how →IDENT[ant]-CC is evaluated. In order for two candidates to be comparable according to this constraint, they must differ in nothing more than the [±ant] specification of *a single sibilant*. Furthermore, this sibilant must be the C₁ member of a C₁←C₂ correspondence pair. Consider the competing candidates (49b) and (49c), which contain the sibilant sequences [s_i...ts' _{i,j}...ʃ_{j,k}...ʃ_k] and [s_i...tʃ' _{i,j}...ʃ_{j,k}...ʃ_k],

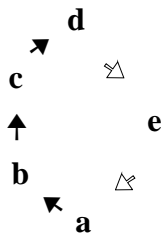
respectively. These only differ in the second sibilant ([ts'] vs. [tʃ']), which moreover is the C_1 member of the $S_j \dots S_j$ correspondent pair ([ts'] $_j \dots$ \int_j] vs. [tʃ'] $_j \dots$ \int_j]). Since this C_1 is 'faithful' to its C_2 counterpart in (49c), but not in (49b), \rightarrow IDENT[ant]-CC prefers (49c) over (49b). Hence the ordering $c > b$. But note that (49c) is *also* comparable to (49d)! The latter contains the sequence [$\int_i \dots$ tʃ' $_{i,j} \dots$ $\int_{j,k} \dots$ \int_k] as opposed to the sequence [$s_i \dots$ tʃ' $_{i,j} \dots$ $\int_{j,k} \dots$ \int_k] in (49c). These two candidates also differ in only one segment, the first sibilant ([\int] vs. [s]), which is the C_1 member of the $S_i \dots S_i$ correspondent pair ([$\int_i \dots$ tʃ' $_i$] vs. [$s_i \dots$ tʃ' $_i$]). Candidate (49d) is preferred over (49c), since it is better for this C_1 to agree with its C_2 counterpart than to disagree with it. This gives us the ordering $d > c$. Since $d > c$ and $c > b$, it must then also be true (by transitivity) that $d > b$; in sum, $d > c > b$. \rightarrow IDENT[ant]-CC also imposes the ordering $b > a$, in a way similar to what was described above, and the full range of harmonic orderings resulting from \rightarrow IDENT[ant]-CC can therefore be summarized as $d > c > b > a$.

But what about (49e)? This candidate contains the sequence [$s_i \dots$ ts' $_{i,j} \dots$ $s_{j,k} \dots$ s_k], and thus differs from the maximally-faithful [$s_i \dots$ ts' $_{i,j} \dots$ $s_{j,k} \dots$ \int_k] sequence (49a) in one segment only: the final sibilant ([s] vs. [\int]). So why does \rightarrow IDENT[ant]-CC not compare the pair (49e) vs. (49a)? This is because the sibilant in question does not qualify as a *target* for \rightarrow IDENT[ant]-CC; the constraint only targets a consonant which is the C_1 member of some $C_1 \leftarrow C_2$ correspondence pair (and which disagrees with its C_2 counterpart in [\pm ant]). A word-final sibilant is obviously not the C_1 member of any such pair (it is completely irrelevant that it is the C_2 member of one such pair). Therefore, the constraint \rightarrow IDENT[ant]-CC neither prefers nor disprefers (49e) relative to (49a)—nor to any of the other candidates either, for that matter.³⁶

³⁶ \rightarrow IDENT[ant]-CC *does* prefer (49e) over the hypothetical candidate [s_i its' $_{i,j}$ iw $\int_{j,k}$ uts $_k$], where the last two sibilants have 'swapped' [\pm ant] values. Such silly candidates are left out of the tableau in (49), since they have no impact on the determination of which candidate constitutes the optimal output.

The contribution of \rightarrow IDENT[ant]-CC to the cumulative ordering of candidates is therefore $d > c > b > a$. This tells us that neither the maximally faithful (49a) nor the incompletely harmonized (49b) or (49c) can possibly be the optimal output. It falls to lower-ranked IDENT[ant]-IO to decide whether consistent right-to-left harmony will prevail, as in (49d), or whether ‘ganging-up’ of the three [+ant] sibilants will result in left-to-right harmony, as in (49e). At first glance, it seems obvious that (49e) should win, since IDENT[ant]-IO explicitly states the ordering $e > d$; after all, (49d) violates IO faithfulness three times but (49e) only once. But things are not quite so simple. Note first that IDENT[ant]-IO also states the preference $a > e$, in addition to $e > d$. Neither $a > e$ nor $e > d$ is individually inconsistent with the ordering expressed by higher-ranked \rightarrow IDENT[ant]-CC ($d > c > b > a$). But they are *mutually inconsistent* with it, in that adding both $a > e$ and $e > d$ to this ordering would result in a circular preference ordering. This is shown graphically in (50), where arrows point to the preferred member of each pair (read ‘ \rightarrow ’ as ‘is worse than’).

(50) Vicious circle of harmonic orderings:



In the resulting ordering in (50), every candidate is worse than some other candidate; hence, no candidate qualifies as the optimal output. If circular orderings such as (50) were allowed to arise, the derivation would simply crash. This means that the orderings $a > e$ and $e > d$ cannot *both* be upheld and added to the cumulative ordering; we must choose *either* $a > e$ or $e > d$, but which? The theory of targeted constraints has a general answer for resolving

mutual-inconsistency dilemmas of this kind, a principle referred to as *priority of the more harmonic*. Imagine two orderings $x > y$ and $x' > y'$ which are individually consistent, but mutually inconsistent, with other independently-established orderings. The principle of priority of the more harmonic gives priority to $x > y$ over $x' > y'$ if and only if the constraint hierarchy judges x to be more harmonic than x' . In other words, if the highest-ranked constraint that compares x and x' prefers x over x' ($x > x'$), rather than the reverse, then it follows that $x > y$ will ‘override’ $x' > y'$. How does this apply to our case in (49)? For ease of reference, an abbreviated version of the above tableau is repeated in (51) below.

(51) Summary of harmonic orderings (repeated from 49)

	\rightarrow IDENT[ant]-CC	IDENT[ant]-IO
<i>Harmonic ordering by constraint</i>	$d > c; c > b; b > a$	$a > \{b, e\} > c > d$ <i>i.e.</i> $a > b; a > e; a > c;$ $a > d; b > c; b > d;$ $e > c; e > d; c > d$
<i>Cumulative harmonic ordering</i>	$d > c > b > a$	$\Rightarrow d > c > b > a > e$

Note that top-ranked \rightarrow IDENT[ant]-CC has already established that $d > c > b > a$. The two orderings $a > e$ and $e > d$ are mutually inconsistent with this ordering, as adding both would give rise to the circle in (50). Priority of the harmonic states that $a > e$ will take priority over $e > d$ iff the constraint hierarchy judges a to be more harmonic than e (these being equivalent to x and x' in the above definition). We must therefore look for the highest-ranked constraint that compares (51a)=(49a) and (51e)=(49e). This is IDENT[ant]-IO itself,

which clearly states that $a > e$, rather than $e > a$.³⁷ This means that of the two ‘competing’ orderings $a > e$ and $e > d$, only $a > e$ is added to the cumulative ranking (as indicated by underlining). The ordering $e > d$ is *ignored* (indicated by italicizing). The same happens to $e > c$, which is likewise mutually inconsistent with the ordering $a > e$.

The end result is that the only harmonic ordering stated by IDENT[ant]-IO which is able to prevail into the cumulative ordering is $a > e$. All the others are either directly overridden by opposite orderings established by higher-ranked \rightarrow IDENT[ant]-CC, or they are ruled out by way of priority of the more harmonic. When $a > e$ is added to the ordering $d > c > b > a$, the end result is the complete ordering $d > c > b > a > e$. The winner is therefore (51d)=(49d), the candidate with iterative right-to-left sibilant harmony.

Our analysis derives the correct result for Ineseño sibilant harmony. The same, by extension, is true of other harmony systems with morphology-insensitive right-to-left directionality. It is important to realize how central a role the conception of \rightarrow IDENT[F]-CC as targeted constraints plays in the analysis. Without this qualification, directionality effects could not be captured. In the following section, we turn to those consonant harmony systems where morphological constituent structure defines the directionality of assimilation.

4.3.2. Stem-controlled harmony: The emergence of left-to-right directionality

Stem control is a quite common phenomenon in the cross-linguistic typology of consonant harmony, just as it is in vowel harmony systems (Baković 2000). In purely descriptive terms, stem control is when an affix segment yields to (i.e. assimilates to) a segment in the base of affixation, rather than vice versa. The essence of this effect is ‘cyclicity’ in the following informal sense: harmony is satisfied in a set of successively larger morphological domains, where each domain preserves intact the domain nested within it (the ‘stem’).

³⁷ It is of no importance that this $a > e$ ordering happens to be one of the two ‘competing’ orderings that we are trying to decide between in the first place ($a > e$ vs. $e > d$). An exactly parallel situation in Wolof [ATR] harmony is discussed by Baković & Wilson (2000).

One way to capture cyclicity effects in an output-oriented framework like Optimality Theory is to assume a separate set of faithfulness constraints holding between the output (the affixed form) and the stem of affixation. This is construed as a type of Output-Output correspondence by Benua (1995, 1997; cf. also Baković 2000)—a view which presupposes that the stem of affixation actually *occurs* as a free-standing output form in the language in question. Related proposals along similar lines involve Uniform Exponence (Kenstowicz 1996, 1997) or Paradigm Uniformity (Steriade 2000); such constraints could ensure that the realization of the stem of affixation will be ‘held constant’ across the entire paradigm of affixed forms, forcing the affix to yield to the stem. Yet another approach to cyclicity effects is the Sign-Based Morphology model (Orgun 1996, 1998; Dolbey 1996; Dolbey & Orgun 1999; Yu 2000), which explicitly encodes word-internal constituent structure in terms of branching tree structures. The phonological grammar (formalized as ranked OT constraints) relates the phonological representation of each mother node to those of its daughter nodes. In this model, cyclic effects arise from the fact that the phonological constraints hold at each node.

For the purposes of this work, it is not directly relevant which formalization is chosen for capturing cyclicity effects. However, in order to facilitate comparison with the analysis of stem-control in vowel harmony systems developed in Baković (2000), the Output-Output correspondence approach (Benua 1995, 1997) will be followed in the analyses presented here. Under this view, stem control effects arise from IDENT[F]-SA constraints, which demand that the output (the affixed form) be faithful to its stem of affixation (‘S’ for stem, ‘A’ for affixed form). The definition in (52) is taken from Baković (2000).

(52) IDENT[F]-SA

A segment in an affixed form [stem + affix] must have the same value of the feature [F] as its correspondent in the stem of affixation [stem].

Note that since affixation is recursive, the stem may itself be an affixed form, e.g., in a nested constituent structure like [[[root] + affix₁] + affix₂]. The IDENT[F]-SA constraints evaluate the faithfulness of the stem portion (i.e. the [[root] + affix₁] part) to the surface realization of that stem when it occurs as an independent output form.³⁸

One example of a stem-controlled consonant harmony system is the sibilant harmony found in many Omotic languages (see 2.4.1.1 above). For example, in Koyra (Hayward 1982), the /s/ of the causative suffix /-(u)s/ assimilates in [±anterior] to a sibilant in the preceding stem, as illustrated in (53). The forms in (53a) show that the suffix sibilant is underlyingly [+ant]. This sibilant surfaces intact after another [+ant] sibilant (53b), but assimilates to a [-ant] sibilant in the stem (53c).

(53) Stem-controlled sibilant harmony in Koyra causative /-(u)s/ (Hayward 1988)

- | | | |
|----|------------|----------------------------|
| a. | pug-us- | ‘cause to blow’ |
| | ta:b-us- | ‘cause to count’ |
| | ʔu:ʔ-us- | ‘cause to sip’ |
| b. | kes-us- | ‘cause to go out’ |
| | su:z-us- | ‘cause to bless’ |
| | sa:ts’-us- | ‘cause to bite’ |
| c. | dʒaʃ-uʃ- | ‘cause to fear’ |
| | go:tʃ-uʃ- | ‘cause to pull’ |
| | ʔordʒ-uʃ- | ‘make big, increase (tr.)’ |
| | ʃaj-ʃ- | ‘cause to urinate’ |

³⁸ Even though the definition of IDENT[F]-SA is here cast in terms of Output-Output correspondence between morphologically related surface forms, this is not essential. In the alternative Sign-Based Morphology model, for example, a constraint with the same effect could be defined as requiring identity between the phonological representation of the mother node (the affixed form) and its *head daughter* (the stem of affixation). One advantage of this alternative is that the stem need not occur as a free-standing output form.

In Koyra, high-ranked CORR-[ant, voi, cont] forces cooccurring sibilants to stand in a $C_1 \leftarrow C_2$ corresponding relation, regardless of differences in [\pm voi], [\pm ant] or [\pm cont] (/dʒ/ vs. /s/ is an example of a segment pair differing in all three features). The constraint responsible for harmony in [\pm ant] between corresponding sibilants is IDENT[ant]-CC. This constraint requires that if an output consonant (C_2) is [α F], then its CC-correspondent (C_1) must also be [α F]. The constraint ranking that results in stem-controlled harmony is shown in (54). For simplicity, the CC correspondence relation (indicated by the subscript ‘i’) is taken for granted; in reality, it is due to high-ranked CORR-[ant, voi, cont], as explained above.³⁹ Here and in subsequent tableaux, the stem portion of the input is enclosed in square brackets. The ‘anti-faithful’ candidate (54d) is included merely for the sake of completeness, even though it cannot possibly win under any ranking permutation.

(54) Koyra: Stem-controlled sibilant harmony

/[ʔordʒ]-us-/	IDENT[ant]-CC	IDENT[ant]-SA	IDENT[ant]-IO
a. ʔordʒ _i -us _i -	*!		
b. ʔordz _i -us _i -		*!	*
c. ʔordʒ _i -uʃ _i -			*
d. ʔordz _i -uʃ _i -	*!	*	**

³⁹ As mentioned in section 2.4.1.1, Koyra sibilant harmony is subject to a stringent proximity requirement: the trigger and target must be separated by no more than one vowel (i.e. they must be in adjacent syllables). Although this detail is ignored here, it would be captured in the analysis by assuming that in Koyra, IDENT[ant]-IO intervenes between the C- μ (μ)-C and C- σ -C versions of *each* of the CORR-CC constraints:

$$\left\{ \begin{array}{l} \text{CORR-[ant]}_{C-\mu\mu-C} \\ \text{CORR-[ant, voi]}_{C-\mu\mu-C} \\ \text{CORR-[ant, cont]}_{C-\mu\mu-C} \\ \text{CORR-[ant, voi, cont]}_{C-\mu\mu-C} \\ \dots \end{array} \right\} \gg \text{IDENT[ant]-IO} \gg \left\{ \begin{array}{l} \text{CORR-[ant]}_{C-\sigma-C} \\ \text{CORR-[ant, voi]}_{C-\sigma-C} \\ \text{CORR-[ant, cont]}_{C-\sigma-C} \\ \text{CORR-[ant, voi, cont]}_{C-\sigma-C} \\ \dots \end{array} \right\}$$

The reason why candidate (54c) wins out over (54b) is that the former diverges from the output realization of the stem [ʔordʒ-] in other contexts (i.e. in morphologically related forms). Although each of the two candidates violates Input-Output faithfulness once, (54c) does so without also violating (Output-Output) faithfulness to the stem of affixation. Inside-out application of sibilant harmony is thus favored over the outside-in directionality in (54b).

Note that if it were not for IDENT[ant]-SA, candidates (54b) and (54c) would be tied—the same indeterminacy problem we encountered in Ngizim voicing harmony and Ineseño sibilant harmony earlier in this chapter. It was argued at length that the solution to this indeterminacy problem is to construe IDENT[F]-CC constraints as *targeted* constraints, evaluating individual candidate pairs in an ‘other-things-being-equal’ fashion. In the analyses of Ngizim and Ineseño, this had the effect of forcing right-to-left harmony, based on the asymmetry of the $C_1 \leftarrow C_2$ correspondence relation. We must therefore make sure that a derivation such as (54) yields the right result, with *left-to-right* harmony, even when IDENT[ant]-CC is interpreted as a targeted constraint.

The tableau in (55) illustrates this, using the same representational conventions as before. Again, the upper half corresponds to an ordinary tableau, listing the candidates along with the violation/satisfaction record for each candidate, constraint by constraint. As for the targeted constraint \rightarrow IDENT[ant]-CC, the tableau simply lists the preference relations expressed by that constraint over individual pairs of candidates. Only certain pairs are ‘comparable’ for the purposes of this constraint, in this case (55a) vs. (55b) on the one hand and (55c) vs. (55d) on the other. The bottom half of the tableau translates the distribution of violation marks into harmonic orderings, i.e. preference relations as expressed by each constraint. The bottom row then shows how the *cumulative* harmonic ordering is built up from the constraint-specific orderings, with higher-ranked constraints overriding lower-

ranked ones in cases of conflict. Orderings that are *not* overridden in this way—and thus contribute to the cumulative ordering—are indicated by underlining.

(55) Koyra: Stem-controlled sibilant harmony with targeted \rightarrow IDENT[ant]-CC

/[ʔordʒ]-us-/	\rightarrow IDENT[ant]-CC	IDENT[ant]-SA	IDENT[ant]-IO
a. ʔordʒ _i -us _i -	(b > a)		
b. ʔordz _i -us _i -	(b > a)	*	*
c. \rightarrow ʔordʒ _i -uʃ _i -	(c > d)		*
d. ʔordz _i -uʃ _i -	(c > d)	*	**
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	{a, c} > {b, d} <i>i.e.</i> a > b; <u>c > b</u> ; <u>a > d</u> ; <u>c > d</u>	a > {b, c} > d <i>i.e.</i> a > b; a > c; <u>a > d</u> ; <u>b > d</u> ; <u>c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	\rightarrow c > b > a > d	(c > b > a > d)

The targeted constraint \rightarrow IDENT[ant]-CC can only compare pairs of candidates, each of which contains a $C_1 \leftarrow C_2$ correspondence pair where C_2 carries a specific value for [\pm ant]. For each such pair of candidates, the constraint prefers the one where C_1 has a matching value for [\pm ant]. In the case where C_2 is [+ant], the right-to-left harmonized candidate (55b) is preferred over the faithful one (55a). In the case where C_2 is [-ant], left-to-right harmonized (55c) is preferred over the ‘anti-faithful’ candidate (55d). This translates into the harmonic orderings $b > a$ and $c > d$. This means that it is already clear that neither (55a) nor (55d) can be the optimal output—each being dispreferred relative to some other candidate—but it is as yet unclear if the winner will be (55b) or (55c).

From the point of view of IDENT[ant]-SA, any candidate that is faithful with respect to the stem sibilant is preferred over any candidate that is not. Translated into pairwise orderings, this means $a > b$, $a > d$, $c > b$ and $c > d$. One of these orderings, $c > d$, was already imposed by higher-ranked \rightarrow IDENT[ant]-CC and is therefore superfluous; another ordering, $a > b$, directly contradicts an ordering imposed by that higher-ranked constraint ($b > a$) and is therefore *overridden*. What remains as the net contribution of IDENT[ant]-SA to the cumulative harmonic ordering is then $c > b$ and $a > d$. The cumulative ordering that results when we combine $c > b$ and $a > d$ with the already-established orderings $b > a$ and $c > d$ is the following: $c > b > a > d$. This exhausts the candidate set examined here, and (55c) thus emerges as the optimal output. The end result is stem control, i.e. left-to-right sibilant harmony from stem to suffix.

It is interesting to note that (55c) fares better than the faithful candidate (55a) in spite of the fact that no individual constraint prefers (55c) over (55a)—in fact, the only constraint that discriminates between the two, IDENT[ant]-IO, actually prefers (55a) over (55c)! The reason why (55c) is able to outdo (55a) has to do with *transitivity*. By the verdict of the top-ranked constraint \rightarrow IDENT[ant]-CC, candidate (55a) is worse than (55b). By lower-ranked IDENT[ant]-SA, (55b) is in turn worse than (55c); therefore, by transitivity, (55a) must also be worse than (55c)! In symbolic terms, if $c > b$ and $b > a$, then it must also be true that $c > a$.

The analysis of Koyra sibilant harmony illustrates how left-to-right directionality can emerge from constraint interaction—in spite of the fact that the CC correspondence relation is by definition a right-to-left mapping ($C_1 \leftarrow C_2$), and that the targeted-constraint analysis explicitly favors ‘repairing’ disharmony by regressive rather than progressive assimilation. Not surprisingly, the same constraint ranking is also able to derive stem control in [prefix + stem] contexts, where inside-out application is indistinguishable from the default right-to-left directionality. One example is the sibilant harmony found in many

Athapaskan languages, as illustrated by the two Navajo forms in (56); the root is indicated in boldface.

(56) Navajo sibilant harmony (data from McDonough 1991)

<i>dz</i> iʃta:l	/dz-iʃ-l- ta:l /	‘I kick him [below the belt]’
<i>dzists</i> ’in	/dz-iʃ-l- ts’in /	‘I hit him [below the belt]’



In the first example, the /ʃ/ of the 1SgSubj prefix /-iʃ-/ triggers harmony in the preceding adverbial prefix /dz-/. In the second example, the ultimate trigger of harmony is the /ts’/ of the verb root (/ts’in/), to which both prefix sibilants must agree. For the purposes of illustration, I will take the somewhat simplistic view that the constituent structure of the forms in (56) is [dz-[iʃ-[l-ta:l]]] and [dz-[iʃ-[l-ts’in]]], respectively.⁴⁰ The fusion of the classifier prefix /l-/ with the preceding /ʃ/ will also be ignored, since it has no bearing on sibilant harmony.

In the example /dz-iʃ-l-ta:l/ → [dz*i*ʃta:l], the derivation is as in (57) below. As in earlier tableaux, the establishment of a C₁←C₂ correspondence relation between the two sibilants is taken for granted, although it too is ultimately due to constraint interaction (high-ranked CORR-CC constraints). As in the tableau in (55), IDENT[ant]-SA evaluates the faithfulness of any sibilants located in the stem portion of the output string—in this case the /ʃ/ of the 1SgSubj prefix /-iʃ-/. Note, though, that it is not faithfulness to the *input* /ʃ/ that is

⁴⁰ The internal morphological structure of the Athapaskan verb is a hotly disputed topic (see, e.g., Kari 1989; McDonough 1990; Speas 1990; Rice 2000). Within the verb of any Athapaskan language, discontinuous dependencies between morphemes abound, and inflectional prefixes frequently occur ‘inside’ derivational ones—at least on the simplistic view that right=‘in’ and left=‘out’. According to the analysis of the Athapaskan verb presented by Rice (2000), the general right-to-left directionality of sibilant harmony in Navajo and other related languages can *not* be regarded as inside-out, since the relevant prefixes are instead taken to form a *left-branching* structure. In that case, these languages must be interpreted as exhibiting not stem-controlled harmony but rather strict right-to-left harmony, insensitive to constituent structure. In light of these concerns, the analysis of Navajo sibilant harmony sketched here should be seen as nothing more than a simple illustration of how constraint interaction can give rise to stem control in [prefix + stem] contexts no less than in [stem + suffix] contexts. See also 3.1.2 for discussion of directionality-related issues in Navajo sibilant harmony.

being evaluated by IDENT[ant]-SA, but faithfulness to the *output* realization of this segment in other, morphologically related surface forms. This is indicated in the tableau by listing the output stem along with the input representation of the entire affixed form. In the particular example examined here, the /ʃ/ of /-iʃ-/ is realized faithfully as [ʃ] in the stem, so the distinction between input /ʃ/ and output-stem [ʃ] as the source of SA correspondence does not make a difference in this case. But it should be kept in mind that when the [s] in (57c-d) violates IDENT[ant]-SA, it does so by being unfaithful to the *output* [ʃ] in the stem of affixation [-iʃta:l], and not by being unfaithful to the *input* /ʃ/ of the morpheme /-iʃ-/.

(57) Navajo: Stem-controlled sibilant harmony

Input: /dz-[iʃ-l-ta:l]/ Stem (Output): -iʃta:l	→IDENT[ant]-CC	IDENT[ant]-SA	IDENT[ant]-IO
a. dz _i -iʃ _i ta:l	(b > a)		
b.  dz _{3i} -iʃ _i ta:l	(b > a)		*
c. dz _i -is _i ta:l	(c > d)	*	*
d. dz _{3i} -is _i ta:l	(c > d)	*	**
<i>Harmonic ordering by constraint</i>	<u>b > a; c > d</u>	{a, b} > {c, d} <i>i.e.</i> <u>a > c; a > d;</u> <u>b > c; b > d</u>	a > {b, c} > d <i>i.e.</i> a > b; <u>a > c; a > d;</u> <u>b > d; c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	 b > a > c > d	(b > a > c > d)

The combined effect of the constraints →IDENT[ant]-CC and IDENT[ant]-SA is the cumulative ordering b > a > c > d. Candidate (57b) thus emerges as the optimal output, with stem-controlled right-to-left harmony winning out over all other alternatives.

Let us now turn to the other derivation, /dz-ɨʃ-l-ts'in/ → dzists'in. This case is somewhat more complicated, in that three sibilants are involved. The ultimate trigger of harmony is now located in the verb root (the /ts'/ of /-ts'in/); this sibilant forces its [+ant] value on the /ʃ/ of /-ɨʃ-/ , and thereby prevents the latter from triggering [-ant] harmony on the /dz-/ prefix as it did in (57) above.

Since this example involves multiple, recursive affixation, and SA correspondence compares the output of the affixed form to the *output* form of the stem of affixation, we must consider two separate (but parallel) derivations. First of all, we must determine what the optimal output is for /-ɨʃ-l-ts'in/, since this is the stem of affixation from the point of view of /dz-/ prefixation. It is only with reference to this output stem that we can then determine the optimal output for the full affixed form, /dz-ɨʃ-l-ts'in/. The tableau for the stem /-ɨʃ-l-ts'in/ is as shown in (58).

(58) Navajo: Determining the output stem for /dz-[ɨʃ-l-ts'in]/

Input: /-ɨʃ-[l-ts'in]/ Stem (Output): -ts'in	→IDENT[ant]-CC	IDENT[ant]-SA	IDENT[ant]-IO
a. -ɨʃ-ts'in	(b > a)		
b. ☞ -is-ts'in	(b > a)		*
c. -ɨʃ-tʃ'in	(c > d)	*	*
d. -is-tʃ'in	(c > d)	*	**
<i>Harmonic ordering by constraint</i>	<u>b > a; c > d</u>	{a, b} > {c, d} <i>i.e.</i> <u>a > c; a > d;</u> <u>b > c; b > d</u>	a > {b, c} > d <i>i.e.</i> a > b; <u>a > c; a > d;</u> <u>b > d; c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	☞ b > a > c > d	(b > a > c > d)

The derivation is exactly as in the example in (57). Right-to-left/inside-out harmony (58b) is better than faithful disharmony (58a), and both are worse than left-to-right/outside-in harmony (58c), which violates SA faithfulness. The resulting cumulative ordering is $b > a > c > d$, and (58b) is therefore optimal. The prefix sibilant /ʃ/ thus assimilates to the root sibilant /tsʰ/.

We have thus determined that the (independent) output realization of /iʃ-l-tsʰin/ is [-istsʰin]. When the prefix /dz-/ is added to this constituent, the optimal output is determined by the tableau in (59). In this case, IDENT[ant]-SA evaluates the faithfulness to the output stem we just derived, [-istsʰin]. Any deviation from *either* of the two sibilants in that string (or both) is penalized by IDENT[ant]-SA. In order to simplify the tableau, the only stem-unfaithful candidates considered are ones which deviate from the [s] belonging to the /-iʃ-/ prefix, rather than the [tsʰ] of the root.⁴¹

⁴¹ Note that any candidate with [...iʃtʰin] would receive *two* violations of IDENT[ant]-SA, and would furthermore not be comparable to any of (59a-d) for the purposes of \rightarrow IDENT[ant]-CC. Such candidates are therefore bound to be suboptimal.

(59) Navajo: Stem-controlled sibilant harmony with multiple affixation

Input: /dz-[i]f-l-ts'in/ Stem (Output): -ists'in	→IDENT[ant]-CC	IDENT[ant]-SA	IDENT[ant]-IO
a. dz _i -i]f _{i,j} ts' _j in	(b > a; c > a)	*	
b. dʒ _i -i]f _{i,j} ts' _j in	(b > a)	*	*
c. ↗ dz _i -is _{i,j} ts' _j in	(c > a; c > d)		*
d. dʒ _i -is _{i,j} ts' _j in	(c > d)		**
<i>Harmonic ordering by constraint</i>	<u>b > a; c > a; c > d</u>	{c, d} > {a, b} i.e. <u>c > a; c > b;</u> <u>d > a; d > b</u>	a > {b, c} > d i.e. a > b; <u>a > c; a > d;</u> <u>b > d; c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > a; c > d	↗c > d > b > a	(c > d > b > a)

The sequence of three sibilants is broken down into two correspondent pairs, indicated by a separate subscript index, e.g. [dz_i...s_i] and [s_j...ts'_j] in (59c). For the purposes of the targeted constraint →IDENT[ant]-CC, each of the two sequences counts. For example, →IDENT[ant]-CC prefers *both* (59b) and (59c) over (59a), i.e. b > a and c > a. Why is this? First of all, (59a) and (59b) are absolutely identical except for the C₁←C₂ sequences [dz_i...]f_i] and [dʒ_i...]f_i]; the latter is preferred, since C₁ there ‘faithfully’ corresponds to C₂ with respect to [±ant]. Hence the ordering b > a. Secondly, (59a) and (59c) are absolutely identical except for the C₁←C₂ sequences [f_i...ts'_j] and [s_j...ts'_j]; again, the latter is preferred, because C₁ is ‘faithful’ to C₂. Hence the ordering c > a.

In the candidate set considered in (59), the individual pairwise orderings determined by undominated →IDENT[ant]-CC are b > a, c > a and c > d. From this we can already conclude that either (59b) or (59c) will be the winner, since these are the only one

candidates that are not dispreferred relative to some other candidate. But we still do not know how (59b) compares to (59c). The orderings expressed by \rightarrow IDENT[ant]-CC alone are compatible with a number of conceivable complete orderings; some of these have (59b) at the top (e.g., $b > c > d > a$) and some have (59c) instead (e.g., $c > b > a > d$). The *actual* cumulative ordering depends on the contribution of lower-ranked IDENT[ant]-SA. This constraint prefers (59c) over (59b), since the latter is unfaithful to the output stem of affixation, [-ists'in]. Combining $c > b$ (as well as $d > a$, $d > b$, $c > a$) with the orderings established by top-ranked \rightarrow IDENT[ant]-CC, we get $c > d > b > a$. This cumulative ordering exhausts the candidate set under consideration, and (59c) emerges as the optimal output. The end result is iterative right-to-left harmony under stem control.

In this section we have seen how stem control, i.e. inside-out directionality, can be derived in the generalized OT analysis of consonant harmony. It was demonstrated how the interaction of targeted \rightarrow IDENT[F]-CC constraints with faithfulness to the stem of affixation (IDENT[F]-SA) can give rise to left-to-right directionality, even though the CC correspondence relation is explicitly defined as a right-to-left relation. In her analysis of Kera voicing harmony, Walker (to appear, 2000a) concluded that the bidirectionality observed there (stem-to-prefix, stem-to-suffix) called for *symmetric* CC correspondence between the consonants involved.⁴² The above analyses show that this is an unnecessary assumption; stem-control effects can be derived regardless of whether CC correspondence is an asymmetric or symmetric relation.

⁴² Likewise, the analysis of stem-controlled vowel harmony by Baković (2000) relies on symmetric AGREE[F] constraints, which for all practical purposes can be equated with IDENT[F]-CC constraints evaluating symmetric $C \leftrightarrow C$ correspondence. The main difference is that CC correspondence is triggered by similarity and/or proximity, whereas the 'correspondence' relation evaluated by AGREE[F] is automatically triggered by (articulatory) adjacency.

4.3.3. Problematic directionality patterns

There exists a very small residue of cases where the observed directionality patterns pose problems for the generalized analysis of consonant harmony developed here. All involve left-to-right directionality in some way that goes over and beyond what the analysis is capable of handling. In one case, Sundanese, left-to-right harmony is assigned a privileged status over right-to-left harmony, in that a markedness overrides the latter but not the former. The remaining cases—which all involve nasal consonant harmony in the Bantu language family—show left-to-right directionality of a kind that cannot be reduced to stem control effects.

The case of Sundanese (Malayo-Polynesian) was briefly discussed in the section on liquid harmony in 2.4.5. That description omitted several important details which are crucial for understanding why this case constitutes a potential problem for the analysis presented in this chapter. In Sundanese, the plural (or distributive) marker /-ar-/ is infixal after the root-initial consonant, like many other affixes with -VC- shape in this and other related languages. When there is another liquid (/l/ or /r/) present in the stem, the rhotic of the /-ar-/ infix interacts with this segment in a complicated manner which involves both assimilation and dissimilation (see, e.g., Robins 1959; Cohn 1992; Holton 1995; Suzuki 1998, 1999). First of all, when followed by another /r/, the infixal /r/ dissimilates to [l], as shown in (60). The forms in (60a) illustrate the infixation pattern itself. In (60b), /-ar-/ surfaces as [-al-] instead, dissimilating to the following /r/ in the stem. Syllable boundaries are indicated (‘.’) for reasons that will become clearer below.

(60) Liquid dissimilation in Sundanese plural/distributive /-ar-/ (data from Cohn 1992)

	<i>Singular</i>	<i>Plural</i>	
a.	ku.sut	k=a.r=u.sut	‘messy’
	po.ho	p=a.r=o.ho	‘forget’
	di-vi.su.a.li.sa.si-kin	di-v=a.r=i.su.a.li.sa.si-kin	‘visualized’
b.	pər.cə.ka	p=a.l=ər.ce.ka	‘handsome’
	com.brek	c=a.l=om.brek	‘cold’
	biŋ.har	b=a.l=iŋ.har	‘rich’
	ŋum.ba.ra	ŋ=a.l=um.ba.ra	‘go abroad’
	si.du.ru	s=a.l=i.du.ru	‘sit by a fire’

Secondly, this dissimilation does *not* apply if the two rhotics form the (non-complex) onsets of adjacent syllables, as the two examples in (61a) show. If the onsets are further apart, dissimilation does take place, as in the last two examples in (60) above (ŋ=a.l=um.ba.ra, s=a.l=i.du.ru). The /r/ of the infix also does not interact in a dissimilatory manner with a *stem-initial* rhotic, as shown in (61b). This can possibly be interpreted as being due to the same inhibitory adjacent-onset effect as the cases in (61a).

(61) Sundanese: No dissimilation between adjacent-syllable liquid onsets (Cohn 1992)

	<i>Singular</i>	<i>Plural</i>		
a.	cu.ri.ga	c=a.r=u.ri.ga	‘suspicious’	(*c=al=uriga)
	di-ki.rim	di-k=a.r=i.rim	‘sent (passive)’	(*di-k=al=irim)
b.	ri.wat	r=a.r=i.wat	‘startled’	(*l=ar=iwat, *r=al=iwat)
	ra.hit	r=a.r=a.hit	‘wounded’	(*l=ar=ahit, *r=al=ahit)

This summarizes the *dissimilatory* behavior of /-ar-/. More relevant in the context of this work is the fact that the /r/ of the infix also *assimilates* to a stem-initial /l/, as shown in (62a). By contrast, a stem-internal /l/ does not trigger this assimilation, regardless of its syllabic affiliation (62b).

(62) Sundanese: Liquid assimilation to stem-initial /l/ (Cohn 1992)

	<i>Singular</i>	<i>Plural</i>	
a.	li.tik	l=a.l=i.tik	‘little’
	lə.ga	l=a.l=ə.ga	‘wide’
b.	gi.lis	g=a.r=i.lis	‘beautiful’
	ŋu.li.at	ŋ=a.r=u.li.at	‘stretch’
	gə.tol	g=a.r=ə.tol	‘diligent’
	ma.hal	m=a.r=a.hal	‘expensive’

It is tempting to draw a direct parallel between the liquid assimilation in (62a) and the dissimilation-blocking pattern in (61)—at least as regards stem-initial /r/, as in (61b). In both cases the interacting consonants are onsets of adjacent syllables, and in both cases the end result is agreement in [\pm lateral]. The assimilatory effect is directly evident in (62a), but serves to block—i.e. override—dissimilation in (61a-b).

It is a well-known fact that segments that share the same syllable position (and, in general, a similar phonotactic environment) are far more likely to interact with one another in slips of the tongue. Word-initial consonants typically interact with other word-initial consonants, onset consonants interact with other onset consonants rather than with coda consonants, and so forth. Given the general claim made here that consonant harmony has its source in the domain of speech production planning, it would not be too drastic a move to assume that in Sundanese, there is a high-ranked CORR-CC constraint on liquids in

adjacent-syllable onsets. Let us refer to this constraint as CORR-[lat]_{Ons(σ₁-σ₂)}, indicating that this constraint requires correspondence between pairs of adjacent-syllable onset consonants which differ at most in the feature [±lateral]. All of the sequences /...rV(C).rV.../, /...IV(C).IV.../, /...rV(C).IV.../ and /...IV(C).rV.../ fall within the scope of this constraint, but sequences like /...rV.CVr.CV.../, /...rV.CV.rV.../, etc. do not, since the liquids in question are not onsets of adjacent syllables.

A constraint like CORR-[lat]_{Ons(σ₁-σ₂)}, combined with →IDENT[lat]-CC, could account for the dissimilation-blocking facts. Let us assume, following Suzuki (1999), that rhotic dissimilation is due to an OCP constraint, *r...r, which disallows the cooccurrence of two rhotics at any distance.⁴³ By ranking this *lower* than the onset-identity constraints, the blocking effect is achieved. This is illustrated in (63) and (64). For the sake of simplicity, the targeted nature of the constraint →IDENT[lat]-CC is ignored, and constraint evaluation proceeds in the usual fashion instead; this has no bearing on the outcome of the derivations. In the case of /b=ar=iḡhar/ ‘rich (pl.)’ in (63), the two rhotics are not onsets of adjacent syllables; CORR-[lat]_{Ons(σ₁-σ₂)} does not require a correspondence relation in this case. Without a CC correspondence mapping to evaluate, IDENT[lat]-CC is satisfied vacuously regardless of whether the liquids agree in [±lat] or not. The result is dissimilation to [b=al=iḡhar], as in (63c).⁴⁴

⁴³ Suzuki’s actual formulation of this constraint is *[rhotic]...[rhotic], with [rhotic] being construed as a value for the feature [LIQUID] (cf. Walsh Dickey 1997); in this context, the difference is negligible. In Suzuki’s analysis, the single constraint IDENT_{σ₁σ₂(rhotic)}_{ONS}, which requires that ‘adjacent syllables have identical onset rhotics’, is the near-equivalent to our combination of CORR-[lat]_{Ons(σ₁-σ₂)} with IDENT[lat]-CC.

⁴⁴ Strictly speaking →IDENT[lat]-CC, being a targeted constraint, only states that (63d) is worse than (63b), i.e. b > d. Since *r...r adds to this the orderings d > a and c > b (as well as c > a), the resulting cumulative ordering is c > b > d > a. Candidate (63c) thus emerges as optimal, exactly as in the simplified tableau shown here.

(63) Sundanese: Dissimilation not blocked (not adjacent-syllable onsets)

/b=ar ₁ =iɲhar ₂ /	IDENT[lat]-CC	CORR- [lat] _{Ons(σ1-σ2)}	*r...r	IDENT[lat]-IO
a. b=ar _{1,i} =iɲhar _{2,j}			*!	
b. b=ar _{1,i} =iɲhar _{2,i}			*!	
c. ↵ b=al _{1,i} =iɲhar _{2,j}				*
d. b=al _{1,i} =iɲhar _{2,i}	*!			*

Note that the hypothetical alternative *[b=ar=iɲhal]—where the *stem* liquid undergoes dissimilation—is not considered. It can easily be ruled out by IDENT[lat]-SA, ensuring that an affix liquids will always yield to a stem liquid (an instance of stem control, really).

In the case of /c=ar=uriga/ ‘suspicious (pl.)’ in (64), the two rhotics *do* constitute the onsets of adjacent syllables. Hence CORR-[lat]_{Ons(σ1-σ2)} does require that they be linked by a CC correspondence relation, preferring (64b,d) over (64a,c).

(64) Sundanese: Dissimilation blocked (adjacent-syllable onsets)

/c=ar ₁ =ur ₂ iga/	IDENT[lat]-CC	CORR- [lat] _{Ons(σ1-σ2)}	*r...r	IDENT[lat]-IO
a. c=ar _{1,i} =ur _{2,j} iga		*!	*	
b. ↵ c=ar _{1,i} =ur _{2,i} iga			*	
c. c=al _{1,i} =ur _{2,j} iga		*!		*
d. c=al _{1,i} =ur _{2,i} iga	*!			*

With a correspondence relation being forced by CORR-[lat]_{Ons(σ1-σ2)}, the constraint IDENT[lat]-CC prefers ‘harmonic’ (64b) over ‘disharmonic’ (64d). This prevents the lower-ranked dissimilation constraint *r...r from having any effect. The result is that dissimilation is *blocked*.

The analysis as presented above has an important drawback. In addition to dissimilationblocking, it also predicts (erroneously) that an adjacent-syllable onset /l/ will trigger *assimilation* in the /-ar-/ infix, e.g., /ŋ=ar=uliat/ → *[ŋ=al=uliat] instead of the correct [ŋ=ar=uliat]. An easy way to fix this would be to make our IDENT-CC constraint value-specific, i.e. IDENT[-lat]-CC. Redefined in this way the constraint prefers [r_i...r_i] sequences over [l_i...r_i], without having anything to say about [l_i...l_i] vs. [r_i...l_i] (recall, once again, that the CC correspondence relation is C₁←C₂, not C₁→C₂ or C₁↔C₂). This is essentially equivalent to the analysis proposed by Suzuki (1999), whose onset-identity constraint refers to rhotics specifically, rather than liquids in general.

But the /r/ of the /-ar-/ *does* assimilate to an adjacent-syllable onset /l/ in one context: when that /l/ is stem-initial, as in (62a) above (/l=ar=əga/ → [l=al=əga], etc.). Likewise, a stem-initial /r/ blocks dissimilation just as a stem-internal (adjacent-syllable onset) /r/ does. If the same kind of between-onset correspondence is responsible for both the dissimilation-blocking effects and the assimilation effects, then the following asymmetry must be accounted for:

- (65) Asymmetric character of between-onset liquid harmony effects in Sundanese
- a. When trigger is to the *left*—a stem-initial onset liquid:
Harmony involves [-lat] (dissimilation blocking) and [+lat] (assimilation)
 - b. When trigger is to the *right*—a stem-internal onset liquid:
Harmony involves [-lat] (dissimilation blocking) only

In all cases, the ‘harmony’ effects obey stem control, in that the trigger is a stem liquid and the target an affix liquid. But since we are dealing with an *infix* rather than a prefix or suffix, the stem is, in effect, on both sides of the affix. In this situation, stem control should result in both left-to-right harmony (from the initial consonant) and right-to-left harmony (from a

non-initial consonant). This is not a problem in the [-lat] case, as [-lat] harmony—manifested as dissimilation-blocking—shows both directionality patterns. It is the [+lat] case that presents an insurmountable problem. Even if we were to posit a separate [+lat] version of the IDENT constraint, \rightarrow IDENT[+lat]-CC, there would be no way to rank this in such a way that it would result in left-to-right (stem-to-affix) harmony *to the exclusion of* right-to-left (stem-to-affix) harmony, as (65) requires. It would be possible to do the reverse, owing to the inherent right-to-left directionality of the $C_1 \leftarrow C_2$ correspondence relation. A hypothetical language ‘Anti-Sundanese’, with right-to-left [+lat] harmony ($/\eta = ar = uliat/ \rightarrow [\eta = al = uliat]$) but without left-to-right [+lat] harmony ($/l = ar = \text{ə}ga/ \rightarrow [l = ar = \text{ə}ga]$), would in fact result from the ranking IDENT[lat]-SA \gg \rightarrow IDENT[+lat]-CC \gg IDENT[lat]-IO. But there is no way to ‘privilege’ left-to-right directionality over right-to-left directionality in the model developed here.⁴⁵

One possible solution is to view the relationship between a stem-initial /r, l/ with the infixal /r/ as being of a *different* nature from the relationship between the infixal /r/ and a following (stem-internal) /r, l/. For example, we might postulate that the former relationship is not one of CC correspondence at all, but some other kind of correspondence instead. This is exactly what Suzuki’s (1999) analysis achieves—by invoking Base-Reduplicant correspondence. Suzuki proposes that the /-ar-/ infix is in fact a reduplicative morpheme, /-ar^{RED}-/ (cf. Gafos 1998; see discussion in 4.1.3 above).⁴⁶ Assuming that constraints such as ANCHOR-L ensure that the infix /r/ will be a BR-correspondent of the stem-initial


⁴⁵ There are other problems with capturing the Sundanese facts in the present model, having to do with the need to block dissimilation in both $/r = ar = V \dots/$ and $/C = ar = VrV \dots/$ contexts. The full ranking that this requires is actually \rightarrow IDENT[+lat]-CC \gg IDENT[lat]-SA \gg \rightarrow IDENT[-lat]-CC \gg $*r \dots r \gg$ IDENT[lat]-IO. As it turns out, this ranking predicts that an affixal *lateral* will trigger assimilation in a preceding stem rhotic. This would include any suffixes with /l/ (e.g., $/CVrV-IV/ \rightarrow [CVIV-IV]$) as well as a hypothetical infix such as /-Vl-/ (e.g., $/r = Vl = VC \dots/ \rightarrow [l = Vl = VC \dots]$). To my knowledge, no such effects are found in Sundanese.

⁴⁶ Suzuki represents the morpheme as /-aL^{RED}-/, where ‘L’ represents an underspecified liquid. The default realization of this segment as [r], in cases where dissimilation or correspondence constraints have no effect, results from the markedness constraint *l. For the purpose of the issues at hand, the two characterizations do not differ in their predictions.

consonant, rather than of some stem-medial consonant, the agreement effect can be captured by a constraint like IDENT[lat]-BR. We now have two freely rankable constraints, operating along entirely independent dimensions of correspondence, IDENT[lat]-BR and \rightarrow IDENT[-lat]-CC. IDENT[lat]-BR penalizes non-identical sequences of stem-initial and infixal liquids, [l=ar=VC...] and [r=al=VC...]. If this constraint is high-ranked, then it will account for both assimilation like /l=ar=VC.../ \rightarrow [l=al=VC...] (as in 62a) and dissimilation-blocking in the context /r=ar=VC.../ (not \rightarrow *[r=al=VC...]). The constraint \rightarrow IDENT[-lat]-CC, on the other hand, serves to block the dissimilation /r...r/ \rightarrow [l...r] in those cases where the two liquids are adjacent-syllable onsets (and hence linked by CC correspondence).

This is illustrated by the derivations in (66)-(69) below. For all practical purposes, the analysis is identical to that proposed by Suzuki (1999), although the latter does not make use of CC correspondence as a general phenomenon. The first two derivations show how \rightarrow IDENT[-lat]-CC is able to block the dissimilatory effect of *r...r (66) without also forcing assimilation of the infixal /r/ to a following /l/ (67).

(66) Sundanese: Dissimilation to a following rhotic blocked (adjacent-syllable onsets)

/c=ar=uriga/	IDENT[-lat]-CC	CORR- [lat] _{Ons(σ1-σ2)}	*r...r	IDENT[lat]-IO
a. c=ar _i =ur _j iga		*!	*	
b.  c=ar _i =ur _i iga			*	
c. c=al _i =ur _j iga		*!		*
d. c=al _i =ur _i iga	*!			*

(67) Sundanese: No assimilation to a following lateral (adjacent-syllable onsets)

/ŋ=ar=uliat/	IDENT[-lat]-CC	CORR- [lat] _{Ons(σ1-σ2)}	*r...r	IDENT[lat]-IO
a. η=ar _i =ul _j iat		*!		
b. ↵ η=ar _i =ul _i iat				
c. η=al _i =ul _j iat		*!		*
d. η=al _i =ul _i iat				*

Here the value-specific character of \rightarrow IDENT[-lat]-CC is crucial, as well as the asymmetric nature of the $C_1 \leftarrow C_2$ correspondence relation. This constraint requires that a [-lat] specification on C_2 also be present on C_1 ; thus the constraint prefers [-lat]...[-lat] over [+lat]...[-lat]. It has nothing whatsoever to say about [-lat]...[+lat], as in the winner (67b). The [+lat] counterpart of this constraint *would* prefer (67d) over (67b); ranking it below IO faithfulness guarantees the right outcome.

The derivations in (68) and (69) show what happens when BR correspondence is thrown into the mix. BR correspondence is indicated with subscript Greek letters ('α, β'). Note that the stem-initial and infixal liquids are linked by *both* CC correspondence (since they are adjacent-syllable onsets) and BR correspondence (since the infix is reduplicative).

(68) Sundanese: Dissimilation to a stem-initial rhotic blocked

/r=ar=iwat/	ID[lat]-BR	ID[-lat]-CC	CORR- [lat] _{Ons}	*r...r	ID[lat]-IO
a. r _{i,α} =ar _{j,α} =iwat			*!	*	
b. ↵ r _{i,α} =ar _{i,α} =iwat				*	
c. r _{i,α} =al _{j,α} =iwat	*!		*		*
d. r _{i,α} =al _{i,α} =iwat	*!				*

(69) Sundanese: Assimilation to a stem-initial lateral

/l=ar=əga/	ID[lat]-BR	ID[-lat]-CC	CORR- [lat] _{Ons}	*r...r	ID[lat]-IO
a. $l_{i,\alpha}=ar_{j,\alpha}=əga$	*!		*!		
b. $l_{i,\alpha}=ar_{i,\alpha}=əga$	*!	*			
c. $l_{i,\alpha}=al_{j,\alpha}=əga$			*!		*
d. $l_{i,\alpha}=al_{i,\alpha}=əga$					*

The value-neutral nature of IDENT[lat]-BR ensures that under *BR* correspondence, unlike CC correspondence, both [-lat] and [+lat] are ‘carried over’ to the infixal liquid.

The analysis of the interaction with stem-initial consonants as Base-Reduplicant correspondence may seem ad hoc, but it is motivated for independent reasons. In Sundanese, as in many related languages, initial CV-reduplication is rampant, resulting in surface forms with the structure $/C_iV-C_iV\dots/$ just as in (68)-(69). Furthermore, identical consonants are generally banned from cooccurring in Sundanese words *except* in word-initial $/C_iVC_iV\dots/$ sequences—whether the word in question can be construed as morphologically reduplicated or not. The behavior of the /r/ of the infix /-ar-/ parallels these patterns in a way that is unlikely to be accidental.

Another problematic case with unexpected directionality patterns is nasal consonant harmony in the Bantu language Tiene (Ellington 1977; Hyman 1996; Hyman & Inkelas 1997). Just as in Sundanese, infixation is involved, at least in part. As described in more detail in section 2.4.4 above, the CVCVC verb-stem template in Tiene requires C_2 and C_3 to agree in nasality. In some cases C_3 belongs to a derivational suffix (e.g., stative /-Vk/), but sometimes it is C_2 that is affixal, belonging to a derivational *infix* (e.g., applicative /-IV-/ or causative /-sV-/). As the forms in (70) show, a stem-final nasal triggers nasalization in a

derivational affix. In (70a) the directionality is left-to-right (from stem to suffix), whereas in (70b) it is right-to-left (from stem to infix).

(70) Tiene: Nasal consonant harmony in the CVCVC template (data from Hyman 1996)

a. Nasalization in suffixed stative /-Vk-/

jaat-a	‘split’	[jat-ak]-a	‘be split’
vwuj-a	‘mix’	[vwuj-eŋ]-ε	‘be mixed’
sɔn-ɔ	‘write’	[sɔn-ɔŋ]-ɔ	‘be written’

b. Nasalization in infixed applicative /-IV-/

bák-a	‘reach’	[bá=la=k]-a	‘reach for’
dum-a	‘run fast’	[du=ne=m]-ε	‘run fast for’
lɔŋ-ɔ	‘load’	[lɔ=nɔ=ŋ]-ɔ	‘load for’

Both directionalities in (70) can be construed as manifestations of stem control, since the affix consistently yields to the stem. But another possibility is to interpret the facts in (70) as being a matter of *single-value* harmony, where [+nasal] is the only active (or ‘dominant’) feature value. As will be explained in section 5.2 below, the factorial typology of the constraints proposed so far does in principle allow systems that are inherently *non-directional* in this way, spreading the active feature value both leftwards and rightwards, just as in a dominant-recessive vowel harmony system.⁴⁷

The problem with Tiene concerns the additional facts shown in (71). When the affix contains an /s/, as in the causative infix /-sV-/, the result is not nasalization of the affix /s/ but *denasalization* of the stem nasal. The ultimate reason, presumably, is that /s/ is

⁴⁷ The crucial ranking required to derive such a system, with [+nas] being the active value, is \rightarrow IDENT[nas]-CC >> IDENT[+nas]-IO >> IDENT[-nas]-IO. The separation of IO faithfulness into value-specific constraints is essential in such cases.

inherently non-nasalizable in Tiene ([š] or [ž] is impossible; faithfulness to features such as [±strident] is high-ranked enough to prevent any other realization of a nasalized /s/).

(71) Tiene: Denasalization with infixated causative /-sV-/ (data from Hyman 1996):

a.	lab-a	‘walk’	[la=sa=b]-a	‘cause to walk’
	lók-a	‘vomit’	[lók=se=k]-ε	‘cause to vomit’
b.	tóm-a	‘send’	[tók=se=b]-ε	‘cause to send’
	dím-a	‘get extinguished’	[dí=se=b]-ε	‘extinguish’
	suom-ɔ	‘borrow’	[sɔ=sɔ=b]-ɔ	‘lend’

The problem with the denasalization effect in (71) is twofold. Firstly, the ‘spreading’ feature value is [-nas] rather than [+nas]. This rules out the possibility, suggested above, that the bidirectionality observed in (70) is due to Tiene harmony being a single-value system, with ‘recessive’ [-nas] consistently yielding to ‘dominant’ [+nas], regardless of their order. In other words, the bidirectional character of the nasalization effect in (70) *must* be due to stem control: an affix consonant consistently yields to a stem consonant, regardless of their order.

This leads us to the second problem. In (71), the directionality of the denasalization effect is *left-to-right from affix to stem*. In the generalized analysis of consonant harmony developed in this chapter, left-to-right directionality can arise in two ways only. One is in a genuine single-value system (see 5.2 below). This alternative is easily ruled out here; Tiene cannot possibly be a single-value [-nas] system, since most of the time, it is [+nas] that is copied and not [-nas]. The only other way in which left-to-right directionality can emerge is through stem control. This too fails in the Tiene case; the [-nas] copying in (71) is from affix to stem.

Tiene is thus a genuine problem case. At present, it remains unclear whether feasible alternatives exist that would allow us to circumvent the directionality dilemma. One conceivable strategy is to construe this as a matter of BR correspondence rather than CC correspondence, just as in the Sundanese case above. The affixes /-Vk/, /-IV-/ and /-sV-/ are then all construed as reduplicative morphemes (along the lines of Gafos 1998), anchored in such a way that their consonant is a BR correspondent of the stem-final consonant (rather than, say, the stem-initial consonant). This should make the effects in (70)-(71) derivable. The affix-to-stem directionality in (71) would be an example of ‘back-copying’, where the base takes after the reduplicant to avoid violating some high-ranked constraint on markedness (* \bar{s}), or faithfulness (IDENT[+strid]-IO); see McCarthy & Prince (1995).

Whether a reduplication analysis of the Tiene data is feasible or not will be left to future research.⁴⁸ An additional point of potential importance, at least from a diachronic perspective, is the fact that the Tiene infixes are originally *suffixes* (as their cognates in other Bantu languages still are). Their infixation arises from templatic restrictions on place of articulation (cf. the discussion in 2.4.4 above); these restrictions are a later innovation. If the [\pm nasal] agreement effects in (70)-(71) date from the period before infixation arose, the problematic affix-to-stem [-nasal] copying in (71) would actually have been a matter of *right-to-left* directionality. Such a system would not have constituted a problem for the analytic framework developed here, although its post-infixation counterpart does.

The Sundanese and Tiene cases are the most important challenges to the model developed here. Whether they should be construed as involving reduplication or not, it is interesting to note that both involve *infixes* in some problematic way. In fact, Tiene and

⁴⁸ One additional advantage of such an analysis is that it would account for the fact that a stem-*initial* nasal will not participate in the Tiene harmony, neither as a trigger (e.g., forcing /l/ → [n] in applicative /-IV-/) nor as a target (denasalizing before causative /-sV-/). The consonant harmony analysis cannot account for the ‘extra-harmonicity’ of stem-initial consonants except by stipulating that Tiene nasal consonant harmony is limited to the domain sometimes referred to as the ‘prosodic trough’ (see, e.g., Hyman 1998). Since consonant harmony systems are *never* bounded by prosodic domains (see section 3.3), such a stipulation would be at least as problematic as the interpretation of /-sV-/ etc. as reduplicative affixes.

Sundanese are the only examples in the database surveyed in this study where infixes play a part in the consonant harmony system. With respect to directionality—and linear precedence relations in general—infixes are rather unique creatures, in that one and the same morph(eme) simultaneously precedes and follows its base of affixation! Perhaps the anomalous behaviour of infixes such as Tiene /-sV-/ and Sundanese /-ar-/ is somehow reducible to this fact? I will leave this as an open question.

The last problematic case is related to the Tiene harmony discussed above. This is the nasal consonant harmony (NCH) found in a large number of related languages of the Bantu family, such as Bemba, Kongo, Lamba, Ndonga, Suku, Yaka, and many others. The details of this phenomenon, which will be referred to here as ‘canonical’ Bantu NCH, were described in 2.4.4. The essence of the harmony effect is that a (voiced) oral consonant in a suffix assimilates to a nasal in the preceding stem, e.g., Yaka /ján-idi/ → [ján-ini] ‘cry out in pain (perf.)’, /tsúm-idi/ → [tsúm-ini] ‘sew (perf.)’ (Hyman 1995). The directionality is thus generally left-to-right, from stem to suffix.⁴⁹ This aspect of canonical Bantu NCH does not constitute a problem for the generalized analysis developed here, since this would be a simple matter of stem control. The problem arises when we look at what happens within the root, where constituent structure is irrelevant and stem control therefore irrelevant.

As Hyman (1995) shows quite conclusively for Yaka, the harmony effects observed in suffix [n] vs. [d]/[l] alternations can be reduced to a more general phenomenon: ‘voiced oral consonants may not occur in stems which have an earlier (full) nasal’. (The ‘stem’ in this context refers to the domain comprising the verb root + derivational suffixes.) In other words, nasal-oral sequences like [m...d], [n...w], [ɲ...l], etc. are not allowed *even within the root*. Nasal-nasal sequences, by contrast, are allowed ([m...n], etc.), as are oral-oral sequences of voiced consonants ([b...l], etc.). Even more importantly, oral-nasal sequences are allowed: [w...ɲ], [d...m], [b...n], and so forth. The generalization seems to be that

⁴⁹ Although there do exist counterexamples with right-to-left directionality (from suffix to stem), e.g., Pangwa, as mentioned in 2.4.4 above.

canonical Bantu NCH observes strict left-to-right directionality *independently* of morphological structure. This is further bolstered by diachronic evidence, which clearly shows that the sound change responsible for the synchronic NCH pattern was due to left-to-right assimilation, even within the root (e.g., /min-/ ‘swallow’ < Proto-Bantu *mid-). In short, explaining the left-to-right directionality in stem + suffix contexts (/tsúm-idi/ → [tsúm-ini]) as being due to stem control appears to miss the bigger generalization. It is this state of affairs, presumably, which leads Walker (2000b) to posit that CC correspondence is a left-to-right relation in Yaka. The analysis developed here rules this out in principle, construing all string-internal correspondence as a strictly right-to-left mapping, $C_1 \leftarrow C_2$.

There is no straightforward solution to the problem posed by canonical Bantu NCH, although several alternatives suggest themselves. The simplest one would simply be to relax the requirement that all CC correspondence be $C_1 \leftarrow C_2$, instead allowing individual languages to differ in the ‘directionality’ of this correspondence relation—along the lines hinted at by Walker (2000ab, to appear). The downside of such a drastic move is that it would considerably weaken the formal synchronic model, making it much less restrictive. The clear empirical generalizations about directionality in consonant harmony systems that were presented in 3.1 above would then no longer fall out automatically from the formal properties of the synchronic analysis. Instead, they would have to be understood as having a diachronic basis; instead of being *synchronically impossible*, strict left-to-right directionality would then be interpreted as *diachronically unlikely* (and therefore synchronically extremely rare). Perhaps this solution is not as unattractive as it may sound. True, inherent right-to-left orientation of CC correspondence was motivated by the fact that phonological encoding in speech production seems to exhibit a clear bias towards anticipatory rather than perseveratory interference, as manifested in slips of the tongue (Schwartz et al. 1994; Dell et al. 1997). But people do make perseveratory speech errors, after all, even though they are

less likely to, other things being equal. The same reasoning might be extended to the domain of consonant harmony.⁵⁰

Another possibility is to ignore the diachronic facts (/min-/ < *mid-, etc.) and reinterpret the synchronic patterns in a slightly different way. For example, canonical Bantu NCH could be reinterpreted as a case of fundamentally ‘dominant-recessive’ harmony, i.e. a single-value system with [+nasal] as the active value. In heteromorphic contexts, high-ranked SA faithfulness can guarantee that a stem consonant will not yield to a suffix consonant (e.g., that reciprocal /-an-/ will not trigger harmony in the preceding stem). In short, stem control will prevail in stem + suffix contexts. Within the root, however, SA faithfulness is vacuous, and the true ‘dominant’ nature of [+nasal] will manifest itself.

Other things being equal, this will mean that not only does /m...d/ harmonize to [m...n] (with [-nas] → [+nas] in C₂), but /b...n/ also harmonizes to [m...n] (with [-nas] → [+nas] in C₁)! As a general description this is clearly incorrect, since sequences like /b...n/, /d...m/, etc. surface intact in these languages; this must be captured in the analysis.⁵¹ One possibility is to invoke high-ranked positional faithfulness to [±nasal] specifications in root-initial consonants. This would make roots of the shape /dVm-/ , /wVɲ-/ , etc. immune to [+nas] harmony, since the grammar would place more importance on preserving the [-nas] specification on root-initial /d/, /w/, etc. than sacrificing it to achieve agreement in [+nas] with C₂. This results in a fairly close approximation of the canonical-NCH facts. The trial cases are CVCVC roots; the analysis would predict that roots could never have the shape CVIVm, CVdVn, etc. (since these would be predicted to harmonize to CVnVm, CVnVn, etc.).

⁵⁰ This is essentially the conclusion drawn about so-called palatal bias effects in coronal harmony systems in chapter 6, i.e. that ‘anti-palatal’ bias effects are synchronically possible, though extremely rare.

⁵¹ Interestingly, Proto-Bantu *bon- ‘see’ does harmonize to /mon-/ in virtually all canonical-NCH languages (Larry Hyman pers. comm.; see 3.1.3). This suggests that the dominant [+nasal] analysis may not be too far off the mark after all. In general, though, oral-nasal sequences *are* allowed synchronically in these languages.

A third possibility, though rather less intuitive, would be to posit that the static NCH restriction within roots is really a matter of right-to-left [*-nasal*] harmony, not left-to-right [*+nasal*] harmony. In other words, the reason that nasal-oral sequences like /m...d/ are not allowed is then that such inputs will get harmonized to [b...d], etc., rather than to [m...n] as in the analysis just suggested! Since we are dealing with static cooccurrence patterns, this analysis would be descriptively adequate; after all, the synchronic facts merely tell us that *[m...d] roots do not surface as such—they do not tell us *how* such (hypothetical) roots would get modified by the phonological grammar. Of course, it is a *diachronic* fact that historical /m...d/ roots (e.g., **mid-* ‘swallow’) became modified to /m...n/ and not to /b...d/, but this should strictly speaking be irrelevant for a synchronic analysis. There is a serious downside to this analysis, though, in that it interprets NCH within roots and across morpheme boundaries as entirely separate phenomena, even though both achieve the same ultimate effect: the elimination of nasal...oral sequences.⁵²

To conclude, canonical Bantu NCH does appear to pose a problem for the general analysis of consonant harmony phenomena that is developed in this chapter, although there may be various ways of reconciling the analysis with the facts. It may ultimately be necessary to give up the restrictive hypothesis that CC correspondence is always right-to-left asymmetric. Nevertheless, the default status of right-to-left directionality in consonant harmony systems remains a highly significant empirical generalization, and as such it needs to be accounted for.

⁵² A number of other alternative directions may be worth exploring. One is to interpret the existence of (voiced) oral-nasal sequences to the exclusion of nasal-oral sequences as a matter of the *linear order* of the two segment types within roots. In other words, cooccurring nasal and (voiced) oral consonants must be in the order D...N, not *N...D. Numerous languages place ordering restrictions on cooccurring consonants within morphemes. To mention a few examples, Javanese allows the liquid sequence /l...r/ but not /r...l/ (Mester 1986[1988]; Curtin 2001); Classical Yucatec allows the coronal-obstruent sequences /s...ts/, /ʃ...tʃ/ and /t...ts/, /t...tʃ/ but not /ts...s/, /tʃ...ʃ/ or /ts...t/, /tʃ...t/ (Lombardi 1990, cf. section 2.4.6); Aymara allows stop sequences like T^h...T, T'...T but not T...T^h, T...T' (MacEachern 1997[1999]; see section 2.4.7). To be sure, some cases of this kind may be interpreted as resulting from (single-value) consonant harmony requirements, but it is likely that ordering restrictions can also arise in other ways.

CHAPTER 5
ANALYZING CONSONANT HARMONY:
BEYOND THE BASICS

The previous chapter introduced the fundamental ingredients of the correspondence-based analysis of consonant harmony as long-distance agreement and demonstrated how the two basic directionality patterns (stem control and anticipatory harmony) arise given the appropriate constraint rankings. This chapter further develops this framework of analysis, showing how it handles patterns that go beyond these basic directionality scenarios. Of particular interest is the interplay between harmony and phonotactics—the latter reflecting contextual markedness constraints. The discussion of such markedness-related effects comprises the bulk of this chapter.

The chapter is organized as follows. Section 5.1 shows how interaction with phonotactic restrictions can result in intricate patterns of overrides. Section 5.2 addresses the special case where harmony applies morpheme-internally as a (static) cooccurrence restriction. Finally, section 5.3 outlines some issues that are left to future research; it also brings up some problematic aspects of the correspondence-based analysis, and makes a tentative proposal for how these might be overcome.

5.1. Interaction with markedness: Overrides and blocking effects

In section 4.3 of the preceding chapter we saw how the targeted-constraint analysis of consonant harmony is able to generate the attested directionality patterns—stem control and morphology-insensitive anticipatory harmony. The differences between these two major types had to do with how the harmony-enforcing \rightarrow IDENT[F]-CC constraints interacted with faithfulness constraints (IDENT[F]-IO, IDENT[F]-SA). But what about markedness, i.e. those constraints that define phonotactic well-formedness? Do these freely interact with the

→IDENT[F]-CC constraints (and/or the CORR-CC constraints)? If so, what patterns result and are they all attested in the cross-linguistic typology of consonant harmony systems? These are some of the questions that are dealt with in this section.

A few words on the factorial typology of markedness constraints in Optimality are in order. Phonotactic generalizations generally arise from the interaction of context-sensitive markedness constraints on the one hand with context-free markedness constraints and (IO) faithfulness constraints on the other. As an abstract example, let us assume a pair of segments X and Y, which differ solely in feature [\pm F]. For example, X vs. Y might represent oral [a] vs. nasal [ã], or voiceless [k] vs. voiced [g]. The relevant constraint would then be the following:

(1) Constraints relevant for deriving contextual effects

a. Faithfulness: IDENT[F]-IO

Input [\pm F] specifications must be preserved in the Output. This constraint penalizes both /X/ \rightarrow [Y] and /Y/ \rightarrow [X], and thus allows a general [X] : [Y] contrast to surface.

b. Context-sensitive markedness: *X / A__B

X is not allowed in the context A__B (e.g., an oral vowel is not allowed before a nasal, a voiceless obstruent is not allowed in intervocalic position, etc.)

c. Context-free markedness: *Y

Y is not allowed in any context (e.g., no nasal vowels, no voiced obstruents, etc.).

What we are interested in is the way these constraints interact to affect the relative distribution of [X] and [Y] in the output. The least interesting situation arises when IDENT[F]-IO is top-ranked; regardless of how the markedness constraints are ranked relative to each other, the result will be that an [X] : [Y] contrast is preserved in all contexts. In such situations, markedness is ranked so low as to be entirely irrelevant, and they are thus

also unable to interact with the harmony-deriving constraint $\rightarrow\text{IDENT}[\text{F}]\text{-CC}$ in any interesting way.

The rankings that interest us are therefore ones where faithfulness is outranked by one or both of the markedness constraints in (1). Moreover, context-sensitive $*\text{X} / \text{A_B}$ must outrank context-free $*\text{Y}$ in order to have any effect. If $*\text{Y} \gg * \text{X} / \text{A_B}$, then $[\text{Y}]$ will never arise at all. Again, there will be no potential for interesting interactions between the phonotactic distribution of $[\text{X}]$ vs. $[\text{Y}]$ and consonant harmony. The ranking $*\text{X} / \text{A_B} \gg * \text{Y}$, by contrast, ensures that $/\text{X}/$ and $/\text{Y}/$ will neutralize to $[\text{Y}]$ in the marked context A_B . In short, the rankings we are interested in are the ones shown in (2).

(2) Relevant rankings for contextual markedness effects

a. Allophonic distribution of $[\text{X}]$ vs. $[\text{Y}]$

$*\text{X} / \text{A_B} \gg * \text{Y} \gg \text{IDENT}[\text{F}]$

b. Contextual neutralization of $/\text{X}/$ vs. $/\text{Y}/$

$*\text{X} / \text{A_B} \gg \text{IDENT}[\text{F}] \gg * \text{Y}$

In each of the rankings in (2), the two higher-ranked constraints together determine the surface distribution of $[\text{X}]$ and $[\text{Y}]$. In the ranking in (2a), $[\text{X}]$ and $[\text{Y}]$ are in complementary distribution: $[\text{X}]$ is found in all environments except A_B , where $[\text{Y}]$ occurs instead. In (2b), on the other hand, $[\text{X}]$ and $[\text{Y}]$ *contrast* in all environments but A_B , where the contrast is neutralized to $[\text{Y}]$.

We now return to the question of how markedness constraints such as those involved in (2) can interact with the constraints enforcing consonant harmony. Specifically, we are interested in the ranking of the constraints in (2) relative to $\rightarrow\text{IDENT}[\text{F}]\text{-CC}$. Given that $[\text{X}]$ and $[\text{Y}]$ differ in $[\pm\text{F}]$, this constraint has the potential of interfering with the general distribution patterns in (2a) and (2b). Likewise, the constraints in (2) can interfere

with the harmony pattern that \rightarrow IDENT[F]-CC otherwise gives rise to. Setting aside the (2a) vs. (2b) distinction for the moment, the two fundamental rankings we need to consider are the once shown in (3).

(3) Interplay of markedness with consonant harmony—possible scenarios

- a. $*X / A_B \gg \rightarrow$ IDENT[F]-CC $\gg *Y, \text{IDENT[F]-IO}$
- b. \rightarrow IDENT[F]-CC $\gg *X / A_B \gg *Y, \text{IDENT[F]-IO}$

We need not consider a ranking like $*X / A_B \gg *Y \gg \rightarrow$ IDENT[F]-CC, because here the harmony constraint is ranked too low to have any effect whatsoever; the same is true of the ranking $*X / A_B \gg \text{IDENT[F]-IO} \gg \rightarrow$ IDENT[F]-CC. In each case, the two higher-ranked constraints exhaustively determine the surface distribution of [X] and [Y], and \rightarrow IDENT[F]-CC is unable to exert any influence on this distribution.

The two scenarios in (3) are both attested in the typology of consonant harmony systems; each gives rise to a distinctive pattern of markedness vs. harmony interaction. The pattern in (3a), where contextual markedness overrides harmony, is discussed in section 5.1.1. In (3b) the interaction between the two constraints is more subtle; this scenario is discussed in 5.1.2 below. Finally, section 5.1.3 discusses the effects that arise when a markedness constraint is interleaved with the similarity-based hierarchy of CORR-CC constraints.

In the analyses developed below, contextual markedness constraints are taken to be *targeted constraints*, just as \rightarrow IDENT[F]-CC itself is. A constraint of the type described here as $*X / A_B$ thus targets [X] as a marked element given the context A__B (typically one where the perceptual cues for the [X] vs. [Y] distinction is weak). This is in complete accordance with the theory of targeted constraints as developed by Wilson (2000, in progress; see also Baković & Wilson 2000); indeed, the strongest motivation for the notion of

targeted constraints comes precisely from the domain of contextual markedness effects (contextual neutralization, specifically). Although the targeted-constraint construal of contextual markedness constraints is not crucial for the (3a) scenario, it is of considerable importance in (3b), as will be discussed in 5.1.2.

5.1.1. Contextual markedness overrides harmony

We first examine the situation that arises when a constraint on contextual markedness outranks the harmony-enforcing constraint: $*X / A_B \gg \rightarrow \text{IDENT}[F]\text{-CC}$. In this state of affairs, consonant harmony will be prevented from deriving [X] in the environment A__B; in other words, markedness *blocks* harmony. For example, an input /Y...X/ sequence—where Y and X differ in $[\pm F]$ will generally be harmonized to [X...X], but in the special case /AYB...X/, the harmony is blocked from resulting in [AXB...X], since this violates the markedness constraint against [X] in A__B.

The clearest example of this kind of blocking effect is Chumash sibilant harmony. The preliminary analysis of Ineseño sibilant harmony in 4.3.1 above skirted around the details of the harmony patterns that have to do with blocking by markedness. In this section we will see how the analysis can be augmented to account for these facts as well.

Many of the Chumashan languages display a so-called ‘precoronal effect’, whereby alveolar sibilants (/s/, /ts/, etc.) are realized differently before the (non-sibilant) coronal consonants /t, d, n, l/ than otherwise. Sometimes the realization in precoronal contexts is described as *apico*-alveolar, as opposed to the normal *lamino*-alveolar articulation (cf., e.g., Mithun 1998). In this case the difference is a purely allophonic one; as such, it should not interfere at all with the sibilant harmony system, which involves the alveolar vs. post-alveolar series (/s/, /ts/, etc. as against /ʃ/, /tʃ/, etc.).

In at least some of the Chumashan languages—including Ineseño (as well as Ventureño, cf. Harrington 1974)—it seems that the apicals resulting from the (allophonic)

precoronal effect have merged with the postalveolars—giving rise to a synchronic pattern of contextual neutralization. As a result, the contrast between /s/ and /ʃ/ is suspended in the environment __{t, n, l}, where only [ʃ] is allowed (and analogously for /ts/ vs. /tʃ/, etc.). The neutralization pattern is illustrated by the Ineseño examples in (4).¹ As the forms in (4b) show, the precoronal effect results in the blocking of right-to-left sibilant harmony. Note also that the postalveolar sibilant resulting from the precoronal effect itself triggers harmony on any preceding sibilant; this aspect of Ineseño sibilant harmony will be further discussed below

(4) Precoronal effect in Ineseño (data from Applegate 1972)

a. [+ant] → [-ant] in 3Subj prefix /s-/:

ʃtepuʔ	/s-tepuʔ/	‘he gambles’
ʃnit ^h oj	/s-nit ^h oj/	‘it is possible’
ʃlok’in	/s-lok’in/	‘he cuts it’

b. Precoronal effect blocks and feeds sibilant harmony:

ʃtijepus	/s-ti-jep-us/	‘he tells him’	(*stijepus)
ʃiʃlusion	/s-iʃ-lu-sisin/	‘they (2) are gone awry’	(*sislusion)
ʃiʃtiʔi	/s-is-tiʔ/	‘he finds it’	(*sistiʔ)

From a synchronic point of view, the markedness constraint responsible for the neutralization observed in Ineseño might be defined as in (5). Note that the constraint is here

¹ The analysis of Ineseño sibilant harmony developed in this section glosses over one very important aspect of the data. The contextual neutralization arising from the precoronal effect takes place only in *derived environments* (see Poser 1982). Morpheme-internally, clusters like /st/, /sn/, etc. do surface intact (cf. /wastu/ ‘pleat’, /slow/ ‘eagle’). The constraint \rightarrow PRECOR must therefore be redefined so as to be irrelevant in non-derived environments; how this is to be achieved will be left to further research. When properly redefined, \rightarrow PRECOR will have no effect in morpheme-internal contexts, and will thus *not* block sibilant harmony from applying there. This is precisely what happens in Ineseño; for example, the underlying /ʃ/ of /uʃla/ ‘with the hand’ undergoes harmony in /uʃla-siq/ → [usla-siq] ‘to press firmly by hand’. Since the sibilant + coronal cluster is non-derived, \rightarrow PRECOR is irrelevant and harmony is not blocked.

defined as a targeted constraint, comparing *pairs* of candidates—those that differ minimally from each other in the presence vs. absence of the (contextually) marked feature specification.



(5) \rightarrow NOALVSIB / __COR (henceforth \rightarrow **PRECOR** for short)

Candidate x' is preferred over x ($x' > x$) iff x' is exactly like x except that at least one target [+ant] sibilant in pre-coronal environment has been replaced by its [-ant] counterpart.

Given a candidate pair like [...sn...s...] vs. [...ʃn...s...], the constraint in (5) will prefer the latter over the former, since the two are absolutely identical except for the fact that the former contains a targeted sibilant (alveolar [s] in the context __n) which the latter has ‘replaced’ with [ʃ].

Recall from 4.3.1 above that the ranking required to derive right-to-left sibilant harmony in Ineseño was \rightarrow IDENT[ant]-CC \gg IDENT[ant]-IO. The tableau in (6) shows how the blocking effect in precoronal sibilants arises from the ranking \rightarrow PRECOR \gg \rightarrow IDENT[ant]-CC \gg IDENT[ant]-IO. Note that the top two constraints are both targeted constraints, and thus compare *pairs* of candidates, rather than the candidate set as a whole. As before, the $C_1 \leftarrow C_2$ correspondence relation between the two sibilants is indicated by subscript ‘i’; the presence of this relation is enforced by a high-ranked CORR-CC constraint, not shown in the tableau.

(6) Ineseño: Precoronal effect overrides sibilant harmony

/s-ti-jep-us/	→PRECOR	→IDENT[ant]-CC	IDENT[ant]-IO
a. s _i tijepus _i	(b > a)	(a > b)	
b.  s _i tijepus _i	(b > a)	(a > b)	*
c. s _i tijepu _f _i	(c > d)	(d > c)	**
d. s _i tijepu _f _i	(c > d)	(d > c)	*
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	a > b; d > c	a > {b, d} > c i.e. a > b; <u>a > d</u> ; <u>a > c</u> ; <u>b > c</u> ; d > c
<i>Cumulative harmonic ordering</i>	b > a; c > d	b > a; c > d	 b > a > c > d

Note that the preference relations expressed by →PRECOR are exactly opposite to those expressed by →IDENT[ant]-CC. As a result, the orderings stated by the latter (a > b and c > d) are both overridden, and therefore fail to carry over into the cumulative ordering. From →PRECOR alone it is clear that the winner must be either (6b) or the reverse-harmonized candidate (6c). But the harmony constraint →IDENT[ant]-CC is not able to discriminate between these two, since it can only compare candidates that *differ only in the C₁ member* of a C₁←C₂ correspondence mapping but are otherwise exactly identical (see 4.3.1 above). The decision between (6b) and (6c) thus falls to IDENT[ant]-IO; since (6b) is more faithful, it emerges as the optimal output candidate.

The tableau in (7) shows that a [-ant] specification arising from the precoronal effect will in turn serve as a trigger of right-to-left sibilant harmony.

(7) Ineseño: Precoronal effect feeds sibilant harmony

/s-is-tiʔ/	→PRECOR	→IDENT[ant]-CC	IDENT[ant]-IO
a. s _i is _i tiʔ	(b > a)	(a > d)	
b. s _i iʃ _i tiʔ	(b > a)	(c > b)	*
c. ↗ ʃ _i iʃ _i tiʔ	(c > d)	(c > b)	**
d. ʃ _i is _i tiʔ	(c > d)	(a > d)	*
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	<u>c > b</u> ; <u>a > d</u>	a > {b, d} > c i.e. a > b; <u>a > d</u> ; <u>a > c</u> ; <u>b > c</u> ; d > c
<i>Cumulative harmonic ordering</i>	b > a; c > d	↗ c > b > a > d	(c > b > a > d)

Again, →PRECOR compares pairs of candidates that differ exclusively in the marked [+ant] vs. unmarked [-ant] sibilant distinction in a precoronal environment. Hence (7b) is preferred over (7a), since the two are otherwise identical, and likewise (7c) is preferred over the silly candidate (7d). At this point, the contenders for the status of optimal output are (7b) and (7c). These two candidates *are* comparable for the purposes of →IDENT[ant]-CC: both are absolutely identical except for the sibilant sequences [s_i...ʃ_i] vs. [ʃ_i...ʃ_i], and they differ in C₁ (the ‘receiving end’ of the asymmetric C₁←C₂ correspondence relation). The constraint prefers harmonic (7c) over disharmonic (7b), as well as the maximally-faithful (7a) over the silly candidate (7d). Combining this with the orderings expressed by top-ranked →PRECOR, the result is the cumulative ordering c > b > a > d. The optimal output is thus (7c), where harmony is fed by the precoronal effect.



A somewhat more complicated example which simultaneously displays both the override effect and the feeding relationship is shown in the tableau in (8), which accounts

for the derivation /s-ɨʃ-lu-sisin/ → [ʃiʃʃlusisin]. To keep things simple, the fourth sibilant is ignored in the output representations. The first three sibilants are related in two pairs of CC-corresponding sibilants, $S_i \dots S_i$ and $S_j \dots S_j$, as was done in the iterativity example (49) of section 4.3.1 above. In the candidate [s_iɨʃ_iʃ_jluʃ_jisin] (8a), the output [ʃ] is simultaneously the C₂ member of the pair [s_i...ʃ_i] as well as being the C₁ member of the pair [ʃ_j...s_j]. The harmony constraint →IDENT[ant]-CC potentially targets the C₁ member of *any* CC-corresponding sibilant pair. Thus, for example, the constraint compares candidate (8a) to both (8b) and (8c). In the comparison of (8a) vs. (8b) the relevant sibilant sequence is $S_j \dots S_j$ (that is, [ʃ_j...s_j] vs. [s_j...s_j]), whereas the relevant sequence is $S_i \dots S_i$ in comparing (8a) with (8c): [s_i...ʃ_i] vs. [ʃ_i...ʃ_i]. Hence the orderings $b > a$ and $c > a$.

Note that in the particular example in, the precoronal sibilant happens to be *underlyingly* [-ant] already (DualSubj /-ɨʃ-/). However, this has no bearing on the outcome of the derivation; the same output candidate would have won out even if the input had been /s-is-lu-sisin/ rather than the actual /s-ɨʃ-lu-sisin/.²

² This is because low-ranked IDENT[ant]-IO has hardly any effect at all on the choice of optimal output. From the orderings expressed by →PRECOR >> →IDENT[ant]-CC alone, it is clear that the winner will be either (8c) or (8d). Regardless of whether the input is /s-is-lu-sisin/ or /s-ɨʃ-lu-sisin/, (8d) would have one more IO faithfulness violation, and thus $c > d$ by IDENT[ant]-IO. In either case, (8c) stands out as the only candidate which is not dispreferred relative to some other candidate.

(8) Ineseño: Simultaneous blocking and feeding of sibilant harmony

/s-ɨʃ-lu-sisin/	→PRECOR	→IDENT[ant]-CC	IDENT[ant]-IO
a. s _i ɨʃ _{i,j} lus _j i...	(a > b)	(b > a; c > a)	
b. s _i is _{i,j} lus _j i...	(a > b)	(b > a)	*
c.  ʃ _i ɨʃ _{i,j} lus _j i...	N/A	(c > a)	*
d. ʃ _i ɨʃ _{i,j} luʃ _j i...	N/A	(d > e)	**
e. s _i ɨʃ _{i,j} luʃ _j i...	N/A	(d > e)	*
<i>Harmonic ordering by constraint</i>	<u>a > b</u>	b > a; <u>c > a</u> ; <u>d > e</u>	a > {b, c, e} > d i.e. <u>a > b</u> ; a > c; <u>a > e</u> ; a > d; <u>b > d</u> ; <u>c > d</u> ; e > d
<i>Cumulative harmonic ordering</i>	a > b	c > a > b; d > e	 c > a > b > d > e

Note that out of the five candidates considered here, only (8a) and (8b) are comparable for the purposes of →PRECOR; this is the only pair of candidates which is absolutely identical except for the precoronal sibilant targeted by this constraint. Of course, (8c) would be comparable to a bizarre hypothetical candidate [ʃ_iis_{i,j}lus_ji...] on this constraint—and similarly silly comparanda can be produced for (8d) and (8e) as well. But such outrageous candidates are simply ignored here, since they cannot possibly have any bearing on the eventual outcome. In sum, the only ordering contributed by →PRECOR is a > b.

The harmonic orderings expressed by →IDENT[ant]-CC are b > a, c > a and d > e. The first of these directly contradicts higher-ranked →PRECOR and is therefore overridden by it. As a result, the cumulative ordering yields c > a > b (since c > a by →IDENT[ant]-CC and a > b by →PRECOR), as well as d > e. The choice between (8c) and (8d) falls to

IDENT[ant]-IO; since the former is less unfaithful (violating IDENT[ant]-IO only in the initial sibilant), it is preferred, i.e. $c > d$. The winning output candidate is therefore (8c), in which the precoronal effect both blocks sibilant harmony (from the right) and feeds it (to the left). This is precisely the pattern found in Ineseño.

5.1.2. Harmony overrides contextual markedness

The Ineseño sibilant harmony case analyzed in the previous section provided an illustration of what happens when a contextual markedness constraint dominates \rightarrow IDENT[ant]-CC. In that situation, the result is that the phonotactics (e.g., ‘no [+ant] sibilants before /t, n, l/’) override the consonant harmony in cases of conflict, but otherwise feed harmony where possible. In descriptive terms, the segment arising from the markedness constraint can be characterized as ‘opaque’, in that it blocks the propagation of harmony from one direction but in turn initiates a new harmonic span in the other direction.

We now turn to another possible ranking, where \rightarrow IDENT[ant]-CC immediately dominates the contextual markedness constraint. This is shown schematically in (9); again, [X] and [Y] represent segments differing in the harmony feature [\pm F]. In (9a), there is generally a /X/ : /Y/ contrast in the language, neutralized in favor of [Y] in the environment A__B. In (9b), on the other hand, [X] and [Y] are generally in complementary distribution in the language.

(9) Harmony outranks (contextual) markedness—possible scenarios

- a. \rightarrow IDENT[F]-CC \gg *X / A__B \gg IDENT[F]-IO \gg *Y
- b. \rightarrow IDENT[F]-CC \gg *X / A__B \gg *Y \gg IDENT[F]-IO

In the scenario in (9a), harmony would override the contextual neutralization in A__B environments. Note that harmony can itself be seen as a case of contextual neutralization of

the /X/ vs. /Y/ contrast. Before a following /X/, the two are neutralized to [X] (/Y...X/ → [X...X], merging with /X...X/); before /Y/, they are neutralized to [Y] (/X...Y/ → [Y...Y], merging with /Y...Y/). What happens under the ranking in (9a) is that the /X/ : /Y/ contrast is normally neutralized to [Y] in the context A__B, *except* when harmony forces it to be neutralized to [X] instead: /AYB...X/ and /AXB...X/ merge as [AXB...X], even though [AXB] is otherwise banned in the language.

To illustrate this, let us imagine a language ‘Pseudo-Ineseño’, which is just like Ineseño except that the ranking is →IDENT[F]-CC >> →PRECOR >> IDENT[F]-IO, rather than →PRECOR >> →IDENT[F]-CC >> IDENT[F]-IO. A comparison between the two is shown in (10). Firstly, both show the effect of the markedness constraint →PRECOR in those cases where sibilant harmony is irrelevant (10a). Secondly, a sibilant which is [-ant] due to →PRECOR will trigger [-ant] harmony on any preceding sibilants (10b); in other words, the precoronal effect feeds harmony in both languages. The difference emerges in cases where there is a [+ant] sibilant to the right of the precoronal context. In Ineseño, as we saw above, the precoronal effect overrides harmony, resulting in blocking; in Pseudo-Ineseño, by contrast, harmony overrides the precoronal effect, progressing unimpeded from right to left (10c).

(10) Comparison of Ineseño with Pseudo-Ineseño (→IDENT[F]-CC >> →PRECOR)

	<i>Ineseño</i>		<i>Pseudo-Ineseño</i>
a. /s-tepuʔ/	ʃtepuʔ	=	ʃtepuʔ
/s-nit ^h oj/	ʃnit ^h oj	=	ʃnit ^h oj
b. /s-is-tiʔ/	ʃiʃtiʔi	=	ʃiʃtiʔi
c. /s-ti-jep-us/	ʃtijepus	≠	stijepus
/s-iʃ-lu-sisin/	ʃiʃlusisin	≠	sislusisin

No consonant harmony systems quite like the Pseudo-Ineseño one appear to be attested. However, there does exist a rather remarkable case where harmony overrides markedness in a very similar manner, but where the overall ranking is as in (9b) rather than (9a). This is the sibilant harmony found in Nkore-Kiga, a dialect complex belonging to the Lacustrine group of Bantu languages. The description presented here follows Hyman (1999b); the data are taken from the computerized version of Taylor's (1959) dictionary, as incorporated into the CBOLD database.³

In Nkore-Kiga, the sibilant fricatives [s] and [ʃ] are largely in complementary distribution, based on the quality of the following vowel; with some qualifications, the same thing can be said of [z] vs. [ʒ]. The distribution of the [+ant] and [-ant], shown in (11), is somewhat counterintuitive, in that the [-ant] sibilant is the default realization, with its [+ant] counterpart surfacing before the high front vowel /i/. In this respect, the distribution is the inverse of the more familiar pattern found, e.g., in Japanese ([ʃi] vs. [sa], [se], [so], etc.).

(11) Nkore-Kiga: Distribution of [s] vs. [ʃ] and [z] vs. [ʒ] by following vowel

si	ʃu	zi	ʒu
ʃe	ʒo	ze	ʒo
	ʃa		ʒa

The same complementary distribution of [+ant] and [-ant] sibilants is found in the closely related language Haya (cf. Byarushengo et al. 1977). In Haya and Nkore-Kiga alike, the distributional pattern in (11) is obscured by one fact: in certain contexts, the high front vowel drops out (or 'fuses' with the preceding sibilant) rendering the pattern opaque. In most cases, the culprit is the causative suffix /-i-/; for example, the causative counterpart of

³ For a recent study of various issues in Nkore phonology see Poletto (1998), although sibilant harmony phenomena are not addressed there.

Haya [ʃá:ʃa] ‘ache, hurt (intr.)’ is [ʃá:sa] = /Sá:S-ǰ-a/.⁴ This means that sequences such as [sa] do in fact occur on the surface, although they can generally be decomposed quite easily into /s-ǰ-a/. The relative distribution of [s] vs. [ʃ] is thus predictable, even though it would not qualify as *allophonic* in terms of structuralist phonemics. The following discussion will mostly avoid the complications involving causative /-ǰ-/, focusing instead on the near-allophonic distribution as depicted in (11).

What is special about Nkore-Kiga is that it has overlaid a system of right-to-left sibilant harmony on top of the Haya system. Sibilant harmony is found in a number of Bantu languages of the Lacustrine group, including Rwanda (Kimenyi 1979) and Rundi (Ntihirageza 1993), but the Nkore-Kiga system is rather unique. Generally speaking, all sibilants in a word will agree in [±anterior], with the rightmost sibilant determining the [±ant] value of all of them. In this respect, Nkore-Kiga is much like any other directional sibilant harmony system, but with one very important difference. The [±ant] value of the rightmost sibilant—the harmony trigger—is *not* underlyingly specified (as it is in Ineseño, etc.) but *predictable*, based on the quality of the following vowel (including /-ǰ-/, which may be invisible on the surface). Some examples illustrating this are shown in (12). The first column shows the underlying representation—using ‘S’ to indicate the absence of a /s:/ʃ/ contrast. The second column shows the expected surface form based on the complementary distribution in (12); the third column gives the actual form attested in Nkore-Kiga.

⁴ Since they are generally not contrastively specified for [±anterior], underlying sibilants in Haya and Nkore-Kiga are represented as /S, Z/ here and in the following discussion.

(12) Directional sibilant harmony in Nkore-Kiga

	<i>UR</i>	<i>Expected</i>	<i>Actual</i>	<i>Gloss</i>
a.	/-Se:S-ire/	*-ʃe:sire	-se:sire	‘pull down [house] (perf.)’
	/-Sa:S-ire/	*-ʃa:sire	-sa:sire	‘be in pain (perf.)’
	/-Sa:S-ɪ-a/	*-ʃa:sa	-sa:sa	‘give pain, hurt (tr.)’
b.	/-Si:S-a/	*-si:ʃa	-ʃi:ʃa	‘do wrong, sin’
	/-Sís-a/	*-síʃa	-ʃíʃa	‘compensate’
	/-SinZ-a/	*-sinʒa	-ʃinʒa	‘testify against’

Sibilant harmony, when combined with the [s]/[ʃ] phonotactics, gives rise to quite substantial alternations in the realization of morphemes. Thus, e.g., [-ʃa:ʃa] ‘be in pain’ vs. perfective [-sa:sire]; [-ʃíʃa] ‘compensate’ vs. [-sísire] (perf.); [-ʃinʒa] ‘testify against’ vs. [-sinzire] (perf.), and so forth.

In all of the cases cited in (12), the two sibilants are tautomorphic, cooccurring within the same root. This is by no means necessary; a suffix sibilant may trigger harmony in the preceding stem. For example, /gɛnd-es-erɛr-ɪ-a/ ‘cause to leave for (s.o.)’ is realized not as *[dʒɛndeʃɛrɛza] (/r+ɪ/ = [z]) but as [dʒɛndesɛrɛza].⁵ This further illustrates that Nkore-Kiga sibilant harmony is directional right-to-left harmony, just as the Ineseño harmony analyzed in sections 4.3.1 and 5.1.1 above.

In order to account for the complementary distribution of [+ant] and [-ant] sibilants, we need to appeal to a context-sensitive markedness constraint banning [+ant] sibilants before /i/. A possible formulation—again, defined as a *targeted* constraint—is given in (13).

⁵ Note that the root-initial /g/ becomes [dʒ] before the front vowel [e]. The affricates that arise through this general ‘palatalization’ process do not interact in any way with the sibilant harmony holding between fricatives in Nkore-Kiga.

(13) $\rightarrow\text{NO}[\text{j}i]$

Candidate x' is preferred over x ($x' > x$) iff x' is exactly like x except that at least one target [-anterior] sibilant in the environment [__i] has been replaced by its [+anterior] counterpart.

Given two candidates that are absolutely identical except that one has [si] where the other has [ji], $\rightarrow\text{NO}[\text{j}i]$ will prefer the former over the latter. It is important to note that $\rightarrow\text{NO}[\text{j}i]$ does *not* address the relative well-formedness of pairs of candidates which differ in *other* respects in addition to the [si] vs. [ji] distinction. For example, $\rightarrow\text{NO}[\text{j}i]$ will prefer [ʃasi] over [ʃaʃi], but it will *not* prefer [sasi] over [ʃaʃi], since these differ in the initial sibilant as well as the [si] vs. [ji] distinction targeted by the constraint. In fact, the constraint has nothing to say about the relative well-formedness of [sasi] and [ʃaʃi].

In order to have any effect, the constraint $\rightarrow\text{NO}[\text{j}i]$ must outrank a general (context-free) markedness constraint against [+ant] sibilants, referred to here simply as *[s].⁶ To account for the complementary distribution of [+ant] and [-ant] sibilants (rather than their neutralization to [-ant] before /i/), it must further be assumed that both $\rightarrow\text{NO}[\text{j}i]$ and *[s] dominate the faithfulness constraint IDENT[ant]-IO:

(14) Nkore-Kiga: Ranking required for complementary distribution of [s] vs. [ʃ]

$\rightarrow\text{NO}[\text{j}i] \gg *[s] \gg \text{IDENT}[\text{ant}]\text{-IO}$

The ‘superimposition’ of right-to-left sibilant harmony onto the distribution pattern generated by this ranking can be straightforwardly accounted for. All that is required is for $\rightarrow\text{IDENT}[\text{F}]\text{-CC}$ to dominate the entire ranking complex in (14). This is shown in the

⁶ Since [s] is generally assumed to be less marked than [ʃ], the relatively high ranking of *[s] may seem rather counterintuitive. (Note that it is necessary to assume that *[s] \gg *[ʃ]!) Nevertheless, unfortunate as it may be, something like this scenario seems to be required to account for the facts of Nkore-Kiga (as well as Haya, and possibly other related languages as well).

tableau in (15). As before, we gloss over the fact that the presence of a $C_1 \leftarrow C_2$ correspondence relation between the two sibilants is ultimately due to a high-ranked CORR-CC constraint. Since IDENT[ant]-IO is ranked too low to have any effect, it is omitted from the tableau. Note that /S/ in the input does not necessarily signify an underspecified sibilant; instead, it simply does not matter whether it is specified [+ant] or [-ant].

(15) Nkore-Kiga: Right-to-left sibilant harmony from [+ant] trigger

/-Se:S-ire/	\rightarrow ID[ant]-CC	\rightarrow NO[fi]	*[s]
a. - $f_i e: s_i$ ire	(b > a)	(a > c)	*
b. \rightarrow - $s_i e: s_i$ ire	(b > a)	(b > d)	**
c. - $f_i e: f_i$ ire	(c > d)	(a > c)	
d. - $s_i e: f_i$ ire	(c > d)	(b > d)	*
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	<u>a > c</u> ; <u>b > d</u>	c > {a, d} > b i.e. c > a; <u>c > d</u> ; c > b; <u>a > d</u> ; a > b
<i>Cumulative harmonic ordering</i>	b > a; c > d	\rightarrow b > a > c > d	(b > a > c > d)

In the above tableau, the constraints \rightarrow ID[ant]-CC and \rightarrow NO[fi] together determine the outcome. Low-ranked *[s] is unable to have any effect—indeed, the winning candidate (15b) is the one which does *worst* on that constraint. Note that \rightarrow ID[ant]-CC and \rightarrow NO[fi] do not contradict each other in any way, in that they do not express contradictory preference relations. Combining the orderings b > a and c > d, stated by \rightarrow ID[ant]-CC, with the ordering a > c expressed by \rightarrow NO[fi] (as well as the redundant b > d), we get the cumulative ordering

$b > a > c > d$. The optimal output is thus (15b), the candidate where the markedness constraint $\rightarrow\text{NO}[\text{fj}]$ ‘feeds’ right-to-left sibilant harmony.

The tableau in (16) shows the opposite scenario, where the phonotactics would predict a $[\text{+ant}] \dots [\text{-ant}]$ sequence. In this case $\rightarrow\text{ID}[\text{ant}]\text{-CC}$ and $\rightarrow\text{NO}[\text{fj}]$ do *not* exhaustively determine the cumulative harmonic ordering (and in part contradict each other). As a result, lower-ranked $*[\text{s}]$ is able to contribute preference relations that crucially determine the optimal output.

(16) Nkore-Kiga: Right-to-left sibilant harmony from $[\text{-ant}]$ trigger

$/\text{-Si:S-a}/$	$\rightarrow\text{ID}[\text{ant}]\text{-CC}$	$\rightarrow\text{NO}[\text{fj}]$	$*[\text{s}]$
a. $-\text{f}_i\text{i}:\text{s}_i\text{a}$	$(b > a)$	$(b > a)$	*
b. $-\text{s}_i\text{i}:\text{s}_i\text{a}$	$(b > a)$	$(b > a)$	**
c. $\rightarrow -\text{f}_i\text{i}:\text{f}_i\text{a}$	$(c > d)$	$(d > c)$	
d. $-\text{s}_i\text{i}:\text{f}_i\text{a}$	$(c > d)$	$(d > c)$	*
<i>Harmonic ordering by constraint</i>	$\underline{b} > a; \underline{c} > d$	$\underline{b} > a; d > c$	$c > \{a, d\} > b$ <i>i.e.</i> $\underline{c} > a; \underline{c} > d; \underline{c} > b;$ $\underline{a} > d; a > b$
<i>Cumulative harmonic ordering</i>	$b > a; c > d$	$b > a; c > d$	$\rightarrow \mathbf{c} > b > a > d$

Since $\rightarrow\text{NO}[\text{fj}]$ does not contribute anything over and beyond what $\rightarrow\text{ID}[\text{ant}]\text{-CC}$ already does, the cumulative ordering based on these two constraints alone is simply $b > a$ plus $c > d$. This means that the winner is going to be either the ‘reverse-harmonized’ (16b) or the correct (16c) with right-to-left harmony. The rival (16b) loses out on $*[\text{s}]$ (specifically, $c >$

b); the cumulative harmonic ordering that emerges is $c > b > a > d$, and (16c) is the optimal output, as desired.

Interestingly, the correct outcome crucially depends on the construal of the contextual markedness constraint $\rightarrow\text{NO}[\text{f}i]$ as a targeted constraint.⁷ The tableau in (17) shows what were to happen if $\rightarrow\text{NO}[\text{f}i]$ were substituted by a *non*-targeted constraint, referred to here as $*[\text{f}i]$.

(17) Nkore-Kiga: Incorrect result with non-targeted $*[\text{f}i]$

/-Si:S-a/	$\rightarrow\text{IDENT}[\text{ant}]\text{-CC}$	$*[\text{f}i]$	$*[\text{s}]$
a. $-\text{f}i:\text{s}_i\text{a}$	$(b > a)$	*	*
b. ! \rightarrow $-\text{s}_i:\text{s}_i\text{a}$	$(b > a)$		**
c. $-\text{f}i:\text{f}_i\text{a}$	$(c > d)$	*	
d. $-\text{s}_i:\text{f}_i\text{a}$	$(c > d)$		*
<i>Harmonic ordering by constraint</i>	$\underline{b > a}; \underline{c > d}$	$\{b, d\} > \{a, c\}$ <i>i.e.</i> $\underline{b > a}; \underline{b > c};$ $\underline{d > a}; d > c$	$c > \{a, d\} > b$ <i>i.e.</i> $\underline{c > a}; \underline{c > d}; c > b;$ $a > d; a > b$
<i>Cumulative harmonic ordering</i>	$b > a; c > d$	$\rightarrow \mathbf{b > c > d > a}$	$(b > c > d > a)$

The crucial difference is that the non-targeted constraint $*[\text{f}i]$ *does* prefer (17b) over (17c), since the latter contains $[\text{f}i]$; the crucial ordering $b > c$ is highlighted in boldface in the tableau. Translated into harmonic ordering relations, $*[\text{f}i]$ states that *any* candidate which contains $[\text{f}]$ before $[\text{i}]$ is worse than *any* candidate which lacks this configuration. By

⁷ Thanks to Suzanne Gessner for pointing this out to me.

contrast, targeted $\rightarrow\text{NO}[\text{j}]$ states that *other things being equal*, a candidate with $[\text{j}]$ before $[\text{i}]$ is worse than one which lacks it (and has $[\text{s}]$ instead).⁸

The fundamental difference between the sibilant harmony systems of Ineseño and Nkore-Kiga can be summed up as follows. In Ineseño, phonotactic restrictions are able to override harmony, whereas in Nkore-Kiga, it is harmony which overrides phonotactics. What is so remarkable about the latter case is that it is those very same phonotactic constraints that create the sibilant distinctions upon which the harmony operates. But it is important to note that in Ineseño and Nkore-Kiga alike, the phonotactics *feed* harmony wherever applicable. In Ineseño, the manifestation of this is that the precoronal sibilant itself triggers $[-\text{ant}]$ harmony to its left. In Nkore-Kiga, phonotactics feed harmony in the sense that they determine the $[\pm\text{ant}]$ value of the rightmost sibilant—the only one that is ‘immune’ to harmony (by not being the C_1 member of any $C_1 \leftarrow C_2$ correspondence mapping).

5.1.3. Interleaving of contextual markedness with similarity hierarchy

In the preceding sections we have seen how the relative ranking of contextual markedness constraints with $\rightarrow\text{IDENT}[\text{F}]\text{-CC}$ can give rise to various override effects. In the analysis of the Ineseño and Nkore-Kiga scenarios, the presence of a $C_1 \leftarrow C_2$ correspondence mapping was ensured by the high ranking of the relevant CORR-CC constraints. In these cases, the undominated status of the CORR-CC constraints demanding correspondence between

⁸ It is interesting to note that the incorrect pattern derived by the ranking in (17) is closely analogous to that of *stem control* (see 4.3.2 above). In this case, harmony is ‘controlled’ not by that sibilant which belongs to the stem, but by that sibilant whose $[\pm\text{ant}]$ specification is derived by high-ranked $*[\text{j}]$. Any sibilant whose $[\pm\text{ant}]$ value is determined by lower-ranked $*[\text{s}]$ must yield to it, regardless of the linear order of the two. Thus $/\text{SaSi}/ \rightarrow [\text{sasi}]$ and $/\text{SiSa}/ \rightarrow [\text{sisa}]$ (but otherwise $[\text{sa}]$ in non-harmony contexts). The ranking $\rightarrow\text{IDENT}[\text{ant}]\text{-CC} \gg *[\text{j}] \gg *[\text{s}]$ is comparable to the ranking for stem-controlled harmony, i.e. $\rightarrow\text{IDENT}[\text{ant}]\text{-CC} \gg \text{IDENT}[\text{ant}]\text{-SA} \gg \text{IDENT}[\text{ant}]\text{-IO}$. In both cases, the two lower-ranked constraints are *non-targeted* constraints. Such bizarre systems as the one arising from (17) are entirely unattested in the cross-linguistic typology of consonant harmony systems, and are highly suspect in principle. Under the assumption that contextual markedness constraints are targeted constraints, the non-existence of systems of this kind is predicted, since they cannot be generated by any ranking permutation.

coccurring sibilants meant that we could in practice limit our candidate set to those candidates in which $C_1 \leftarrow C_2$ correspondence was present (i.e. $S_i \dots S_i$ rather than $S_i \dots S_j$). But what about the relative ranking of a markedness constraint and the CORR-CC constraints themselves? Is it possible for markedness to override consonant harmony not by overriding \rightarrow IDENT[F]-CC (as in Ineseño), but by overriding the very establishment of a correspondence relation between the two consonants? The answer is yes; an example of this type of override effect will be discussed and analyzed in this section.

Recall from section 4.2 that harmony results from the combined efforts of a CORR-CC constraint, enforcing a $C_1 \leftarrow C_2$ correspondence relation, and an \rightarrow IDENT[F]-CC constraint, requiring that C_1 agree with C_2 in feature [F]. As we saw in the analysis of Ngizim voicing harmony in section 4.2.3, both constraints need to be ranked high enough in order for harmony to take effect. If \rightarrow IDENT[F]-CC is ranked too low, then ‘unfaithful’ CC correspondence can arise (i.e. C_1 may *disagree* with C_2 in [F]). On the other hand, if the relevant CORR-CC constraint is ranked too low, then a $C_1 \leftarrow C_2$ correspondence mapping may not be established at all. In that case, C_1 will *not* be a correspondent of C_2 , and \rightarrow IDENT[F]-CC will be totally irrelevant.

In the case of Ngizim voicing harmony, the inertness of (voiced) sonorants was accounted for by the fact that CORR-[voi, son] (the constraint responsible for establishing correspondence between obstruents and sonorants) was dominated by IO faithfulness to [\pm voi]. Given an input sequence like /t...r/, it is then more important to preserve the input [-voi] specification of /t/ than it is to establish $C_1 \leftarrow C_2$ correspondence between (the output realizations of) /t/ and /r/. Since the harmony constraint \rightarrow IDENT[+voi]-CC is undominated, having $C_1 \leftarrow C_2$ correspondence would entail forcing [+voi] harmony: /t...r/ \rightarrow [d_i...r_i]. But due to the low ranking of CORR-[voi, son], the best alternative is instead to *sacrifice* $C_1 \leftarrow C_2$ correspondence altogether. This makes it possible to obey IO faithfulness (and without a $C_1 \leftarrow C_2$ relation to evaluate, \rightarrow IDENT[+voi]-CC will be entirely irrelevant). The optimal

output is then $[t_1 \dots r_j]$, without $C_1 \leftarrow C_2$ correspondence and, therefore, without harmony (see section 4.2.3 for the relevant tableaux).

In the Ngizim case, the antagonistic constraint—i.e. the one which needs to be dominated by both \rightarrow IDENT[F]-CC and CORR-CC in order for harmony to arise—is Input-Output faithfulness to the harmony feature, IDENT[F]-IO. But the antagonistic constraint may just as well be a markedness constraint. For harmony to apply, \rightarrow IDENT[F]-CC and CORR-CC both need to outrank *any* constraint that somehow mitigates against harmony. In section 5.1.1 above we saw how harmony is overridden when a markedness constraint dominates \rightarrow IDENT[F]-CC (without also dominating CORR-CC). This scenario is repeated in (18a). The exact same kind of override effect arises when a markedness constraint dominates CORR-CC (without also dominating \rightarrow IDENT[F]-CC), as shown in (18b).

(18) Markedness overriding harmony—two alternative scenarios:

- a. CORR-CC >> *X / A__B >> \rightarrow IDENT[F]-CC >> IDENT[F]-IO
- b. \rightarrow IDENT[F]-CC >> *X / A__B >> CORR-CC >> IDENT[F]-IO

In principle, the result is no different in the two cases in (18); harmony is simply prevented from applying where it would go against the higher-ranked markedness constraint (by producing [X] in the environment A__B). In practice, however, the domination of markedness over CORR-CC as in (18b) allows for an interesting difference. Recall that CORR-CC constraints form a hierarchy based on the relative similarity of the two consonants involved. It is then possible for a markedness constraint to dominate *part* of that hierarchy—the lower part—while itself being dominated by the higher portion of the hierarchy. A schematic example is shown in (19).

(19) Interleaving of markedness with similarity-based CORR-CC hierarchy:

- a. $\rightarrow\text{ID}[\text{F}]\text{-CC}, \text{CORR-}[\text{F}] \gg *X / \text{A_B} \gg \text{CORR-}[\text{F}, \text{G}] \gg \text{ID}[\text{F}]\text{-IO}$

The result here is that markedness overrides correspondence between consonants that differ in both [F] *and* [G]—and hence it overrides harmony in [F] between such consonants. But in the case of consonants that differ *only* in [F], the demand for correspondence is stronger than the markedness constraint. As a result, markedness blocks harmony between less similar segments, but not between more similar segments. As it turns out, there are attested cases of consonant harmony that have exactly this character. We shall now turn to one of them.

In the Nguni subgroup of the Bantu language family, some languages display a morpheme-internal laryngeal harmony, whereby (non-click) stops are required to agree in their laryngeal feature specifications (Hyman 1999a). For example, Khumalo (1987) states that in Zulu, cooccurring stops are either all aspirated, all fully voiced or all unspecified for laryngeal features.⁹ The harmony is illustrated by the verb stems in (20). Khumalo adds that ‘a very careful study of regular disyllabic roots in Zulu has revealed no counter-examples to consonant harmony’ (p. 26). Besides being a valid generalization over the native Zulu lexicon, the existence of laryngeal harmony is also corroborated by loanword phonology, as shown by forms such as the ones cited in (20d), where the rendering of English word-final /t/ is governed by harmony with a preceding stop.

⁹ Khumalo uses [+aspirated] for the aspirates, and [+depressed] for the fully voiced stops—owing to the role that the latter play as tonal depressors. The phonetic realization of the ‘unspecified’ stops varies depending on environment; they are realized as ejectives in some contexts and as (voiced) fricatives in other contexts. In the following discussion, the unspecified stops are represented as [p, t, k], but it should be kept in mind that this glosses over some of the phonetic detail.

(20) Laryngeal harmony in Zulu verb stems (Khumalo 1987)

a.	-peta	‘dig up’	(T...T)
	-tápa	‘collect (honey, etc.)’	(T...T)
b.	-k ^h et ^h a	‘to choose’	(T ^h ...T ^h)
	-p ^h át ^h a	‘to hold’	(T ^h ...T ^h)
c.	-guba	‘to dig’	(D...D)
d.	í-k ^h ô ^h o	‘court’ (< English <i>court</i>)	
	úm-bídi	‘conductor’ (< English <i>beat</i>)	

The Zulu cooccurrence pattern can be interpreted as agreement due to \rightarrow IDENT[Lar]-CC, where [Lar] may be construed either as the (feature-geometric) Laryngeal node dominating the relevant features, or as a feature class in the spirit of Padgett (1995b).

The agreement pattern in (20) is overridden by a phonotactic limitation on the distribution of velar stops. In Zulu, aspirated /k^h/ is restricted to root-initial position (Khumalo 1987:58). In the closely related language Ndebele, the exact same laryngeal harmony obtains as in Zulu, along with the same restriction against non-initial /k^h/.¹⁰ Hyman (1999a) ran a computerized search of /C₁VC₂.../ verb stems in the CBOLD database version of Pelling’s (1971) Ndebele dictionary. Setting aside non-initial velars for the moment, Hyman found that out of 172 verb stems where both C₁ and C₂ are (non-click) stops, only 3 violate the harmony pattern (of which 2 share the same root, with /k^h...d/; the third exceptional stem has /d...p^h/).

When C₂ is velar, the markedness constraint against non-initial /k^h/ clearly overrides the demand for harmony. The verb-stem search revealed no examples of harmonic /p^h...k^h/ or /t^h...k^h/; instead we consistently find /p^h...k/, /t^h...k/, as (21) illustrates.

¹⁰ See the detailed discussion in 2.4.7 above for some additional complications of the harmony pattern, especially as regards the participation of /g/. The discussion below will focus on the restriction against /k^h/ and its interaction with harmony, and ignore the issue of how to deal with the behavior of /g/.

(21) Ndebele: Markedness overrides harmony (CBOLD version of Pelling 1971)

- p^hek-a ‘cook, brew’
-p^hik-a ‘argue, deny’
-t^huk-a ‘abuse, curse’

In the examples in (21), C₁ is either labial or coronal, whereas C₂ is velar; the two stops are thus heterorganic, disagreeing in both place of articulation and (due to markedness) in laryngeal features. When C₁ is velar, however, harmony instead overrides markedness, giving rise to /k^h/ in the non-initial C₂ position.

(22) Ndebele: Harmony between homorganic stops overrides markedness

- k^hok^h-a ‘pull, draw out’
-k^huk^h-ul-a ‘sweep away’

Instead of disharmonic /k^h...k/—which would be expected, based on the evidence from the heterorganic stop sequences in (21) above—we consistently find fully harmonic /k^h...k^h/. In sum, the interaction of markedness and harmony in Ndebele is not as simple as in Ineseño or Nkore-Kiga. Markedness overrides laryngeal harmony between heterorganic stops, but is itself overridden by laryngeal harmony between homorganic stops.

In order to capture the Ndebele pattern, we must first posit a markedness constraint that is responsible for the general absence of [k^h] from non-root-initial position. It seems reasonable to assume that this pattern is *not* a matter of a context-sensitive markedness constraint (since ‘non-root-initial position’ is not a well-defined phonological context). Instead, we will assume that it is due to the *context-free* markedness constraint *[k^h]. This is dominated by a constraint enforcing positional faithfulness to [Lar] specifications in root-

initial position, referred to here as IDENT[Lar]-IO_{RTONS}. An underlying /k^h/ is thus prevented from surfacing intact *except* in root-initial position, where it is ‘protected’ by positional faithfulness.

There are two CORR-CC constraints that are relevant for Ndebele laryngeal harmony. The first of these is CORR-[Lar], which demands C₁←C₂ correspondence between two stops that differ *at most* in their laryngeal features. This covers all homorganic sequences, such as [p^h...b], [d...t], [k^h...k], [b...b], [t^h...t^h], etc. (note that sequences of identical stops are included as well). The second constraint is CORR-[Lar, Place], which demands a C₁←C₂ correspondence relation between two stops that differ at most in their laryngeal *and* place features. In addition to the homorganic sequences covered by CORR-[Lar], the constraint CORR-[Lar, Place] also encompasses heterorganic sequences like [p^h...t], [d...k], [k^h...b], [b...g], [t^h...k^h], and so on. The ranking between these two CORR-CC constraints is fixed, as part of the similarity hierarchy (see the discussion in 4.2.1.1 above), thus: CORR-[Lar] >> CORR-[Lar, Place]. The stop sequences referred to by CORR-[Lar] constitute a proper subset of those referred to by CORR-[Lar, Place].

As explained above, the ban on non-initial [k^h] results from the combination of positional faithfulness and (context-free) markedness: IDENT[Lar]-IO_{RTONS} >> *[k^h]. The latter takes the place of the markedness constraint *X / A__B in the interleaving schema of (19) above, resulting in the following ranking:

- (23) Interleaving of CORR-CC hierarchy and markedness in Ndebele laryngeal harmony:
 ... >> CORR-[Lar] >> ID[Lar]-IO_{RTONS} >> *[k^h, g] >> CORR-[Lar, Place] >> ...

The tableau in (24) shows how Ndebele laryngeal harmony applies in contexts where markedness is irrelevant. In the particular hypothetical example shown here, the stops are heterorganic, and the relevant CORR-CC constraint is thus CORR-[Lar, Place], rather than

higher-ranked CORR-[Lar] (the latter is omitted from this tableau). Given the hypothetical disharmonic input /-p^hed-a/, the optimal output is (24f) [-p^het^ha].

Note that the result of the ranking in (23) and (24) is in fact *left-to-right* harmony, issuing from the root-initial stop—the one protected by the positional faithfulness constraint ID[Lar]-IO_{RTONS}. In effect, this is entirely parallel to the phenomenon of stem control, as analyzed in 4.3.2 above. In a stem-controlled harmony system, left-to-right directionality can arise if C₁ is ‘protected’ by the special faithfulness constraint IDENT[F]-SA. Just as the ranking \rightarrow IDENT[F]-CC >> IDENT[F]-SA >> IDENT[F]-IO gives rise to left-to-right harmony under stem control, the ranking \rightarrow IDENT[F]-CC >> IDENT[F]-IO_{RTONS} >> IDENT[F]-IO produces left-to-right harmony under ‘root-onset control’, so to speak. Loanwords such as the ones in (20d) seem to confirm this pattern: the realization of C₂ depends on that of the root-initial C₁, rather than vice versa.

(24) Ndebele: Laryngeal harmony between heterorganic stops (markedness irrelevant)

/-p ^h ed-a/	→ID[Lar]-CC	ID[Lar]-IO _{RTONS}	*[k ^h]	CORR-[Lar, Place]	ID[Lar]-IO
a. -p ^h _i ed _i a	N/A			*	
b. -p ^h _i ed _i a	(d > b)				
c. -b _i ed _i a	N/A	*		*	*
d. -b _i ed _i a	(d > b)	*			*
e. -p ^h _i et ^h _i a	N/A			*	*
f. ↗ -p ^h _i et ^h _i a	N/A				*
<i>Harmonic ordering by constraint</i>	<u>d > b</u>	{a,b,e,f} > {c,d} <i>i.e.</i> <u>a > c</u> ; <u>a > d</u> ; <u>b > c</u> ; <u>b > d</u> ; <u>e > c</u> ; <u>e > d</u> ; <u>f > c</u> ; <u>f > d</u>	(none)	{b,d,f} > {a,c,e} <i>i.e.</i> <u>b > a</u> ; <u>b > c</u> ; <u>b > e</u> ; <u>d > a</u> ; <u>d > c</u> ; <u>d > e</u> ; <u>f > a</u> ; <u>f > c</u> ; <u>f > e</u>	{a,b} > {c,d,e,f} <i>i.e.</i> <u>a > c</u> ; <u>a > d</u> ; <u>a > e</u> ; <u>a > f</u> ; <u>b > c</u> ; <u>b > d</u> ; <u>b > e</u> ; <u>b > f</u>
<i>Cumulative harmonic ordering</i>	d > b	{a,e,f} > d > b > c	{a,e,f} > d > b > c	↗ f > {a,e} > d > b > c	(f > a > e > d > b > c)

Top-ranked →IDENT[Lar]-CC states that d > b (given C₁←C₂ correspondence, right-to-left harmony is better than disharmony). The positional constraint IDENT[Lar]-IO_{RTONS} prefers any candidate over (24c) and (24d). However, the ordering b > d is overridden by the higher-ranked constraint; what this constraint crucially contributes to the cumulative ordering is b > c on the one hand and {a, e, f} > d on the other. Combined with the already-established ordering d > b, this gives us {a, e, f} > d > b > c. (Note that all the other orderings stated by IDENT[Lar]-IO_{RTONS} hold by transitivity here, such as a > c, b > c, etc.) It

is thus clear at this point that the winner will be either (24a), (24e) or (24f). The decision between the three falls to CORR-[Lar, Place], which prefers (24f) over both of the other two ($f > a$ and $f > e$). Thus (24f) is the optimal output.

The next tableau shows how the markedness constraint $*[k^h]$ overrides harmony between heterorganic stops. An input like $/-p^h e k^h -a/$ surfaces as disharmonic $[-p^h e k a]$ rather than harmonic $[-p^h e k^h a]$ or $[-p e k a]$. To reduce cluttering, CORR-[Lar] is again omitted from the tableau.

(25) Ndebele: Markedness overrides harmony between heterorganic stops

$/-p^h e k^h -a/$	\rightarrow ID[Lar]-CC	ID[Lar]-IO _{RTONS}	$*[k^h]$	CORR-[Lar, Place]	ID[Lar]-IO
a. $-p^h_i e k^h_j a$	N/A		*	*	
b. $-p^h_i e k^h_i a$	N/A		*		
c. $\rightarrow -p^h_i e k_j a$	N/A			*	*
d. $-p^h_i e k_i a$	($f > d$)				*
e. $-p_i e k_j a$	N/A	*		*	**
f. $-p_i e k_i a$	($f > d$)	*			**
<i>Harmonic ordering by constraint</i>	$f > d$	$\{a,b,c,d\} > \{e,f\}$ <i>i.e.</i> $\underline{a} > \underline{e}; \underline{a} > \underline{f};$ $\underline{b} > \underline{e}; \underline{b} > \underline{f};$ $\underline{c} > \underline{e}; \underline{c} > \underline{f};$ $\underline{d} > \underline{e}; \underline{d} > \underline{f}$	$\{c,d,e,f\} > \{a,b\}$ <i>i.e.</i> $\underline{c} > \underline{a}; \underline{c} > \underline{b};$ $\underline{d} > \underline{a}; \underline{d} > \underline{b};$ $\underline{e} > \underline{a}; \underline{e} > \underline{b};$ $\underline{f} > \underline{a}; \underline{f} > \underline{b}$	$\{b,d,f\} > \{a,c,e\}$ <i>i.e.</i> $\underline{b} > \underline{a}; \underline{b} > \underline{c};$ $\underline{b} > \underline{e}; \underline{d} > \underline{a};$ $\underline{d} > \underline{c}; \underline{d} > \underline{e};$ $\underline{f} > \underline{a}; \underline{f} > \underline{c}; \underline{f} > \underline{e}$	$\{a,b\} > \{c,d\} > \{e,f\}$ <i>i.e.</i> $\underline{a} > \underline{c}; \underline{a} > \underline{d}; \underline{a} > \underline{e};$ $\underline{a} > \underline{f}; \underline{b} > \underline{c}; \underline{b} > \underline{d};$ $\underline{b} > \underline{e}; \underline{b} > \underline{f}; \underline{c} > \underline{e};$ $\underline{c} > \underline{f}; \underline{d} > \underline{e}; \underline{d} > \underline{f}$
<i>Cumulative harmonic ordering</i>	$f > d$	$\{a,b,c\} > f > d > e$	$\rightarrow c > \{a,b\} > f > d > e$	$(c > b > a > f > d > e)$	$(c > b > a > f > d > e)$

The top-ranked constraint \rightarrow IDENT[Lar]-CC prefers right-to-left-harmonized (25f) over the candidate (25d), where harmony has been sacrificed to uphold the ban against non-initial $[k^h]$; hence $f > d$. This ordering overrides root-initial faithfulness, IDENT[Lar]-IO_{RTONS} which would otherwise have preferred (25d) over (25f): $d > f$. What the latter constraint contributes to the cumulative ordering is then on the one hand $\{a, b, c\} > f$, and on the other hand $\{a, b, c, d\} > e$. When this is combined with the already-established $f > d$, we arrive at the cumulative ordering $\{a, b, c\} > f > d > e$. At this point it is thus clear that the optimal output will be either (25a), (25b) or (25c). The choice between the three falls to $*[k^h]$, which prefers (25c) over the other two; hence (25c) wins.¹¹

What is important to note is that the harmony-enforcing constraint \rightarrow IDENT[Lar]-CC is dependent on the presence of a $C_1 \leftarrow C_2$ correspondence relation ($'C_i \dots C_i'$); without such a correspondence mapping (i.e. $'C_i \dots C_j'$) this constraint is completely irrelevant. For this reason, it only prefers harmonic (25f) over disharmonic (25d), but has nothing whatsoever to say about the other disharmonic candidate, (25c), which lacks $C_1 \leftarrow C_2$ correspondence. Faithfulness to the root-initial consonant equally prefers left-to-right-harmonized (25a,b) *or* disharmonic (25c) over right-to-left-harmonized (25f)—and thus by transitivity also over (25d). Left-to-right harmony loses out on markedness, and disharmonic (25c) is able to emerge as the winner by virtue of *sacrificing* $C_1 \leftarrow C_2$ correspondence and thereby making the demand for harmony vacuous. The reason this is possible is that the relevant CORR-CC constraint, CORR-[Lar, Place] is ranked too low to have any effect.

The tableau in (26) shows what happens when the two stops are homorganic. In this case, the relevant CORR-CC constraint is not the low-ranked CORR-[Lar, Place] but instead

¹¹ The same winner, (25c), would also win if the input were disharmonic $/-p^h ek-a/$. This is because faithfulness to the [Lar] specifications of the root-internal stop (general IDENT[Lar]-IO) is ranked so low that it has no effect at all.

CORR-[Lar], which *dominates* both positional faithfulness and the markedness constraint *[k^h]. In this case, then, it is more important to have a C₁←C₂ correspondence mapping between the two stops than it is to uphold the phonotactic ban against non-initial [k^h]. The tableau shows that a disharmonic input /-k^hok-a/ is forced to harmonize to [-k^hok^ha] in violation of markedness.¹² Note that the lower-ranked constraint CORR-[Lar, Place] (ranked between *[k^h] and IDENT[Lar]-IO) is omitted to save space, since it is ranked too low to have any effect anyway.

¹² Note that *[k^h] is a context-free markedness constraint, so a root-initial [k^h] constitutes as much a violation of it as a root-internal [k^h]—hence (26a-b) violate the constraint once and (26c-d) twice. Candidates (26e-f) avoid violating *[k^h] altogether, but at the price of violating higher-ranked positional faithfulness to root-initial [Lar] specifications.

(26) Ndebele: Harmony between homorganic stops overrides markedness

/-k ^h ok-a/	→ID[Lar]-CC	CORR-[Lar]	ID[Lar]-IO _{RTONS}	*[k ^h]	ID[Lar]-IO
a. -k ^h _i ok _j a	N/A	*		*	
b. -k ^h _i ok _j a	(f > b)			*	
c. -k ^h _i ok ^h _j a	N/A	*		**	*
d. ☞ -k ^h _i ok ^h _i a	N/A			**	*
e. -k _i ok _j a	N/A	*	*		*
f. -k _i ok _j a	(f > b)		*		*
<i>Harmonic ordering by constraint</i>	f > b	{b,d,f} > {a,c,e} i.e. b > a; b > c; b > e; d > a; d > c; d > e; f > a; f > c; f > e	{a,b,c,d} > {e,f} i.e. a > e; a > f; b > e; b > f; c > e; c > f; d > e; d > f	{e,f} > {a,b} > {c,d} i.e. e > a; e > b; e > c; e > d; f > a; f > b; f > c; f > d; a > c; a > d; b > c; b > d	{a,b} > {c,d,e,f} i.e. a > c; a > d; a > e; a > f; b > c; b > d; b > e; b > f
<i>Cumulative harmonic ordering</i>	f > b	f > b > {a,c,e}; d > {a,c,e}	☞ d > f > b > {a,c} > e	(d > f > b > a > c > e)	(d > f > b > a > c > e)

Here the two top-ranked constraints, →IDENT[Lar]-CC and CORR-[Lar], do not conflict in the preference orderings they express. By the verdict of CORR-[Lar], (26b), (26d) and (26f) are preferred over any other candidate. Among these, →IDENT[Lar]-CC has already established that right-to-left-harmonized (26f) is better than disharmonic (26b). At this point, then, only (26f) and (26d) stand out as possible contenders for being chosen as optimal output. Candidate (26f) loses out over (26d) on positional faithfulness, IDENT[Lar]-IO_{RTONS}, and the optimal output is therefore (26d). In the case of homorganic stops, left-to-

right harmony is thus preferred over disharmony, even at the cost of violating the prohibition against [k^h] in non-root-initial position.

What the Ndebele case shows us is that phonotactics—enforced either by context-sensitive markedness or by context-free markedness combined with positional faithfulness—is able to override consonant harmony not by outranking the agreement constraint →IDENT[F]-CC but by outranking the relevant CORR-CC constraint instead. Given the fact that CORR-CC constraints are arranged in a fixed similarity hierarchy, we expect to find that markedness can override harmony between less similar consonants, while itself being overridden by harmony between more similar constraints. Laryngeal harmony in Ndebele confirms this prediction.¹³

5.2. Morpheme-internal harmony

In the discussion of directionality effects and their analysis in 4.3 above, the major distinction drawn was between morphology-sensitive harmony (obeying stem control) and morphology-insensitive harmony (obeying right-to-left directionality). This dichotomy determines the directionality of assimilation in heteromorphemic context, i.e. stem + suffix or prefix + stem. But what about morpheme-*internal* contexts, where there is no constituent structure and stem control is thus irrelevant? The prediction appears to be that morpheme-internal harmony should *always* follow right-to-left directionality. As noted in the

¹³ One issue which has not been addressed here is the fact that the disharmonic [k] appears to be *transparent*, at least in Zulu. In loanwords, the rendering of English word-final /t/ is governed by harmony *across* an intervening [k], cf. /-p^háket^he/ ‘packet’, /-bakêde/ ‘bucket’; otherwise the default realization is /t^h/, cf. /-máket^he/ ‘market’ (Khumalo 1987). In this respect, disharmonic [k] in Zulu is different from disharmonic [ʃ] in Ineseño; the latter is *opaque* in the sense that it initiates a new harmony span on its other side (see 5.1.1).

It is tempting to try to derive this difference from the type of markedness interaction involved. In Ineseño, CORR-CC is undominated, and all three sibilants in a S...ʃ...S sequence are thus forced to stand in correspondence with each other. In Zulu, by contrast, CORR-CC is ranked low enough that correspondence can be sacrificed, if need be. Hence T₁ and T₂ in a T...k...T sequence are able to correspond across the intervening [k], without either of them standing in a correspondence relation to that [k]. (The intervening [k] is thereby rendered just as irrelevant as other types of intervening material, such as vowels or sonorants.) How this is best accounted for in the formal analysis will be left as a topic of further investigation.

typological overview of chapter 2, a great number of consonant harmony systems are limited to root-internal contexts. It is therefore important to ask if this prediction is validated—and if not, what might be the explanation.

First of all, it should be noted that in many cases, the directionality of root-internal harmony is simply indeterminable. This is generally the case when the harmony is a *double-value* system, ‘spreading’ both [+F] and [-F]. When all we know is that $[\alpha F] \dots [\alpha F]$ sequences are allowed but $*[\alpha F] \dots [-\alpha F]$ ones are not, it is impossible to tell whether this is because a disharmonic input $/\alpha F \dots -\alpha F/$ would undergo left-to-right harmony to $[\alpha F] \dots [\alpha F]$ or right-to-left harmony to $[-\alpha F] \dots [-\alpha F]$.¹⁴ Most root-internal harmony systems are of this kind, and do therefore not bear on the issue of directionality effects in any way.

In *single-value* harmony systems, where only one of the two feature values is active, there is sometimes a possibility to detect directionality effects. We have already encountered one example of such a system: Ngizim obstruent voicing harmony. As was discussed in detail in the analysis of this consonant harmony system in section 4.2.3, it obeys right-to-left directionality: $[-\text{voi}] \dots [+ \text{voi}]$ sequences harmonize to $[+ \text{voi}] \dots [+ \text{voi}]$, whereas $[+ \text{voi}] \dots [-\text{voi}]$ surface intact rather than undergo harmony (e.g., $/k \dots z/ \rightarrow [g \dots z]$, but $/b \dots k/ \rightarrow [b \dots k]$, not $[p \dots k]$). Ngizim voicing harmony thus seems to fit the prediction stated above, that all morpheme-internal harmony follow the default right-to-left directionality.

¹⁴ Under left-to-right harmony, $/+F \dots -F/$ and $/+F \dots +F/$ merge as $[+F] \dots [+F]$ in the output, whereas $/-F \dots +F/$ and $/-F \dots -F/$ yield $[-F] \dots [-F]$. Under right-to-left harmony, the merger goes the other way, with $/-F \dots +F/$ and $/+F \dots +F/$ merging as $[+F] \dots [+F]$ in the output, whereas $/+F \dots -F/$ and $/-F \dots -F/$ both yield $[-F] \dots [-F]$. In either case, the outputs generated by the grammar are harmonic $[+F] \dots [+F]$ and $[-F] \dots [-F]$. Yet another possibility is an inherently non-directional *single-value* harmony system (i.e. a ‘dominant-recessive’ one). If [+F] is the active or ‘dominant’ value, the inputs $/+F \dots +F/$, $/+F \dots -F/$ and $/-F \dots +F/$ are all merged as $[+F] \dots [+F]$ in the output, whereas $/-F \dots -F/$ surfaces faithfully as $[-F] \dots [-F]$. (See below for a constraint ranking that would derive such a system.) In this system, too, there are only two possible outputs: $[+F] \dots [+F]$ and $[-F] \dots [-F]$. Other things being equal, it would be impossible to tell these three systems apart from the evidence of root-internal cooccurrence patterns alone.

But note that our *synchronic* evidence about the directionality of Ngizim harmony is merely that the possible output sequences are harmonic D...D, T...T and disharmonic D...T, whereas *T...D is not allowed. It would be equally possible in principle to account for this synchronic distribution by assuming *left-to-right [-voi] harmony* instead of right-to-left [+voi] harmony. In terms of Input-Output mappings, the difference between these two interpretations lies in whether a hypothetical input /T...D/ is assumed to merge with /D...D/ (as output [D...D]) or with /T...T/ (as output [T...T]). Since all we can see is the attested output forms, there is no synchronic evidence from within Ngizim that speaks for right-to-left [+voi] harmony rather than left-to-right [-voi] harmony. The evidence we *do* have is external to the synchronic sound patterns of Ngizim. On the one hand we can appeal to *historical-comparative* evidence, e.g., /gâazá/ ‘chicken’ corresponds to Hausa /kàazáa/, and /zèdù/ ‘six’ corresponds to Hausa /ʃídà/. Another kind of evidence is *typological-comparative*: other voicing harmony systems seem to involve [+voi] rather than [-voi] (e.g., Kera; see 2.4.7). On the basis of these types of external evidence, it seems reasonable to conclude that Ngizim voicing harmony does indeed display right-to-left directionality, as would be expected.

Sometimes synchronic language-internal evidence does exist, such as when the same directional asymmetry is observed in morpheme-internal and heteromorphemic contexts. As an example, consider stricture harmony in the Oceanic language Yabem (see 2.4.6). In this language, a prefixal /s/ assimilates to a homorganic stop ([t], [d] or [ʰd]) in the following stem.¹⁵ Some examples are shown in (27). The assimilation is here characterized as obligatory, following (Dempwolff 1939), but Ross (1995) notes that in present-day Yabem, stricture harmony is optional—presumably due to levelling of the [s] ~ [t] (etc.) alternations.¹⁶

¹⁵ Sources from different periods disagree on whether prenasalized [ʰd] triggers harmony, or only the plain stops [t], [d]. See section 2.4.6 for discussion of this issue.

¹⁶ The realization of harmonized /s/ as [t] or [d] is predictable from tone/voicing harmony, and is irrelevant here (see 3.3.2 for discussion). Note that the stem-initial stop has to be homorganic in order to trigger

(27) Stricture harmony in Yabem 3pl /se-/ prefix

a.	sé-líʔ	/se-líʔ/	‘see (3pl realis/irrealis)’	(Ross 1995)
b.	té-táŋ	/se-táŋ/	‘weep (3pl realis/irrealis)’	(Ross 1995)
	dè-dèŋ	/se-dèŋ/	‘move towards (3pl realis)’	(Ross 1995)
	té-dàgùʔ	/se-dàgùʔ/	‘follow (3pl realis)’	(Dempwolff 1939)

The apparent directionality here is right-to-left, but since it is also stem-to-affix, stem control might be involved. Furthermore, the harmony is a single-value system, with [-continuant] being the active value. A prefixal coronal stop, e.g. in the 1pl inclusive prefix /ta-/, will not harmonize to a stem-initial /s/ (/ta-sùŋ/ → [dàsùŋ] ‘we (incl.) push’, /ta-sèlèn/ → [tá-sèlèn] ‘we (incl.) wander’). In sum, the evidence from heteromorphemic contexts is that homorganic [+cont]...[-cont] sequences (/s...t/, /s...d/) undergo right-to-left stricture harmony to [+cont]...[+cont], whereas [-cont]...[+cont] sequences (/t...s/, /d...s/) surface intact, unaffected by harmony.

This is mirrored exactly by the static cooccurrence patterns found within roots. Native morphemes in the Yabem lexicon do not contain /s...t/ or /s...d/ sequences (Dempwolff 1939; Bradshaw 1979; Ross 1995). Non-homorganic fricative-stop sequences are allowed, just as they are in prefix + stem contexts (e.g., /sákíŋ/ ‘service’, /sàb^wàʔ/ ‘potsherd; spleen’). Taken by itself, the morpheme-internal cooccurrence restriction could be interpreted in either of two possible ways. A hypothetical input like /s...t/ does not surface intact, either because it undergoes right-to-left [-cont] harmony yielding [t...t], or because it undergoes left-to-right [+cont] harmony yielding [s...s]. This is the same indeterminacy we encountered in the Ngizim case just cited. But in Yabem we can appeal to the evidence from harmony in heteromorphemic contexts. The unattested morpheme-internal

stricture harmony. Roots with non-coronal stops, such as /gàb^wàʔ/ ‘untie’, do not induce harmony in the /se-/ prefix.

sequences /s...t/ and /s...d/ are the exact same ones that actively undergo right-to-left [-cont] harmony across a prefix-stem boundary, as in (27). Even though it is impossible to observe morpheme-internal harmony ‘in action’, as it were, the convergence of the morpheme-internal and heteromorphemic facts suggest that Yabem stricture harmony follows right-to-left directionality.¹⁷

Other types of synchronic language-internal evidence can often be brought to bear on the question of determining the directionality of morpheme-internal consonant harmony. For example, consonant harmony may be fed by alternations within the root. Where an independently motivated alternation would give rise to root-internal disharmony, we are in a position to observe directly how the disharmony is avoided—by right-to-left or left-to-right harmony. A case in point is the coronal harmony found in many Western Nilotic languages, as discussed in 2.3 and 2.4.1.2 above. In these languages, contrastively alveolar and dental consonants are not allowed to cooccur within roots, as illustrated by the Pāri forms in (28a). Consonants that are *redundantly* alveolar, such as /l/ and /r/, are free to cooccur with dentals and alveolars alike (28b). (In some related languages, such as Alur and Dholuo, /n/ is redundantly alveolar as well, and also neutral with respect to coronal harmony.)

(28) Root-internal coronal harmony in Pāri (Andersen 1988)

a. Well-formed roots with multiple coronals

t̪ùŋ̪	‘male’
ŋ̪t̪	‘sucking’
ɖá:ŋ̪-é̃`	‘person (ergative)’
àtwá:t̪`	‘adult male elephant’
àdú:nd-ó̃`	‘heart’

¹⁷ It is precisely this kind of convergence that makes so-called canonical Bantu nasal consonant harmony systems (Bemba, Lamba, Yaka, etc.) problematic with respect to their directionality, as was discussed in 4.3.3 above (see also 3.1.3). Left-to-right directionality can easily arise in heteromorphemic contexts—through stem control—but in morpheme-internal contexts it is not to be expected, other things being equal.

b. Redundantly alveolar /l, r/ are neutral (no dental /ɺ, ɺ/ in inventory)

tɪɛl	‘legs’
-tɔ̀:l̥-ɪ̀	‘ropes’
rù:t	‘grind’
rwɺt̥	‘chief’

Based on the static cooccurrence patterns in (28a) alone, we have no obvious way of determining whether Pãri coronal harmony is inherently right-to-left (predicting /d...ɺ/ → [ɺ...ɺ]) or left-to-right (/d...ɺ/ → [d...n]). The crucial evidence comes from the interplay of coronal harmony with other phenomena in the grammar of Pãri. As was mentioned in 2.3 and 2.4.1.2 above, Western Nilotic languages make extensive use of root-final consonant alternations in their derivational and inflectional morphology (see, e.g., Andersen 1988, 1999; Tucker 1994; Reh 1996). The alternations that are most directly relevant involve changing a root-final /l/ to either /t/ or /nd/, and vowel-final roots adding final /n(:)/. In contexts where coronal harmony is irrelevant, the ‘derived’ root-final consonants are consistently alveolar, not dental, e.g., /bò:t-â/ ‘my handles’ from /bò:l-/ or /á-gò:nd-é/ ‘they scratched it’ from /gò:l-/. But in those cases where this root-final alternation would be expected to yield a disharmonic dental...alveolar sequence, coronal harmony prevails. The root-final alveolar yields to the root-initial dental, resulting in a dental...dental sequence instead. This is shown in (29).

(29) Pãri: Root-final consonant alternations feed coronal harmony (Andersen 1988)

<i>Unpossessed</i>	<i>Possessed (1Sg)</i>	
dè:l	dè:nd-á	‘skin’ vs. ‘my skin’
tùol	túond-à	‘snake’ vs. ‘my snake’
tà-à	tà:n:-á	‘pancreas’ vs. ‘my pancreas’
ùtó`-ó	ùtó:n`-á	‘fox’ vs. ‘my fox’

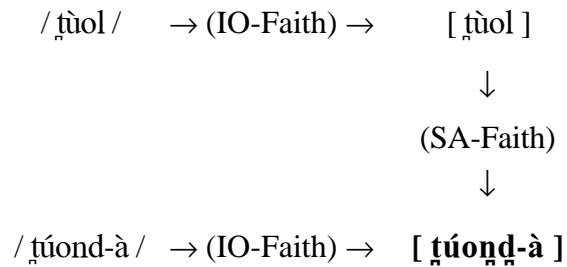
Somewhat unexpectedly, root-internal coronal harmony in Pãri thus seems to obey *left-to-right* directionality, since it is the root-final consonant that yields to the root-initial one. Interestingly, the opposite directionality is found in the related language Shilluk (Gilley 1992). In Shilluk, as in Pãri, dental vs. alveolar stops and nasals are not allowed to cooccur root-internally (/t̪n̪/ ‘small’, /t̪n̪/ ‘today’, where underlining indicates [+ATR]). But unlike the Pãri situation in (29), it is the root-initial dental that yields to a derived root-final alveolar. Thus the Shilluk verb root /t̪al/ ‘cook (trans.)’ is realized as /t̪at/ in the antipassive and /t̪ā:d-ā/ in the instrumental (not */t̪at/ and */t̪ā:d-ā/, respectively). Unlike its Pãri counterpart, then, Shilluk coronal harmony does show the expected right-to-left directionality.

How can we account for the left-to-right directionality in Pãri? Interestingly, it turns out that stem control could be invoked here after all, in spite of the fact that the consonants in question are tautomorphemic.¹⁸ Take as an example the pair /tùol/ ‘snake’ vs. /túond-à/ ‘my snake’ in (29) above. The possessed form should be */túond-à/, were it not for coronal harmony. Unlike the root-final alveolar /nd/, which is morphologically *derived* and only shows up in certain forms, the root-initial dental /t̪/ is constant across all surface realizations of this root in the paradigm, including the basic (underlying) form /tùol/. If the output form

¹⁸ Of potential relevance is the fact that the root-final /t/, /n/, /nd/ that show up under the consonant alternations in (29) are almost certainly independent suffixes *historically* (see, e.g., Hall & Hall 1996 on antipassive formation with /-t/).



of /t̥ùol/ ‘snake’ is construed as the base of derivation for the possessed form ‘my snake’, we can map the orthogonal dimensions of IO and SA faithfulness as in (30).

(30) Päri: Orthogonal dimensions of faithfulness



Let us assume that the [t̥] of the derived output form [t̥úond-à] corresponds to the [t̥] of the base [t̥ùol] by SA-correspondence, but that the nasal+stop cluster [nd̥] does *not* correspond to the [l] of the base in this way. In that case, the dentality of the root-initial /t̥/ is protected by the SA faithfulness constraint IDENT[distr]-SA as well as by IO faithfulness, IDENT[distr]-IO. The alveolarity of the derived root-final /nd̥/, on the other hand, is subject only to IO faithfulness, not to SA faithfulness. The ranking for stem control, \rightarrow IDENT[F]-CC >> IDENT[F]-SA >> IDENT[F]-IO, will then produce the right result, as shown in the tableau in (31). The top-ranked harmony constraint \rightarrow IDENT[F]-CC prefers right-to-left harmony (31b) over disharmony (31a), i.e. b > a. But faithfulness to [\pm distributed] specifications present in the (output) stem of derivation, [t̥ùol], prefer left-to-right harmony (31c) over right-to-left harmony (31b). As a result, left-to-right harmony from the root-initial consonant emerges as the optimal strategy, with [t̥úond-à] as the winning output candidate.

(31) Päri: Stem-controlled coronal harmony

Input: /tʰúond-/ Stem: [tʰúol-]	→IDENT[distr]-CC	IDENT[distr]-SA	IDENT[distr]-IO
a. tʰjúondj-	(b > a)		
b. tʰjúondj-	(b > a)	*	*
c.  tʰjúondj-	(c > d)		*
d. tʰjúondj-	(c > d)	*	**
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	{a, c} > {b, d} <i>i.e.</i> a > b; <u>a > d</u> ; c > b; <u>c > d</u>	a > {b, c} > d <i>i.e.</i> a > b; a > c; <u>a > d</u> ; <u>b > d</u> ; <u>c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	 c > b > a > d	(c > b > a > d)

An alternative possibility is to appeal to *positional* faithfulness instead of SA faithfulness. On this interpretation, root-initial position is privileged and it is more important to preserve underlying feature specifications in this position than elsewhere. If Päri coronal harmony were interpreted in this way, then [tʰjúond-à] wins out over its rival *[tʰúond-à] not because the latter violates SA faithfulness to the output base [tʰúol], but because it violates *positional* faithfulness to the root-initial consonant /tʰ/. This would result in a tableau exactly identical to that in (31)—violation marks, harmonic orderings and all—but with the positional faithfulness constraint IDENT[distr]-IO_{RTONS} substituting the SA faithfulness constraint IDENT[distr]-SA.

In fact, we have already encountered an example of morpheme-internal harmony under this type of ‘root-onset control’: the laryngeal harmony in Zulu and Ndebele, as discussed and analyzed in 5.1.3 above. In these languages, left-to-right harmony from the root-

initial stop emerged from the ranking $\rightarrow\text{IDENT}[\text{Lar}]\text{-CC} \gg \text{IDENT}[\text{Lar}]\text{-IO}_{\text{RTONS}} \gg \text{IDENT}[\text{Lar}]\text{-IO}$. It would be quite possible to extend the same analysis to the case of Pări coronal harmony. The stem control analysis, though a viable alternative for Pări, can *not* in the same way be extended to Ndebele and Zulu.

There are other cases of left-to-right harmony within roots which can be captured by appealing to root-initial positional faithfulness in the way outlined here. In Tlachichilco Tepehua (Watters 1988), dorsal consonant harmony—whereby velar and uvular stops assimilate to each other—normally applies in a right-to-left fashion, from stem to prefix, as described in 2.4.2 above. Root-internally, however, harmony also interacts in interesting ways with a phonotactic requirement that coda stops or nasals (i.e. non-continuants) must be dorsal. An underlying /p/ will surface as [p] in onset position but [^wk] in coda position; similarly, /t/ is realized as onset [t] or coda [k]. As was briefly mentioned in 2.4.2 (see also 3.1.3), this process of coda dorsalization feeds dorsal consonant harmony. An underlying root with the structure /-qVt-/ will surface as [-qV.t-] when the root-final consonant is syllabified as an onset, as expected. When it is syllabified as a coda, dorsalization would be expected to yield *[-qVk-], were it not for dorsal consonant harmony. Instead we find [-qVq-]. The directionality of harmony is thus left-to-right: the root-final stop yields to the root-initial one. This is illustrated by the tableau in (32). The undominated markedness constraint responsible for coda dorsalization is omitted from the tableau; all candidates under consideration obey it. The velar vs. uvular contrast is represented in terms of [$\pm\text{RTR}$], although the choice of feature has no bearing on the issue.

(32) Tlachichilco Tepehua: Dorsal consonant harmony with ‘root-onset control’

Input: /qVt-CV/	\rightarrow IDENT[RTR]-CC	IDENT[RTR]- IO _{RTONS}	IDENT[RTR]-IO
a. q _i Vk _i .CV	(b > a)		
b. k _i Vk _i .CV	(b > a)	*	*
c. \leftarrow q _i Vq _i .CV	(c > d)		*
d. k _i Vq _i .CV	(c > d)	*	**
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	{a, c} > {b, d} <i>i.e.</i> a > b; <u>a > d</u> ; c > b; <u>c > d</u>	a > {b, c} > d <i>i.e.</i> a > b; a > c; <u>a > d</u> ; <u>b > d</u> ; <u>c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	\leftarrow c > b > a > d	(c > b > a > d)

In general, the cases of morpheme-internal consonant harmony in the database surveyed in this work can be accounted for with the analytical machinery developed in this chapter. Inasmuch as their directionality can be determined at all, the majority of root-internal consonant harmony systems display the expected right-to-left directionality. The remaining ones, where left-to-right directionality is found instead, can all be accounted for by appealing to positional faithfulness in root-initial consonants, as in the Tlachichilco Tepehua example above or the Zulu/Ndebele case analyzed in section 5.1.3. The only problematic residue consists of the languages that constitute the ‘canonical’ cases of Bantu nasal consonant harmony, as was discussed extensively in 4.3.3 above.

In a small number of cases, there is tentative evidence that suggests that the harmony might in fact be *bidirectional*—a single-value or ‘dominant-recessive’ system where the active feature value triggers both right-to-left and left-to-right harmony. The evidence in

these cases is primarily *diachronic* rather than synchronic. (Note that in terms of the static patterns it generates, a system of this type is identical to a left-to-right or right-to-left double-value system: all three allow only [+F...+F] and [-F...-F].)

One example is Basque sibilant harmony, which prohibits apico-alveolar and lamino-alveolar sibilants from cooccurring within a morpheme (Hualde 1991; Trask 1997). When sibilant harmony applies in the domain of loanword adaptation, laminals tend to assimilate to apicals rather than vice versa, regardless of the order of the two—indicating that [+apical] is the active or ‘dominant’ value and [-apical] the ‘recessive’ one. The same asymmetry is found in cases where compounds are reanalyzed as single morphemes, and thus subjected to morpheme-internal sibilant harmony. Examples involving right-to-left assimilation are /fran(t)ʃeʃ/ ‘French’ < /fran(t)seʃ/ (from Spanish *francés*) and the reanalyzed compound /ʃinetʃi/ ‘believe’ < /sin-etʃi/ (cf. /sin/ ‘truth’, /(h)etʃi/ ‘consider’). Left-to-right directionality is observed in forms like /ʃatʃuri/ ‘mole’ (17th century; originally a compound */ʃat-suri/) and /ʃaʃoi(n)/ < */ʃasoi(n)/ from Spanish *sazón* (Michelena 1985).¹⁹

Another potential example, though far less clear, is liquid harmony in the Bantu language Bukusu. As described in 2.4.5 above, Bukusu liquid harmony results in a suffixal /l/ assimilating to an /r/ in the preceding stem, but it is also manifested root-internally as a static cooccurrence restriction. Bukusu /l/ and /r/ are generally the historical reflexes of Proto-Bantu *d and *t, respectively. The root-internal sequences *t...d and *d...t would be expected to yield /r...l/ and /l...r/ in Bukusu, were it not for liquid harmony. Interestingly, it appears that both /r...l/ and /l...r/ tend to get harmonized to /r...r/, which suggests that the [-lateral] feature value is ‘dominant’ and the harmony applies bidirectionally. Thus, for example, /-rare/ ‘iron/copper ore’ goes back to PB *tade, whereas /-reer-a/ ‘bring’ and

¹⁹ In some dialects, right-to-left directionality appears to prevail regardless of the feature value involved, e.g., */ʃasoi(n)/ > /sasoi/. Given the default status of right-to-left directionality in the analysis developed in this work, the existence of such systems is only to be expected.

/-roor-a/ ‘dream (v)’ go back to PB **deet-a* and **doot-a*, respectively. Root-internal /l...l/ sequences in Bukusu are virtually always reflexes of Proto-Bantu **d...d* rather than being the result of liquid harmony (e.g., /-lilo/ ‘fire’ < PB **dido*, /-lol-a/ ‘look at’ < Proto-Bantu **dod-a*). Nevertheless, the overall picture of root-internal liquid harmony in Bukusu is muddled by a great degree of variation, and it does therefore not constitute a very convincing case of bidirectional ‘dominant-recessive’ consonant harmony.²⁰

The analytical framework developed in this chapter actually does allow for the existence of bidirectional single-value consonant harmony, where the ‘recessive’ feature value yields to the ‘dominant’ one, regardless of which precedes which. But this is only possible under one major assumption: that IO faithfulness can be split up into value-specific versions of IDENT[F]. The necessary ranking is \rightarrow IDENT[F]-CC >> IDENT[α F]-IO >> IDENT[- α F]-CC, where the active value is [α F]. This is demonstrated by the schematic derivations below. In (33) we see how /-F...+F/ surfaces as [+F]...[+F]. The tableau in (34) shows how /+F...-F/ yields the very same output [+F]...[+F].

²⁰ For example, the verb stems just cited, /-reer-a/ and /-roor-a/, also have the non-harmonized variant forms /-leer-a/, /-loor-a/. Furthermore, the former even occurs as /-leel-a/, with left-to-right [+lat] harmony. It is unclear to what extent the observed variation is due to dialectal differences or the like.

(33) Bidirectional ‘dominant-recessive’ system—right-to-left [+F] harmony:

/-F...+F/	→IDENT[F]-CC	IDENT[+F]-IO	IDENT[-F]-IO
a. -F...+F	(b > a)		
b. ☞ +F...+F	(b > a)		*
c. -F...-F	(c > d)	*	
d. +F...-F	(c > d)	*	*
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	{a, b} > {c, d} <i>i.e.</i> <u>a > c</u> ; <u>a > d</u> ; <u>b > c</u> ; <u>b > d</u>	{a, c} > {b, d} <i>i.e.</i> a > b; <u>a > d</u> ; c > b; <u>c > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	☞ b > a > c > d	(b > a > c > d)

(34) Bidirectional ‘dominant-recessive’ system—left-to-right [+F] harmony:

/+F...-F/	→IDENT[F]-CC	IDENT[+F]-IO	IDENT[-F]-IO
a. +F...-F	(b > a)		
b. -F...-F	(b > a)	*	
c. ☞ +F...+F	(c > d)		*
d. -F...+F	(c > d)	*	*
<i>Harmonic ordering by constraint</i>	<u>b > a</u> ; <u>c > d</u>	{a, c} > {b, d} <i>i.e.</i> a > b; <u>a > d</u> ; <u>c > b</u> ; <u>c > d</u>	{a, b} > {c, d} <i>i.e.</i> a > c; <u>a > d</u> ; b > c; <u>b > d</u>
<i>Cumulative harmonic ordering</i>	b > a; c > d	☞ c > b > a > d	(c > b > a > d)

Whether constraint rankings such as the one in (33)-(34) should be allowed by the theory will be left as an open question. No genuinely ‘dominant-recessive’ consonant harmony systems exist, whereby, for example, a [-ant] sibilant induces harmony on any and all preceding and following [+ant] sibilants, regardless of whether it is found in an affix or in the stem. The ranking schema used in the above tableaux would yield such a non-existent system (unless impeded by high-ranked SA faithfulness). In spite of the fact that truly dominant-recessive consonant harmony systems are unattested, it is unclear whether they should be ruled out in principle. For example, dominant-recessive vowel harmony systems are quite rare, and appear to be limited to the feature [\pm ATR], a typological fact which has yet to be explained (see Baković 2000 for an OT analysis of such systems).

5.3. Outstanding issues

The analytical framework developed in this chapter is an attempt at providing a generalized analysis of consonant harmony, based on the idea that this phenomenon has its sources (diachronic and/or synchronic) in the domain of speech-production planning. The analysis has been tailored to capture the empirical-typological generalizations discussed in chapters 2 and 3. Nevertheless a number of unanswered questions remain, which will have to await further research. The main ones will be outlined in this section.

First of all, as was discussed in section 3.3 above, consonant harmony is never sensitive to stress or other metrical structure, and is never bounded by prosodic domains such as the foot. In this respect consonant harmony stands in sharp contrast both to vowel harmony and to ‘vowel-consonant harmony’ phenomena (nasal harmony, pharyngealization harmony, etc.), which are very frequently sensitive to prosodic structure. It is difficult to see how prosodically-bounded consonant harmony can be ruled out wholesale as a synchronic possibility (under any analysis, not merely the one developed here). For example, any kind

of prosodically-defined positional faithfulness will have the potential of influencing the directionality of consonant harmony, in the same way as high-ranked SA faithfulness can lead to stem control. We have already seen how *morphologically* defined positional faithfulness to root-initial segments can result in ‘root-onset control’. Shouldn’t ‘stressed-syllable control’ be equally possible, whereby consonant harmony emanates from the stressed syllable to unstressed ones? The absence of such systems is likely to have more to do with the (diachronic) sources of consonant harmony phenomena than what is or is not a synchronically possible phonological grammar.

Although consonant harmony is never bounded by prosodic domains, it is quite often limited to domains of a *morphological* nature. Frequently consonant harmony applies only within roots. Even when it does reach beyond the confines of the root, harmony is often limited to derivational affixes while leaving inflectional ones unaffected (e.g., dorsal harmony and sibilant harmony in Totonacan languages, nasal consonant harmony in Bantu languages).²¹ Consonant harmony thus tends to be a *lexical* phenomenon, in the pre-OT sense of Lexical Phonology (see, e.g., Kiparsky 1982, 1985; Kaisse & Shaw 1985; Mohanan 1986)—applying at earlier levels (including the root level), but not necessarily at later ones. There are no attested cases whatsoever of consonant harmony reaching beyond the domain of the morphological word, the way vowel harmony frequently does.²² Consonant harmony is thus never a *postlexical* phenomenon.

²¹ Not all of the suffixes that fall within the scope of nasal consonant harmony in Bantu can be comfortably categorized as derivational (e.g. the perfective suffix -ile, -idi, etc.). Nevertheless the suffixes as a set do seem to form an ‘inner’ domain along with the root, with prefixes attaching to this domain, rather than to the root as such.

²² Numerous vowel harmony systems include clitics in the harmony domain, which is then assumed to be defined as the clitic group. In some of the Cantabrian dialects of Spanish, most notably the Pasiago dialect, height and [ATR] harmony reaches proclitics, prepositions, etc. (Penny 1969ab, McCarthy 1984; Vago 1988; Hualde 1989). As another example, right-to-left [ATR] harmony in Karajá (Macro-Jê) can be triggered by enclitics, and even applies across a word boundary as long as the two words forms one phonological word, e.g. in possessive constructions like /wa-ritʃɔrɛ dʒ-u/ (1p-offspring REL-tooth) → [waritʃɔrɛ¹dʒu] ‘my child’s tooth’ (Ribeiro 2000).

In an output-oriented non-derivational framework such as Optimality Theory, it is not immediately clear how the limitation of consonant harmony to roots or derivational stems is best accounted for. One alternative is to appeal to the notion of cophonologies (see, e.g., Inkelas 1996, 1998, 1999; Inkelas & Orgun 1998; Inkelas et al. 1997; Orgun 1996, 1998; Yu 2000), whereby separate phonological grammars—with slightly different constraint rankings—can hold over different types of morphological constructions and domains.²³ For example, a given language might have $\rightarrow\text{IDENT}[\text{F}]\text{-CC} \gg \text{IO-FAITH}$ in the cophonology for roots—or the cophonology for derived stems (root + derivational affixes)—but the reverse ranking $\text{IO-FAITH} \gg \rightarrow\text{IDENT}[\text{F}]\text{-CC}$ in the ‘word-level’ cophonology. The empirical generalization is then that cross-linguistically, consonant harmony tends to be found in relatively ‘lexical’ or ‘internal’ cophonologies, i.e. those governing roots and/or derivational constructions rather than inflectional constructions or entire phonological words. This is interesting in that *vowel* harmony tends to gravitate in precisely the opposite direction. In vowel harmony systems, disharmony is often rampant within roots, and also in the phonological behavior of derivational morphemes. For example, in their overview of vowel harmony phenomena, van der Hulst & van de Weijer (1995:502) state that ‘inflectional affixes are usually more regular undergoers of harmony than derivational affixes’. This typological asymmetry between vowel harmony and consonant harmony can be added to those discussed in chapter 3. The lexical character of consonant harmony is likely to have something to do with its diachronic sources, the ways in which it is phonologized, and may well be tied to psycholinguistic issues of lexical storage and retrieval. This is most certainly an interesting topic of further investigation.

More importantly, there are certain aspects of consonant harmony which are more directly relevant to the analytical framework that has been developed here, and which may

²³ In this respect, cophonologies are equivalent to the ‘levels’ or ‘strata’ of Lexical Phonology, but without the assumption that these are intrinsically ordered relative to one another, cf. Inkelas & Orgun (1995, 1998).

not be adequately captured by it. A major issue is the role *contrast* plays in defining trigger-target pairs, as well as the relationship between contrast and *similarity*. In general, the set of consonants that interact in any given consonant harmony system consists of those who are contrastively specified for the feature in question. Segments that are redundantly specified for the feature are completely inert and transparent to the harmony. For example, sonorants never participate in voicing harmony (even though they are [+voiced]), nonsibilant coronals such as /t, d/ never participate in sibilant harmony (though they are [+anterior]), and so forth. In the analysis of Ngizim obstruent voicing harmony developed in 4.2.3 above, it was assumed that the inertness of sonorants was a matter of *similarity*. In effect, it was simply stipulated that any obstruent/sonorant pair, such as [d]/[r] or [b]/[m], was by definition less similar than any obstruent/obstruent pair, such as [k]/[z] or [d]/[f]. As such, the failure of sonorants to trigger voicing harmony was made to fall out from the similarity hierarchy of CORR-CC constraints: given that an obstruent/sonorant pair is less similar, the demand for a CC correspondence relation will be less stringent than in the case of an obstruent/obstruent pair.

This is a somewhat suspect stipulation. In general, the correlation between inertness to consonant harmony involving [F] and redundant specification for [F] is strikingly tight. For example, as was pointed out in the Ngizim analysis developed in section 4.2.3, implosives are also inert to voicing harmony. Just like the sonorants, these are predictably (and thus redundantly) [+voiced], and fail to interact with the harmony in any way. The analysis in 4.2.3 was forced to stipulate that this, too, was a matter of relative similarity. But it seems somewhat suspect to have to assume that the members of a homorganic pulmonic vs. implosive stop pair like [t]/[d] are *less* similar to each other than those of a heterorganic stop/fricative pair like [t]/[v]—the latter, unlike the former, will be subjected to voicing harmony).

The same can be said of various sibilant harmony systems, where entire sibilant series interact with each other, regardless of manner and laryngeal features, such as the [s, z, ts, dz, ts'] vs. [ʃ, ʒ, tʃ, dʒ, tʃ'] series of many Athapaskan languages. We may assume that the reason why [+anterior] stops like [t] are inert to sibilant harmony is that sibilants like [ts] and [tʃ] are more similar to each other than either is to [t]. But we need to go much further, and say that even [z] is more similar to [tʃ] than [t] is—since the former will trigger [tʃ] → [ts], but the latter will not. This seems counterintuitive, since [tʃ] and [z] differ in many more features than [tʃ] and [t]. Instead, the crucial factor seems to be that the feature specification is redundant in [t] but not in [z].

An especially striking case in point is the morpheme-internal laryngeal harmony found in the Ijoid languages (Jenewari 1989), where implosive and pulmonic voiced stops are not allowed to cooccur. Representative examples were briefly described in 2.4.7 above. In the language Izon (Bumo dialect), the stop inventory is as shown in (35), following the description in Efere (2001).

(35) Voiced stop inventory of Bumo Izon (Efere 2001)

<i>labial</i>	<i>coronal</i>	<i>velar</i>	<i>labial-velar</i>
b	d	g	
ɓ	ɗ		ɡɓ

Within morphemes, Bumo Izon does not allow implosive and pulmonic voiced stops to cooccur. Thus sequences like /b...b/, /b...d/ or /d...ɓ/ are allowed, but not */ɓ...b/, */d...ɓ/, */b...d/, and so forth, as illustrated in (36a-b). However, the laryngeal harmony restriction only applies to *contrastively* implosive and *contrastively* pulmonic stops. The velar stop /g/ is redundantly pulmonic (there is no implosive /g/ in the inventory), and is allowed to cooccur not only with the other pulmonic voiced stops /b, d/, but also with the implosives /ɓ,

d, \widehat{gb} /, as shown in (36c). Similarly, the doubly articulated labial-velar stop $/\widehat{gb}/$ is redundantly implosive (since the inventory lacks a pulmonic $/\widehat{gb}/$). This stop is likewise allowed to cooccur freely both with other implosives and with the pulmonic stops /b, d, g/, as in the forms in (36d).

(36) Bumo Izon: Laryngeal harmony sensitive to contrastiveness (data from Efere 2001)

- | | | |
|----|--|---------------------------------|
| a. | búbú | ‘rub (powder in face)’ |
| | bídé | ‘cloth’ |
| | búbai | ‘yesterday’ |
| | dó:dó: | ‘cold’ |
| | dábá | ‘swamp’ |
| b. | *b...d | *b...d |
| | *d...b | *d...b |
| c. | igódó | ‘padlock’ |
| | idégé | ‘type of fish’ |
| | dúgó | ‘to pursue’ |
| | búgí | ‘to wring (hand)’ |
| d. | \widehat{gb} ábú: | ‘crack! (of a stick breaking)’ |
| | \widehat{gb} írííbú: | ‘not well-cooked (e.g. of yam)’ |
| | \widehat{gb} ódag \widehat{gb} oda | ‘(rain) hard’ |

The direct role which contrastiveness appears to play in delimiting the set of interacting segments is indeed striking. It is hard to see how the inertness of velars and labial-velars in Bumo Izon laryngeal harmony can be explained away as a *similarity* effect except by ad hoc stipulation. If similarity were the relevant factor here, one might intuitively expect the exact

opposite effect: /b/ should be *less* similar to /d/ than /g/ is, since /b/ is (contrastively) *non-*implosive whereas /g/ carries no contrastive value for the implosive/pulmonic distinction.

It should be noted that there do exist proposals for objective similarity metrics in which contrastive vs. redundant specification plays a role. This is true of the so-called natural classes model of similarity, as developed by Frisch (1996) and Frisch et al. (1997). This model takes as its point of departure the notion of structured specification (Broe 1993), whereby a segment inventory is represented in terms of a hierarchy of natural classes. In this framework, redundancy is not encoded by way of (underlying) underspecification, but instead falls out from the hierarchical relationships between natural classes—and, by extension, between the features that define these classes. In the natural classes model, the similarity of two consonant is computed in a very simple manner, by comparing the number of *shared* natural classes and *non-shared* natural classes, using the following equation:

(37) Similarity metric in the natural classes model (Frisch 1996)

$$\textit{Similarity} = \frac{\textit{Shared natural classes}}{\textit{Shared natural classes} + \textit{Non - shared natural classes}}$$

Total identity is similarity 1.0 (since a segment shares all natural classes with itself). Natural classes are defined in terms of features and feature combinations—for example, [coronal] defines the class of all coronal, and [coronal, -sonorant] defines the (narrower) class of all coronal obstruents. Only *distinct* natural classes are counted. Contrastive features have a greater effect on similarity than redundant features, because adding a redundant feature does not result in a new natural class. Taking the Bumo Izon stop inventory as an example, [velar, -son, -cont, +voi] exhaustively defines the (singleton) set {g}. Adding [-constr.gl.] has no effect, since the extension of the feature description will still be the same: {g}. This is not the case with labials; [labial, -son, -cont, +voi] defines the set {b, ʙ}, whereas adding [-c.g.] results in another (singleton) natural class {b}. Both are classes which /b/ belongs to, and

both get counted when computing the similarity of /b/ to any other consonant. In the case of /g/, a single natural class gets counted as against these two because of the fact that [-c.g.] is redundant in /g/.

The natural classes model has proven extremely effective in accounting for both psycholinguistic and phonological data (Frisch 1996; Frisch et al. 1997; Frisch 2001; Frisch & Zawaydeh 2001), especially as regards speech errors as well as consonant co-occurrence restrictions in a wide range of languages. It is therefore worth pursuing the question to what extent this model and the similarity metric in (37) can be integrated with the formal-phonological account that has been developed here—or at the very least with some of the properties built into this account.

Nevertheless, it is clear that the similarity metric in (37) cannot by itself solve the problem outlined earlier, that of contrastiveness vs. redundancy as a determinant of participation or total inertness with respect to a given harmony process. Let us return to the cooccurrence restrictions holding over the Bumo Izon segments in (35)-(36). An analysis appealing to the similarity hierarchy of CORR-CC constraints has to assume that a pair like [d] vs. [g] is less similar than a pair like [d] vs. [b] (since the former two are allowed to cooccur but the latter two are not). But the similarity metric in (37) gives the exact opposite result. Precisely because of the fact that [g] is redundantly [-c.g.], the pair [d] vs. [g] is actually judged to be *more* similar than are [d] vs. [b]!²⁴ The same is true in sibilant harmony systems with inert [t, d]. Any reasonable similarity metric, including the one in (37), will judge a pair like [t] vs. [tʃ] to be more similar than [z] vs. [tʃ], contrary to what the CORR-CC analysis appears to require.

Given the independent merits of the natural classes model, and its success in other domains, it seems likely that the flaw is in the formulation of the similarity hierarchy as

²⁴ The fact that [b] is contrastively [-c.g.] means that it enters into a greater number of distinct natural classes—such as {b}, {b, ʙ} as against the lone {g}. To the extent that these classes are not shared with [d], they have the effect of reducing the similarity between [b] and [d] as compared to that between [g] and [d].

consisting of a fixed ranking of CORR-CC constraints. Furthermore, consider the fact that what is crucial in determining inertness vs. participation in a given harmony system is redundant vs. contrastive specification *in the harmony feature*. But in the analysis developed here—following Walker (2000ab, to appear)—the designation of the harmony-defining feature is a matter of separate constraints, IDENT[F]-CC. These are entirely independent constraints and have no connection whatsoever to the similarity hierarchy defined by the CORR-CC constraints. If a homorganic sonorant-stop pair like [r] vs. [t] is indeed judged to be less similar than a heterorganic fricative-stop pair like [z] vs. [k] by the phonology of Ngizim, then this is in principle completely unrelated to the fact that Ngizim also *happens* to have voicing harmony (driven by \rightarrow IDENT[+voi]-CC). The same similarity scaling should hold true if the language happened to have some other kind of consonant harmony instead.

It seems more reasonable to encode the contrast-sensitivity directly into the analysis, rather than have it be mediated by relative similarity in a highly stipulative manner. Furthermore it would be more logical to build this sensitivity into the harmony-enforcing constraints themselves (the IDENT[F]-CC constraints), since they are the ones that explicitly mention the feature whose contrastive vs. redundant nature is so important. How exactly this should be done is left to future research (but see below for a related proposal).²⁵

There are also more direct reasons for wanting to shift some of the work from the CORR-CC constraints over to the IDENT[F]-CC constraints—perhaps to the extent that the former can be done away with altogether. The crucial case is Nkore-Kiga sibilant harmony, where the full range of facts goes beyond what the analysis developed above is able to handle even in principle. In this case, the problem does not have to do with contrastiveness,

²⁵ To some extent, this would be similar to the procedure followed in the analysis of Arabic OCP-Place restrictions by Frisch et al. (1997). In that case, the sets corresponding to different values for [Place] were examined separately ([labial], [coronal] vs. [dorso-guttural]) and similarity values were computed for all pairs *within* each of those sets. For our purposes, one would need to pick out the set of all consonants that are contrastively [+F] or [-F], and then compute similarity values over that set. This would be the basis for true similarity effects, such as the distinct behavior of homorganic and heterorganic stop pairs in Ndebele laryngeal harmony (see 5.1.3) or the Place-sensitivity of the Ngbaka cooccurrence restrictions (see 4.1.3).

but with the very nature of scaling by relative similarity and proximity. When considered in detail, the Nkore-Kiga harmony system appears to require that this be handled not by the CORR-CC constraints but the IDENT[F]-CC constraints instead, by splitting these into an array of similarity-scaled (and proximity-scaled) versions of the same constraint.

As we saw in section 5.1.2 above, Nkore-Kiga has right-to-left sibilant harmony between [s, z] and [ʃ, ʒ], such that cooccurring sibilants are forced to agree in [\pm anterior], the rightmost one determining whether the feature value is [+ant] or [-ant]. This was analyzed as a double-value harmony system, encoded as such in terms of value-neutral \rightarrow IDENT[ant]-CC. This was something of an idealized picture of Nkore-Kiga sibilant harmony. This simplified state of affairs does obtain when the two sibilants agree in voicing ([s] vs. [ʃ]) and are in adjacent syllables—separated, in effect, by nothing more than a vowel—i.e. in the context ...S_iV.S_iV... In such contexts we do indeed find [ʃ...ʃ] and [s...s] instead of otherwise expected [s...ʃ] and [ʃ...s], respectively, just as described and illustrated in section 5.1.2.

However, when the sibilants disagree in voicing and/or are separated by a greater distance, the interaction is slightly different. The directionality is unchanged, proceeding from right to left, but here the sibilant harmony is a *single-value* system, with [-ant] being the active value and [+ant] the inactive one. In other words, [ʃ, ʒ] trigger harmony on a preceding [s, z], but the latter do *not* trigger harmony on a preceding [ʃ, ʒ] (or at least not obligatorily so). This is illustrated by the examples below. In the forms in (38a)—which all happen to be frozen causatives—the sibilants [ʃ] and [s] are not in adjacent syllables and harmony fails to apply. In (38b), the two sibilants are in adjacent syllables, but they differ in voicing, and harmony does not apply. All data are from Taylor's (1959) dictionary as incorporated into the CBOLD database.

(38) Nkore-Kiga: Sibilant harmony is single-value in certain contexts

a. No harmony in [ʃVCVs] sequences

-fomesa	/-Som-iS-ɿ-a/	‘teach’	(-foma ‘read’)
-fá:gisa	/-Sá:g-iS-ɿ-a/	‘make profit’	(-fá:ga ‘be plenty, left over’)
-fuŋgisa	/-Suŋg-iS-ɿ-a/	‘tease’	(-fuŋga ‘flatter’)
-fambisa	/-Samb-iS-ɿ-a/	‘go sour (of milk)’	(-famba ‘get dry; kick’) ²⁶

b. No harmony in [ʃV(n)Z] sequences

-fanzire	/-SanZ-ire/	‘spread out (perf.)’	(-fanɜ-a ‘spread out’)
-fá:zja	/-Sá:g-ɿ-a/	‘bully; leave over’	
aka-fúzi	/-SúZi/	‘bug’	
omw-ejezi	/-eSeZi/	‘cattle-waterer’	

Hyman (1999b) ran a search of the computerized CBOLD version of Taylor (1959), looking for cooccurrence patterns holding between sibilants in C₁ vs. C₂ position in stems, and also C₁ vs. C₃ position in the case of [s] vs. [ʃ]. The results were as reported in (39).

(39) Sibilant harmony patterns in Nkore-Kiga stems (Hyman 1999b)

a. C₁ vs. C₂ position—harmony between sibilants *agreeing* in voicing:

<i>Sequence</i>	<i>Count</i>	<i>Sequence</i>	<i>Count</i>
ʃ...ʃ	78	ɜ...ɜ	34
s...s	67	z...z	22
ʃ...s	0	ɜ...z	(2)
s...ʃ	0	z...ɜ	0

²⁶ The forms /omu-sambisi/ ‘sour milk’ and /-sámbisiriwa/ ‘be in a rage’, which are likely to be from this same root, do show harmony.

- b. C₁ vs. C₂ position—harmony between sibilants *disagreeing* in voicing:²⁷

<i>Sequence</i>	<i>Count</i>
ʃ...ʒ	40
s...z	14
ʃ...z	38 ← disharmony allowed
s...ʒ	0

- c. C₁ vs. C₃ position—long-distance sibilant harmony:

<i>Sequence</i>	<i>Count</i>
ʃ...ʃ	25
s...s	13
ʃ...s	13 ← disharmony allowed
s...ʃ	0

The difference between the sequences in (39a) vs. (39b) is one of relative similarity. In (39a) the trigger and target sibilants differ only in the harmony feature, whereas in (39b) they also differ in voicing. Just as this is a matter of relative *similarity*, the difference between the sequences in (39a) vs. (39c) is based on relative *proximity*. In (39a) we find that both [-ant] and [+ant] harmony is upheld, whereas only [-ant] harmony is enforced in (39b-c). This fits the general pattern—well established in the typology of consonant harmony systems—that the tendency for harmony grows weaker the less similar and/or more distant the two consonants are. The harmony pattern in (39a) is ‘stronger’ than that observed in (39b) or (39c). However, the particular way in which the similarity and proximity effects are manifested in Nkore-Kiga is interesting, and leads to an intractable problem for the analytical framework that has been developed in this chapter. What is

²⁷ Stems with a voiced sibilant as C₁ and a voiceless one as C₂ simply do not occur; hence the only combinations considered here consist of [s, ʃ] as C₁ and [z, ʒ] as C₂.

special about this case is that relative similarity and proximity is only relevant for [+ant] harmony, not for [-ant] harmony.

Right-to-left harmony in [-ant] applies regardless of similarity and proximity differences. Right-to-left harmony in [+ant], on the other hand, breaks down if the consonants in question are not similar enough or too far apart from each other, as in (39b-c). In principle, the analysis developed in this chapter does allow us to distinguish between [+ant] harmony and [-ant] harmony by positing two separate IDENT-CC constraints. The one responsible for enforcing [-ant] harmony is then \rightarrow IDENT[-ant]-CC, whereas \rightarrow IDENT[+ant]-CC is the constraint driving [+ant] harmony. Being two separate constraints, these can differ in their ranking, and thus [-ant] harmony and [+ant] harmony have the potential to behave in different ways. (For example, it is conceivable for a markedness constraint to block one but not the other.)

But this is not enough to capture the way [-ant] and [+ant] harmony differ from each other in Nkore-Kiga. Each of the two IDENT-CC constraints presupposes the existence of a CC correspondence relation ($C_1 \leftarrow C_2$) between two cooccurring sibilants. This relation is independently established by CORR-CC constraints, and it is *these* that are parametrized with respect to relative similarity and/or proximity. One such constraint is CORR-[ant, voi], which demands that any and all cooccurring sibilant pairs taken from the set /s, ʃ, z, ʒ/ (i.e. those differing at most in [\pm ant] and [\pm voi]) must stand in a $C_1 \leftarrow C_2$ correspondence relation. This applies as much to a sequence like /ʃ...z/ as it does to /s...ʒ/; in both cases, C_1 is a CC-correspondent of C_2 . It is impossible to establish CC-correspondence in the /s...ʒ/ case without also doing it in the /ʃ...z/ case—both are completely equivalent for the purposes of CORR-[ant, voi]. But in Nkore-Kiga, [-ant] harmony is enforced in /s...ʒ/ (\rightarrow [ʃ...ʒ]) whereas [+ant] harmony is *not* enforced in /ʃ...z/. The only conceivable way to

capture this would be to rank \rightarrow IDENT[-ant]-CC higher than its counterpart \rightarrow IDENT[+ant]-CC, and to have the latter be outranked by Input-Output faithfulness.²⁸

This leads us into an impasse, because the very same IDENT-CC constraints are responsible for *all* sibilant harmony, in all the contexts in (39a-c). In the situation in (39a), where the two sibilants are similar enough and close enough, [+ant] harmony *does* apply, which can only mean that \rightarrow IDENT[+ant]-CC is ranked *higher* than IO faithfulness. But if this is the case, then it should also force [+ant] harmony in the situation in (39b). The fact that [-ant] harmony does apply in (39b) clearly shows that sibilants differing in voicing *do* stand in a CC correspondence relation to one another. The exact same dilemma applies when we consider the lack of [-ant] harmony between [s] and [ʃ] at greater distances, as in (39c). The failure of [+ant] harmony there suggests low-ranked \rightarrow IDENT[+ant]-CC, but (39a) at the same time demands high-ranked \rightarrow IDENT[+ant]-CC.

The problem, again, appears to be that the CORR-CC constraints are too general to be useful. By dividing the effort of enforcing consonant harmony into two tasks—establishing a CC correspondence relation vs. demanding agreement in [αF] between CC-correspondents—we have *created* a problem which would otherwise not exist. The analysis assumes that it is only the CORR-CC constraints that are sensitive to similarity and/or proximity, not the \rightarrow IDENT[F]-CC constraints. A pair of consonants, [s] vs. [ʃ], are equally similar and equally distant in /sVCVʃ/ as they are in /ʃVCVs/. Hence there is either CC correspondence in both cases or in neither case. Since there is *some* harmony at this degree of distance and similarity (namely right-to-left [-ant] harmony), we must assume that CC correspondence holds, both in /sVCVʃ/ and in /ʃVCVs/. Of course, CC correspondence also holds in /sVʃ/ and /ʃVs/, where we find both [-ant] and [+ant] harmony. But the problem is that we

²⁸ In reality, it is not IO-Faith that is responsible for the [s, z] vs. [ʃ, ʒ] surface distinction in Nkore-Kiga (see 5.1.2 above), but instead the output markedness constraints \rightarrow NO[ʃi] >> *[s, z]. It is thus the relative ranking of \rightarrow IDENT[+ant]-CC and \rightarrow NO[ʃi] that is really at stake here. Since this rather unique aspect of Nkore-Kiga sibilant harmony is entirely orthogonal to the nature of the problem at hand, the argumentation follows the somewhat simplified assumption that the important ranking involves the \rightarrow IDENT[F]-CC constraints vs. IO faithfulness constraints.

somehow need to distinguish between CC correspondence at greater distances and that at closer distances (and analogously for differences in similarity). \rightarrow IDENT[-ant]-CC is not sensitive to this distinction (i.e. [-ant] harmony always holds), but \rightarrow IDENT[+ant]-CC is; the latter enforces [+ant] harmony *only* under the closer-and-more-similar kind of CC correspondence, but not under the CC correspondence which holds in SVCVS or SVZ contexts.

But notice that this is completely equivalent to abandoning CORR-CC constraints altogether as independent constructs—and, by extension, the very notion of CC correspondence. By conflating the similarity-scaling and proximity-scaling functions of CORR-CC constraints with the \rightarrow IDENT[F]-CC constraints themselves, the same goal can be achieved. Since we are no longer dealing with *correspondence*, IDENT is a somewhat inappropriate label. Directionality still needs to be built in, in order to account for the default nature of right-to-left harmony; this suggests that ANTICIPATE might be a suitable name. A tentative definition of such a constraint is given in (40). This definition also attempts to capture the role of *contrastivity* alluded to earlier in this section.²⁹

(40) \rightarrow ANTICIPATE[α F]

Let $C_1 \dots C_2$ be an output sequence of consonants. If C_2 is contrastively [α F], then C_1 must not be contrastively [- α F].

Candidate x' is preferred over candidate x ($x' > x$) iff x' is exactly like x except that at least one target consonant (i.e. C_1 that is [- α F]) has been replaced by its unmarked [α F] counterpart.

²⁹ It would be perfectly possible to separate this into an independent markedness statement (a ‘grounding condition’ of sorts), corresponding roughly to the first half of (40), and the targeted constraint proper, corresponding to the second half. This would bring (40) somewhat closer in line with the kind of definition Baković & Wilson (2000) give for their \rightarrow NO(+HI,-ATR) constraint in Wolof and Yoruba [ATR] harmony, for example.

This constraint takes over the function of CORR-CC and \rightarrow IDENT[α F]-CC. Just as the previous analysis captures similarity and proximity effects by scaling CORR-CC constraints hierarchically, the same can be done with \rightarrow ANTIC[α F] constraints. For example, we can split this constraint up into \rightarrow ANTIC[α F]_{C- μ -C} \gg \rightarrow ANTIC[α F]_{C- σ -C} \gg \rightarrow ANTIC[α F]_{C- ∞ -C} etc., to yield a proximity hierarchy. A similarity hierarchy can also be established in an analogous way.

This allows us a way out of the Nkore-Kiga dilemma. To account for the fact that in SVS contexts, both [-ant] and [+ant] harmony hold, whereas in SVCVS contexts only [-ant] harmony holds, all we need is to assume the following ranking:³⁰

(41) Constraint ranking for Nkore-Kiga proximity effect—revised model:

$$\left. \begin{array}{l} \rightarrow\text{ANTIC}[-\text{ant}]_{\text{C-}\mu\text{-C}} \gg \rightarrow\text{ANTIC}[-\text{ant}]_{\text{C-}\sigma\text{-C}} \\ \rightarrow\text{ANTIC}[+\text{ant}]_{\text{C-}\mu\text{-C}} \end{array} \right\} \gg \text{ID}[\text{ant}]\text{-IO} \gg \rightarrow\text{ANTIC}[+\text{ant}]_{\text{C-}\sigma\text{-C}}$$

The \rightarrow ANTICIPATE[-ant] constraints enforce right-to-left [-ant] harmony, /s...ʃ/ \rightarrow [ʃ...ʃ]. These dominate IO faithfulness to [\pm ant] specifications *regardless* of the distance between the sibilants involved. Hence /sVCVʃ/ \rightarrow [ʃVCVʃ], as in (39c), no less than /sVʃ/ \rightarrow [ʃVʃ] as in (39a). However, the same is not true of \rightarrow ANTICIPATE[+ant], the constraints which give rise to right-to-left [+ant] harmony. Here it is only the ‘C- μ -C’ version which dominates IO faithfulness, not the ‘C- σ -C’ version. This means that although [+ant] harmony applies in SVS contexts (/ʃVs/ \rightarrow [sVs]), it will *not* apply in SVCVS contexts; /ʃVCVs/ thus remains disharmonic, as in (39c).

Whether the alternative approach sketched here is a viable alternative to the CC correspondence approach remains to be seen. At this point, the only role played by CORR-CC constraints seems to be to give IDENT-CC constraints their *raison d’être*. The two types of

³⁰ Again, we are working with the somewhat simplified assumption that the antagonistic constraint is IO faithfulness (IDENT[ant]-IO), rather than the markedness constraint \rightarrow NO[ʃi] (see fn. 28 above).

constraints do not (and cannot) interact with each other in any crucial way, and they interact with other constraints in suspiciously similar ways. For example, both need to be high-ranked in order for harmony to happen; in order for a given constraint to block harmony, it needs to outrank either CORR-CC, IDENT-CC, or both.³¹ The division of labor between the two families constraints seems to buy us rather little. It might be objected that constraints of the type \rightarrow ANTICIPATE[F] are otherwise unmotivated, unlike IDENT[F] constraints. But the former are really nothing more than contextual markedness constraints, i.e. pure well-formedness constraints. What is more, CORR-CC constraints are themselves entirely stipulated, and are unlike any other constraint type previously proposed within Optimality Theory. In the case of other dimensions of correspondence, be it Input-Output, Base-Reduplicant or Stem-Affixed-form correspondence (or even the Syntagmatic correspondence of Krämer to appear), the correspondence relation is present by definition, not as a result of independently-ranked constraints that require its presence. In light of these considerations, and of the problems discussed above, it seems that the complete elimination of CC correspondence (and with it the family of CORR-CC constraints) is a path well worth pursuing.

³¹ Note that the ‘conflated’ analysis withm scaled \rightarrow ANTICIPATE[F] constraints is perfectly able to handle the Ndebele facts analyzed in &&. The claim made there, that harmony-blocking was a matter of markedness outranking CORR-CC rather than \rightarrow IDENT[F]-CC, was based on the *assumption* that it is CORR-CC constraints that are scaled by similarity, not \rightarrow IDENT[F]-CC constraints. It is precisely this assumption that has been called into question here.

CHAPTER 6
CONSONANT HARMONY AND SPEECH PLANNING:
EVIDENCE FROM PALATAL BIAS EFFECTS

One of the central claims made in this study is that consonant harmony is to be construed as *agreement* at-a-distance, rather than local *spreading* of features or articulatory gestures between root-adjacent segments.¹ Furthermore, it has been suggested that, as a synchronic phonological phenomenon, this kind of agreement has its roots (diachronic and/or synchronic) in the domain of speech planning—more specifically, phonological encoding for speech production. Under this view, consonant harmony processes are driven—or at the very least facilitated—by the relative similarity of the interacting segments; the more similar two cooccurring consonants are, the more likely it is that they will be forced to agree with one another in some particular feature. (A similar argument has been made for a wide range of phonological *dissimilation* phenomena by Frisch 1996, 2001; Frisch et al. 1997.) In a sense, then, the systematic consonant harmony effects that can be observed in many languages constitute the phonologized counterpart of on-line processing phenomena such as slips of the tongue.

This chapter reviews the evidence for the view that consonant harmony is intimately connected to the psycholinguistic domain of language processing. A number of parallels between consonant harmony processes and speech errors are discussed. The focus of the chapter is on one particular parallel of this kind, one which has not been documented previously in the literature on consonant harmony. This concerns the so-called ‘Palatal Bias’ effect, which has been robustly documented in psycholinguistic speech error studies: in phonological slips of the tongue, alveolar obstruents like /s/ or /t/ are far more frequently

¹ An earlier and much-condensed version of this chapter was presented as Hansson (2001).

replaced by ‘palatals’ like /ʃ/ or /tʃ/ than vice versa. As demonstrated in this chapter, the very same asymmetry clearly shapes the cross-linguistic typology of coronal harmony systems.

As supportive evidence for the agreement-based analysis of consonant harmony, the existence of Palatal Bias effects in coronal harmony systems is very important. One reason is that coronal harmony is by far the most commonly attested type of consonant harmony; indeed, coronal harmony (especially sibilant harmony) can be seen as the ‘canonical’ type of consonant harmony phenomena. More importantly, however, coronal harmony systems and their phonetic-phonological properties are the central piece of evidence adduced for the analysis of consonant harmony as articulatory-gesture spreading. Since the agreement-based analysis developed in chapters 4 and 5 is presented as an alternative to such spreading-based analyses, any evidence for the agreement-based analysis which directly involves *coronal* harmony in particular carries considerable weight. In addition to other parallelisms between speech errors and consonant harmony processes, the existence of Palatal Bias effects in both domains thus provides strong evidence for the view that consonant harmony is long-distance agreement, rooted in the domain of speech planning.

The chapter is organized as follows. Section 6.1 summarizes various types of evidence showing that consonant harmony processes share significant affinities with slips of the tongue. Section 6.2 introduces a further parallelism between consonant harmony and speech errors, the phenomenon referred to as the ‘Palatal Bias’, and discusses how it has been documented in speech error studies. Section 6.3 demonstrates how the Palatal Bias manifests itself in the cross-linguistic typology of sibilant harmony systems of the relevant kind. The same is shown in section 6.4 for those rare coronal harmony systems that involve a coronal stop vs. affricate contrast. The findings of this chapter are summarized in section 6.5.

6.1. Consonant harmony and speech errors—a review of the evidence

Elsewhere in this study several aspects of consonant harmony systems and their cross-linguistic typology have been described which are mirrored in the psycholinguistic domain of speech errors. The subsequent sections of this chapter discuss an especially striking parallel of this kind—the existence of ‘Palatal Bias’ effects in coronal harmony systems. Before introducing this particular phenomenon, this section will summarize the various aspects of consonant harmony which have already been described in previous chapters and which bear on the relationship between consonant harmony and slips of the tongue. These are: relative-similarity effects, directionality effects, and transparency of intervening segmental material. These three aspects of consonant harmony, and of speech errors, will here be discussed in turn, starting with similarity effects.

It is a well-documented fact that speech errors are highly sensitive to the relative similarity of the elements involved. Segments that share a large number of properties are far more likely to interact in slips of the tongue than are segments that have fewer properties in common (see, e.g., Nooteboom 1969; MacKay 1970; Fromkin 1971; Shattuck-Hufnagel & Klatt 1979; Frisch 1996). In neural network models of language production (e.g., Stemmerger 1985; Dell 1986), this effect falls out from spreading activation. When two cooccurring consonants share a large number of features, there is extensive overlap in the neurons activated for C_1 and C_2 . The greater the overlap, the greater the potential for interference effects between the two consonants.

As for consonant harmony phenomena, it is evident from the overview in chapter 2, as well as some of the cases analyzed in chapters 4 and 5, that similarity effects abound in the typology of consonant harmony systems. The interacting consonants are frequently required to agree in a particular feature (or set of features). In several cases, harmony between less similar consonants is restricted in ways that do not apply to harmony between more similar consonants. Note that it is similarity effects of precisely this type that origi-

nally motivated Walker's (2000ab) analysis of various laryngeal harmony and nasal consonant harmony phenomena as being due to agreement under correspondence rather than feature spreading. However, similarity effects are no less characteristic of *coronal* harmony—the phenomenon which is argued to involve spreading by Gafos (1996[1999]), Ní Chiosáin & Padgett (1997), and others. For example, sibilant harmony may be limited to fricative-fricative pairs and/or affricate-affricate pairs, without applying to fricative-affricate combinations (e.g., in Rwanda or Wanka Quechua). Furthermore, coronal harmony may be sensitive to voicing differences. For example, Nkore-Kiga sibilant harmony is more limited in mixed-voicing combinations (e.g., /ʃ...z/) than it is in same-voicing combinations such as /ʃ...s/ or /ʒ...z/, as discussed in section 5.3 above.

In non-coronal consonant harmony systems, place and manner distinctions are often involved in similarity-related restrictions on harmony. For example, laryngeal harmony (e.g., voicing harmony) is always restricted to obstruent-obstruent pairs. However, it may be further limited to stop-stop combinations and/or fricative-fricative combinations, without affecting stop-fricative combinations (e.g., in Kera or Imdlawn Berber). Stricture harmony may be limited to homorganic obstruent pairs (e.g., in Yabem). Laryngeal harmony is frequently limited in the same way to homorganic obstruent pairs (e.g., in Ngbaka). Alternatively, laryngeal harmony may override certain phonotactic constraints in the case of homorganic consonants but not heterorganic ones, as in the Ndebele case analyzed in 5.1.3 above.

In sum, relative similarity is a major determinant of the likelihood of consonant-consonant interactions both in the psycholinguistic domain of language production (as evident from speech errors) and in the phonological domain of those long-distance assimilatory interactions that are here defined as consonant harmony. Although this parallel is hardly conclusive evidence in itself, it is nevertheless consistent with the hypothesis that

consonant harmony—involving coronal and non-coronal consonants alike—has its roots in speech planning.

A second parallelism between consonant harmony processes and slips of the tongue lies in the domain of directionality effects. As discussed in section 3.1 above, anticipatory or right-to-left directionality is by far the predominant one in the cross-linguistic typology of consonant harmony systems, other things being equal. In fact, anticipation appears to be the default directionality for all consonant harmony interactions; when perseveratory (left-to-right) harmony does occur, it arises as a by-product of high-ranked faithfulness to the stem of affixation (resulting in ‘inside-out’ harmony from stem to affix).

Interestingly, the same default directionality has been observed to be characteristic of the harmony processes very frequently found in child language. In her survey of consonant harmony in child language, Vihman (1978) notes that the reported data predominantly show anticipatory assimilation. Of all the documented examples of consonant harmony in the corpus surveyed by Vihman, 67% involved anticipation. The same bias remained when the data was broken down further. For example, in Amahl’s speech, anticipations constituted 79%, whereas in Virve’s speech the relevant figure was 69% (these two children accounted for nearly half of the harmony forms in Vihman’s corpus). For the remaining group of children, 61% of the harmony assimilations were anticipatory.

What is more important in the present context is the fact that anticipatory or right-to-left directionality has also been shown to have a privileged status in the domain of speech errors. This was discussed in section 4.2.1.2, but the relevant facts are repeated here for convenience. First, note that when translated into the perspective of phonological encoding in speech production, the prevalence of anticipatory rather than perseveratory assimilation in consonant harmony processes (whether in adult or child language) can be formulated in the following way:

(1) Anticipation as default from the perspective of production planning:

In the production of a phonological string containing several consonants, the realization of a given consonant (C_n) tends to be influenced by a consonant which is being planned (C_{n+1}), rather than by one which has already been realized (C_{n-1}).

The formulation in (1) takes into account the fact that, at the time when the production of the 'current' element is being executed, the production of upcoming elements is already being planned. The basic functional requirements of any serial-order production mechanism, including the one responsible for language production, are summarized by Dell et al. (1997) as follows:

(2) Functional requirements of the language production mechanism:

- a. Turn-on function: The system must activate the *present*.
- b. Turn-off function: The system must deactivate the *past*.
- c. Prime function: The system must prepare to activate the *future*.

In most language production models, the prime function in (2c) is implemented by activating a *plan representation* of some kind. Activation of this plan causes anticipatory activation of upcoming elements (the 'future'), which may in turn interfere with the realization of the current element (the 'present'). With respect to the functions in (2), anticipatory effects in speech errors thus result from (2c) interfering with the basic turn-on function in (2a). By contrast, perseveratory effects would have to arise from *not* carrying out the turn-off function in (2b) in the proper way—activation from a 'past' element lingers on and interferes with the execution of the present.

As discussed by Schwartz et al. (1994) and Dell et al. (1997), anticipatory interference in language production is considerably more common than perseveratory interfer-

ence, other things being equal. Under normal circumstances, anticipatory speech errors outweigh perseveratory errors by a ratio of 2:1 to 3:1, a fact which Dell et al. (1997) refer to as the *general anticipatory effect*. This appears to be the normal state of affairs in a relatively error-free production system: ‘when the language-production system is working well, it looks to the future and does not dwell on the past’ (Dell et al. 1997:123). Unlike anticipatory errors, perseveratory errors appear to be more characteristic of relatively more ‘dysfunctional’ states of the production system (as reflected in a higher overall error rate). In general, the proportion of perseveratory errors seems to be directly correlated with overall error rate. The findings are as summarized in (3).

(3) Correlation of perseveratory errors with ‘dysfunctional’ (error-prone) states:

a. Practice effect:

When producing unfamiliar and difficult phrases, practice reduces the overall error rate and also greatly lowers the proportion of perseveratory errors as compared to anticipatory ones (Schwartz et al. 1994; Dell et al. 1997).

b. Speech rate effect:

The proportion of perseveratory errors relative to anticipatory ones increases with increasing speech rate—i.e. as available time for speaking decreases (Dell 1990; Dell et al. 1997).

c. Aphasic speech:

The speech of many aphasic patients is characterized by a much higher proportion of perseveratory errors than nonaphasic speech (Schwartz et al. 1994).

c. Children’s speech:

The proportion of perseveratory errors over anticipatory ones is considerably higher in the speech of children—especially younger children—than it is in adult speech (Stemberger 1989).

To sum up, the generalization seems to be that *other things being equal*, slips of the tongue are far more likely to involve anticipation (right-to-left interference) than perseveratory (left-to-right interference). Ultimately, the default nature of anticipatory interference falls out from the nature of the serial-order mechanism responsible for language production: A segment which is currently being produced may be influenced by an upcoming segment that is being planned (and thus activated) at the same time (see Dell et al. 1997 for further discussion). This is entirely parallel to the directionality asymmetry observed in the typology of consonant harmony systems. In the domain of consonant harmony, anticipation is the norm. By contrast, perseveration emerges as a by-product of morphology-sensitive harmony, where the directionality of assimilation is really ‘inside-out’ rather than literally ‘left-to-right’. The parallelism that holds between consonant harmony phenomena and speech errors with regard to directionality effects strongly supports the view that the former has its roots in the domain of speech-production planning.

In addition to similarity effects and directionality biases, a third factor to consider is transparency of the segmental material intervening between the trigger and target consonants. As explained in sections 1.2.3 and 4.1.1 above, the spreading-based analysis of consonant harmony advocated, e.g., by Gafos (1996[1999]) does not countenance genuine transparency. In apparent cases of long-distance assimilation, such as Ineseño Chumash /ha-s-xintila-waʃ/ → [haʃxintilawaʃ] ‘his former Indian name’, the claim is that the spreading articulatory gesture responsible for the /s/ → [ʃ] change in fact targets all the vowels intervening between the two sibilants, including the coronals /n, t, l/ (and presumably the /h/ and /a/ on the opposite side of the affected /s/ as well). These non-sibilant segments are thus assumed to be phonetically co-articulated with the spreading gesture, though this has little or no acoustic-auditory effect and is thus not noted in the transcriptions given in descriptive sources. The same is taken to be true of all coronal harmony systems. However, it cannot be

emphasized enough that this hypothesis has as yet not been supported by anything but conjectural evidence—i.e. the mere observation that the assimilating gesture *could* conceivably be targeting intervening segments as well, with little noticeable effect. The hypothesis that coronal harmony involves local articulatory-gesture spreading has yet to be corroborated by instrumental-phonetic studies of actual languages with such harmony systems (e.g., Navajo or Rwanda).

As argued at length in section 3.2 above, the local-spreading hypothesis makes the prediction that segmental opacity should be expected to occur in at least some coronal harmony systems—resulting from the incompatibility of particular segment types (esp. other coronals) with the spreading property. However, opacity effects are entirely unattested in the cross-linguistic typology of consonant harmony systems; in short, intervening segmental material shows no signs whatsoever of being targeted by the feature/gesture involved in the harmony.² Furthermore, as also discussed in section 3.2, many *non*-coronal harmony systems show direct evidence for the genuine transparency of intervening vowels and consonants. This is trivially true of such phenomena as nasal consonant harmony, which quite obviously does not result in the nasalization of vowels and non-target consonants. But even in cases where the triggering consonant *does* phonetically affect immediately adjacent segments (e.g., neighboring vowels), there is often clear evidence that the *harmony* effect it has on a non-adjacent target consonant is genuinely a long-distance effect, where intervening segments are ‘skipped’ rather than ‘permeated’ by the harmony

² A well-known case which is usually treated as an example of coronal harmony, and which *does* display segmental opacity effects, is Vedic Sanskrit *n*-retroflexion (see, e.g., Steriade 1987; Gafos 1996[1999]; Ní Chiosáin & Padgett 1997). However, as argued extensively in 3.2.3 above, there are strong independent reasons to view the Sanskrit phenomenon as something entirely distinct from consonant harmony. This particular phenomenon does indeed seem to involve spreading, and as such displays a series of properties which are commonly found in vowel harmony and ‘vowel-consonant harmony’ systems, but *not* in consonant harmony systems; segmental opacity is merely one of these. Vedic Sanskrit *n*-retroflexion thus does not constitute a counterexample to the generalization that consonant harmony systems never displays opacity effects.

feature. One such case will here be repeated from section 3.2.2; but see that section for more detailed discussion of transparency issues.

In the dorsal consonant harmony found in some languages of the Totonacan family, the velar stops /k, k'/ become uvular when followed by a uvular stop (/q/ or /q'/) in the same word (cf. section 2.4.2 above). In other words, underlying sequences like /k...q/ are harmonized to /q...q/, and so forth. This phenomenon has been documented by Watters (1988) for Tlachichilco Tepehua and MacKay (1999) for Misantla Totonac. In both cases, the harmony coexists with a local assimilatory effect (a pan-Totonacan phenomenon) whereby high vowels are lowered by a neighboring uvular stop. This is illustrated by forms such as the Tlachichilco Tepehua ones in (4), where /i, u/ are realized as [e, o] when immediately preceded or followed by /q/ or /q'/. (Note that in this particular language, ejective /q'/ surfaces as [ʔ] phonetically, as in the last two examples.)

(4) Vowel lowering by adjacent uvulars in Tlachichilco Tepehua (Watters 1988).

- | | | | |
|----------------|---|--------------|------------------------|
| /qin-t'uj/ | → | [qen-t'uj] | 'two (people)' |
| /ʔaq(-)tʃuq/ | → | [ʔaq-tʃoq] | 'pot' |
| /lak-tʃiq'i-j/ | → | [laq-tʃeʔej] | 'X shatters Y (perf.)' |
| /tsuq'u/ | → | [tsoʔo] | 'bird' |

This invites the interpretation that dorsal harmony is due to the very same kind of local interaction as that observed in (4). In other words, that when an underlying sequence like /...kiCuq.../ surfaces as [...qeCoq...], the gesture responsible for the uvularity of the underlying /q/ (possibly tongue-root and/or tongue-dorsum retraction) is in fact spreading throughout the entire CVCVC sequence, hitting everything in its path.

However, words where the dorsal stops are spaced even further apart clearly show that this is not the case. The /k...q/ → /q...q/ assimilation resulting from dorsal consonant

harmony is in fact a genuine long-distance effect; the intervening vowels are *not* affected but instead genuinely transparent. This is shown by the examples in (5), where the crucially non-lowered vowels are indicated by underlining.

(5) Tlachichilco Tepehua: No lowering within dorsal harmony span (Watters 1988)

/lak-pu:tiq'i-ni-j/ → [laq-pu:teʔe-ni-j] 'X recounted it to them'

/ʔak-pitiq'i-j/ → [ʔaq-piteʔe-j] 'X folds it over'

Vowel lowering is a local process, which only applies to vowels *immediately* adjacent to a uvular consonant. This process is blocked by any intervening segments; for example, in both examples in (5) the [p] blocks the (progressive) lowering of a following high vowel in the contexts [...qpu:...] and [...qpi...]. The dorsal consonant harmony holding between the underlying velar vs. uvular stops, by contrast, is a *non-local* phenomenon, which does not affect intervening vowels and consonants in any way.

On the issue of whether intervening segments are genuinely transparent, i.e. 'skipped', or instead permeated by the harmonic feature/gesture, what little direct evidence there exists seems to be in favor of *transparency*. This is entirely in conformity with the analysis of consonant harmony presented in this work, since it treats intervening vowels and consonants as irrelevant and not participating in the harmony at all. It also accounts for the complete lack of segmental opacity effects in consonant harmony systems.

For the purposes of the present chapter, what is relevant in this connection is that gesture/feature spreading does also not appear to be involved in speech errors. The interaction of consonants in phonological slips of the tongue is a genuine case of 'action at a distance'. Where the error in question is a matter of anticipation or perseveration, with a following or preceding consonant 'intruding' on the one currently being produced, inter-

vening vowels and consonants are genuinely transparent. In no way are they ‘permeated’ by the articulatory (or other) properties of the intruding segment.

Again, this is trivially true in those cases where the substitutions involve a change in features such as [\pm nasal] (e.g., *mask math* for the word pair *bask math*), where the slip obviously does not result in the nasalization of vowels or other consonants. Far more importantly, however, the same is also true of slips involving exactly the same distinctions as those forming the basis of most coronal harmony systems, such as /s/ vs. /ʃ/. This can be seen from data reported in instrumental studies on the articulatory aspects of speech errors. In a study using electromyographic recordings, Mowrey & MacKay (1990) monitored single-motor unit activity during the production of tongue twisters, including the familiar sequence *she sells seashells by the seashore*. Their EMG tracings of anomalous tokens of this tongue twister phrase—where some degree of [ʃ]-related activity occurred on the /s/ of *seashells* and/or *seashore*—clearly show that spreading is not involved. The articulatory activity associated with /ʃ/ which ‘intrudes’ on /s/ does so in a non-local manner, i.e. it constitutes an independent burst of activity occurring solely on the target /s/, not on any of the preceding or following vowels and non-sibilant consonants.

The same can be concluded from the kinematic data reported by Pouplier et al. (1999), who used magnetometric methods to track articulatory movements during utterances exhibiting speech errors. In elicited utterances consisting of prolonged repetitions of phrases like *sop shop* at relatively fast speech rates, gestures associated with [ʃ] were often found to intrude on the production of /s/. The articulatory tracings clearly show that the effect of /ʃ/ on a nearby /s/ is a matter of a *separate* gesture intruding on the target /s/—not the *same* gesture being extended (‘spread’) from a triggering /ʃ/ to the target /s/. This is true of both of the two [ʃ]-related gestures monitored in the study, viz. lip protrusion and the raising of the front part of the tongue dorsum.

With respect to slips of the tongue, the findings are thus unequivocal. In the anomalous production of [ʃ]op [ʃ]op instead of intended [s]op [ʃ]op, or of [ʃ]ea[ʃ]ore instead of intended [s]ea[ʃ]ore, the gestures involved in the articulation of [ʃ] are thus *repeated*, not extended from one [ʃ] to the other. The claim made in this study is that there is reason to believe that the same is also true of the assimilatory interactions observed in phonological consonant harmony processes. These are a matter of agreement rather than spreading, and as such involve ‘repetition’ of phonological features/gestures, not their temporal extension throughout some domain.

6.2. Speech error corpora and the Palatal Bias

In a landmark study of phonological speech errors and their sensitivity (or lack thereof) to segmental markedness, Shattuck-Hufnagel & Klatt (1979) noted a curious asymmetry in how frequently certain segment types occurred as targets vs. intrusions in single-segment errors. (In an error utterance like ‘change the *p*irst part’, the /f/ of the intended word ‘first’ is referred to as the *target* segment and the /p/ which substitutes for it is the *intrusion* segment—in this case due to anticipation from the following word ‘part’.) What Shattuck-Hufnagel & Klatt discovered was the surprising fact that certain high-frequency alveolar consonants, in particular /s/ and /t/, are significantly more often targets than they are intrusions, whereas their lower-frequency ‘palatal’ counterparts /ʃ, tʃ/ are more often intrusions than they are targets. (Note that here and in the remainder of this chapter, segments of the latter type will be referred to as ‘palatals’ in keeping with common practice, although it should be kept in mind that this usage of the term is phonetically inaccurate.)

They found this asymmetry to hold both in the MIT speech error corpus (see, e.g., Garrett 1975) and in the UCLA corpus (Fromkin 1971). Moreover, both corpora clearly show that the asymmetric target/intrusion distributions of /s, t/ and /ʃ, tʃ/ are connected. The true generalization is that the alveolars tend to be replaced by the palatals significantly more

often than vice versa, e.g. errors like /s/ → /ʃ/ are much more commonly found than /ʃ/ → /s/. This generalization is summarized in (6), illustrated with examples from Stemberger (1991).³

(6) Asymmetries in phonological speech errors involving coronal obstruents

a. Palatal intruding on alveolar (frequent)

/s/ → /ʃ/ Example: *And **sho** (= so) **she** just cashed it.*

/t/ → /tʃ/ Example: *Then we could just **choss** (= toss) out these **checks**.*

b. Alveolar intruding on palatal (less frequent)

/ʃ/ → /s/ Example: *...seventy percent to sow—to show that it's not random.*

/tʃ/ → /t/ Example: *Rapa **Tortilla tips**—chips.*

Shattuck-Hufnagel & Klatt (1979) refer to the asymmetry in (6) as being due to an as-yet-unexplained ‘palatalization mechanism’. Stemberger (1991) instead uses the term ‘Palatal Bias’, and this is the term which will be used here.

The data in table (7), extracted from a similar table cited by Shattuck-Hufnagel & Klatt (1979:47) shows the numbers underlying this asymmetry in the MIT and UCLA corpora. Alveolar/palatal pairs other than the ones cited here (e.g., /z/ vs. /ʒ/, /d/ vs. /dʒ/, etc.) are omitted for the reason that the incidence of such errors is too low to show any significant asymmetry or lack thereof. (Note that the labels ‘C1’ and ‘C2’ are merely for reference and do not imply anything about the relative *order* of the target and the source of the intrusion.)⁴

³ It so happens that the examples cited in (6b) both involve *perseveratory* errors, as compared to the anticipatory errors cited in (6a). This is purely accidental.

⁴ In fact, in many of the errors the source cannot be identified—often because the utterance is aborted immediately after the error, so that the source of what might be an anticipatory error is impossible to determine. An error like /s/ → /ʃ/ thus simply indicates that a word containing /s/ (e.g., *sing* or *bus*) was uttered with [ʃ] instead of the correct [s].

(7) The Palatal Bias in the MIT and UCLA corpora (Shattuck-Hufnagel & Klatt 1979)

<i>C1 : C2</i>	<i>MIT corpus</i>		<i>UCLA corpus</i>	
	<i>C1 → C2</i>	<i>C2 → C1</i>	<i>C1 → C2</i>	<i>C2 → C1</i>
s : ʃ	68	33	32	9
s : tʃ	17	1	3	2
t : tʃ	14	4	3	1

Note that the fricative-affricate pair /s/ vs. /tʃ/ is among the ones listed in (7), even though such errors are hardly found at all in the UCLA corpus, unlike the MIT corpus. Shattuck-Hufnagel & Klatt (1979) note this discrepancy and add the following comment: ‘The difference between the MIT and UCLA corpus with respect to the s : č pair is large enough to suspect some sort of transcription bias in one or the other data set, making it all the harder to determine the exact form of any palatalization mechanism’ (p. 47, n. 2). For this reason, the remaining discussion in this section will focus on the pairs /s/ vs. /ʃ/ on the one hand and /t/ vs. /tʃ/ on the other.

Since Shattuck-Hufnagel & Klatt (1979) made this discovery, the Palatal Bias has been reported in other speech error corpora as well, e.g., in that collected by Stemberger (cf. Stemberger 1991). Furthermore, it has been documented in other languages as well, e.g. in the German speech error corpus of Berg (1988). Bolozky (1978) describes the same asymmetry in Hebrew in the following manner:

[I]n Hebrew, non-consecutive š-s or š-z sequences are hardly ever confused, whereas the opposite, i.e. the replacement of s by š in anticipation of another š, occurs quite often, primarily in casual speech and in child language.

(Bolozky 1978:214)

Bolozky cites examples such as the slips /oʃek murʃe/ for /osek murʃe/ ‘certified business owner’ and /ʃar ʃalom/ for /sar ʃalom/ (proper name), and the child-language form /ʃaʃa/ ‘Sasha (proper name)’, and points out that forms like /ʃastom/ ‘valve’ or /ʃazuf/ ‘sun-tanned’ typically do not result in slips like /sastom/, /zazuf/.

All the data cited so far comes from speech error corpora, which consist of collections of naturally occurring slips of the tongue. Stemberger (1991) also found the Palatal Bias to be reliably present in experimentally induced errors (using the SLIPS technique; cf. Motley & Baars 1975; Motley et al. 1983). In his experiment, Stemberger found 65 errors where an alveolar was replaced by a palatal, vs. only 38 errors where a palatal was replaced by an alveolar. The difference was most striking for the pairs s/ʃ (22 ‘palatalizations’ vs. 8 ‘depalatalizations’) and t/tʃ (14 vs. 1). In short, the existence of a Palatal Bias was robustly confirmed by experimental methods. In an earlier experimental study, Levitt & Healy (1985) had failed to find this asymmetry. However, as pointed out by Stemberger (1991), this was likely due to the design of the target stimuli used in their experiment.⁵

It is also possible to interpret results reported in studies of articulatorily gradient speech errors as indicating a Palatal Bias effect, although the data are not always straightforward to interpret from this perspective. As mentioned earlier in this chapter, Mowrey & MacKay (1990) carried out experiments using electromyography (EMG) to monitor single-motor-unit activity in the production of speech errors. Among the tongue twisters used in their study was the familiar *she sells seashells on the seashore*. In all the s/ʃ errors Mowrey & MacKay report, the effect—whether gradient or categorical—some degree motor activity associated with /ʃ/ is intruding on a nearby /s/, rather than vice versa. In another study investigating gradience in speech errors, Pouplier et al. (1999) examined articulatory

⁵ Levitt & Healy used simple CV nonsense syllables, and the priming pairs were exactly identical to the errors being primed. It is thus possible to determine whether a given error was truly a phonological error (involving single-segment substitution) or a ‘lexical error’ (with whole-syllable substitution). As Stemberger points out, the latter would not be expected to show any sort of Palatal Bias effect; the sensitivity of the experiment was thus severely decreased, and this may account for the null results obtained.

movement data in order to observe errors at the level of individual gestures. Some of the stimuli used in this kinematic study involved alternating sequences with /s/ and /ʃ/ (*sip ship, sop shop* or *bass bash*, each repeated for 10 seconds). Out of the 18 s/ʃ errors elicited by Pouplier et al., 16 were of the type /s/ → /ʃ/. In all of these, some degree of gestural activity associated with the /ʃ/ intruded on the nearby /s/. (The relevant gestures were on the one hand raising of the front part of the tongue dorsum, and lip protrusion on the other.) In sum, these instrumental studies of experimentally induced speech errors appear to replicate the Palatal Bias asymmetry documented in earlier studies.

As noted in the cross-linguistic survey presented in chapter 2, coronal harmony is by far the most widely attested type of consonant harmony in the world's languages. More specifically, the predominant variety is coronal *sibilant* harmony, which is found in a great number of language families across different continents. In most cases, sibilant harmony involves the fricative contrast /s/ vs. /ʃ/—though the precise phonetic parameter may vary from language to language, and is not always clear from descriptive sources—and sometimes corresponding affricate contrasts like /ts/ vs. /tʃ/ are involved in the harmony as well. The claim advocated in the present study, namely that the sources of consonant harmony phenomena are to be found in the domain of speech planning, makes the prediction that any generalizations found to characterize segmental speech errors are expected to manifest themselves to some degree in the typology of consonant harmony systems. This has already been argued to be true of directionality effects, i.e. the predominance of anticipatory (right-to-left) directionality in speech errors and consonant harmony processes alike, as well as the role played by relative similarity in both phenomena. Given the fact that segment distinctions like /s/ vs. /ʃ/ are so frequently involved in consonant harmony, we would expect to find some analogue of the Palatal Bias in the phonological processes referred to as coronal harmony. As will be argued in the remaining sections of this chapter, the Palatal Bias *does* indeed manifest itself in the cross-linguistic typology of coronal harmony sys-

tems. This is true not only of sibilant harmony systems of the *s/ʃ* type, but also of the much rarer phenomenon whereby alveolar stops and ‘palatal’ affricates interact (i.e. *t/tʃ*). These are precisely the segment pairs for which Palatal Bias effect were originally documented, cf. (6)-(7) above.

Note that in the above discussion of Palatal Bias effects in speech errors, no attempt was made to explain why such asymmetries might exist in the first place. One reason is that the Palatal Bias has as yet not received any satisfactory explanation; its sources are as yet largely a mystery. More importantly, however, the issue of explaining *why* the Palatal Bias exists is entirely orthogonal to the purpose of this study. The main point here is to show that the Palatal Bias—an effect which characterizes speech errors, and is thus somehow involved in the process of phonological encoding for language production—is ‘replicated’ in the typology of coronal harmony systems. This is adduced as additional evidence that consonant harmony in general, and coronal harmony in particular, has its roots in phonological encoding, i.e. speech planning. The validity of this argument is entirely independent of the question what the reason behind the existence of Palatal Bias effects is.

Nonetheless, it is worth noting that one attempt has in fact been made at explaining the Palatal Bias in speech errors, by Stemberger (1991). The main points of his argument will be outlined here. The gist of Stemberger’s proposal is to reduce the Palatal Bias to another independently established asymmetry also found to obtain in speech error data. This is the so-called Addition Bias (Stemberger & Treiman 1986), whereby the tendency to add consonants to singleton consonants (resulting in a consonant cluster) is considerably greater than the tendency to remove consonants from clusters (resulting in a singleton consonant). For example, in sequences like *back blocks* or *black box*, a speaker is more likely to produce an error like **black blocks* than **back box*. This Addition Bias has been found to obtain in corpora of naturally occurring errors in the speech of adults (Stemberger & Treiman 1986) as well as children (Stemberger 1989). Furthermore, it has been replicated

in several experiments using the SLIPS technique (Stemberger & Treiman 1986; Stemberger 1991). The existence of an Addition Bias—whatever its explanation—has thus been securely demonstrated.

What Stemberger (1991) argues is that the Palatal Bias can in fact be reduced to a special case of Addition Bias effects, given certain assumptions about phonological *underspecification*. The idea is that ‘palatals’ like /tʃ/ or /ʃ/ are specified as [-anterior], whereas the unmarked alveolars like /t/ or /s/ are *unspecified* for this feature, in accordance with proposals for radical underspecification (see, e.g., Kiparsky 1982, 1985; Archangeli 1984; and several of the contributions in Paradis & Prunet 1991). Based on this assumption, an error like /s/ → /ʃ/ constitutes the *addition* of a feature specification, whereas the reverse change /ʃ/ → /s/ involves *removal* of that same feature. From this perspective, such changes are then roughly parallel to singleton/cluster interactions like /b/ → /bl/ and /bl/ → /b/, respectively. Both can be attributed to the same basic effect—the Addition Bias. Stemberger (1991) goes on to show that other feature-specification asymmetries implied by radical underspecification are also matched by asymmetries in experimental speech error data. For example, he finds the change alveolar → labial to be more common than labial → alveolar (59 vs. 32), whereas labial vs. velar interactions do not show this kind of asymmetry. This is consistent with the hypothesis that alveolars are unspecified for Place, whereas labials and velars are not. Secondly, Stemberger also finds that for obstruents differing only in voicing, the change voiceless → voiced is more common than voiced → voiceless; this is as expected if voiceless obstruents are unspecified for [±voice]. Finally, in errors involving homorganic nasals vs. stops (voiced or voiceless), the change stop → nasal was more frequent than nasal → stop, consistent with the hypothesis that stops are unspecified for nasality. Errors involving fricative/nasal pairs did not show any such asymmetry; the proposed explanation is that [±continuant] is specified in fricatives but not nasals, and [±nasal] is specified in nasals but not fricatives.

The findings reported by Stemberger (1991) are quite interesting, although in some cases the asymmetries found are relatively small and the study is well worth replicating. Furthermore, the implications of these findings for theories of phonological specification have yet to be fully explored. For example, it is unclear to what extent they can be accommodated within alternatives to underspecification, such as the structured specification approach developed by Broe (1993; cf. also Frisch 1996), where redundancy relations among features are encoded in ways that do not involve presence vs. absence of features. Finally, it remains to be seen to what extent the other target/intrusion asymmetries reported by Stemberger are mirrored by the typology of phonological consonant harmony phenomena. It is at least suggestive that nasal consonant harmony effects predominantly involve nasalization (e.g., /d/ → /n/ or /k/ → /ŋ/) rather than ‘oralization’, and obstruent voicing harmony typically involves assimilation in [+voi] rather than [-voi] (see sections 2.4.4 and 2.4.7, respectively). Both fit the asymmetric patterns emerging from Stemberger’s experimental findings.

6.3. Palatal Bias effects in sibilant harmony systems

As is well known, the single most common type of consonant harmony in the world’s languages is sibilant harmony, i.e. the long-distance assimilatory interaction between strident fricatives and/or affricates. Within the class of sibilant harmony systems, the phonological contrast involved is most commonly an alveolar vs. ‘palatoalveolar’ (i.e. postalveolar) one, such that the interacting consonants are /s/, /ts/ etc. as against /ʃ/, /tʃ/ etc.

On the assumption that consonant harmony is ‘homologous’ with speech errors, these are precisely the kinds of processes that would be expected to be shaped by the Palatal Bias in one way or another. The fact that sibilant harmony of this type is in fact quite well attested cross-linguistically—even more so than has been recognized in earlier surveys—makes it more reasonable to expect to find some manifestation of the Palatal Bias in sibilant harmony systems and their typology. This section aims to demonstrate that this is indeed

the case; assimilatory process like /s/ → /ʃ/ are far more common than, and in some cases take precedence over, their mirror images like /ʃ/ → /s/. The argument crucially depends on the distinction between symmetric and asymmetric harmony systems, and this dichotomy will therefore be clarified first.

6.3.1. Symmetry in consonant harmony systems

Simply defined, a harmony system involving the feature [\pm F] is *symmetric* if both feature values are equally active. In other words, in a symmetric system the ‘spreading’ property can be either [+F] or [-F] depending on contextual variables—e.g., the linear order of the two segments or their morphological affiliation. For example, in a symmetric *directional* harmony system (with fixed right-to-left directionality), the effect of the harmony is both $/-F\dots+F/ \rightarrow /+F\dots+F/$ and $/+F\dots-F/ \rightarrow /-F\dots-F/$. In the first case harmony results in the change $[-F] \rightarrow [+F]$, whereas in the latter case the change is the reverse, $[+F] \rightarrow [-F]$. In a symmetric *stem-controlled* system, the same is true, but here the assimilation is to whatever feature value is in the base of affixation. If the stem has [+F], then we find $[-F] \rightarrow [+F]$ in affixes attaching to it; on the other hand, if the stem has [-F], affixes will show the change $[+F] \rightarrow [-F]$.⁶

An asymmetric harmony system, the opposite of a symmetric one, is where only one feature value appears to be ‘active’. (Elsewhere in this study, this has occasionally been

⁶ Note that this abstract scenario presupposes that the harmony actually obliterates a lexical [+F] : [-F] contrast. Although this is frequently the case in consonant harmony systems (e.g., in the Athapaskan or Chumashan languages), it is hardly attested at all in vowel harmony systems. The reason may be mostly accidental. Vowel inventories are relatively small compared to consonant inventories, and vowel harmony typically divides the entire vowel system into two interacting sets (possibly with one or two vowels being ‘neutral’). The set of segments interacting in a given consonant harmony system, on the other hand, typically constitute a small subset of the full consonant inventory. More importantly, every polysyllabic word will have more than one vowel—and thus a context where vowel harmony will be expected to apply—whereas not all words will have more than one sibilant (or even a single sibilant). In a stem-controlled vowel harmony system, this means that affix vowels have little or no opportunity to show their ‘true colors’, i.e. their underlying [\pm F] specification. In a stem-controlled sibilant harmony system, by contrast, affix sibilants will surface with their underlying [\pm F] value in all those cases where the base of affixation does not happen to contain a sibilant as well.

referred to as a ‘single-value’ harmony system.) Thus in an asymmetric system we may find only the assimilatory change $[-F] \rightarrow [+F]$ as a result of harmony, never the reverse change $[+F] \rightarrow [-F]$ (or, alternatively, we may find $[+F] \rightarrow [-F]$ to the exclusion of $[-F] \rightarrow [+F]$). Dominant-recessive systems, where only one feature value spreads bidirectionally regardless of morphological constituent structure, are by definition asymmetric. In a dominant-recessive ATR vowel harmony system where the dominant value is $[+ATR]$, for example, recessive $[-ATR]$ vowels always assimilate to dominant $[+ATR]$ vowels, never vice versa; hence the only change observed is $[-ATR] \rightarrow [+ATR]$.

As noted in section 3.1, truly dominant-recessive consonant harmony systems do not appear to be attested in the world’s languages. Instead, the asymmetric consonant harmony systems that are attested are either of the stem-controlled or directional variety. An example of an asymmetric *directional* system is Ngizim obstruent voicing harmony, as discussed in 2.4.7 and analyzed in 4.2.3 above. In this system, the only change observed is $[-voi] \rightarrow [+voi]$: disharmonic obstruent sequences like $[-voi] \dots [+voi]$ are harmonized to $[+voi] \dots [+voi]$, whereas sequences like $[+voi] \dots [-voi]$ remain intact (i.e. not harmonized to $[-voi] \dots [-voi]$). An example of an asymmetric *stem-controlled* system is the nasal consonant harmony found in many Bantu languages (see 2.4.4 for examples) Here harmony typically results only in $[-nas] \rightarrow [+nas]$, not $[+nas] \rightarrow [-nas]$. In affixes, oral /d/ is harmonized to [n] when the preceding stem contains a nasal, but nasal /n/ is not ‘oralized’ (e.g., in reciprocal /-an-/) in harmony with a (voiced) oral consonant in the stem.

In cases like the ones just mentioned, the harmony system as a whole is asymmetric, in that one feature value is consistently active ($[+voi]$, $[+nas]$) whereas the opposite value is consistently inactive ($[-voi]$, $[-nas]$). Another possibility is that both feature values do participate in the harmony—i.e. both values do trigger assimilation—but that harmony in $[\alpha F]$ is somehow restricted as compared to $[-\alpha F]$. For example, the assimilatory change $[+F] \rightarrow [-F]$ may be subject to more stringent conditions on the relative similarity or prox-

imity of the trigger/target consonant pair, whereas the reverse change [-F] → [+F] is not constrained in such a way and applies across the board. In systems with these characteristics, the asymmetry is thus confined to particular contexts; such systems might be referred to as ‘partially symmetric’ rather than completely asymmetric.

In the form in which it has been documented in speech error studies, the Palatal Bias is essentially an asymmetry, whereby alveolars like /s/ or /t/ are replaced by ‘palatals’ like /ʃ/ or /tʃ/ more frequently than the other way around. A substitution like /s/ → /ʃ/ is thus more common than its mirror image /ʃ/ → /s/. If there is any analogue to the Palatal Bias to be found in the phonological domain of sibilant harmony processes, then it seems clear that the place to look is in the class of sibilant harmony systems that are asymmetric (or partially symmetric). The prediction is that in systems that contain any kind of asymmetry, the bias should be in favor of ‘palatalizing’ assimilations (/s/ → /ʃ/) at the expense of ‘depalatalizing’ ones (/ʃ/ → /s/). The data reported in the following section, extracted from the consonant harmony database described in chapter 2, shows that this is indeed the case. With virtually no exceptions, attested asymmetries in sibilant harmony systems are always in the direction consistent with the Palatal Bias.

6.3.2. Symmetric vs. asymmetric sibilant harmony and the Palatal Bias

In the database of consonant harmony systems on which the present study is based, sibilant harmony systems—especially of the s/ʃ variety—are quite common. However, not all of these can be categorized as either symmetric or asymmetric. For example, when sibilant harmony operates as a morpheme-internal restriction, there is often no direct evidence of the assimilations involved in giving rise to the (static) cooccurrence pattern observed. It is thus in principle *possible* to interpret a system which allows only /s...s/ and /ʃ...ʃ/ as an asymmetric system of the ‘dominant-recessive’ type with only /s/ → /ʃ/ (i.e. where both */s...ʃ/ and */ʃ...s/ harmonize to /ʃ...ʃ/), rather than a symmetric system with both /s/ → /ʃ/

and /ʃ/ → /s/. Typically, when a sibilant harmony system is confined to morpheme-internal contexts in this way, the only evidence that can be brought to bear on the symmetry issue is *diachronic-comparative*. A closely related dialect or language (or a documented earlier stage of the same language) may reveal precisely how the harmony manifested itself, e.g., whether original /ʃ...s/ sequences were harmonized to /s...s/ or to /ʃ...ʃ/. But in many cases such evidence is not readily available, and it is thus impossible to determine whether the system in question is symmetric or asymmetric.

Leaving aside such indeterminate cases, the database surveyed here contains a considerable number of symmetric sibilant harmony systems involving contrasts of the s/ʃ type. These are listed in (8); regarding the questionable status of Misantla Totonac as a symmetric system, see section 6.3.3 below.

(8) Symmetric sibilant harmony systems (displaying both /s/ → /ʃ/ and /ʃ/ → /s/):

Navajo (Athapaskan)

Chiricahua Apache (Athapaskan)

Kiowa-Apache (Athapaskan)⁷

Tanana (Athapaskan)

Barbareño (Chumashan)

Ineseño (Chumashan)

Ventureño (Chumashan)

Southern Paiute (Uto-Aztecan)

Nebaj Ixil (Mayan)

?Misantla Totonac (Totonacan)

⁷ Bittle (1963) describes Kiowa-Apache sibilant harmony as involving *partial* assimilation, with the resulting sibilants being intermediate in phonetic quality between those of the /s/ and /ʃ/ series. (Furthermore, he seems to imply that in terms of their quality, ‘harmonized’ /s/-series sibilants and ‘harmonized’ /ʃ/-series sibilants are even distinct from *each other*—which would be rather remarkable.) If Bittle’s characterization is correct, this is a very interesting fact, but one which does not bear on the classification of Kiowa-Apache sibilant harmony as a symmetric system rather than an asymmetric one.

Most of the languages listed in (8) belong either to the Athapaskan or the Chumashan language families. In all of the symmetric languages belonging to these two families, the symmetric character of the harmony can be directly observed as it results in surface alternations that obliterate underlying contrasts like /s/ : /ʃ/, /ts/ : /tʃ/, etc. This can be seen from examples such as the ones in (9) from Ineseño, a symmetric system with fixed (right-to-left) directionality. In the form in (9a), the 3Obj suffix /-us/ triggers harmony in the preceding stem morpheme /-tʃ^ho-/, resulting in the change /tʃ^h/ → /ts^h/. When the past tense suffix /-waʃ/ is added, as in (9b), this causes the affricate to flip back to /tʃ^h/ (i.e. /ts^h/ → /tʃ^h/), as well as causing /s/ → /ʃ/ in the preceding /-us/ suffix. The changes involved in Ineseño sibilant harmony are thus both [-anterior] → [+anterior] (9a) and [+anterior] → [-anterior] (9b).

(9) Symmetric sibilant harmony in Ineseño (data from Applegate 1972):

- a. /s-api-tʃ^ho-us/ → [sapits^holus] ‘he has a stroke of good luck’
- b. /s-api-tʃ^ho-us-waʃ/ → [ʃapitʃ^holuʃwaʃ] ‘he had a stroke of good luck’

Similar effects can be directly observed in the other Chumashan languages, as well as in the Athapaskan languages listed in (8), such as Navajo. In another language mentioned in (8), the Mayan language Ixil (Nebaj dialect), the evidence for the symmetric character of the harmony is mostly diachronic-comparative. Based on a comparison with cognate forms in the neighboring Chajul dialect, it can be concluded that Nebaj Ixil sibilant harmony is a symmetric system with fixed right-to-left directionality. A further indication is the fact that sibilant harmony is to some extent optional, resulting in the Nebaj dialect having a number of doublet forms, one disharmonic and the other harmonized. This is illustrated by the

examples in (10). Note that Nebaj Ixil sibilant harmony is in fact a three-way system, involving the alveolar, ‘palatal’ (i.e. lamino-postalveolar) and retroflex sibilant series.

(10) Evidence for symmetric sibilant harmony in Ixil (Mayan; Ayres 1991)

a. Dialect differences (Nebaj vs. Chajul dialects):

<i>Nebaj</i>	<i>Chajul</i>	
tʃitʃam	tʃitʃam	‘coche; coche de monte’
tʃʼatʃ	tʃʼatʃ	‘cama’

b. Doublet forms in Nebaj dialect:

tʃʼis ~ tsʼis	‘basura’
tʃʼisis ~ tsʼisis	‘ciprés’
tʃʼeveʃ ~ tʃʃʼeveʃ	‘anona’
tʃʼiʃi ~ tʃʃʼiʃi	‘encino (blanco)’
si:n-ʃeʔ ~ ʃi:n-ʃeʔ	‘conmigo’

A considerably more common state of affairs is for sibilant harmony systems to be *asymmetric* (or partially symmetric) in the sense defined in the previous section. In such asymmetric systems, the harmony only manifests itself in the change [+ant] → [-ant], or only in [-ant] → [+ant]. On the hypothesis that the Palatal Bias does shape the typology of sibilant harmony systems, the former is expected to have ‘privileged’ status (giving rise to /s/ → /ʃ/, etc.), whereas the latter should be less common (i.e. /ʃ/ → /s/, etc.).

The table in (11) lists all the asymmetric sibilant harmony systems of the relevant type that are attested in the consonant harmony database underlying the present study. Note that in the headings in (11), ‘s’ and ‘ʃ’ stand for whole series of alveolar vs. ‘palatal’ sibilants, since often voiced fricatives like /z, ʒ/ and/or affricates like /ts, tʃ/ participate in the harmony as well. Where different dialects are involved but the sources available were

insufficient to rule out significant differences across dialects, these are lumped together (e.g., in the case of Berber and Coptic). Note also that two of the languages listed here as asymmetric—Nkore-Kiga and Tzeltal—are really ‘partially symmetric’ in the terminology of the preceding section, as will be discussed below.

(11) Asymmetric sibilant harmony systems

/s/ → /ʃ/ only:

Sarcee (Athapaskan)

Slave (Athapaskan)

Wiyot (Algic)

Tzeltal (Mayan)

Aari (Omotic)

Koyra (Omotic)

Benchnon Gimira (Omotic)

Zayse (Omotic)

Moroccan Arabic (Semitic)

Berber (various dialects; Afroasiatic)

Coptic (various dialects; Afroasiatic)

Nkore-Kiga (Bantu)

Rwanda (Bantu)

Rundi (Bantu)

Shambaa (Bantu)

Izere (Bantu)

/ʃ/ → /s/ only:

Tlachichilco Tepehua (Totonacan)

The overview in (11) speaks for itself: in all but one case, the asymmetry is in the direction predicted by the Palatal Bias effect. The generalization is thus that if only one type of assim-

ilation is attested, or if one is privileged over the other, the favored one will be /s/ → /ʃ/ rather than /ʃ/ → /s/. The sole counterexample to this generalization, Tlachichilco Tepehua, will be dealt with in the following section.

As an illustration of an asymmetric sibilant harmony system consider the data in (12) from the Athapaskan language Sarcee (Cook 1979, 1984). This language appears to have directional (right-to-left) sibilant harmony, whereby a /s/-series sibilant will shift to its /ʃ/-series counterpart when followed by a /ʃ/-series sibilant later in the word. In the examples in (12), the stem is indicated in boldface.

- (12) Asymmetric sibilant harmony in Sarcee (Athapaskan; data from Cook 1979, 1984)
- | | | | |
|-----------------------------------|---|---------------------|-----------------------|
| /si- tʃiz -aʔ/ | → | [ʃi-tʃidz-àʔ] | ‘my duck’ |
| /si- tʃogo / | → | [ʃi-tʃógò] | ‘my flank’ |
| /na-s- yatʃ / | → | [nā-ʃ-yátʃ] | ‘I killed them again’ |
| /sa-ts’i-gu-si-ni-s- jáj / | → | [ʃá-tʃ’i-gù-ʃi-ʃáj] | ‘you forgot me’ |

In the first two examples in (12), the 1SgPoss prefix /si-/ undergoes harmony to [ʃi-] under the influence of a /tʃ/ in the following noun stem. In the third example, the same applies to the 1SgSubj verb prefix /s-/. Finally, in the fourth example, the incorporated postpositional phrase /sá-/, the deictic subject marker /ts’i-/ and the perfective marker /si-/ all undergo harmony, triggered by the [ʃ] which results from fusion of the valency prefix /s-/ with the root-initial glide /j/. In all cases, the change involved is [+anterior] → [-anterior].

Although descriptive sources on Sarcee clearly state that the sibilant harmony involves ‘palatalization’ to the exclusion of ‘depalatalization’, it is not easy to provide hard evidence that this is the case—i.e. forms which show that harmony does *not* apply in sequences like /ʃ...s/, /ʃ...dz/ etc. This is because /ʃ/-series sibilants are almost completely absent from prefixes in Sarcee. Nevertheless, forms such as the first example in (12) do

constitute evidence for the asymmetry; if Sarcee sibilant harmony were symmetrical, we would expect /si-**tʃiz**-aʔ/ to turn out as *[sɨ́-tsɨ́dz-àʔ], with the rightmost sibilant /z/ triggering [+ant] harmony, instead of the actual [ʃɨ́-tʃɨ́dz-àʔ].

Another example of an asymmetric sibilant harmony system of this type is the Bantu language Rwanda (Kimenyi 1979; see also Gafos 1996[1999]). Here too harmony is directional, with the [+ant] fricatives /s, z/ becoming [-ant] by assimilation to a following /ʃ/ or /ʒ/. Some representative examples are shown in (13); again, stems are indicated in boldface.

(13) Asymmetric sibilant harmony in Rwanda (data from Kimenyi 1979):

- | | | | | |
|----|--------------------------|---|--------------|----------------------------|
| a. | /ku- sas -i:ʃ-a/ | → | [guʃaʃi:ʃa] | ‘to cause to make the bed’ |
| | /ku- saz -i:ʃ-a/ | → | [guʃa:ʒi:ʃa] | ‘to cause to get old’ |
| | /ku- uzuz -i:ʃ-a/ | → | [ku:ʒuʒi:ʃa] | ‘to cause to fill’ |
| b. | /ba-ra- saz -je/ | → | [baraʃa:ʒe] | ‘they are old’ |
| | /a- sas -je/ | → | [aʃaʃe] | ‘he just made the bed’ |
| | /a- sokoz -je/ | → | [aʃokoʒe] | ‘he just combed’ |

In the examples in (13a), the harmony trigger is the causative suffix /-i:ʃ-/; in (13b), the [-anterior] sibilant triggering harmony results from fusion of a stem-final /s/ or /z/ with the initial glide of the following perfective suffix /-je/. Again, harmony only results in the change [+ant] → [-ant]. As in the Sarcee case, it is difficult in practice to find hard evidence to prove that the reverse effect (/ʃ...s/ → /s...s/, etc.) *fails* to apply. Nevertheless, forms like /-ʃorez-/ ‘to sniff’ and /ku-kin-i:ʃ-ir-ir-j-a/ → [gukini:ʃiriza] ‘to play for with’, where /ʃ...z/ sequences remain unaffected by harmony, suggest that the apparent asymmetry is indeed genuine.

As noted above, two of the asymmetric languages listed in (11) are strictly speaking partially symmetric rather than completely asymmetric: Nkore-Kiga (Bantu) and Tzeltal (Mayan). In these languages, both ‘palatalizing’ (/s/ → /ʃ/) and ‘depalatalizing’ (/ʃ/ → /s/) effects are found, but the latter are restricted in ways that the former are not. In other words, certain contexts exist where the sibilant harmony is asymmetric, even though it is fully symmetric in other contexts. This aspect of Nkore-Kiga sibilant harmony was discussed in detail in section 5.3 above, and the particulars do not need to be repeated here. The general facts are as follows: When the trigger and target agree in voicing (i.e. /s/ vs. /ʃ/ or /z/ vs. /ʒ/) *and* are in the onsets of adjacent syllables, the harmony is fully symmetric. We thus find harmonic /ʃ...ʃ, ʒ...ʒ/ where we would otherwise expect disharmonic */s...ʃ, z...ʒ/, and we also find harmonic /s...s, z...z/ replacing disharmonic */ʃ...s, ʒ...z/. However, when the two sibilants disagree in voicing, or are in non-adjacent syllables, the harmony is *asymmetric* and we find only /s/ → /ʃ/, not /ʃ/ → /s/. Thus, for example, disharmonic sequences of the type */s...C...ʃ/ do not occur—presumably because these are harmonized to /ʃ...C...ʃ/—whereas disharmonic */ʃ...C...s/ occur and are not ‘repaired’ by sibilant harmony. Again, the asymmetry is in precisely the direction consistent with the Palatal Bias.

As for the other partially symmetric case, the Mayan language Tzeltal, the facts are less clear, owing to the nature of descriptive sources at my disposal. According to my understanding of Kaufman’s (1971) analysis of Tzeltal morphophonemics, /s/ → /ʃ/ when followed by a /ʃ/-series sibilant (/ʃ, tʃ, tʃ’/), as in /s-wàkaʃ/ → [ʃ-wákaʃ] ‘his cattle’.⁸ On the other hand, the reverse change /ʃ/ → /s/ (and similarly /tʃ/ → /ts/ and /tʃ’/ → /ts’/) only takes place when the sibilant in question is both followed *and preceded* by /s/, as in the form /s-kùʃ^{-h}-es-ik/ → [s-kús-es-ik] ‘they revive’. Thus the ‘depalatalizing’ version of Tzeltal

⁸ Because of the paucity of data cited in Kaufman’s description, it is hard to tell whether the /s/-series affricates /ts, ts’/ are actually *excluded* from this harmony, or whether the relevant sibilant sequences simply never arise.

sibilant harmony appears to be more constrained than its ‘palatalizing’ counterpart, in conformity with the Palatal Bias.⁹

To sum up, the Palatal Bias evident in speech error studies is robustly replicated in the cross-linguistic typology of sibilant harmony systems involving alveolar vs. ‘palatal’ distinctions. As a surface manifestation of harmony, the assimilatory change /s/ → /ʃ/ is far more common than the reverse change /ʃ/ → /s/. With virtually no exceptions (but see the following section) any kind of asymmetry favors the former rather than the latter.

Interestingly, the handful of examples of sporadic sound changes cited as cases of ‘consonant-harmonization’ by Jespersen (1904, 1922; cf. section 1.2.1 above) show the very same asymmetry. One of these is the French sound change *chercher* < *cercher* (cf. English *search*), where the historical development is /s...ʃ/ > /ʃ...ʃ/. Another is the ‘vulgar’ pronunciation [ʃer¹ʃant] ~ [ʃer¹ʒant] in Danish and German, instead of correct [ser¹ʃant] or [ser¹ʒant]. Here, too, we see /s...ʃ/ > /ʃ...ʃ/ or /s...ʒ/ > /ʃ...ʒ/. Although they constitute sporadic rather than systematic sound changes, both of these cases are exactly parallel to the regular phonological assimilations found in languages like Sarcee or Rwanda, as described above.

6.3.3. Apparent counterexamples

In the table of asymmetric sibilant harmony systems in (11) above, there is a single example of a language where the asymmetry is in favor of /ʃ/ → /s/ rather than /s/ → /ʃ/. This is the Tlachichilco dialect of Tepehua, a Totonacan language, as described by Watters (1988). Some examples illustrating sibilant harmony in Tlachichilco Tepehua are given in (14). Harmony is directional (right-to-left), with /ʃ/-series sibilants assimilating to a /s/-series sibilant occurring later in the word, as in (14a). By contrast, /s/-series sibilants do *not* appear

⁹ To complicate matters even further, /ʃ/ also becomes /s/ by harmonizing to /s, ts, ts’/ ‘in the following syllable with no intervening written juncture except ||^||’ (Kaufman 1971:22).

to undergo harmony when followed by a /ʃ/-series sibilant, as forms such as the ones in (14b) show.

(14) Sibilant harmony with ‘anti-Palatal Bias’ in Tlachichilco Tepehua (Watters 1988)

a. Right-to-left ‘depalatalizing’ harmony:

/tʃ’an-q’isiti/ → [ts’anʔesi:ti] ‘toe nail’
(foot-nail)

/ʔukʃ-k’atsa:/ → [ʔuksk’atsa:] ‘feel, experience sensation’
(surface-know)

/ʔaqʃ-kis/ → [ʔaqs kis] ‘five flat things’
(CLAS-five)

b. No right-to-left ‘palatalization’ harmony:

/tasa-ʃka-/ → [tasaʃka-] ‘tooth ache’ (not *[taʃaʃka-])
(tooth-hurt)

/pas-tʃaʃan/ → [pastʃaʃan] ‘six bundles’ (not *[paʃtʃaʃan])
(CLAS-six)

Watters (1988) explicitly describes sibilant harmony as asymmetric in this way: ‘there are no cases of sibilant harmony that involve an [s] or [ts] becoming [ʃ] or [tʃ] preceding an alveopalatal’ (p. 503). However, it should also be noted that sibilant harmony is optional in Tlachichilco Tepehua; all speakers consulted by Watters accept unassimilated forms as well-formed even in cases like (14a), although assimilated ones are more common.

Misantla Totonac, another language of the Totonacan family, also has a sibilant harmony system similar (and possibly cognate) to that found in Tlachichilco Tepehua. This harmony too is optional, but differs from its Tepehua counterpart in that it is confined to the stem, consisting of the root and any derivational (but not inflectional) prefixes. However, unlike the Tlachichilco Tepehua harmony system, Misantla Totonac sibilant harmony was categorized as a *symmetric* system in (8). This is based on the description in MacKay (1999), who explicitly discusses the harmony as a symmetric process. MacKay first

describes sibilant assimilation under adjacency—i.e. in consonant clusters (e.g., /s+tʃ/ → [ʃtʃ] and /ʃ+ts/ → [sts])—which she formalizes as the right-to-left autosegmental spreading of the binary feature [±anterior] between the [Coronal] articulator nodes of [+strident] segments. MacKay then goes on to describe sibilant harmony in the following way (replacing her ‘ç’, ‘č’ and ‘š’ with conventional IPA symbols):

Strident assimilation also applies optionally across intervening segments within a stem. [...O]nly derivational prefixes are affected. When a stem contains two strident segments, /tʃ/ or /ts/ and /s/ or /ʃ/, the feature [anterior] spreads from right to left ... (MacKay 1999:57)

Although MacKay clearly describes Misantla Totonac sibilant harmony as a symmetric process, ‘spreading’ the feature [±anterior] as such rather than only the specific value [+ant], she unfortunately cites only two examples to illustrate this harmony. Both of these involve the body-part prefix /tʃaː-/ as the harmony target, as shown in (15b).

(15) Sibilant harmony in Misantla Totonac (MacKay 1999)

- a. /min-tʃaː-ni/ → [mɪntʃaːn] ‘your body’
- b. /tʃaː-staːlah/ → [tsaːstaːleh] ‘clean-bodied’
- /tʃaː-spit/ → [tsaːspit] ‘s/he peels X (trunk-like object)’

Since the particular morpheme /tʃaː-/ happens to have a /ʃ/-series sibilant, the only examples MacKay (1999) gives us to illustrate Misantla Totonac sibilant harmony involve the same type of change in the ‘Anti-Palatal Bias’ direction (/tʃ/ → /ts/) as that found in Tlachichilco Tepehua. There is thus a distinct possibility that Misantla Totonac is also asymmetric in the

‘wrong’ direction, just like Tlachichilco Tepehua, even though MacKay’s formulation of the phenomenon suggests otherwise.

The reason for this ambiguity may have something to do with the optionality of the harmony process in Misantla Totonac (as well as in Tlachichilco Tepehua). Another potentially confounding factor is the coexistence of sibilant harmony with a pervasive system of *sound symbolism*, which is widespread throughout the Totonacan family. Many Totonacan languages display sound-symbolic alternations related to semantic ‘intensity’, and these in part involve the /s/-series vs. /ʃ/-series contrast (see MacKay 1999:113 and references cited there). This is illustrated by the following pairs from Misantla Totonac:

(16) Sound symbolism involving sibilants in Misantla Totonac (MacKay 1999)

/tsukunky/	‘cool’	vs. /ʃukunky/	‘cold’
/tsutsu/	‘s/he smokes’	vs. /ʃutsu/	‘s/he sucks’
/squ-kuhu-la(ʔ)/	‘it was all smoked’	vs. /ʃqu-kuhu-la(ʔ)/	‘it was blackened’
/muksun/	‘little, few’	vs. /mukʃun/	‘a few (handful)’

MacKay notes that these sound-symbolic alternations are no longer very productive in Misantla Totonac, and have in many cases lost all correlation with semantic differences. As a result, there are numerous examples of doublet forms, where a given morpheme may contain either /s/-series or /ʃ/-series sibilants without any corresponding change in meaning, as in (17).

(17) Doublet forms with alternating sibilants in Misantla Totonac (MacKay 1999)

/ʃquq/ ~ /squq/	‘salty’
/tʃaʃaʃ/ ~ /tsasas/	‘white’
/tʃiʃit/ ~ /tsisit/	‘hairs’

The fact that the /s/-series vs. /ʃ/-series contrast is simultaneously involved both in this elaborate pattern of sound symbolism and in a systematic sibilant harmony process may not be accidental. For example, it so happens that Misantla Totonac and Tlachichilco also display dorsal consonant harmony (cf. 2.4.2 above), and the very same /k/ vs. /q/ contrast involved in that harmony *also* takes part in the sound symbolism pattern in Misantla Totonac (e.g., /staq-ni/ ‘green’ vs. /stak-ni/ ‘flower that just bloomed’). It would seem an odd coincidence that both of the distinctions which form the basis of harmony interactions also happen to be the ones participating in sound-symbolic alternations.¹⁰ Furthermore, the domain in which both segmental harmonies operate is the derivational stem (in Misantla Totonac at least)—i.e. a relatively lexicalized morphological unit—which seems somewhat parallel to the kind of domain within which sound symbolism alternations tend to operate.

Note that symbolism-related alternations such as those in (16) and (17) result in a superficial pattern of *global* agreement in the feature [\pm anterior] between the sibilants within a word/stem. The very same is true of sibilant harmony as well: the end result of that process is that all sibilants within the word (or, in Misantla Totonac, the derivational stem) agree in [\pm anterior]. This invites the hypothesis that the latter may in fact have arisen diachronically from the former by way of analogical reanalysis. In other words, the pervasive agreement patterns which originally resulted from sound symbolism (but which had become less and less correlated with systematic semantic differences) were reinterpreted as being due to a *phonological* restriction demanding that all sibilants within the word (or stem) agree in [\pm anterior].

More detailed descriptive and comparative-historical data would need to be consulted in order for this hypothesis to be raised above the level of pure speculation. Never-

¹⁰ It should be noted that the sound-symbolic alternations among coronal continuants are really a three-way system, involving not only /s/ and /ʃ/ but also the lateral fricative /ɬ/. In some other Totonacan languages, there is a three-way system among affricates as well, /ts/ vs. /tʃ/ vs. /tɬ/, but Misantla Totonac lacks a lateral affricate /tɬ/ (instead showing /t/ where cognates in other languages have /tɬ/).

theless, if the sibilant harmony observed in Totonacan languages did indeed arise through analogical reanalysis of sound-symbolic patterns, then this may shed some light on the typologically anomalous character of Tlachichilco Tepehua. As noted earlier, this is a sibilant harmony system which displays the ‘wrong’ kind of asymmetry, in that it goes in the reverse direction from that predicted by the Palatal Bias. But if the development of Totonacan sibilant harmony did *not* involve ‘phonologized speech errors’—or the exigencies of the speech-planning domain in general—then it is not clear that we would have any reason to expect this harmony system to conform to the Palatal Bias in the first place. The explanation for its *synchronically* anomalous properties may thus lie in its *diachronic* origins.¹¹ (Of course, this diachronic scenario does not explain why this particular case exhibits any kind of asymmetry at all, rather than full symmetry, but given the fact that it is asymmetric—for whatever reason—there is no reason why an asymmetry in the ‘anti-palatal’ direction should be impossible.)

In fact, there are other cases where diachronic considerations can shed light on synchronic anomalies of a very similar kind in certain sibilant harmony systems. In the consonant harmony database underlying this study, at least two languages with three-way sibilant harmony alternations show an unexpected ‘latency’ of the /ʃ/ series. These are the Athapaskan language Tahltan (Hardwick 1984; see also Nater 1989; Shaw 1991; Gafos 1996[1999]) and the Costanoan language Rumsen (Garrett 1999, based on Miller to appear). In the Tahltan case, the three series participating in the harmony are /ʃ/ : /s/ : /θ/ (and /tʃ/ : /ts/ : /tθ/, /ʒ/ : /z/ : /ð/, etc.), whereas in Rumsen the three relevant series are /ʃ/ : /s/ :

¹¹ A similar analogical reanalysis scenario involving sound symbolism and consonant harmony may account for another typologically peculiar case, Wiyot coronal harmony (see, e.g., Teeter 1959; cf. 2.4.1.1 above, fn. 6). Here sound-symbolic alternations hold between /s/ and /ʃ/, as well as between /l/ and /r/. The same segments also participate in consonant harmony assimilations, but the striking fact is that harmony lumps the two pairs together, yielding the sets /s, l/ vs. /ʃ, r/. This means that an /ʃ/ elsewhere in the word will trigger /l/ → /r/, and so forth. Note that in Totonacan, too, two separate contrasts are involved in both sound-symbolic and harmony alternations: /s, ts/ vs. /ʃ, tʃ/ on the one hand and /k/ vs. /q/ on the other. But unlike the sibilant vs. liquid contrasts in Wiyot, these do not ‘cross over’ in the harmony system: dorsal harmony is independent from sibilant harmony, and the two do not interact phonologically in any way.

/ʃ/. In both cases, the /ʃ/-series sibilants are latent in the sense that they appear to be less forceful harmony triggers than the sibilants belonging to the other two series. This is manifested in either of two ways (or both): /ʃ/-series sibilants may trigger harmony only optionally, or they may trigger *partial* assimilation. In both the Tahltan and the Rumsen, the explanation of this ‘palatal latency’ appears to lie in the diachronic background of the systems. As a three-way sibilant harmony, the Tahltan system seems to have developed out of what was originally a *two-way* system, involving the /s/ vs. /θ/ contrast. The same scenario seems to apply to the Rumsen case as well (with /s/ vs. /ʃ/), although the facts are less clear. If this is correct, then the inclusion of /ʃ/-series sibilants in Tahltan and Rumsen sibilant harmony constitutes a later expansion of the system. Presumably, then, the apparent latency of the /ʃ/ series reflects the fact that these segments have not been integrated completely into the sibilant harmony.

Because it provides a near-parallel to the scenario hypothesized for Totonacan sibilant harmony (both involving ‘analogical change’, as traditionally defined), it is useful to examine one of these cases in somewhat greater detail. The choice here is Tahltan, because more extensive descriptive as well as comparative data is available on that language than on Rumsen. The basic facts of Tahltan coronal harmony—and their analysis in Shaw (1991)—were described already in section 1.2.2. To summarize, Tahltan coronal harmony involves the fricatives and affricates belonging to the dental series /θ, ð, tθ, tθ’, dð/, the alveolar series /s, z, ts, ts’, dz/ and the postalveolar or ‘palatal’ series /ʃ, ʒ, tʃ, tʃ’, dʒ/. Harmony obeys right-to-left directionality, with the rightmost coronal of the /θ/, /s/ or /ʃ/ series triggering harmony on any and all preceding such coronals. This is illustrated by the examples in (18) and (19), taken from Shaw (1991). The data in (18) show harmony affecting an underlying /s/-series consonant, whereas in (19) it targets an underlying /θ/-series consonant. Note that the plain coronal series /t, t’, d, n/, as well as the lateral series /ɬ, l, tɬ, tɬ’, dl/, do not participate in the harmony and are transparent to it.

(18) Tahltan: Harmony alternations in 1SgSubj prefix /-s-/ (Shaw 1991)

- a. $\varepsilon s-k'a:$ 'I'm gutting fish'
 $n\varepsilon-s-t\text{ɛ}t$ 'I'm sleepy'
- b. $na-\theta-t\theta'\varepsilon t$ 'I fell off (horse)'
 $\varepsilon-d\varepsilon-d\varepsilon-\theta-du:\theta$ 'I whipped myself'
- c. $hu-di-f-tʃa$ 'I love them'
 $no-ʔ\varepsilon-d\varepsilon:f-\text{ɬ}\varepsilon dʒi$ 'I melted it over and over'

(19) Tahltan: Harmony alternations in 1DuSubj prefix /-θi(d)-/ (Shaw 1991)

- a. $d\varepsilon-\theta i-git\text{ɬ}$ 'we threw it'
 $\theta i:r-t\theta\text{æ}di$ 'we ate it'
- b. $d\varepsilon-si-dz\text{ɛ}l$ 'we shouted'
 $xa-si:d\text{ɛ}ts$ 'we plucked it'
- c. $u-f i-dʒ\varepsilon$ 'we are called'
 $m\varepsilon-ʔ\varepsilon-f i-t'otʃ$ 'we are breast-feeding'

Different phonological analyses of Tahltan coronal harmony have captured the phonetic-phonological distinction between the /θ/, /s/ and /ʃ/ series in various ways. Gafos (1996[1999]) interprets this as a three-way scalar distinction, based on the articulatory parameter Tongue-Tip Constriction Area (TTCA). The TTCA value is [wide] for the /θ/ series, [narrow] for the /s/ series, and [mid] for the /ʃ/ series. On this interpretation, coronal harmony simply involves the leftward extension of a particular TTCA setting throughout the word. Shaw (1991), who crucially relies on radical underspecification, assumes that under the [Coronal] articulator node, the /θ/ series consonants are specified as [+distributed], the

/s/ series as [+strident], and the /ʃ/ series as [-anterior]. As discussed in section 1.2.2, Shaw interprets coronal harmony as leftward spreading of the [Coronal] node as a whole.

Finally, Hardwick (1984) simply cross-classifies the three series by means of the two binary features [\pm strident] and [\pm anterior]. The / θ / series is [-strid, +ant], the /s/ series [+strid, +ant], and the /ʃ/ series [+strid, -ant]. This cross-classification allows Hardwick to separate coronal harmony into two distinct processes: leftward spreading of [\pm strident] on the one hand, and leftward spreading of [\pm anterior] on the other. This is made necessary by a peculiar asymmetry observed in the data Hardwick reports on—and it is precisely this asymmetry that makes the Tahltan case somewhat parallel to the Totonacan one discussed earlier. What Hardwick finds is that whereas agreement in [\pm strident] is obligatory and without exceptions, agreement in [\pm anterior] appears to be optional.

First of all, Hardwick notes that a /ʃ/ series consonant does not consistently trigger harmony in a preceding /s/-series consonant. For example, the 1SgPoss prefix /es-/ regularly assimilates to / θ /-series coronals, yielding [e θ -], but before /ʃ/-series coronals, unassimilated [es-] ‘is the dominant form’ (Hardwick 1984:102). Gafos (1999:187) points out that unassimilated [es-] is also found before / θ /-series coronals in several forms cited elsewhere by Hardwick (especially on pp. 43ff.), and concludes that ‘the harmony may in some sense be optional for all alternations and not just for the s \rightarrow ʃ one’. Optionality alone is therefore not a strong argument for separating [\pm strident] harmony from [\pm anterior] harmony (although it does seem that [s...ʃ] disharmony is more commonly found in Hardwick’s data than [s... θ] disharmony, pace Gafos 1996[1999]).¹²

¹² Paradigm levelling is a likely explanation in the case of 1SgPoss /es-/, but it also appears that part of the explanation is that in nominal prefixes, the coronal assimilations are subject to an adjacency requirement. In the data cited by Hardwick, /es-/ is realized as [e θ -] or [eʃ-] only before stems with an *initial* / θ /-series or /ʃ/-series consonant, respectively. (An interpretation along these lines is in fact hinted at by Hardwick herself, p. 113, n. 3.) It is not at all clear that this local assimilation—which thus applies within coronal obstruent *clusters*—should be analyzed as harmony at all. As a result, coronal harmony may in fact be restricted to verbal prefixes in Tahltan.

More interestingly, a robustly attested pattern in Hardwick's data is that a /ʃ/-series consonant may trigger *partial* harmony in a preceding /θ/, shifting it to a [s] realization instead of all the way to [ʃ]. This is shown in (20). Before a stem (or prefix-stem string) containing a /ʃ/-series consonant, the 1DuSubj prefix /-θi(d)-/ is frequently realized as [si] rather than the expected [ʃi].¹³

(20) Partial assimilation in 1DuSubj prefix /-θi(d)-/ (Hardwick 1984)

si-dʒɪn	'we sang'
de-si-dʒih	'we are breathing'
ʔe-si-tʃɪtʃ	'we tied it'
ʔe-ne-si-tʃuʒ	'we folded it'
ʔi-si-tʃut	'we grabbed it'
me-ʔe-si-t'otʃ	'we are breast-feeding'

On Hardwick's interpretation, the partial assimilation observed in (20) indicates that [±strident] harmony is obligatory, whereas [±anterior] harmony is to some extent optional. Incidentally, the facts in (20) are hard to reconcile with the analyses of Tahltan coronal harmony proposed by Shaw (1991) and Gafos (1996[1999]). In Shaw's case, spreading of a [Coronal] node should not be dependent on what subordinate features happen to be specified below that node, and the partial assimilation in (20) is simply impossible to describe in terms of [Coronal] spreading. In the case of Gafos' analysis, the /ʃ/ series is assumed to represent the *intermediate* value [mid] on the TTCA scale, located in between the extremes [wide] and [narrow] (/θ/ and /s/, respectively). In the partial assimilations in (20), a coronal

¹³ The conjugation marker /-θe-/ shows the same partial-assimilation behavior; this prefix is often realized as [s(ε)] instead of [ʃ(ε)] before stems with /ʃ/-series consonants, cf. [ʔe-s-i-tʃɪtʃ] 'I tied s.t.', [s-in-dʒaŋ] 'you are old'.

with a [mid] TTCA value is causing a preceding coronal to shift from [wide] to [narrow]; this can hardly be made sense of on the basis of articulatory gestures at all.¹⁴

In sum, the Tahltan /ʃ/-series consonants are ‘weak’ harmony triggers in that they do not consistently trigger harmony, and sometimes trigger only partial harmony (in [±strident] but not [±anterior]). The explanation seems to lie in the fact that these consonants are newcomers to the Tahltan coronal inventory, and thereby also to the coronal harmony system. As the table in (21) shows, the /ʃ/ series—here represented by the affricate /tʃ/—is the historical reflex of what was in Proto-Athapaskan a (front) *velar* series, reconstructed as *k̚, *x̚, etc. (cf. Cook & Rice 1989a).

(21) Proto-Athapaskan and Tahltan correspondences:

PA:	*ts	*tʃ̥/*tʃ̥ ^w	*k̚
Tahltan:	/tθ/	/ts/	/tʃ/

There is reason to believe that coronal harmony in Tahltan originally encompassed only the /θ/ and /s/ series, i.e. the reflexes of the Proto-Athapaskan *ts and *tʃ̥/*tʃ̥^w series. Firstly, these are the series which were subject to (morpheme-internal) coronal harmony already in Proto-Athapaskan-Eyak, as demonstrated by Krauss (1964). Secondly, in those daughter languages with sibilant harmony that have maintained the PA *ts vs. *tʃ̥/*tʃ̥^w contrast, it is precisely these two series that participate in the harmony. For example, this is true of Navajo and Apache, where the *ts : *tʃ̥ contrast is preserved intact (/ts/ vs. /tʃ/, etc.), and also in Tsilhqot’in (Chilcotin), where the *ts : *tʃ̥ distinction has developed into a pharyngeal-

¹⁴ Shaw (1991) does not report any asymmetries like the ones in (20)—quite possibly dialect or age-group differences between native-speaker consultants are to blame—and does not address the implications of the facts reported by Hardwick. Gafos (1999:187) does note the asymmetry discussed by Hardwick, i.e. that the /s/ → /ʃ/ alternation alone is optional, and admits that ‘[t]his would be a rather puzzling difference’. However, he does not comment on the partial-assimilation data in (20), which seem far more problematic for his analysis than the mere issue of optionality.

ization contrast: /ts¹/ vs. /ts/, etc.¹⁵ Tsilhqot'in shares with Tahltan (and a large number of other Northern Athapaskan languages) the 'coronalization' of the PA front velar series, *k̲ > /tʃ/, etc. It is significant in this context that in Tsilhqot'in, the /ʃ/ series does *not* participate in the harmony system. The same was almost certainly once true of Tahltan as well.

The diachronic-comparative evidence thus indicates that in Tahltan, the /ʃ/ series is a secondary addition to what was originally a two-way coronal harmony system (as it is in most other Athapaskan languages which show any harmony at all). It seems plausible that this is the reason why /ʃ/-series coronals do not trigger harmony as consistently as those of the /θ/ and /s/ series do in the phonology of at least some speakers.¹⁶ This 'latency' of the /ʃ/ series thus has nothing whatsoever to do with any inherent phonetic-phonological properties of these segments; the explanation instead lies in the diachronic development of the particular harmony system in question. This is exactly what was suggested in the Tlachi-chilco Tepehua case discussed at the beginning of this section. The Tepehua system displays an asymmetry which is otherwise unattested in the cross-linguistic typology of sibilant harmony systems. However, this may be related to the diachronic origins of the system—on the assumption that the parallelism between sibilant harmony and sound-symbolic sibilant alternations is more than a mere accident.

6.4. Palatal bias effects in non-sibilant coronal harmony systems

The previous section showed that the Palatal Bias is robustly replicated in the cross-linguistic typology of coronal sibilant harmony—the type of consonant harmony which is most widely attested in the world's languages. However, not all harmony processes involving alveolar vs. 'palatal' (i.e. postalveolar) obstruents fall in the category of sibilant

¹⁵ As argued in Hansson (2000), the curious Tsilhqot'in development most likely passed through an intermediate stage where the contrast was dental vs. alveolar (/t̪s/ vs. /ts/, or possibly /tθ/ vs. /ts/), as it still is in some nearby Northern Athapaskan languages, such as Dakelh (Carrier), Beaver and Kaska—in addition, of course, to Tahltan itself.

¹⁶ Note that the curious partial-assimilation facts in (20) do *not* fall out automatically from this account.

harmony. In some coronal harmony systems, the segments interacting in the harmony are alveolar *stops* on the one hand and ‘palatal’ affricates on the other. The handful of cases of this type of which I am aware were discussed and illustrated in section 2.4.1.2 above. For ease of reference, most of the relevant data will be repeated here.

What is particularly striking about such coronal stop/affricate harmonies is that they all show an asymmetry consistent with the Palatal Bias. As discussed in section 6.2 above, phonological speech errors involving the change /t/ → /tʃ/ (e.g., [tʃ]im’s *check* for *Tim’s check*) are far more common than those involving the change /tʃ/ → /t/ (e.g., [t]uck’s *tooth* for *Chuck’s tooth*). This is mirrored by the phonological coronal stop/affricate harmonies in question; they all involve the assimilatory change stop → affricate (e.g., /t/ → /tʃ/ or /d/ → /dʒ/), to the exclusion of the reverse change affricate → stop. In other words, the alveolar stop is always the target of harmony, whereas the palatal affricate is the harmony trigger.

One example of this phenomenon is the Chadic language Kera (Ebert 1979). In this language, root-internal /t...tʃ/ sequences harmonize to /tʃ...tʃ/ (22a); the process appears to be optional to some extent. By contrast, the reverse sequence /tʃ...t/ remains intact (22b).

(22) Root-internal coronal harmony in Kera (data from Ebert 1979)

a. ‘Palatalizing’ harmony (optional?):

tutʃi ~ tʃutʃi ‘tamarind’

tʃətʃerká ‘backbone’ (cf. Tupuri /tʃtʃèrè/)

b. No ‘depalatalizing’ harmony:

tʃérté ‘split’ (not → *térté)

Interestingly, this harmony appears to result in alternations as well as in root-internal co-occurrence effects. The feminine gender prefix /t-/ occurs on a variety of nominals, as

shown in (23a). When the root it attaches to contains /tʃ/, this appears to trigger harmony in the prefix, judging from examples like the one cited in (23b).

(23) Kera: Harmony alternations in feminine prefix /t-/ (data from Ebert 1979)

- | | | | |
|----|----------|----------------|-----------------------|
| a. | t-ó:já | ‘dog (fem.)’ | (cf. masc. /k-ó:já/) |
| | t-e:ŋa | ‘dry (fem.)’ | (cf. masc. /k-e:ŋe/) |
| b. | tʃ-ə:tʃá | ‘small (fem.)’ | (cf. masc. /k-o:tʃé/) |

A second example is the Dravidian language Pengo (Burrow & Bhattacharya 1970), where the effects of the harmony appear to be confined to the root. As shown in (24a), coronal stop-affricate sequences like /t...tʃ/, /t...dʒ/, /d...dʒ/, etc. undergo harmony—to some extent optionally—with the preceding alveolar assimilating to the palatal, rather than vice versa.¹⁷ As in Kera, the reverse sequences (/tʃ...t/, etc.) do not harmonize (24b).

(24) Root-internal coronal harmony in Pengo (data from Burrow & Bhattacharya 1970)

a. Harmony involving alveolar → palatal (optional?):

- | | | | |
|----------|------------|------------------------|-----------------------------|
| tʃitʃ- | ~ tʃitʃ- | ‘to eat (past stem)’ | (derived from /tin-/ ‘eat’) |
| to:tʃ- | ~ tʃo:tʃ- | ‘to show’ | |
| ta:ndʒ- | ~ tʃa:ndʒ- | ‘to weave (a garland)’ | |
| dʒo:tʃ- | | ‘to carry on the head’ | (cf. Gondi /to:tʃa:na:/) |
| tʃo:ndʒ- | | ‘to appear’ | (cf. Kuvi /to:ndʒ-/) |

¹⁷ Burrow & Bhattacharya (1970) actually describe the stops here labelled ‘alveolar’ as being *dental*, although it is not entirely clear whether this is based on phonetic fact or merely a matter of terminological tradition in Dravidian linguistics. In any case, this issue is of no relevance to the case being made here—i.e. the existence of Palatal Bias effects in coronal harmony systems.

b. No harmony involving palatal → alveolar:

tʃeta man-	‘to be awake’	(not → *teta ...)
tʃinta ki-	‘to think; to worry’	(not → *tinta ...)
dzunda	‘spinning top’	(not → *dunda)

Note that although the Pengo harmony is confined to the root, it nevertheless does result in surface alternations in a few situations, as shown by the first example in (24a). The verb ‘eat’ has the root /tin-/; when the root-final consonant is replaced by /tʃ/ (a morphologically driven process), this feeds harmony by giving rise to a /t...tʃ/ sequence. The root-initial /t/ thus alternates with /tʃ/ depending on the tense of the verb—although this kind of alternation can only be observed in a very small number of cases (which may well be *synchronically* frozen, and thus suppletive).

Yet another case where coronal harmony of this type is manifested as a root-internal cooccurrence restriction—though in this case without resulting in any alternations—is the dialect of Aymara referred to by MacEachern (1997[1999]) as ‘Bolivian’ Aymara, as represented in the dictionary of De Lucca (1987). Bolivian Aymara places severe restrictions on the cooccurrence of alveolar stops (/t, t^h, tʰ/) and ‘palatal’ affricates (/tʃ, tʃ^h, tʃʰ/) within morphemes, which to some degree are sensitive to laryngeal specifications. When two cooccurring coronal plosives are both laryngeally specified, i.e. ejective or aspirated, they must either both be alveolar or both must be palatal. Thus sequences like /t^h...tʃ^h/, /tʃ^h...t^h/, /tʰ...tʃ^h/ or /tʃʰ...t^h/ are all excluded from the lexicon of Bolivian Aymara—a fact noted by MacEachern (1997[1999]). However, a search of word-initial coronal-CVC sequences in De Lucca (1987) reveals that when one of the coronal plosives is laryngeally unspecified, or if both of them are, then the cooccurrence restriction is asymmetric. Whereas alveolar-palatal sequences are excluded, palatal-alveolar sequences are allowed and are quite well attested. This is shown in (25).

(25) Root-internal coronal harmony in Bolivian Aymara (data from De Lucca 1987)

a. No *T...Č sequences allowed:

*t...tʃ

*t^h...tʃ

*t'...tʃ

b. Č...T sequences are allowed:

tʃatu 'jug, small vessel of clay'

tʃitu 'minute, tiny (dial.)'

tʃ^hita 'string, row of objects put on a thread'

tʃ'uta 'collision of two round objects'

Note that the disallowed sequences in (25a) are precisely the ones which are eliminated by (anticipatory) coronal harmony in languages like Kera and Pengo. It therefore seems reasonable to interpret the static cooccurrence pattern of Bolivian Aymara as being due to the same kind of harmony. In other words, hypothetical sequences like /t...tʃ/ are ruled out because they would get harmonized to /tʃ...tʃ/, whereas mirror-image sequences like /tʃ...t/ are *not* harmonized to /t...t/ in the same way. The distributional patterns of Bolivian Aymara thus display a Palatal Bias effect: Coronal harmony involving /t/ → /tʃ/ is enforced, but the reverse change /tʃ/ → /t/ is not.¹⁸

¹⁸ A similar sequential ordering restriction on coronal plosives morpheme-internally is found in Javanese (Malayo-Polynesian; Uhlenbeck 1949; Mester 1986[1988]), with respect to dentals and retroflexes on the one hand and the so-called 'palatals' on the other. Uhlenbeck (1949) noted that whereas palatal...dental and palatal...retroflex sequences are quite common, their mirror images are rare. The statistical analysis of Javanese cooccurrence restrictions undertaken by Mester (1986[1988]) reveal that the facts are somewhat more complicated than this, but nevertheless concludes that '[t]here are more combinatorial restrictions in the order coronal + palatal [...] than the order palatal + coronal' (p. 162). Although the 'palatal' plosives of Javanese are frequently analyzed phonologically as [+high] (e.g., by Mester 1986[1988]), they are in fact phonetically *alveolar* affricates [ts, dz] (see, e.g., Ladefoged & Maddieson 1996 and references cited there). If the ordering asymmetry in Javanese is connected to the Palatal Bias effect, then this can only be true diachronically, not synchronically.

Finally, it is worth noting that the morphological palatalization phenomena of Harari (Semitic; Leslau 1958; Rose 1997) follow the same pattern, although it is unclear to what extent these effects involve consonant harmony (synchronically and/or diachronically). As described in section 2.4.3 above, a suffix /-i/ triggers ‘palatalization’ of the immediately preceding stem-final consonant, resulting in such changes as /s/ → /ʃ/, /d/ → /dʒ/ and /t/ → /tʃ/, among others. When the stem contains another coronal in addition to the stem-final one, morphological palatalization should produce stem-internal sequences like /t...tʃ/, /t...dʒ/, /t...ʃ/, consisting of an alveolar followed by a ‘palatal’. However, as described in greater detail in 2.4.3, such forms often optionally undergo *double* palatalization. This can be seen from examples such as the following 2SgFem imperative forms: /bit’äʃ-i ~ bitʃ’äʃ-i/ ‘rip!’ (cf. 2SgMasc /bit’äs/), /t’imädʒ-i ~ tʃ’imädʒ-i/ ‘put the yoke!’ (cf. 2SgMasc /t’imäd/), /kisäʃ-i ~ kiʃäʃ-i/ ‘take to court!’ (cf. 2SgMasc /kisäs/). Note that the Harari case involves not only fricative/fricative alternations (s/ʃ), as are found in most sibilant harmony systems, but also stop/affricate alternations (t/tʃ, t’/tʃ’, d/dʒ) as in Kera and Pengo. If coronal harmony is involved in the Harari ‘double-palatalization’ effects, then it is consistent with the patterns found in the other languages discussed earlier in this section—both in terms of the directionality of the assimilation (right-to-left) and in terms of the Palatal Bias asymmetry (only /t/ → /tʃ/, /s/ → /ʃ/, no /tʃ/ → /t/ etc.). However, the fact that the Harari alternations are *morphologically* driven—combined with the fact that they involve sonorants as well as obstruents (cf. 2.4.3 for examples)—makes them hard to interpret as consonant harmony in the same sense as the other phenomena that have been examined here.

To sum up, Palatal Bias effects are found not only in the cross-linguistic typology of sibilant harmony systems, but also in that of the much rarer type of coronal harmony that involves alveolar stops vs. ‘palatal’ affricates. In both cases alveolars have a far stronger tendency to assimilate to a nearby palatal than vice versa. Insofar as this asymmetry mirrors the Palatal Bias that has been robustly demonstrated in speech error studies, it can be taken

as strong circumstantial evidence that coronal harmony—and by extension consonant harmony in general—has its roots in the domain of speech planning/phonological encoding.

6.5. Summary

This chapter has focused on the relationship between consonant harmony and the domain of speech planning, i.e. phonological encoding for language production. In particular, several parallels have been pointed out between slips of the tongue and the effects resulting from consonant harmony processes. Some of these were already discussed in earlier chapters to a greater or lesser extent. One such parallel is the fact that both consonant harmony processes and speech errors are sensitive to the relative similarity of the interacting segments. Similarity effects of this kind are attested in coronal harmony systems no less than in other types of long-distance consonant assimilation. For example, sibilant harmony may hold only between fricatives (and thus not apply to fricative/affricate combinations), or it may hold only between fricatives which agree in voicing.

Another parallel is the default status of right-to-left directionality in consonant harmony systems, as demonstrated in section 3.1, which has gone unnoticed by previous studies in this area. Just as anticipatory assimilation is the norm in consonant harmony processes, so are anticipations far more common in slips of the tongue than perseverations. Although perseveratory errors do occur, they appear to be associated with relatively ‘dysfunctional’ production systems (e.g., in aphasics and young children), and are generally correlated with high-error-rate situations (increased speech rate, unfamiliarity with the phrase being produced, etc.). The same is not true of anticipatory slips of the tongue.

The main purpose of this chapter has been to document the existence of another such parallel: the so-called ‘Palatal Bias’ effect. In slips of the tongue involving alveolar and ‘palatal’ (postalveolar) obstruents, alveolars tend to be replaced by palatals far more often than the reverse. This asymmetry has been documented in several corpora of naturally

occurring slips of the tongue, and the effect has also been replicated in psycholinguistic studies of speech errors elicited in a laboratory setting. As demonstrated in section 6.3, the Palatal Bias is directly reflected in the cross-linguistic typology of those sibilant harmony systems which involve the /s/ vs. /ʃ/ distinction. When there is any kind of asymmetry present in such systems, the favored assimilatory change is always /s/ → /ʃ/ rather than the reverse /ʃ/ → /s/. This is a direct parallel to the Palatal Bias as manifested in speech errors. The sole exception to the generalization, Tlachichilco Tepehua, shows that the preference of /s/ → /ʃ/ over /ʃ/ → /s/ cannot be elevated to a *synchronic* universal (e.g., by building it into phonological theory in terms of fixed constraint rankings in Optimality Theory). Nevertheless, it appears that the typologically anomalous character of Tlachichilco Tepehua sibilant harmony may have something to do with the diachronic sources of this particular harmony system, as argued in section 6.3.3.

Finally, section 6.4 demonstrated that, in addition to sibilant harmony systems, the Palatal Bias also manifests itself in the much rarer type of coronal harmony where alveolar stops and ‘palatal’ affricates interact. In all attested harmony systems of this type, the alveolar stop is always the target, assimilating to a following affricate (/t...tʃ/ → /tʃ...tʃ/, etc.). This is again consistent with the findings of speech error studies: /t/ is considerably more likely to be replaced by /tʃ/ than vice versa. The fact that the Palatal Bias rears its head in the typology of phonological harmony processes of two distinct types—that involving alveolar vs. palatal ‘stridents’ (fricatives and affricates) and that involving alveolar stops vs. palatal affricates—makes it highly unlikely that the parallel between speech errors and consonant harmony phenomena is purely accidental.

To sum up, the wide-ranging parallels that can be demonstrated to hold between slips of the tongue and phonological consonant harmony processes provide strong support for the hypothesis that the latter has its roots (diachronic and/or synchronic) in the domain of speech planning. This hypothesis in turn underlies the synchronic analysis of consonant

harmony as phonological *agreement* rather than feature/gesture *spreading*, as developed in chapters 4 and 5. To the extent that the hypothesis is validated by facts such as the ones discussed in this chapter, that analysis is justified.

CHAPTER 7

SUMMARY AND CONCLUSIONS

In the preceding chapters I have presented an analysis of consonant harmony as agreement, based on a comprehensive typological investigation into the phonological properties and cross-linguistic variation of consonant harmony systems in the world's languages. A key ingredient in the proposal is that consonant harmony—including its most canonical manifestation, coronal (sibilant) harmony—is motivated in the domain of speech planning. I have defended this view by pointing out a great number of striking parallels between consonant harmony processes on the one hand and phonological slips of the tongue on the other, most of which have not been noted by previous works on consonant harmony.

The empirical foundation of this study was a survey of attested consonant harmony phenomena in the world's languages, based on a database consisting of roughly 120 distinct cases. This survey was presented in chapter 2, where most of the individual cases were mentioned and many were explicitly described and illustrated with examples from descriptive sources. It is my hope that this detailed overview, and the data and bibliographic references in it, will serve as a useful resource for future research on topics related to consonant harmony; it is certainly the most comprehensive survey of such phenomena that has appeared to date.

The main conclusion to draw from the survey in chapter 2 is that consonant harmony systems are remarkably varied in terms of the phonetic/phonological properties that may assimilate at-a-distance. As had already been noted in earlier works (e.g., Shaw 1991; Gafos 1996[1999]), coronal harmony—and sibilant harmony in particular—is the most commonly attested type of consonant harmony by far. This kind of harmony involves certain coronal-specific distinctions that could be characterized as 'minor' place of articulation. But a wide range of other features may be involved in consonant harmony processes.

For example, consonants may agree in secondary-articulation features (pharyngealization, velarization, possibly palatalization), dorsal consonants may agree in ‘uvularity’, liquids may agree in laterality/rhoticity (and possibly the tap/non-tap distinction) and glides may agree with liquids (or vice versa). With respect to nasality, voiced obstruents may interact with full nasals or with prenasalized (voiced) obstruents, or full nasals vs. prenasalized consonants may interact; alternatively, oral sonorants (liquids and/or glides) may interact with nasals. Obstruents may agree in one or more laryngeal features such as [\pm voiced], [\pm spread glottis] or [\pm constricted glottis]; often the interaction is limited to obstruents which already agree in place or manner (or both). Finally, consonants may agree in stricture ([\pm continuant]), with fricatives or even sonorants interacting with stops and/or affricates.

In sum, there are very few properties that are never involved in the kind of long-distance agreement that qualifies as consonant harmony. A glaring exception is major place of articulation, a fact which has been accorded great significance in many previous works (see, e.g., Gafos 1996[1999]; Ní Chiosáin & Padgett 1997). Although the absence of major-place harmony is certainly significant, and has yet to be fully explained (given that such phenomena as stricture harmony *do* exist), it is possible that this unattested phenomenon appears to be at the far end of a gradient scale of decreasing frequency of occurrence. For example, although stricture harmony does occur, it is exceedingly rare cross-linguistically. Laryngeal harmony, though quite common as a root-internal cooccurrence restriction, hardly ever reaches across morpheme boundaries. Note that major place is also sometimes involved in root-internal cooccurrence restrictions, but these are then always *dissimilatory* rather than *assimilatory*. The apparent absence of major-place harmony might thus be due to a bias in favor of place dissimilation over assimilation, rather than any inherent impossibility of this phenomenon. Such biases are found in other harmony types as well, whatever their explanation may turn out to be; for example, long-distance liquid interactions (/l/ vs. /r/) far

more frequently involve dissimilation or metathesis than assimilation. Conversely, sibilant interactions (e.g., /s/ vs. /ʃ/) hardly ever involve dissimilation—here harmony is the norm.

Even though consonant harmony can be based on a highly diverse set of features, a major finding of this study is that the attested consonant harmony systems are remarkably uniform with respect to a number of properties, of which three major ones were discussed in chapter 3. The first is directionality: consonant harmony processes seem to generally obey a fixed right-to-left (i.e. anticipatory) directionality. Where the opposite is true, this can virtually always be explained as a by-product of stem control, whereby the direction of assimilation falls out from morphological constituent structure. Secondly, consonant harmony is never curtailed by segmental opacity effects, where a specific class of intervening segments blocks the propagation of harmony. Instead, the segmental material separating the trigger and target consonants is consistently irrelevant (and thus ‘transparent’). Thirdly, consonant harmony is never influenced in any way by prosodic factors such as stress or syllable weight, and is never bounded by prosodically-defined domains (e.g., the foot). Overall, the typological profile that characterizes consonant harmony systems is quite distinctive, especially with regard to segmental opacity effects and sensitivity to prosody, both of which are extremely frequent in vowel harmony and vowel-consonant harmony systems but absent in consonant harmony.

Based on the empirical generalizations of chapters 2 and 3, I developed a generalized phonological analysis of consonant harmony in chapters 4 and 5, couched in the output-oriented and constraint-based framework of Optimality Theory. The core of the analysis is the idea that consonant harmony is due to agreement under (string-internal) correspondence, following proposals originally developed by Walker (2000ab, to appear; see also Rose & Walker 2001). The default nature of right-to-left directionality was built directly into the correspondence relation itself ($C_1 \leftarrow C_2$), with left-to-right harmony under stem control emerging as a by-product of constraint interaction. Nevertheless, deriving absolute direc-

tionality proves problematic—having to do with the output-oriented character of Optimality Theory—and I suggested dealing with this issue by assuming that the constraints enforcing harmony are in fact *targeted* constraints in the sense of Wilson (2000, in progress; see also Baković 2000; Baković & Wilson 2000).

Given these assumption, I demonstrated how the framework can deal not only with the basic directionality patterns, but also with more intricate effects resulting from the interplay of harmony with phonotactic (markedness) constraints. At the end of chapter 5, however, I called attention to certain problematic aspects of the correspondence-based analysis, and pointed out particular phenomena that it appears incapable in principle of handling. The tentative conclusion drawn was that a radical revision might become necessary, by which the similarity-scaled CORR-CC constraints and the harmony-enforcing \rightarrow IDENT[F]-CC constraints would be conflated into a single constraint type. In effect, this move would entail doing away with the string-internal correspondence relation as such. The exploration of the details and implications of this alternative approach are left to future investigation.

Finally, chapter 6 adduced evidence in support of the claim that consonant harmony effects are motivated in the domain of speech planning, i.e. phonological encoding for speech production. I pointed out a number of parallels between consonant harmony processes and phonological speech errors, including not merely relative-similarity effects (whereby similar segments interact more frequently than less similar ones), but also the predominance of anticipatory directionality, as well as the inertness/irrelevance of segmental material separating trigger and target consonants. I introduced yet another striking parallel which has not previously been noticed, namely the existence of a so-called Palatal Bias effect in the cross-linguistic typology of coronal harmony systems. This effect, along with its well-documented counterpart in the domain of speech errors, was discussed in detail and illustrated with a number of examples from a variety of languages.

The view of consonant harmony processes that I have argued for in the preceding chapters, and the concomitant phonological analysis, has the potential of shedding new light on the relationship between such phenomena in adult language and the analogous consonant assimilations which are rampant in *child* language (see, e.g., Smith 1973; Vihman 1978; Berg 1992; Bernhardt & Stemberger 1998; Berg & Schade 2000). The fact that consonant harmony in child language most typically involves major place of articulation—a pattern which is never attested in adult language—has often led phonologists to conclude that this phenomenon must be fundamentally distinct from consonant harmony in adult languages (see, e.g., Gafos 1996[1999]; Ní Chiosáin & Padgett 1997). However, viewing consonant harmony as agreement, based in the domain of phonological encoding and triggered by relative similarity, puts this issue in a fresh perspective. At the developmental stage when major-place harmony most frequently occurs (typically late in the second year), the segmental inventory available to the child is considerably impoverished. Consequently, place of articulation is presumably far less entrenched as a systematic parameter of lexical differentiation than it is in an adult's grammar. In her detailed survey of consonant harmony in child language, Vihman (1978) addresses the relationship between this phenomenon and adult consonant harmony, and draws the following parallel:

It may be that *s* - *ʃ* (and other combinations of the alveolar and palato-alveolar fricatives) represent, for adults, the same kind of difficulty that *p* - *t*, *t* - *k*, etc. apparently present for children. (Vihman 1978:324)

It should also be emphasized that consonant harmony in child language may involve properties other than major place of articulation; the resulting effects often have clear parallels in adult languages. For example, harmony may take the form of nasal consonant harmony (e.g., /minz/ for *beans*), or even that most canonical type of consonant harmony,

sibilant harmony involving the /s/ vs. /ʃ/ distinction. An example of the latter is found in the speech of Suzanne, as reported by Deville (1891) and analyzed by Berg & Schade (2000); e.g., /ʃo:se:/ *chausser* → [ʃo:ʃe:] or [so:se:].

The similarity-based agreement analysis developed in the preceding chapters may help explain the differences between child and adult consonant harmony. It is reasonable to assume that in early stages, when the inventory is small and major-place distinctions are closer to the limits of the child's phonological capabilities, pairs like /t/ vs. /k/ are judged as far more similar than they are in adult language. Consequently, they should be more likely to enter into the kind of agreement patterns that we find in adult language. As the consonant inventory grows, contrasts that have been mastered earlier (such as major place) become more entrenched than those acquired later (e.g., the 'minor-place' contrast between /s/ and /ʃ/), and less likely to give rise to agreement effects.¹ This might explain why major-place harmony is so common in child language but unattested in adult language.

Furthermore, there are certain parallels between consonant harmony in child and adult language that suggest that the two phenomena are homologous. For example, as noted in chapter 6, the predominance of right-to-left directionality is also characteristic of child consonant harmony (Vihman 1978). Nevertheless, differences may also exist. For example, Rose (2000) argues that differences between harmony patterns displayed by French and English learners are due to the different prosodic structure of the two target languages. Recall that adult consonant harmony is never sensitive to prosodic factors in any way, and this divergence is therefore somewhat surprising. A more detailed and systematic comparison of the consonant harmony effects attested in child and adult language would undoubtedly help further our understanding of each of the two phenomena.

¹ Berg (1992) and Berg & Schade (2000) develop an analysis of consonant harmony in child language based on spreading activation in a connectionist network model, where harmony most often results from particular links in the network being impoverished (resulting in a hypoactivation effect). It would be interesting to see if it is feasible to capture consonant harmony in adult language in a similar manner, although this raises thorny questions about the relationship between competence and performance and the status of phonologized sound patterns.

Setting aside the issue of consonant harmony in child language, a few final words of caution are in order in connection with the claim, stated above, that consonant harmony is motivated (or ‘has its roots’) in the domain of speech planning. Elsewhere in this work, it was suggested that consonant harmony effects could be regarded, loosely speaking, as ‘phonologized speech errors’. This phrase should not be taken too literally. Given how relatively rare errorful productions of a given word is, as compared to productions without error, it seems rather unlikely that sporadic on-line errors would be able to spawn regular sound changes, yielding systematic phonological patterns. I suggested at the end of chapter 2 that the diachronic origins of the consonant harmony phenomena surveyed here may in fact turn out to be quite diverse. If true, this makes the relative uniformity of their collective typological profile (in terms of *synchronic* properties) all the more interesting. If considerations of planning and phonological encoding are involved in consonant harmony phenomena, as I have argued here, then this connection must hold at a relatively grammaticalized cognitive level.

The precise nature of this connection has yet to be explained, but it should be noted that the same (or similar) questions arise in the case of other types of sound patterns. For example, Frisch (1996) and Frisch et al. (1997) argue convincingly that the dissimilatory OCP place restrictions on roots in Arabic are governed by a similarity metric of precisely the same kind as that which manifests itself in slips of the tongue. However, the question remains how these dissimilatory patterns came into existence in the first place, i.e. precisely how Arabic (or its ancestor) ‘phonologized’ the similarity-based dispreference for certain consonant combinations. The same applies to other languages with similar root-internal co-occurrence restrictions. In these cases, as in a great number of the consonant harmony cases examined in this dissertation, the effect is restricted to tautomorphic segment combinations. It is therefore quite possible that considerations of lexical storage and retrieval are somehow involved as well (recall that consonant harmony is often limited to

relatively lexicalized morphological domains). These intriguing questions, which are key to developing a full understanding of the nature and origins of consonant harmony, must await future investigation.

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CONSONANT HARMONY DATABASE

Note: Nonsibilant coronal harmonies are entered as ‘coronal harmony’. Sources cited are not exhaustive

<i>Language</i>	<i>Harmony type</i>	<i>Manifestation</i>	<i>Sources</i>
Aari (Omotic)	sibilant harmony	MSC + alternations	Hayward (1988, 1990a)
Alur (Nilotic)	coronal harmony	MSC	Tucker (1969), Mester (1986)
Anywa (Nilotic)	coronal harmony	MSC + alternations	Reh (1996)
Aymara (‘Bolivian’ dial.; Aymaran)	dorsal harmony	MSC	MacEachern (1997)
Aymara (‘Bolivian’ dial.; Aymaran)	coronal harmony	MSC	MacEachern (1997)
Aymara (‘Bolivian’ dial.; Aymaran)	laryngeal harmony	MSC	MacEachern (1997)
Aymara (‘Peruvian’ dial.; Aymaran)	laryngeal harmony	MSC	MacEachern (1997)
Barbareño Chumash (Chumashan)	sibilant harmony	MSC + alternations	Beeler (1970), Mithun (1998)
Basaa (Bantu)	liquid harmony	alternations (1 suffix)	CBOLD, Lemb & de Gastines (1973)
Basaa (Bantu)	nasal consonant harmony?	MSC + alternations	Greenberg (1951)
Basque (Baztan dial.; isolate)	sibilant harmony (3-way)	MSC	Salaburu (1984), Hualde (1989)
Basque (other diall.; isolate)	sibilant harmony	MSC	Hualde (1989), Trask (1997)
Beaver (Doig River dial.; Athapaskan)	sibilant harmony (3-way)	MSC + alternations	Story (1989)
Bemba (Bantu)	nasal consonant harmony	MSC + alternations	Hyman (1995)

Berber (various dial.; Afroasiatic)	sibilant harmony	MSC + alternations	Laoust (1918), Elmedlaoui (1992)
Berber (various dial.; Afroasiatic)	laryngeal harmony (sibilants)	MSC + alternations	Laoust (1918), Elmedlaoui (1992)
Bukusu (Bantu)	liquid harmony	MSC + alternations	CBOLD, de Blois (1975), Odden (1994)
Capanahua (Panoan)	sibilant harmony (3-way)	MSC	Loos (1967)
Chilcotin: see Tsilhqot'in			
Chiricahua Apache (Athapaskan)	sibilant harmony	MSC + alternations	Hojjer (1946)
Chontal (Mayan)	laryngeal harmony?	MSC	Keller (1959)
Coptic (Bohairic dial.; Afroasiatic)	sibilant harmony	MSC	Chaine (1933), Till (1961), Westendorff (1977)
Coptic (Sahidic dial.; Afroasiatic)	sibilant harmony	MSC	Chaine (1933), Till (1961), Westendorff (1977)
Dholuo (Nilotic)	coronal harmony	MSC	Tucker (1994)
Fang (Bantu)	nasal consonant harmony	MSC?	Greenberg (1951)
Flemish (Teralfene dial.; Germanic)	sibilant harmony	MSC + alternations	Willem de Reuse (pers. comm.)
Ganda (Bantu)	nasal consonant harmony	MSC	Katamba & Hyman (1991)
Old Georgian (Kartvelian)	laryngeal harmony	MSC	MacEachern (1997)
Gimira (Benchnon dial.; Omotic)	sibilant harmony (3-way)	MSC + alternations	Hayward (1988), Breeze (1990)
Gojri (Indo-Iranian)	laryngeal harmony	MSC	MacEachern (1997)
Harari (Ethio-Semitic)	palatalization/coronal harmony?	alternations	Leslau (1958), Rose (1997)
Hausa (Chadic)	laryngeal harmony	MSC	Parsons (1970), MacEachern (1997)

Hausa (Chadic)	nasal consonant harmony	MSC	Newman (2000)
Hausa (Chadic)	liquid harmony	MSC	Newman (2000)
Herero (Bantu)	nasal consonant harmony	MSC + alternations	Booyesen (1982)
Hupa (Athapaskan)	sibilant harmony	MSC + alternations	Golla (1970)
Ijo (Kalabari dial.; Niger-Congo)	laryngeal harmony	MSC	Jenewari (1989)
Ila (Bantu)	nasal consonant harmony	MSC + alternations	Greenberg (1951)
Ineseño Chumash (Chumashan)	sibilant harmony	MSC + alternations	Applegate (1972), Poser (1982)
Ixil (Nebaj dial.; Mayan)	sibilant harmony	MSC	Ayres (1991)
Izere (Bantu)	sibilant harmony	MSC + alternations	Blench (2000)
Izon (Bumo dial.; Niger-Congo)	laryngeal harmony	MSC	Efere (2001)
Javanese (Malayo-Polynesian)	coronal harmony?	MSC	Uhlenbeck (1949), Mester (1986)
Javanese (Malayo-Polynesian)	liquid harmony?	MSC	Uhlenbeck (1949), Mester (1986)
Karaim (Turkic)	palatalization harmony?	MSC + alternations	Jakobson et al. (1963), Lightner (1965)
Kera (Chadic)	laryngeal harmony	MSC + alternations	Ebert (1979), Odden (1994)
Javanese (Malayo-Polynesian)	coronal harmony	MSC + alternations	Ebert (1979)
Kiowa-Apache (Athapaskan)	sibilant harmony	MSC + alternations	Bittle (1963)
Kongo (Bantu)	nasal consonant harmony	MSC + alternations	Ao (1991), Piggott (1996)
Koyra (Omotic)	sibilant harmony	MSC + alternations	Hayward (1982, 1988, 1990b)

Kwanyama (Bantu)	nasal consonant harmony	MSC + alternations	Meinhof (1932)
Lamba (Bantu)	nasal consonant harmony	MSC + alternations	Doke (1938), Odden (1994)
Luba (Bantu)	nasal consonant harmony	MSC + alternations	Johnson (1972), Howard (1973)
Malto (Dravidian)	coronal harmony	MSC	Mahapatra (1979)
Malto (Dravidian)	dorsal harmony	MSC	Mahapatra (1979)
Malto (Dravidian)	laryngeal harmony (dorsals)	MSC	Mahapatra (1979)
Mayak (Nilotic)	coronal harmony	MSC + alternations	Andersen (1999)
(Ki)Mbundu	nasal consonant harmony	MSC + alternations	Chatelain (1888-89)
Misantla Totonac (Totonacan)	dorsal harmony	MSC + alternations	MacKay (1999)
Misantla Totonac (Totonacan)	sibilant harmony	MSC + alternations	MacKay (1999)
Mokilese (Oceanic)	velarization harmony	MSC	McCarthy (1989)
Moroccan Arabic (Semitic)	sibilant harmony	MSC	Harrell (1962), Heath (1987)
Mwiini (Bantu)	liquid harmony	alternations	Kisseberth & Abasheikh (1970)
Navajo (Athapaskan)	sibilant harmony	MSC + alternations	Sapir & Hoijer (1967), McDonough (1991)
Ndebele (Bantu)	laryngeal harmony	MSC	CBOLD, Pelling (1971)
Ndonga (Bantu)	nasal consonant harmony	MSC + alternations	Viljoen (1973), Tirronen (1986)
Ngbaka (Niger-Congo)	laryngeal harmony	MSC	Thomas (1963), Mester (1986)
Ngbaka (Niger-Congo)	nasal consonant harmony	MSC	Thomas (1963), Mester (1986)

Ngizim (Chadic)	laryngeal harmony	MSC	Schuh (1978, 1997)
Nkore-Kiga (Bantu)	sibilant harmony	MSC + alternations	CBOLD, Taylor (1959)
Pangwa (Bantu)	nasal consonant harmony	MSC + alternations	Stirnemann (1983)
Pare (Bantu)	liquid harmony	alternations	Odden (1994)
Pare (Bantu)	stricture harmony?	alternations	Odden (1994)
Päri (Nilotic)	coronal harmony	MSC + alternations	Andersen (1988)
Pengo (Dravidian)	coronal harmony	MSC	Burrow & Bhattacharya (1970)
Pohnpeian (Oceanic)	velarization harmony (labials)	MSC	Rehg (1981), Mester (1986, 1988)
Pohnpeian (Oceanic)	coronal harmony	MSC	Rehg (1981)
Pohnpeian (Oceanic)	liquid harmony	MSC	Rehg (1981)
Proto-Athapaskan-Eyak (reconstr.)	sibilant harmony	MSC	Krauss (1964)
Proto-Bantu (reconstr.)	nasal consonant harmony?	MSC	Hyman (pers. comm.)
Proto-Omoti (reconstr.)	sibilant harmony (3-way)	MSC	Hayward (1988)
S. Peruvian Quechua (col. period; Quechuan)	sibilant harmony	MSC	Mannheim (1988, 1991)
S. Peruvian Quechua (modern?; Quechuan)	dorsal harmony	MSC	Mannheim (1991)
Wanka/Huanca Quechua (Quechuan)	sibilant harmony	MSC	Cerrón-Palomino (1977), Mannheim (1988)
Rumsen (Costanoan)	sibilant harmony	alternations	Garrett (1999) based on Miller (to appear)
Rundi (Bantu)	sibilant harmony	MSC + alternations	Meeussen (1959), Ntahirageza (1993)

Rwanda (Bantu)	sibilant harmony	MSC + alternations	Kimenyi (1979)
Sanskrit (Indo-Iranian)	coronal harmony?	MSC + alternations	Schein & Steriade (1986), Gafos (1996)
Sarcee (Athapaskan)	sibilant harmony	MSC + alternations	Cook (1978, 1979, 1984)
Sawai (Austronesian)	nasal consonant harmony	alternations	Whistler (1992)
Slave (Bearlake dial.; Athapaskan)	sibilant harmony	MSC + alternations	Rice (1989)
Shambaa (Bantu)	stricture harmony?	alternations (1 suffix)	Besha (1989), Odden (1994)
Shambaa (Bantu)	sibilant harmony?	alternations?	Roehl (1911)
Shilluk (Nilotic)	dental vs. alveolar harmony	MSC + alternations	Gilley (1992)
Suku (Bantu)	nasal consonant harmony	MSC + alternations	Piper (1977)
Southern Paiute (Uto-Aztecan)	sibilant harmony	MSC + alternations?	Lovins (1972)
Sundanese (Austronesian)	liquid harmony	alternation (1 infix)	Cohn (1993), Suzuki (1999)
Tahltan (Athapaskan)	sibilant harmony (3-way)	MSC + alternations	Hardwick (1984), Nater (1989), Shaw (1991)
Tanana (Athapaskan)	sibilant harmony	MSC + alternations	Tuttle (1998)
Teke (dialect cluster; Bantu)	nasal consonant harmony	alternations	Greenberg (1951)
Tiene (Bantu)	nasal consonant harmony	alternations	Hyman & Inkelas (1997)
Tlachichilco Tepehua (Totonacan)	dorsal harmony	MSC + alternations	Watters (1988)
Tlachichilco Tepehua (Totonacan)	sibilant harmony	MSC + alternations	Watters (1988)
Tonga (Bantu)	nasal consonant harmony	MSC + alternations	Collins (1975)

Tsilhqot'in (Athapaskan)	pharyngealization harmony (sibilants)	MSC + alternations	Krauss (1975), Cook (1983, 1987, 1993)
Tututni (Athapaskan)	sibilant harmony	MSC + alternations	Golla (1976)
Tzeltal (Mayan)	sibilant harmony	MSC + alternations	Kaufman (1971)
Tzotzil (Mayan)	sibilant harmony	MSC + alternations	Cowan (1969)
Tzotzil (Mayan)	laryngeal harmony	MSC	Weathers (1947)
Tzutujil (Mayan)	sibilant harmony	MSC	Dayley (1985)
Tzutujil (Mayan)	laryngeal harmony	MSC	Dayley (1985), MacEachern (1997)
Ventureño Chumash (Chumashan)	sibilant harmony	MSC + alternations	Harrington (1974)
Wiyot (Algic)	sibilant harmony	MSC + alternations	Teeter (1959, 1964)
Wiyot (Algic)	liquid harmony	MSC + alternations	Teeter (1959, 1964)
Yabem (Oceanic)	laryngeal harmony	MSC + alternations	Dempwolff (1939), Ross (1993, 1995)
Yabem (Oceanic)	stricture harmony	MSC + alternations	Dempwolff (1939), Ross (1995)
Yabem (Oceanic)	nasal consonant harmony?	alternations	Dempwolff (1939), Ross (1995)
Yucatec (classical; Mayan)	sibilant harmony	MSC	Lombardi (1991)
Yucatec (modern; Mayan)	stricture harmony	MSC	Straight (1976), Lombardi (1991)
Yucatec (modern; Mayan)	sibilant harmony	MSC	Straight (1976), Lombardi (1991)
Yucatec (modern; Mayan)	laryngeal harmony	MSC	Straight (1976)
Zayse (Omotic)	sibilant harmony	MSC + alternations	Hayward (1988, 1990c)

Zoque (Mixe-Zoquean)

palatalization harmony?

alternations

Wonderly (1951)

Zulu (Bantu)

laryngeal harmony

MSC

Khumalo (1987)